(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 October 2012 (04.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/134857 A1

(51) International Patent Classification:
B01D 35/28 (2006.01)

(21) International Application Number:
PCT/US2012/029643

(22) International Filing Date:
19 March 2012 (19.03.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/470,862 1 April 2011 (01.04.2011) US

(71) Applicant *(for all designated States except US)*: **EXXONMOBIL UPSTREAM RESEARCH COMPANY** [US/US]; CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **GUY, Ashley, R.** [US/US]; 600 Studemont Street #3425, Houston, TX 77007 (US). **SITES, Angus** [US/US]; 2410 Randall Point Court, Spring, TX 77388 (US). **DHANUKA, Sulabh, K.** [US/US]; 111 Post Oak Boulevard #201, Houston, TX 77056 (US). **CALAFELL, Dag, O.** [US/US]; 23130 San Nicholas Place, Katy, TX 77494 (US).

(74) Agents: **COURTNEY, Edward, A.** et al.; ExxonMobil Upstream Research Company, CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

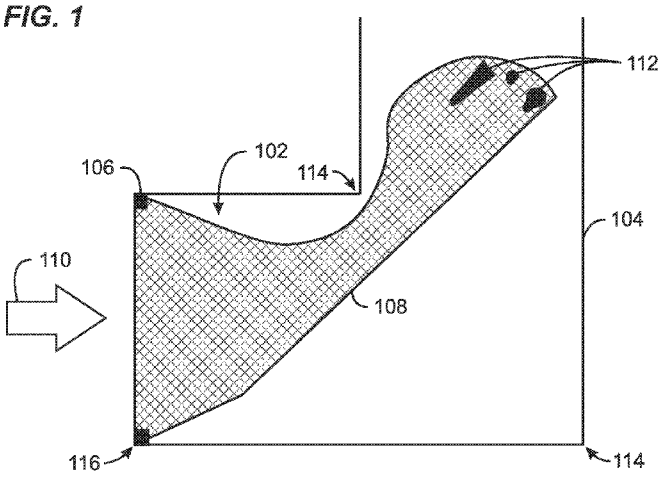
Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: FLEXIBLE PROCESS STRAINERS

FIG. 1



100

(57) Abstract: A strainer for removing debris from a fluid stream. The strainer includes a protective element, wherein the protective element comprises a flexible net configured to trap solids carried in a fluid stream, and a mount to hold the protective element within the fluid stream.

WO 2012/134857 A1

FLEXIBLE PROCESS STRAINERS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from U.S. Provisional Application No. 61/470,862, filed on April 1, 2011, entitled Flexible Process Strainer, which is incorporated by reference herein in its entirety.

FIELD

[0002] The present techniques relate to the use of flexible process strainers. The flexible strainers may be made from strong, chemically resistant fibers.

BACKGROUND

[0003] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present techniques. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present techniques. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0004] Strainers are generally perforated metal plates or metal screens used during the startup, commissioning, and operation of facilities to protect rotating machinery, valves, and other sensitive equipment. Strainers are intended to block the debris left behind during construction or dislodged during operation. However, they often fail themselves and may cause damage to downstream equipment.

[0005] A common issue with strainers is the decision of whether or when to take a plant shutdown to remove or replace the strainers. Running plants beyond the design life of a strainer can cause the strainer to fail due to stress caused by flow induced vibration. Strainers are generally a low cost item that have limited design data provided by manufacturers, such as flow versus expected pressure drop curves, design life predictions, or analysis for susceptibility to flow induced vibration, among others. Strainers are often placed at the suction side of rotating machinery, vessels, valves, etc. to protect internal components of the pump from damage.

[0006] Typical suction strainers include bathtub, basket, and conical types, also known as "witch-hats." The bathtub type may have a larger surface area formed into one or more catch basins. The bathtub strainer may have a higher capacity for holding debris without fouling than a conical type, but may require a dedicated holder be inserted into a pipe section to hold the strainer. In contrast, the conical type is a circular structure that tapers to a point. Being

round and smaller than the bathtub type, the conical type can fit inside a pipe, for example, taking the place of a gasket between opposing pipe flanges. Basket type strainers are cylindrical and are often mounted with the cylinder axis offset to the piping axis. Bathtub, basket, and conical type are welded designs with the bathtub strainer providing ease of removal and a conical strainer providing higher strength. The strainers are generally constructed from a punched metal mesh having finer mesh screens overlaid the punched metal.

[0007] Differential pressure (dP) may be used to determine when a shutdown should be taken to clean the strainer. The dP is usually monitored across the strainer and compared to a design pressure. However, the expected "clean" dP of current metal strainers can be unknown, which may lead to premature collapse. The limited differential pressure capability of current strainers may lead to excessive intervention and down time. Common failure modes are poor construction quality, excessive dP (static stress), and flow induced vibration (alternating stress).

[0008] Strainers can be difficult to install because of their weight and size. For example, a strainer used to replace a gasket between flanges on pipe segments may require prying apart the pipe flanges to install the strainer. Further, there may often be a shortage of readily available equipment to install strainers because of their weight and size.

[0009] Current strainers can be prone to failure and often lack design data. They are susceptible to failure in high vibration applications or when excessive differential pressure results from debris buildup. Strainers are generally designed with an open area twice that of the structural components. Their size and weight prevent them from having more open area which would yield lower "clean differential pressure" and allow them to remain installed longer.

SUMMARY

[0010] An embodiment of the present techniques provides a flexible strainer for removing debris from a fluid stream. The flexible strainer includes a flexible net configured to trap solids carried in a fluid stream and a mount to hold the flexible net within the fluid stream.

[0011] The flexible net may include a high-strength fiber. Further, the flexible net may include an aramid, a carbon fiber, an organic polymer, an inorganic polymer, a synthetic fiber, or any combinations thereof. The flexible net may have openings between about 63 μm and about 7620 μm. The flexible net may have a protective coating configured to protect the flexible net from corrosion or degradation.

[0012] The flexible strainer can be shaped to fit into process piping. For example, the flexible strainer can be circular, cylindrical, or "D" shaped. The process piping may be equal to or larger than Nominal Pipe Size (NPS) 8. The flexible net may also be shaped like a cone, a cone with a cylindrical extension, or a rectangle. The flexible net may be collapsible and may be detachable from a mount.

[0013] The mount may include high-strength fibers, metal, a spiral wound gasket, ring gasket, or any combinations thereof. The mount may be integral to the flexible net. Further, the mount may be configured to be held between two pipe flanges, with the flexible net configured to project into a pipe segment within the fluid stream. The mount may be configured to be held within the fluid stream by being attached to support structures along an interior wall of a pipe. A deflector may protect the protective element, the mount, or both from damage.

[0014] Units may be included in the flexible net to perform other functions. For example, such units may stabilize the flexible net within the fluid stream. Sensors may be included to determine the condition of the flexible net. Imaging targets may allow non-invasive assessment of a condition of the flexible net. Aerodynamic devices may be included to stabilize the flexible net in a fluid flow. Radio frequency identity tags may be included to allow non-invasive assessment of the apparatus condition.

[0015] Another embodiment provides a system configured to remove debris from a fluid flow. The system includes a single layer of a flexible net, wherein the flexible net comprises polymeric fibers.

[0016] The flexible net may be suspended from an integral mount within a pipe spool. The system may include a gasket for a raised face flange, wherein an upper opening of the flexible net is integrated into the windings of the gasket. The system may include a spiral wound gasket, wherein an upper opening of the flexible net is integrated into the spiral wound gasket. The system may include a ring-type flange gasket, wherein an upper opening of the flexible net is integrated into the gasket. A mount may be configured to hold the flexible net by axial or radial compression.

[0017] Another embodiment provides a method for protecting equipment from debris in a pipe. The method includes placing a flexible strainer in the pipe, wherein the flexible strainer is configured to capture debris upstream of process equipment, and wherein the pipe is not designed specifically designed to hold the flexible strainer.

[0018] The equipment may comprise a pump. The method may include replacing a gasket between two pipe segments with a gasket incorporating the flexible strainer. The status of the flexible strainer may be determined by obtaining an x-ray image of the pipe.

DESCRIPTION OF THE DRAWINGS

[0019] The advantages of the present techniques are better understood by referring to the following detailed description and the attached drawings, in which:

[0020] Fig. 1 is a cross-sectional view of a flexible strainer in a pipe;

[0021] Fig. 2 is a drawing of two examples of shapes that may be use with flexible strainers;

[0022] Fig. 3 is a drawing of a flexible strainer having a flexible net suspended from a mount within a pipe;

[0023] Fig. 4 is a front and side view of a flexible strainer which has an integrated gasket as the mount;

[0024] Fig. 5 is a drawing of two techniques for integrating a wire wound gasket with a flexible net to form a flexible strainer;

[0025] Fig. 6 is a drawing of a flexible strainer that incorporates tools for determining the status of the flexible strainer from the exterior of a pipe;

[0026] Fig. 7 is a cross-sectional view of an upstream flexible strainer configuration; and

[0027] Figs. 7A and 7B show exemplary mounting rings.

DETAILED DESCRIPTION

[0028] In the following detailed description section, specific embodiments of the present techniques are described. However, to the extent that the following description is specific to a particular embodiment or a particular use of the present techniques, this is intended to be for exemplary purposes only and simply provides a description of the exemplary embodiments. Accordingly, the techniques are not limited to the specific embodiments described below, but rather, include all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

[0029] Debris left over from construction or dislodged during operation can damage downstream equipment including compressors, pumps, valves, suction drums, heat exchangers, and the like. Embodiments described herein are directed to a flexible strainer comprising a flexible net made from high-strength fabric that can protect downstream components from debris contained in piping, vessels, or process components. The flexible

net can be made from synthetic or natural polymers, and is held in place by a mount that places the flexible net in a fluid stream, for example, inside a pipe.

[0030] As used herein "flexible" has its ordinary meaning known to those skilled in the art. For example, "flexible" means capable of being flexed without breaking. In one or more embodiments, a "flexible strainer" means a strainer having a shape that can be modified or adapted without breaking. In one or more embodiments, a "flexible strainer" is a woven or unwoven mesh, cloth, web, or net of fibers.

[0031] The flexible strainer may have a higher differential pressure capability than metal strainers which allows it to accumulate more debris and run longer than a metal strainer. Further, the flexible strainer may be more resistance to overstress failure than a standard metal strainer. The flexible strainer is also less vulnerable to vibration triggered failure than a metal strainer because the fabric of the flexible net has minimal stiffness. In addition, the flexible strainer may be used to trap debris with flow going in either direction across the strainer. For example, the strainer can be structured to capture debris either in its concave or convex side.

[0032] Fig. 1 is a cross-sectional view of a flexible strainer **102** in a pipe **104**. The flexible strainer **102** includes a mount **106** that holds a flexible net **108** in the pipe **104**, with an open end positioned in a fluid stream **110**. The flexible net **108** may capture debris **112** from the fluid stream, including construction debris and process debris, such as metal fragments, broken thermowells, and the like.

[0033] The flexible net **108** can be made from high strength fibers. The fibers may be synthetic, natural, or a combination of the two and may be made from either inorganic or organic materials. High strength fibers can be stronger in tension than steel and may have a low stiffness which may make the flexible net **108** less vulnerable to cyclic fatigue stress. For example, the flexible net **108** can be formed from aramids, carbon fibers, organic polymers, inorganic polymers, synthetic fibers, or any combinations thereof. In some embodiments, the fibers may include metal wires or even metal chains. The flexible net **108** is not limited to these materials, and they may be used in combination with each other and with other materials, for example, to stiffen or strengthen the flexible net **108**.

[0034] The flexible net **108** may have a protective coating configured to protect the flexible net **108** from corrosion, degradation, or physical damage. For example, the protective coating may be a polyethylene coating designed to make the flexible net more resistant to chemical attack. Other coatings may be used, including a polyphenylene sulfide (PPS), which may make the flexible net **108** more resistant to oxidative degradation. As

another example, a silicone polymer coating may make the flexible net 108 more resistant to physical damage, such as sharp edges. Other materials may also be used as coatings to be for protecting a flexible net **102** from various damaging agents. For example, in some applications, a polyamide net with a polytetrafluoroethylene (PTFE) coating may be useful in environments having chemical and abrasion hazards. Further, the fibers may be chosen to be resistant to oxygen degradation, for example, being fire resistant.

[0035] The flexible net **108** may bend, allowing the flexible strainer **102** to be used in situations that a metal strainer would not be useable, such as in pipes **104** that have a bend **114** close to the installation point **116**. Further, the flexible strainer **102** can be collapsible to allow fitting the flexible strainer **102** into narrow spaces such as the gap between two pipe flanges.

[0036] The flexible net **108** may have any number of mesh sizes. For example, the mesh sizes may be comparable to the mesh sizes of a metal strainer, e.g., from a size 3 mesh, which has openings of about 0.2790 in. (7087 μm) and a 70.1% open area, to a size 250 mesh, which has openings of .0024 in. (61 μm) and a 35.0 % open area. The mesh is designed with different mesh sizes depending on the size of debris that is appropriate to flow through the strainer. Debris can range in size from grains of sand to large construction debris such as tools, boards, or scaffolding. Broken process components such as thermowells and tower internals may also occur in the fluid stream **110**. Accordingly, the flexible net may have openings between about 0.0025 in. (63 μm) and about 0.30 in. (7620 μm).

[0037] In some embodiments, the flexible strainer **102** may be used to capture large debris prior to sending the fluid stream **110** through a downstream unit, such as a pump, valve, or the like. In this embodiment, the flexible net **108** may have openings of about 0.03 in. (762 μm) to about 0.3 in. (7620 μm). These embodiments may be useful in upstream lines from process filters, which generally have many layers of fine mesh to provide higher surface area, but may be vulnerable to damage or plugging from larger fragments or objects. Because the high strength fibers are lightweight in comparison to steel, larger strainers can be manufactured, which may allow for a lower pressure drop for the same amount of particulate protection as a comparable steel strainer. Accordingly, the flexible strainers **102** may be useful for larger pipe sizes, such as nominal pipe size (NPS) 8 and larger. Further, as noted, the flexibility of the flexible strainer **102** may allow it to be installed in spaces were a metal strainer of similar size cannot reach

[0038] The mount **106** may not only hold the flexible net **108** open and provide an overall shape, but may also provide an attachment point to secure the flexible strainer **102** in the fluid

flow **110**. Many methods of attachment or shapes of the strainer design can be used, as discussed with respect to Fig. 2. The mount **106** may be made from any number of materials, including, for example, metal or high strength fibers, for example, welded into a composite structure. The mount **106** is not limited to rigid materials, but may be flexible to allow for easier installation in some applications.

[0039] Fig. 2 is a drawing of two examples of shapes that may be use with flexible strainers. The first flexible strainer **202** is similar to that shown in Fig. 1, and may be useful for replacing metal cone strainers in some applications. This flexible strainer **202** may be installed in pipes without using a specifically designed holder, for example, as part of a gasket installed between pipe flanges, as discussed further with respect to Fig. 4.

[0040] The second flexible strainer **204** can be recognized as a "T" strainer used in a dedicated holder that is installed between pipe segments. A T strainer generally has a piping section with "porthole" that allows the strainer's replacement in the line. A flexible strainer **204** could use a much smaller porthole because the flexible strainer **204** can be squeezed into the hole. The rounded front **206** of the second flexible strainer **204** may fit against a rounded edge of a pipe wall in a holder. The flexible strainers are not limited to these configurations, as any number of other shapes may be used, including, for example, flexible strainers configured as basket strainers, Y-strainers, and the like.

[0041] Further, the flexibility and strength of the fiber used to form the flexible nets **108** allows the flexible nets **108** to be made into different shapes. For example, a flexible strainer that is used to replace a cone strainer in a pipe installation may have a flexible net **108** shaped like a cone, a cone with a uniform diameter extension in the center of the cone (as shown in Fig. 3), a hemisphere, a parabola (as seen in flexible strainer **202**), and the like. The variable geometry of the flexible strainer may be used to aid in determining when the flexible strainer is holding debris, and can be replaced. For example, a flexible net **108** having a series of extensions of decreasing diameter may provide measurement points for a pressure drop across the strainer, since the pressure may step up as each diameter of extension fills up with debris.

[0042] Fig. 3 is a drawing of a flexible strainer **300** having a flexible net **108** suspended from a mount **106** within a pipe **302**. In this example, the mount **106** has rings **304** designed to fit over internal hooks **306** along the interior wall of the pipe **302**. The mount **106** may be flexible to allow for easier insertion past the internal hooks **306**.

[0043] In an embodiment, the internal hooks **306** can be replaced with mounting brackets having areas designed to engage with matching areas on the mount **106**. In this case, the

mount **106** may be more rigid to decrease the chance of the mount **106** bending and disengaging from the mounting brackets. The use of mounting brackets may allow for the use of multiple flexible strainers in series, wherein each flexible strainer can be rotated to slide past a first mounting bracket to engage with a subsequent mounting bracket. In an embodiment, each subsequent flexible strainer may have a finer mesh size. Similarly, a mount **106** may be designed to hold multiple strainers in parallel, for example, for use in a large diameter pipe.

[0044] In some embodiments above, a deflector may be used to protect the mount **106** and the flexible net **108** at the point of attachment to the mount **306**. The deflectors may be used to divert the fluid stream away from the mount **106** and towards the opening in the flexible strainer. The deflectors may provide a longer useful life for the flexible strainer by lowering the chance of the flexible net **108** tearing away from the mount **106** after a debris impact.

[0045] Fig. 4 is a front and side view of a flexible strainer **400** which has an integrated gasket **402** as the mount **106**. In some embodiments, the integrated gasket **402** may have bolt holes that correspond to bolt holes on the flanges. The gasket may be a configured to seal a raised face flange. In the embodiment shown in Fig. 4, the gasket **402** may have a flexible net **108** interwoven with the spiral windings **404** of the gasket material. This may help to ensure that the flexible net **108** is strongly integrated into the gasket **402**. The flexible strainer **400** may then be used to replace a normal gasket between the flanges of two pipes, allowing installation of the flexible strainer **400** into the fluid flow of the pipe. As noted, the flexible net **108** may be collapsed for installation, lowering the amount of separation between the flanges during installation.

[0046] Fig. 5 is a drawing of two techniques for integrating a wire wound gasket with a flexible net to form a flexible strainer. In Fig. 5(A), the wire winding materials **502**, such as graphite and a soft wire, incorporate an upper portion **504** of the flexible net **108**, which is wound about the wire winding materials **502**. In this example, the wire winding materials **502** and the upper portion **504** of the flexible net **108** are axially compressed by two pipe flanges, as indicated by arrows **506**. In the example shown in Fig. 5(B), the wire winding materials **502** and the upper portion **504** of the flexible net **108** are radially compressed by two pipe flanges, as indicated by arrows **508**. In either of the configurations shown in Fig. 5, as the wire winding materials **502** are compressed, they may flow or weld together, incorporating the upper portion **504** of the flexible net **108**.

[0047] In addition to forming a flexible strainer from a gasket, other materials and tools may be incorporated into the flexible net **108**. For example, the use of a polymeric fiber allows the use of x-ray imaging to determine the status of the flexible strainer. The x-rays may not clearly image the flexible strainer, but may instead image the contents. However, if the flexible strainer is not imaged, the amount of material in the flexible strainer relative to the capacity of the flexible strainer may be difficult to determine. Tools may be incorporated into the flexible net **108** for this determination, as discussed with respect to Fig. 6.

[0048] Fig. 6 is a drawing of a flexible strainer **600** that incorporates tools **602**, **604**, or **606** for determining the status of the flexible strainer **600** from the exterior of a pipe **607**. In this example, the flexible strainer **600** is formed into a gasket **608** as the mount. However, the tools may be used with any sort of mount, including, for example, the mounts discussed with respect to Fig. 2. In this example, a rod **602** may be included in the flexible net **108** to provide a gauge for the amount of debris caught in the flexible net **108**. The rod **602** may have one or more spheres **610** formed at known intervals along the rod **602** to measure the debris level. Further, if the rod **602** has a sphere **610** at the end of the flexible net **108**, this may provide a weight that assists in stabilizing the flexible net **108**, for example, in case of shift flow rates in the fluid stream. Other stabilization devices may also be used, such as weights, or aerodynamic fins **602** that keep the flexible net **108** stable, for example, in the presence of uneven debris loads. Further, tools or devices may be incorporated to keep the flexible strainer **600** stable during flow conditions in either direction, i.e., when the flow through the strainer is from the convex or concave side.

[0049] In another embodiment, a monitoring device, such as a strain gauge **604**, may be incorporated into the flexible net **604**. For example, the strain gauge **604** may be a spring designed to provide an x-ray target. The spring may have a known lengthening in response to a certain applied stress and, thus, allow determination of the stress on the flexible net **102**. In some embodiments, the strain gauge **604** may be an electronic strain gauge read from the outside of the pipe **607**, for example, using a radio frequency identifier tag powered by the energy of the reading device.

[0050] In an embodiment, x-ray targets **606** may be attached to the flexible net **102** to show the position and amount of content of the flexible net **102**. The tools and systems that may be included are not limited to those discussed above. Any number of other systems or materials may be included in the flexible net **102** for various purposes. For example, wires may be included in the weave of the flexible net **102** to provide some increase in stiffness, which may help to prevent emptying of the flexible strainer **600** during intermittent reversals in flow.

[0051] Fig. 7 is a cross-sectional view of an upstream flexible strainer configuration. Referring to Fig. 7, a flexible strainer **700** may be mounted within a pipe such that the strainer extends, or "points", upstream, i.e., into a fluid flow. Any of the foregoing embodiments may be adapted to an "upstream" configuration.

[0052] In this configuration, the flexible strainer **700** directs debris away from the middle of the pipe where fluid travels at a maximum fluid speed, i.e., highest energy. In one or more embodiments, an "upstream" configuration reduces debris accumulation at areas of highest energy, such as at the middle of the pipe. Without being limited by theory, the upstream configuration reduces flow disruptions for downstream equipment and reduces stresses in the flexible strainer.

[0053] Flexible strainer **700** is mounted within a pipe **701** using any technique described above. In one or more embodiments, flexible strainer **700** is positioning by an internal or external rigid frame (not shown). In one or more embodiments, the cone apex **702** of flexible strainer **700** may be attached to the pipe, preferably farther upstream of the cone apex **702**, by an attachment means. The attachment means includes one or more flexible guy-straps **703**, wires, cables, chains, clamps, bisected or sectored ring or rings **704**, etc. Exemplary rings are shown in Figs. 7A and 7B. Such attachments means may be held in place by one or more conventional flanges or clamps (not shown). In one or more embodiments, the flexible strainer **700** may be installed in a pipe that is fabricated, forged, or cast to mount the flexible strainer.

[0054] In one or more embodiments, the flexible strainer **700** is held between a fixed circular flange (not shown) and a solid or segmented removable flange (not shown). The removable flange or segments can be held by bolts threaded into the fixed flange or by other fasteners or means with some provision for positive retention, e.g., tie-wires, thread sealant, or other means. Furthermore, these fasteners are upstream of the flexible strainer **700** and thus would not be able to migrate downstream if the retention system failed.

[0055] Preferably, flexible strainer **700** is mounted with debris collection areas **705**, which may include vessels, access ports, valves, or drains, etc. for debris removal.

[0056] Preferably, the flexible strainer is mounted with one or more access flanges, doors, or compartments so that it can be serviced and replaced. The flexible strainer **700** may be replaced through the access provisions without disturbing any pipework.

[0057] While the present techniques may be susceptible to various modifications and alternative forms, the exemplary embodiments discussed above have been shown only by way of example. However, it should again be understood that the techniques is not intended to be limited to the particular embodiments disclosed herein. Indeed, the present techniques

include all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

CLAIMS

What is claimed is:

1. A flexible strainer for removing debris from a fluid stream, comprising:

a flexible net configured to trap solids carried in a fluid stream; and

a mount to hold the flexible net within the fluid stream.

2. The flexible strainer of claim 1, wherein the flexible net comprises a high-strength fiber.

3. The flexible strainer of claim 1, wherein the flexible net comprises an aramid, a carbon fiber, an organic polymer, an inorganic polymer, a synthetic fiber, or any combinations thereof.

4. The flexible strainer of claim 1, wherein the flexible net has openings between about 63 μm and about 7620 μm.

5. The flexible strainer of claim 1, wherein the flexible net has a protective coating configured to protect the flexible net from corrosion or degradation.

6. The flexible strainer of claim 1, wherein the flexible strainer is shaped to fit into process piping.

7. The flexible strainer of claim 6, wherein the flexible strainer is circular, cylindrical, or "D" shaped.

8. The flexible strainer of claim 6, wherein the process piping is equal to or larger than Nominal Pipe Size (NPS) 8.

9. The flexible strainer of claim 1, wherein the flexible net is shaped like a cone, a cone with a cylindrical extension, or a rectangle.

10. The flexible strainer of claim 1, wherein the flexible net is collapsible.

11. The flexible strainer of claim 1, wherein the flexible net is detachable from the mount.

12. The flexible strainer of claim 1, wherein the mount comprises high-strength fibers, metal, a spiral wound gasket, ring gasket, or any combinations thereof.

13. The flexible strainer of claim 1, wherein the mount is integral to the flexible net.

14. The flexible strainer of claim 1, wherein the mount is configured to be held between two pipe flanges, and the flexible net is configured to project into a pipe segment within the fluid stream.

15. The flexible strainer of claim 1, wherein the mount is configured to be held within the fluid stream by being attached to support structures along an interior wall of a pipe.

16. The flexible strainer of claim 1, comprising a deflector configured to protect the flexible net, the mount, or both from damage.

17. The flexible strainer of claim 1, comprising units configured to stabilize the flexible net within the fluid stream.

18. The flexible strainer of claim 1, comprising sensors configured to determine the condition of the flexible net.

19. The flexible strainer of claim 1, comprising imaging targets to allow non-invasive assessment of the condition of the flexible net.

20. The flexible strainer of claim 1, comprising aerodynamic devices configured to stabilize the flexible net in a fluid flow.

21. The flexible strainer of claim 1, comprising radio frequency identity tags to allow non-invasive assessment of the condition of the flexible net.

22. A system configured to remove debris from a fluid flow, comprising a single layer of a flexible net, wherein the flexible net comprises polymeric fibers.

23. The system of claim 22, wherein the flexible net is suspended from an integral mount within a pipe spool.

24. The system of claim 22, comprising a gasket for a raised face flange, wherein an upper opening of the flexible net is integrated into the windings of the gasket.

25. The system of claim 22, comprising a spiral wound gasket, wherein an upper opening of the flexible net is integrated into the spiral wound gasket.

26. The system of claim 22, comprising a ring-type flange gasket, wherein an upper opening of the flexible net is integrated into the gasket.

27. The system of claim 22, comprising a mount configured to hold the flexible net by axial compression.

28. The system of claim 22, comprising a mount configured to hold the flexible net by radial compression.

29. A method for protecting equipment from debris in a pipe, comprising placing a flexible strainer in the pipe, wherein the flexible strainer is configured to capture debris upstream of process equipment, and wherein the pipe is not designed specifically designed to hold the flexible strainer.

30. The method of claim 29, wherein the equipment comprises a pump.

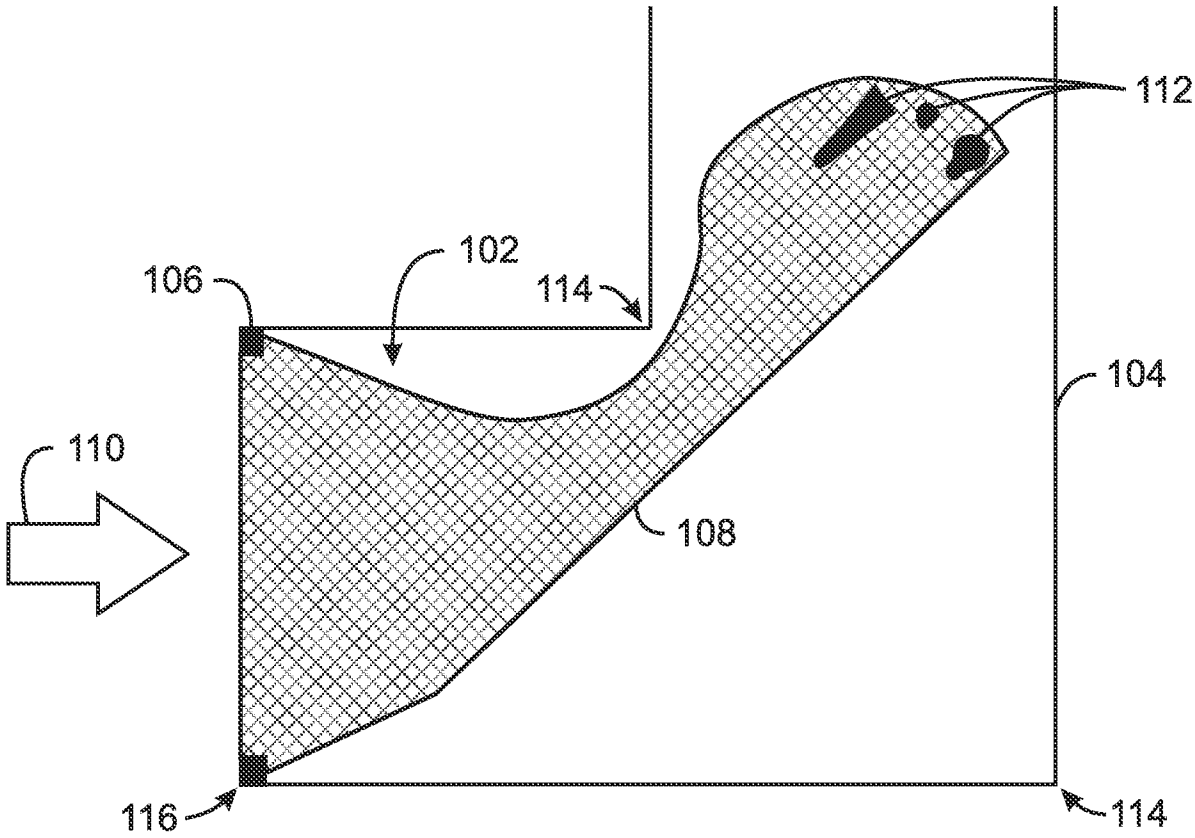
31. The method of claim 29, comprising replacing a gasket between two pipe segments with a gasket incorporating the flexible strainer.

32. The method of claim 29, comprising determining the status of the flexible strainer by obtaining an x-ray image of the pipe.

33. The flexible strainer of any of claims 1-21, wherein the flexible net is mounted in an upstream configuration.

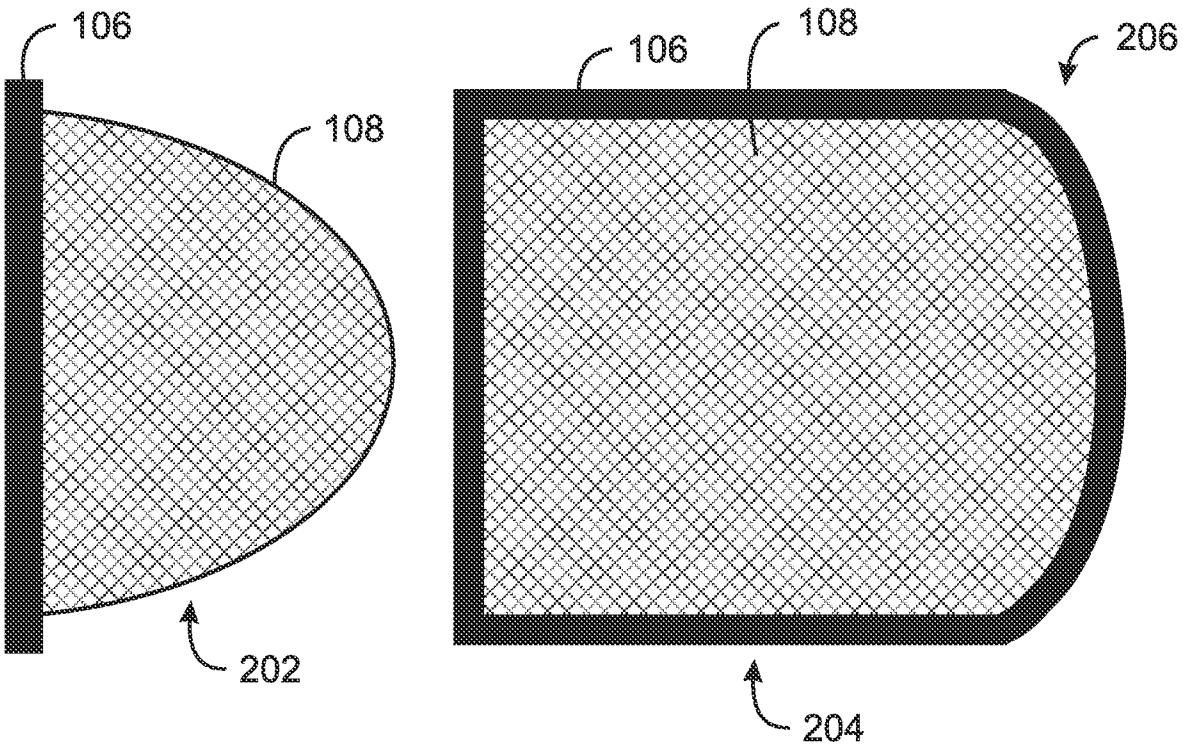
34. A system configured to remove debris from a fluid flow of any of claims 22-28, wherein the flexible net is mounted in an upstream configuration.

35. The method of any of claims 29-32, wherein the flexible strainer is mounted in an upstream configuration.



100

FIG. 1



200

FIG. 2

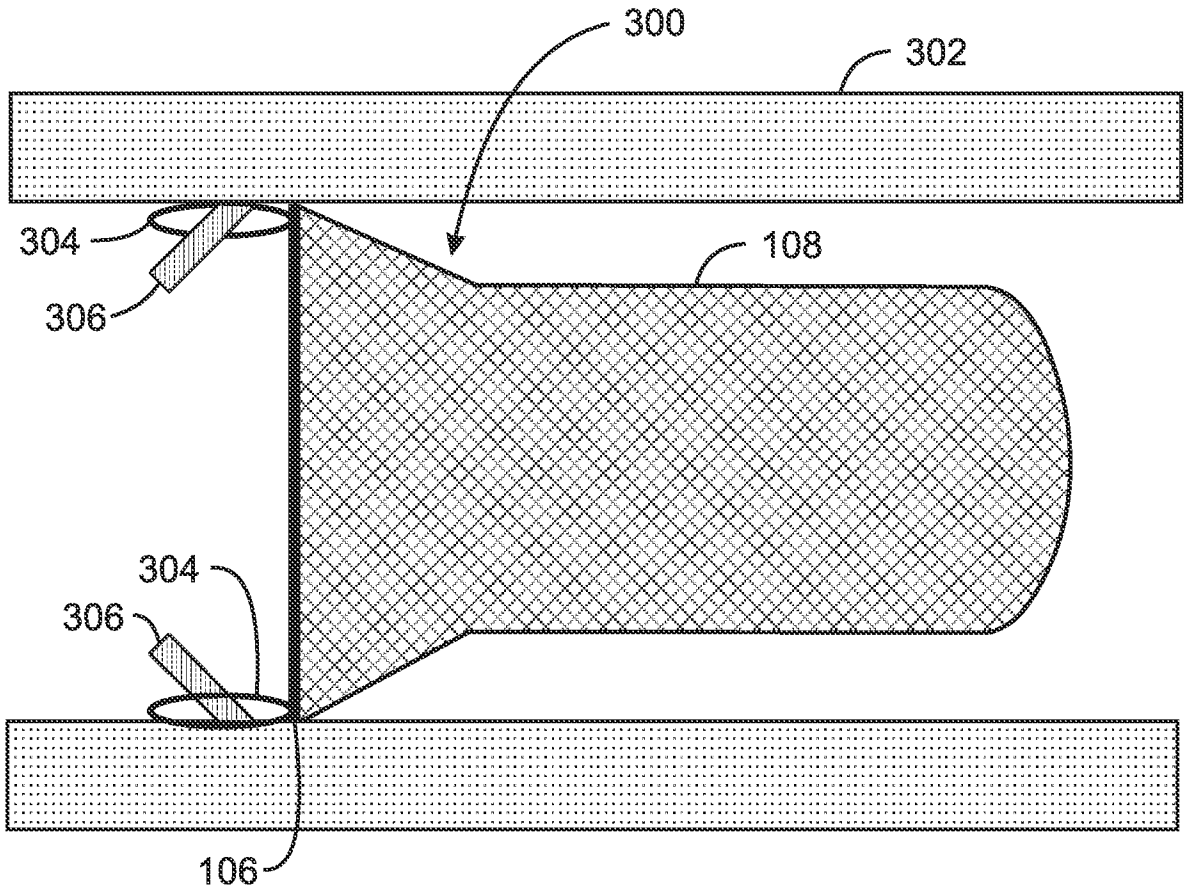
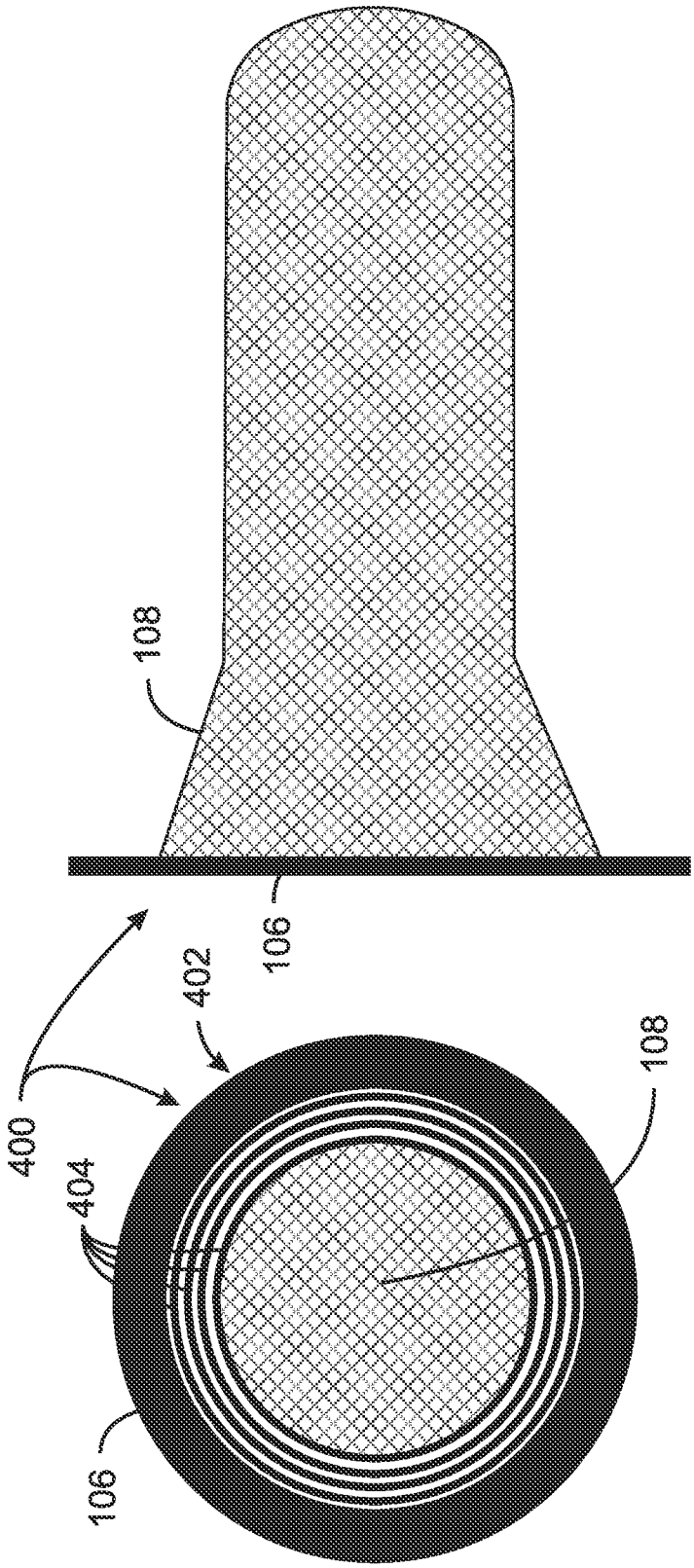


FIG. 3



400

FIG. 4

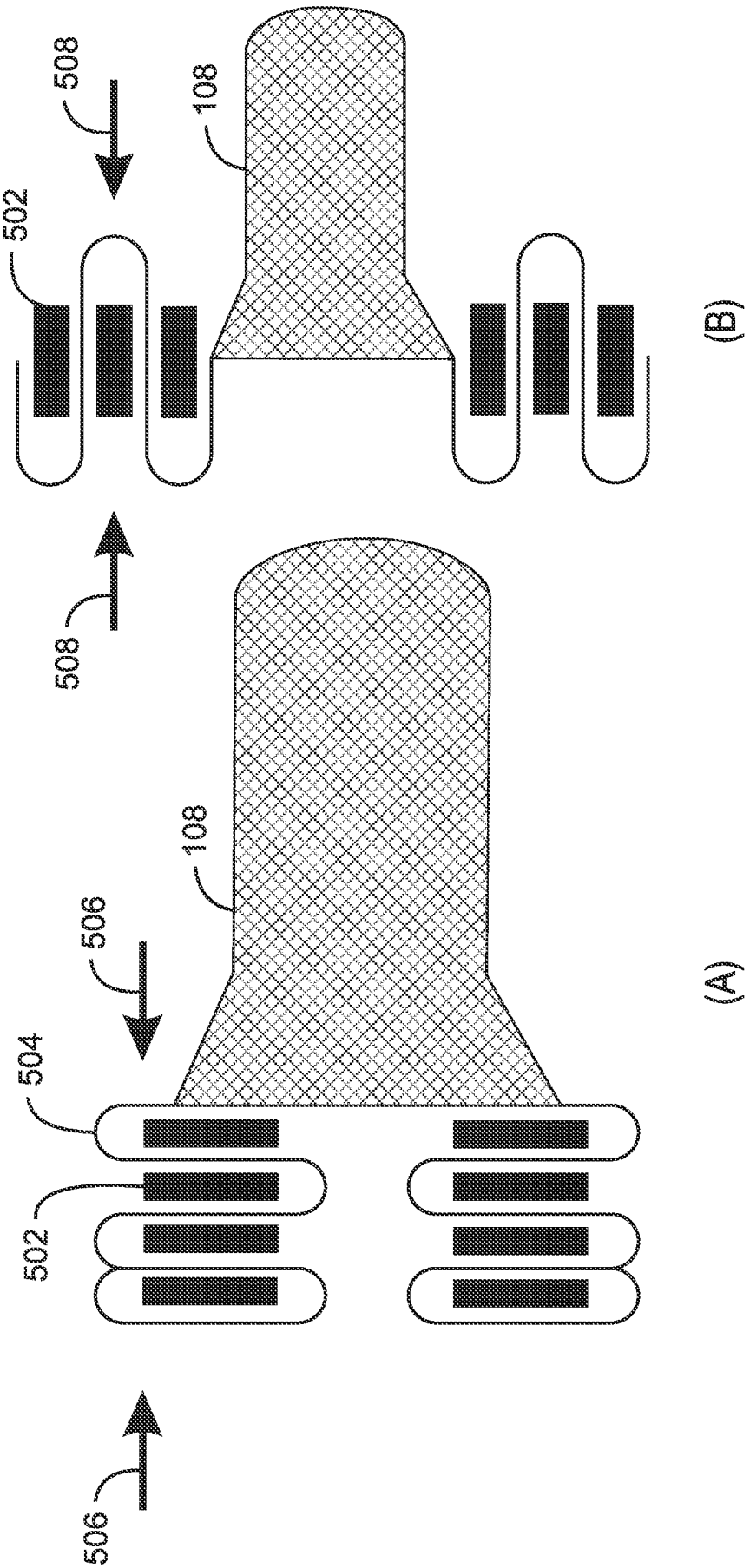
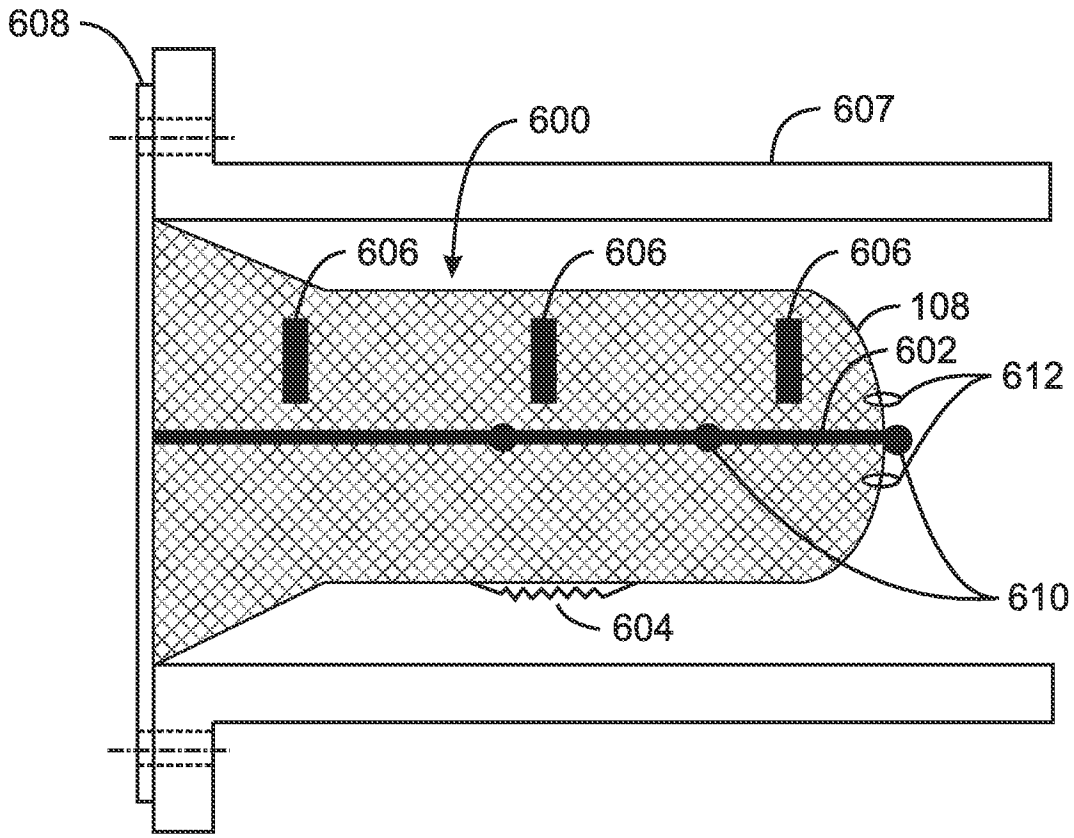


FIG. 5



600

FIG. 6

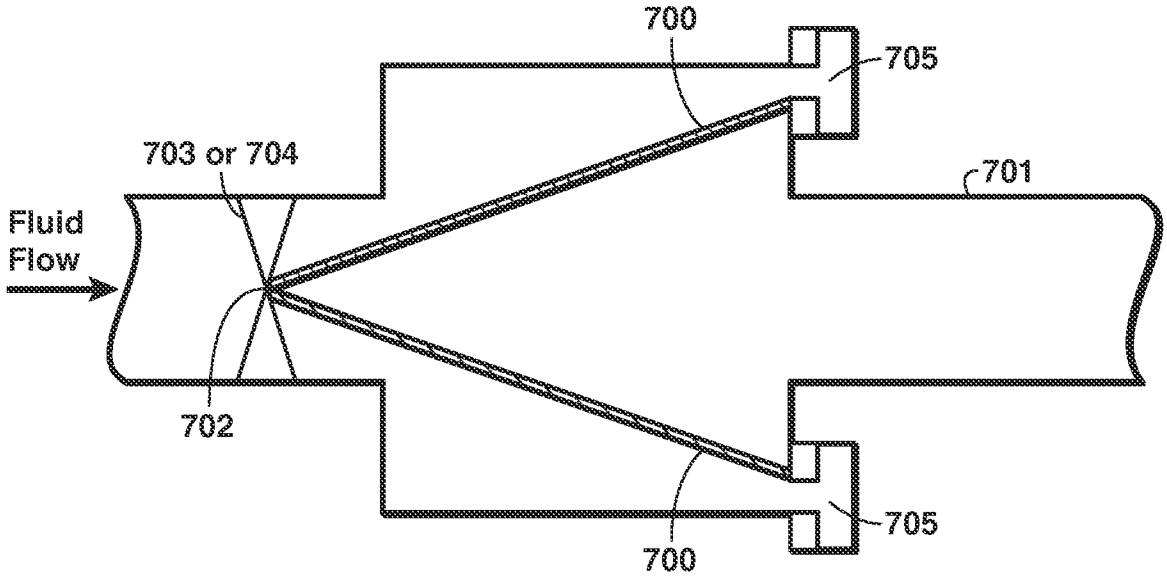


FIG. 7

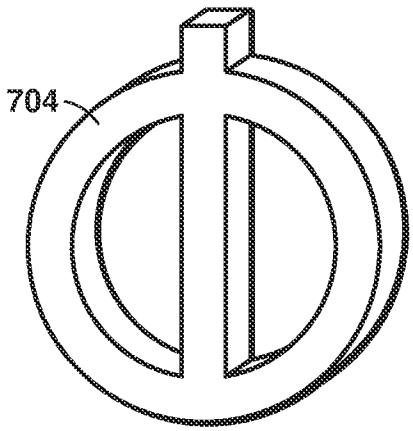


FIG. 7A

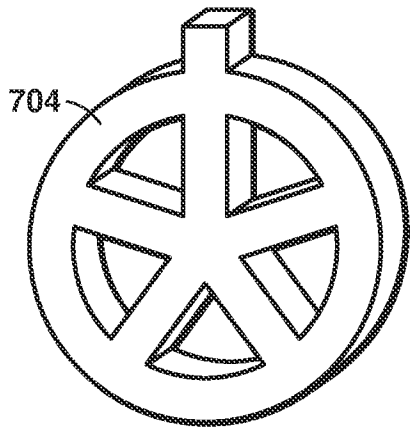


FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/29643

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01D 35/28 (2012.01)
USPC - 210/167.19; 210/241; 210/162
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)
USPC: 210/167.19; 210/241; 210/162

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 210/167.19; 210/241; 210/162 (key word search - see term below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (USPT, PGPUB, EPAB, JPAB), Google Patent/Scholar
Search terms: Flexible, process strainer, net, piping, in-line

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2004/0045883 A1 (Miller Jr.) 11 March 2004 (11.03.2004); entire document, especially para. [0007] and Figs. 1-3	1-3, 5-7, 9, 10, 13, 14, 33 ---------- 4, 8, 11, 12, 15-21
Y	US 4,052,319 A (Friedman) 04 October 1977 (04.10.1977); entire document, especially col. 1, ln. 25-27	4, 11, 12
Y	US 6,523,554 B1 (Bryant, Sr.) 25 February 2003 (25.02.2003); entire document, especially, abstract and col. 2, ln. 6-7	8
Y	US 2,805,731 A (Kron) 10 September 1957 (10.09.1957); col. 4, ln. 20-22	15
Y	US 4,366,056 A (Jackson) 28 December 1982 (28.12.1982); entire document, especially col. 1 and Fig. 3	16, 17, and 20
Y	US 2009/0218297 A1 (Glessner et al.) 03 September 2009 (03.09.2009); para. [0061] and Fig. 8	18 and 19
Y	US 5,562,819 A (Turner, Jr. et al.) 08 October 1996 (08.10.1996); col. 4, ln. 5-8	19 and 21

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

* 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 application or patent but published on or after the international filing date
"L" document which 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
17 August 2012 (17.08.2012)	28 AUG 2012
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/29643

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:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-21, 33/1-21 directed to a flexible strainer for removing debris from a fluid stream, comprising:
a flexible net configured to trap solids carried in a fluid stream; and
a mount to hold the flexible net within the fluid stream.

Group II: claims 22-28, 34/22-28 directed to a system configured to remove debris from a fluid flow, comprising a single layer of a flexible net, wherein the flexible net comprises polymeric fibers.

-----See Supplemental Sheet Below----------

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 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.:
1-21 and 33

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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US 12/29643

Continuation of Box No. III

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-21, 33/1-21 directed to a flexible strainer for removing debris from a fluid stream, comprising:
a flexible net configured to trap solids carried in a fluid stream; and
a mount to hold the flexible net within the fluid stream.

Group II: claims 22-28, 34/22-28 directed to a system configured to remove debris from a fluid flow, comprising a single layer of a flexible net, wherein the flexible net comprises polymeric fibers.

Group III: claims 29-32, 35/29-32 directed to a method for protecting equipment from debris in a pipe, comprising placing a flexible strainer in the pipe, wherein the flexible strainer is configured to capture debris upstream of process equipment, and wherein the pipe is not designed specifically designed to hold the flexible strainer.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because under PCT Rule 13.2 they lack the same or corresponding technical features for the following reasons:

Groups I and II do not include the protecting equipment from debris in a pipe of wherein the pipe is not designed specifically designed to hold the flexible strainer group III.

Groups I and III do not include the polymeric fibers of group II.

Groups II and III do not include the mount to hold the flexible net of group I.

The common feature of groups I, II and III of a flexible strainer or net configured to capture debris in a fluid stream is taught by US 5,672,271 A (Dye) (30 September 1997) (fig. 1; col 1, ln 52 to col 2, ln 9); therefore the common feature is not an improvement over the prior art.

Groups I-III therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.