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(54) **POLYMER-METALLIC REAGENT HEAD**

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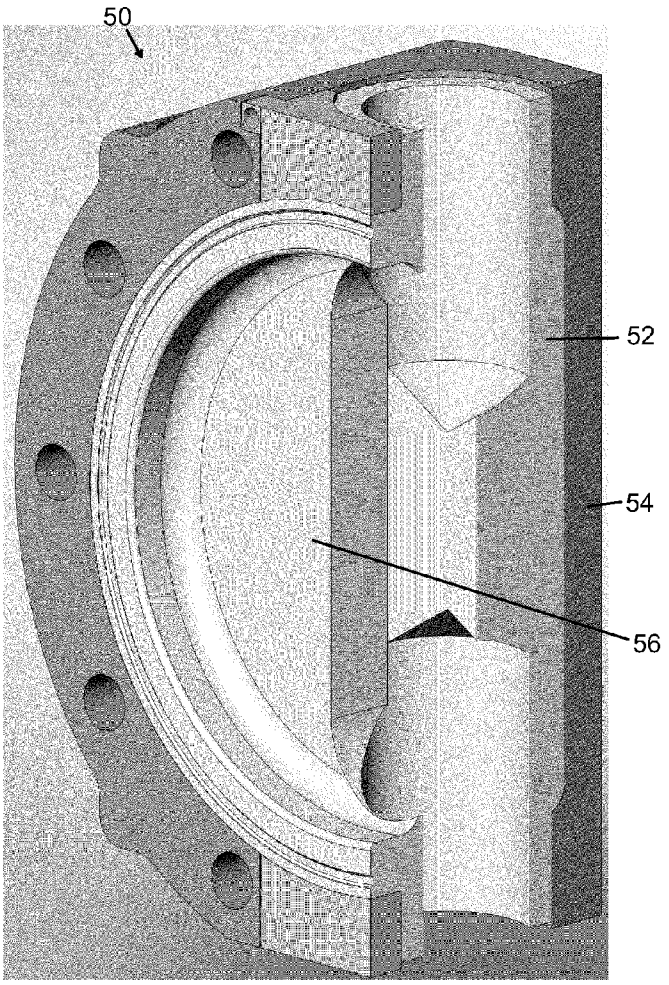
(52) **U.S. Cl.** **417/395**

(57) **ABSTRACT**

A reagent head has a housing, an inlet and an outlet. Check valves and other details are not shown for clarity. The reagent head may have a dish where a diaphragm may seat when in a fully forward position. The reagent head may be constructed primarily from a high-strength material, e.g. ductile iron, in a substrate layer. The reagent head may also comprise a polymer layer. The polymer-metal interface may incorporate key grooves to provide an increased surface area for the polymer-metal bond. The key grooves may be any shape which increases the bonding surface area. Certain key groove cross-sectional shapes, such as dovetails, will create an interlocking interface that may provide increase resistance to separation of the polymer layer from the substrate layer.



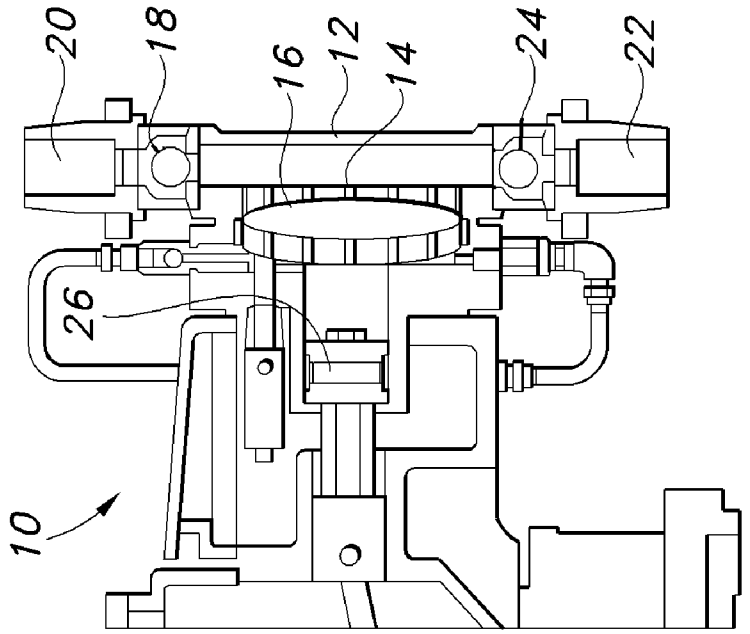


FIG. 1B
(PRIOR ART)

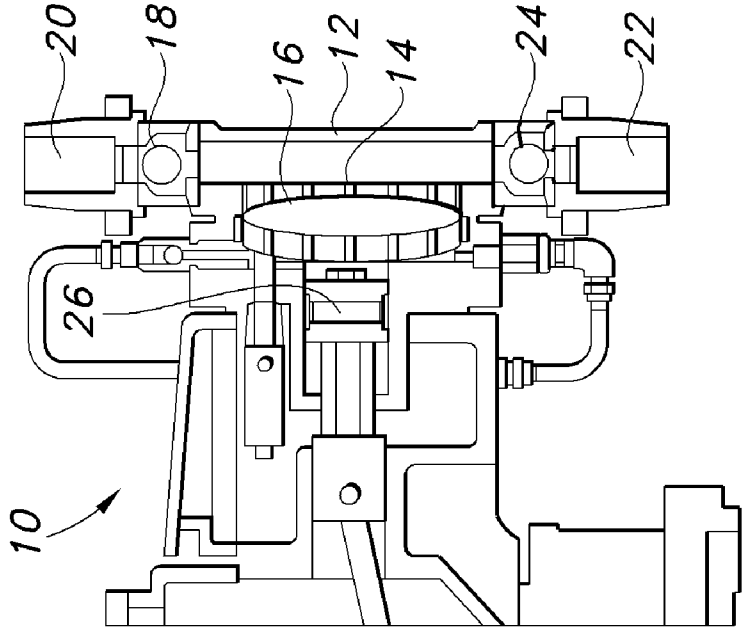


FIG. 1A
(PRIOR ART)

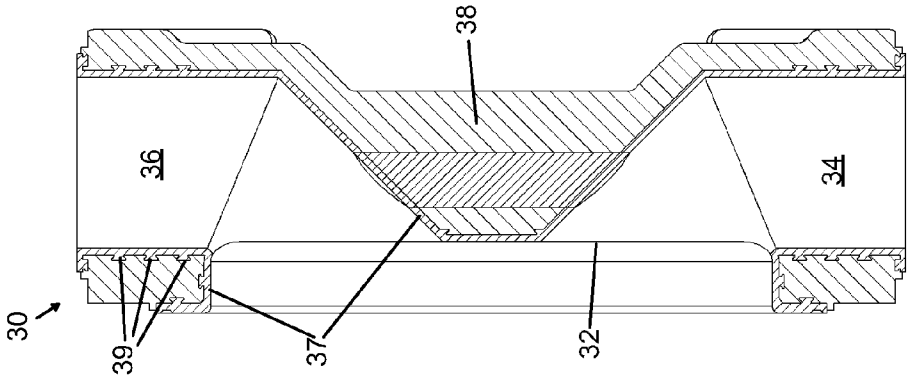


Fig. 3

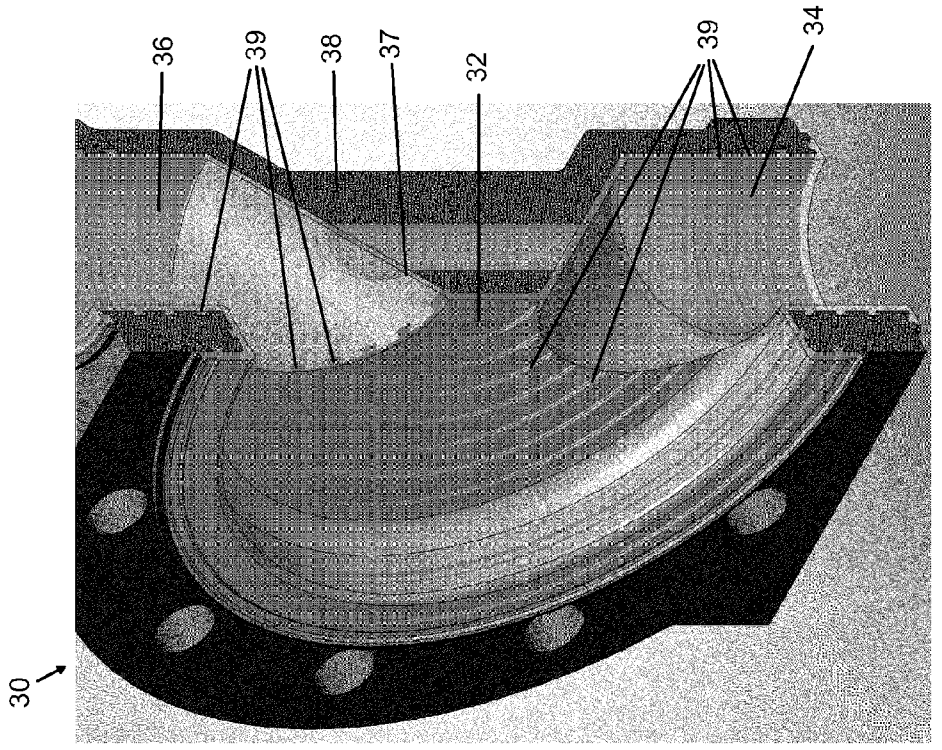
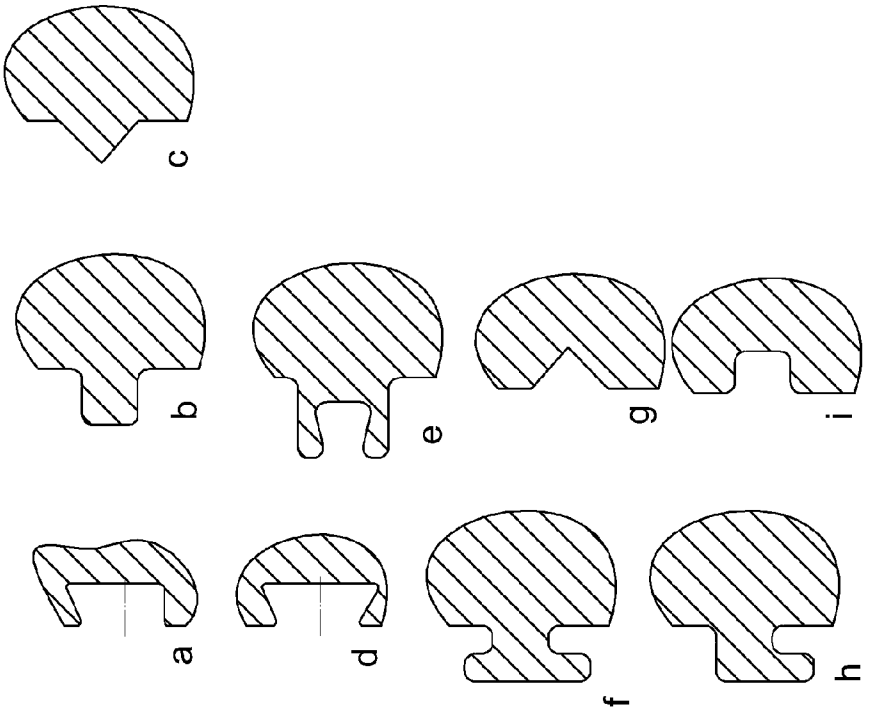


Fig. 2



Figs. 5a-5i

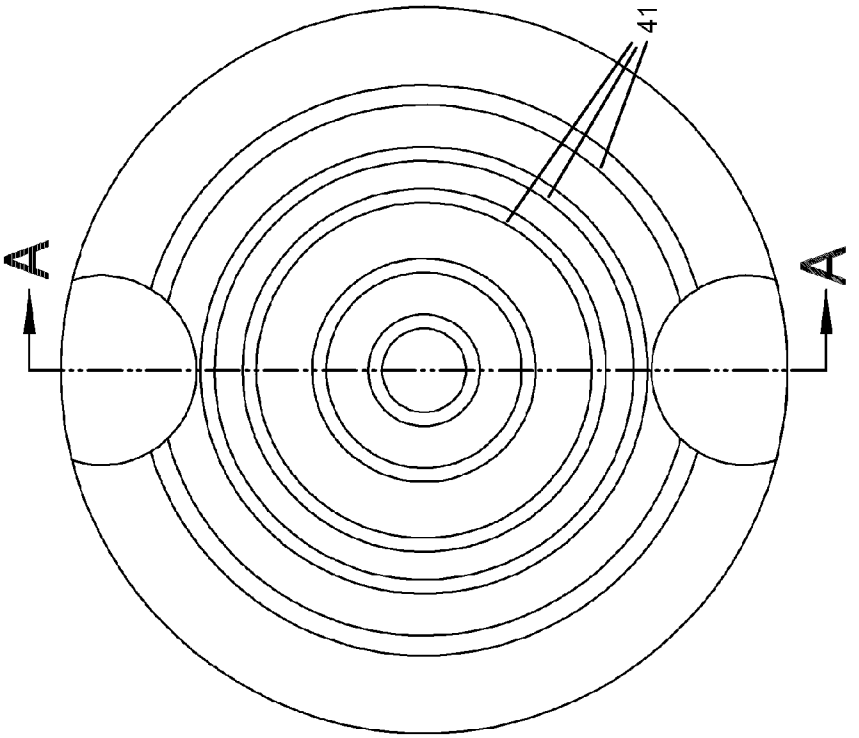


Fig. 4

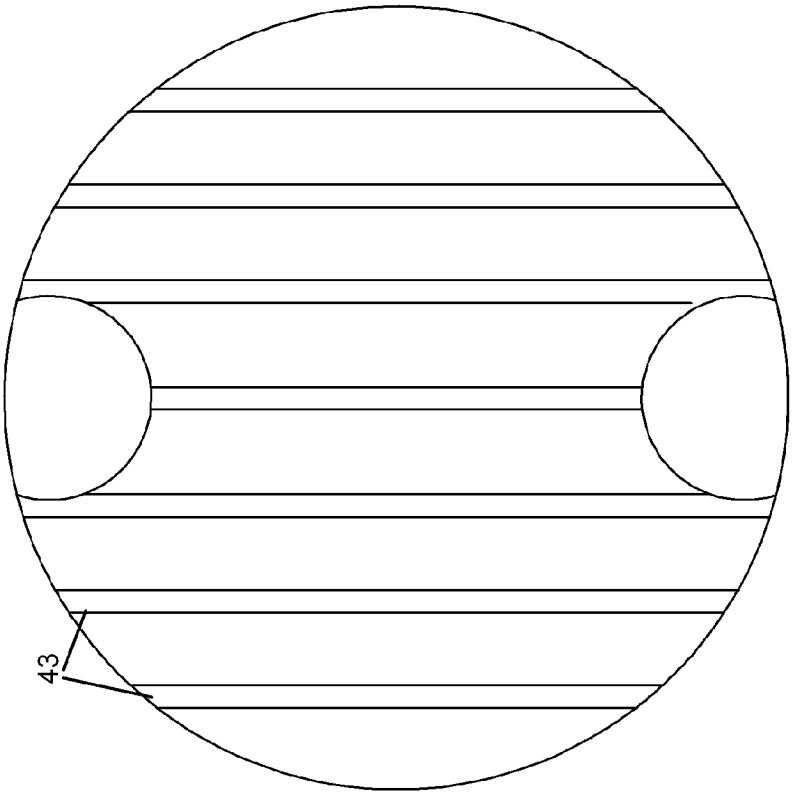


Fig. 7

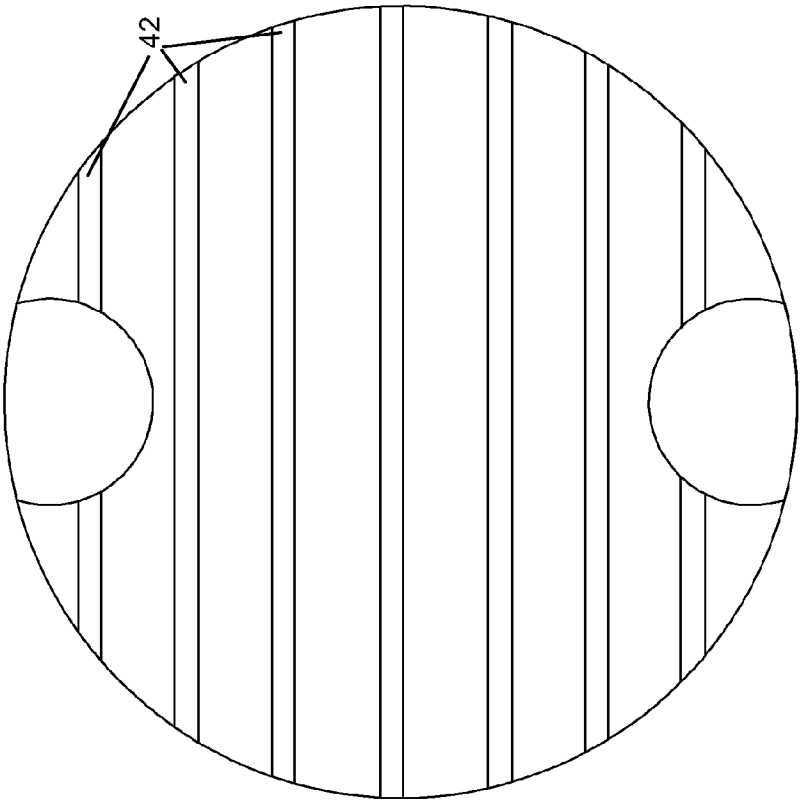


Fig. 6

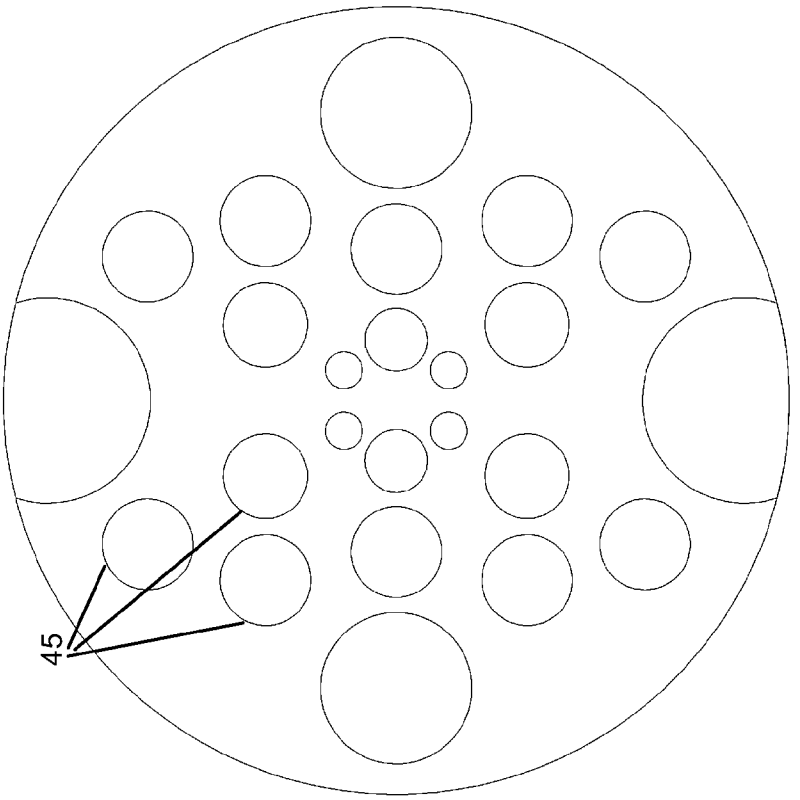


Fig. 9

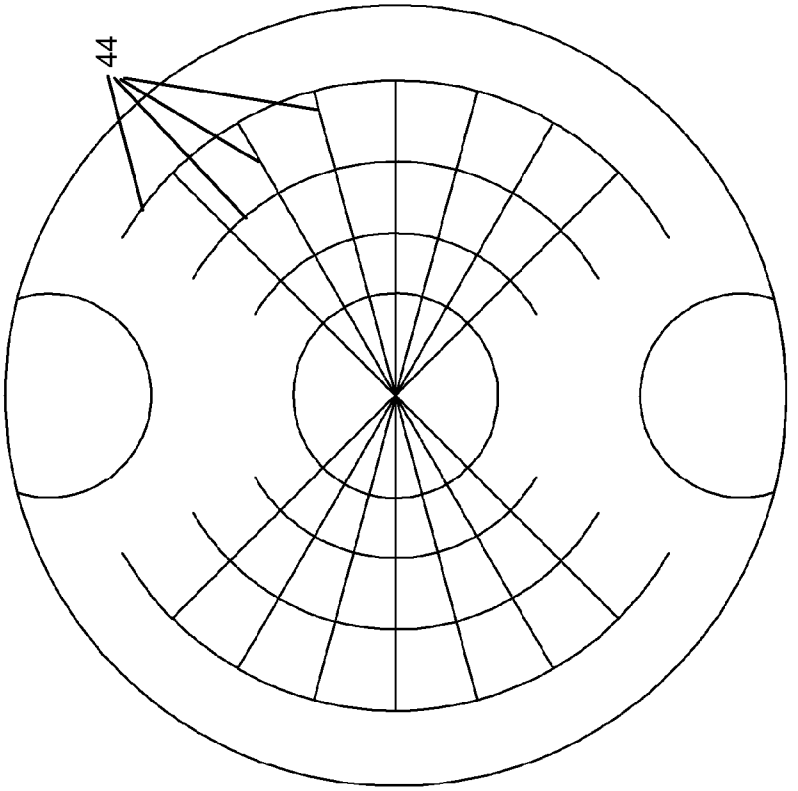


Fig. 8

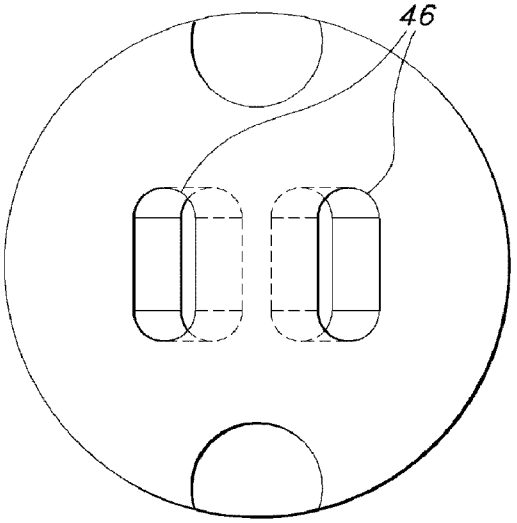


FIG. 10

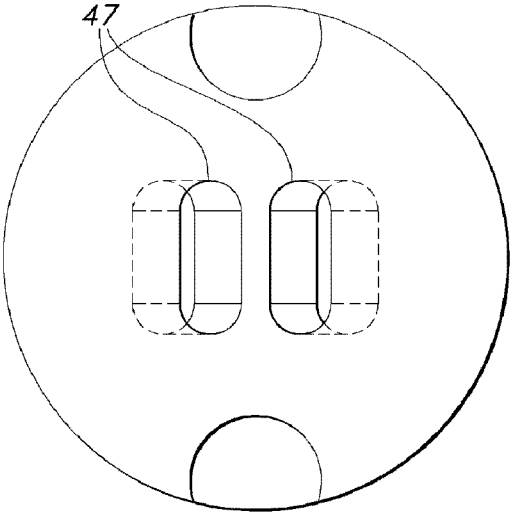


FIG. 11

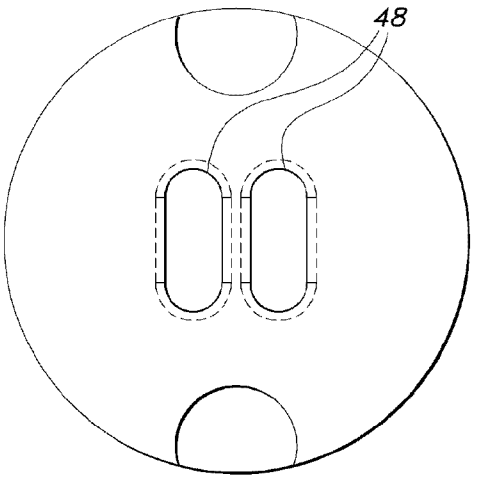


FIG. 12

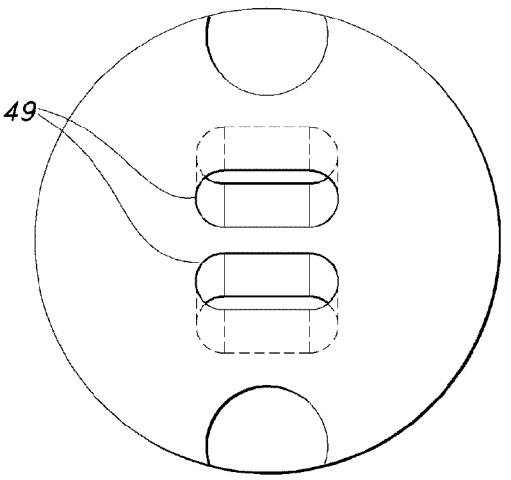


FIG. 13

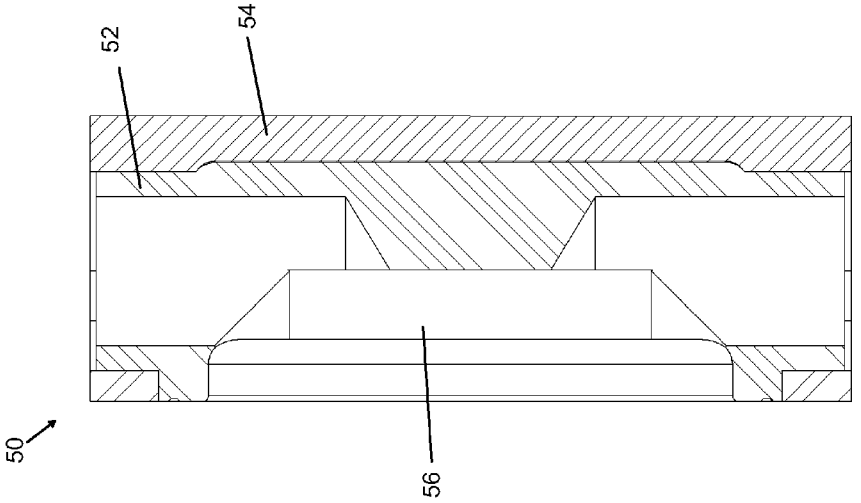


Fig. 14b

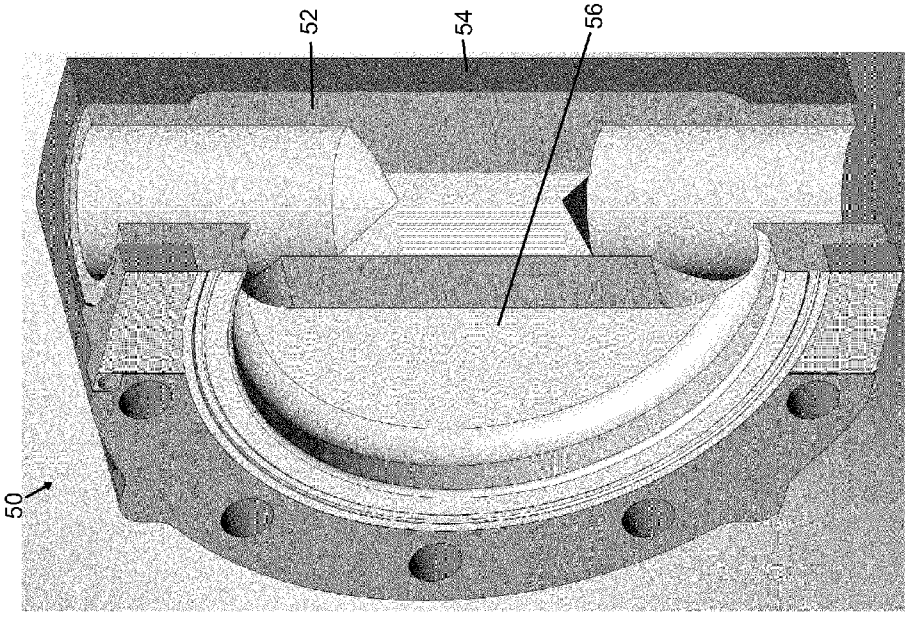


Fig. 14a

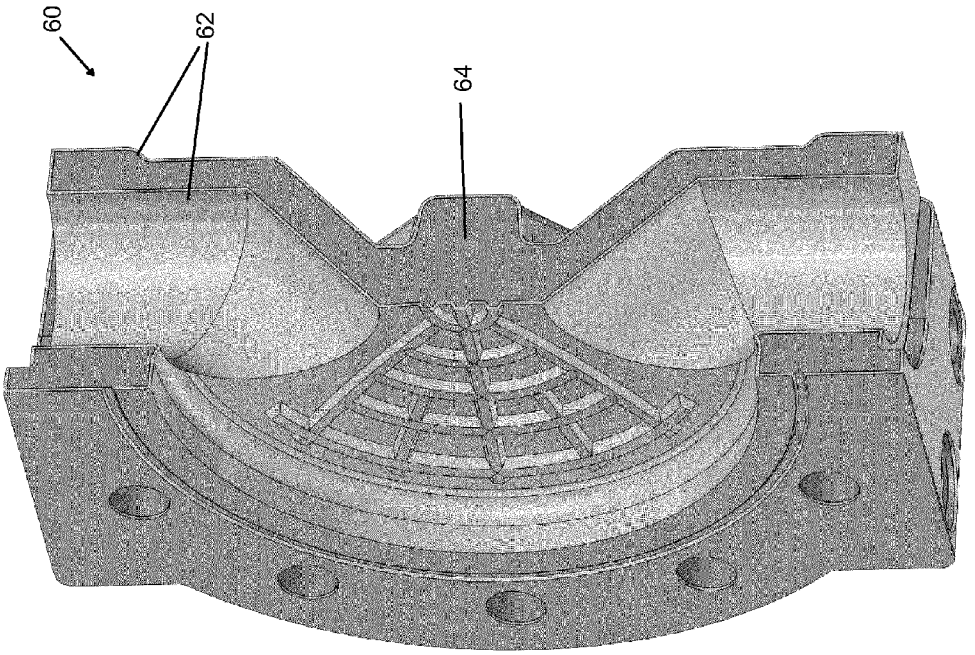


Fig. 15b

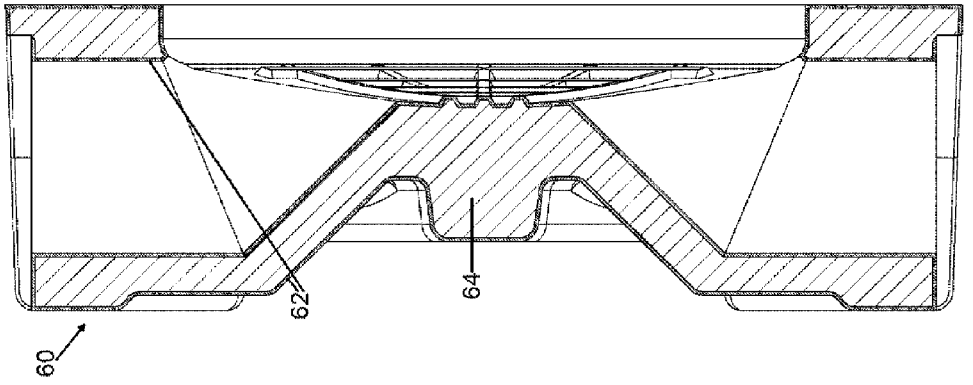


Fig. 15a

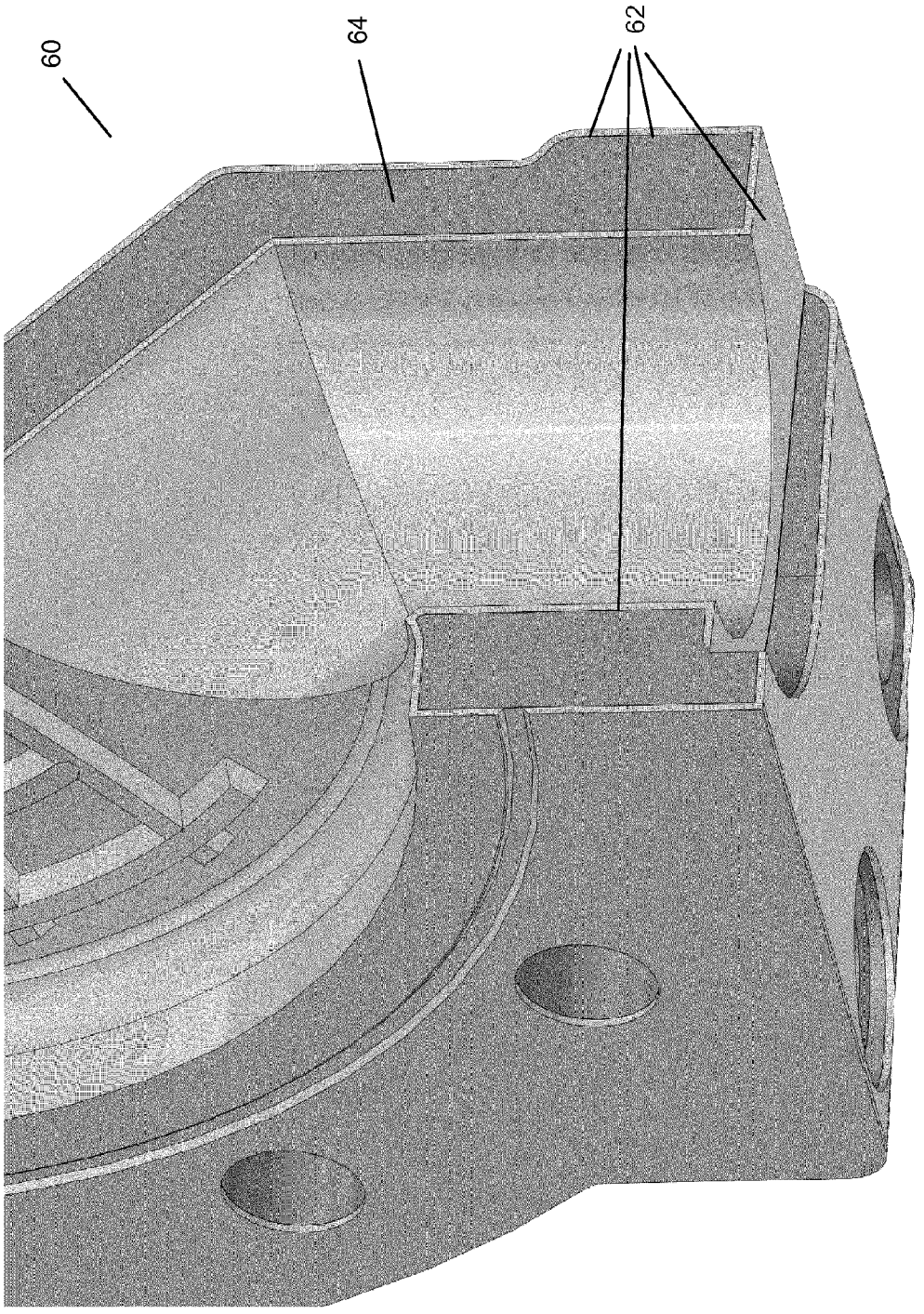


Fig. 15c

POLYMER-METALLIC REAGENT HEAD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority to U.S. provisional patent application Ser. No. 61/176,939, filed on May 10, 2009, now pending, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to pumps, and more specifically, to reagent heads used with pumps.

BACKGROUND OF THE INVENTION

[0003] Metering pumps are used to pump liquids in precise amounts and/or flow rates. These pumps may operate by using a piston which operates in a hydraulic reservoir. A diaphragm may separate the hydraulic reservoir from the liquid being pumped ("process fluid"). In such a pump, forward movement of the piston transmits hydraulic force against the diaphragm. The diaphragm moves in relation to the piston and forces process fluid through an outlet check valve. Conversely, rearward movement of the piston causes the diaphragm to suction process fluid from an input check valve into the pump head ("reagent head").

[0004] In this way, the forward and rearward movement of the diaphragm causes a cycle of pressurization (forcing process fluid out of the head) and suction (drawing process fluid into the head).

[0005] Other pumps are known in the art including, but not limited to, mechanically actuated diaphragm metering pumps (not using hydraulics) and plunger pumps (no hydraulics or diaphragm).

[0006] Metering pumps are used with a broad spectrum of process fluids. Often these process fluids are corrosive liquids, such as, for example, sulphuric acid or sodium hypochlorite, that may not be compatible with traditional reagent head materials (e.g. iron or steel). In such cases, reagent heads are produced from, for example, stainless steel and other, more exotic, alloys. These exotic alloys, however, are expensive and may drive the cost of a reagent head to over $5,000.

[0007] Polytetrafluoroethylene ("PTFE") is a plastic known for being chemically inert. The low reactivity of PTFE makes it a good choice for use with corrosive liquids. However, other properties (e.g. strength, ductility, and the like) make PTFE a poor choice as the primary material in a reagent head.

[0008] PTFE has found use in coating metals to enhance the properties of products made from those metals. For example, cookware is often coated with PTFE to provide a "non-stick" surface. Some pumps, other than metering pumps, have used PTFE coatings on low cost metals to provide a less expensive way to handle corrosive process fluids. However, the properties that make PTFE useful (e.g. low reactivity) also make the bond between PTFE and the coated metal less than ideal in a metering pump reagent head. During the vacuum phase of the pressure-vacuum cycle used to move liquid through the head, the PTFE-metal bond is subject to enormous stresses and may suffer a mechanical failure.

[0009] Accordingly, there is a need for a low-cost metering pump reagent head which can be used with corrosive process fluids.

SUMMARY OF THE INVENTION

[0010] The present disclosure meets the above described need by providing a metering-pump reagent head which utilizes polymer-coated metals. The polymer-metal interface incorporates features to strengthen the bond and maintain the integrity of the coating.

[0011] The polymer coating may be any chemically resilient polymer, including but not limited to PTFE, ETFE, PFA, or other fluorocarbon polymers.

[0012] It should be noted that while reference is made throughout the instant disclosure to metering pumps, the technology described herein applies equally to any type of reciprocating pump, and such matter is intended to fall within the scope of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention is illustrated in the drawings in which like reference characters designate the same or similar parts throughout the figures of which:

[0014] FIG. **1***a* is a cross-section view of a prior-art metering-pump and reagent head, showing the diaphragm in a forward position;

[0015] FIG. **1***b* is a cross-section view of the metering pump and reagent head of FIG. **1***a*, showing the diaphragm in a rearward position;

[0016] FIG. **2** is a perspective section view of a reagent head according to one embodiment of the instant disclosure;

[0017] FIG. **3** is a cross-section view of the reagent head of FIG. **2**;

[0018] FIG. **4** is a reagent head dish according to another embodiment of the instant disclosure;

[0019] FIG. **5***a*-**5***i* are partial cross section views showing several different embodiments of a polymer-metal interface;

[0020] FIG. **6** is a reagent head dish according to another embodiment of the instant disclosure;

[0021] FIG. **7** is a reagent head dish according to another embodiment of the instant disclosure;

[0022] FIG. **8** is a reagent head dish according to another embodiment of the instant disclosure;

[0023] FIG. **9** is a reagent head dish according to another embodiment of the instant disclosure;

[0024] FIG. **10** is a reagent head dish according to another embodiment of the instant disclosure;

[0025] FIG. **11** is a reagent head dish according to another embodiment of the instant disclosure;

[0026] FIG. **12** is a reagent head dish according to another embodiment of the instant disclosure;

[0027] FIG. **13** is a reagent head dish according to another embodiment of the instant disclosure;

[0028] FIG. **14***a* is a perspective section view of a reagent head dish according to another embodiment of the instant disclosure;

[0029] FIG. **14***b* is a cross section view of the reagent head dish of FIG. **14***a;*

[0030] FIG. **15***a* is a cross section view of a reagent head dish according to another embodiment of the instant disclosure;

[0031] FIG. **15***b* is a perspective view of the reagent head dish of FIG. **15***a*; and

[0032] FIG. **15***c* is a perspective view of a portion of the reagent head dish of FIGS. **15***a* and **15***c*.

DETAILED DESCRIPTION OF THE INVENTION

[0033] FIGS. **1***a* and **1***b* depict a metering pump **10** having a reagent head **12**. In such reagent heads **12**, a process fluid is pulled through an inlet **22** into a pumping chamber **14** by the vacuum created by a diaphragm **16** moving rearward (away from the pumping chamber **14**) and expanding the volume of the pumping chamber **14**. An inlet check valve **24** located at the inlet **22** may open by the vacuum created by the diaphragm **16** to allow process fluid to flow from the inlet **22**. An outlet check valve **18** may be located at an outlet **20** of the pumping chamber **14** in order to prevent process fluid from re-entering the pumping chamber **14** from the outlet side. FIG. **1***b* depicts where the diaphragm **16** is in a rearward position, the inlet check valve **24** is open, and the outlet check valve **18** is closed.

[0034] Similarly, when the diaphragm **16** is moved forward (toward the pumping chamber **14**) by the piston **26**, the volume of process fluid which may be contained in the pumping chamber **14** is reduced, thereby forcing process fluid through the outlet check valve **18** and the outlet **20**. In this case, the inlet check valve **24** will close to prevent process fluid from flowing back into the inlet **22**.

[0035] It should be apparent to those skilled in the art that the pumping chamber **14** of a reagent head **12** is subject to enormous forces and stresses. Not only high pressures when forcing fluids out of the chamber, but low pressures (vacuum) in suctioning fluid into the chamber. And this 180 degree reversal from high-to-low pressure and again from low-to-high pressure happens constantly as the process fluid flows through. Certain properties of process fluids (e.g. viscosity) may cause even more extreme pressure differentials in the pumping chamber **14**. Pressures of 2-5 Kpsi are or more are common.

[0036] FIG. **2** shows a perspective section view of a reagent head **30** according to an embodiment of the present disclosure. FIG. **3** shows a cross section view of the reagent head **30**. The reagent head **30** has a housing, an inlet **34** and an outlet **36**. Check valves and other details are not shown for clarity. The reagent head may have a dish **32** where the diaphragm (not shown) may seat when in a fully forward position. The reagent head **30** may be constructed primarily from a high-strength material, e.g. ductile iron, in a substrate layer **38**.

[0037] The reagent head **30** may also comprise a polymer layer **37**. The polymer-metal interface may incorporate key grooves **39** to provide an increased surface area for the polymer-metal bond. The key grooves **39** may be any shape which increases the bonding surface area (see, e.g., FIGS. **5***a*-**5***i*—other shapes will be readily apparent to those skilled in the art). Certain key groove cross-sectional shapes, such as dovetails, will create an interlocking interface that may provide increase resistance to separation (see, e.g., FIGS. **5***a*, **5***d*, **5***e*, **5***f*, and **5***h*—others will be readily apparent to those skilled in the art).

[0038] Such a polymer layer **37** may be molded onto the substrate layer **38** by, for example, blow molding, roto molding, or transfer molding. Other techniques will be apparent to those skilled in the art.

[0039] The key grooves **39** may be arranged in various configurations. FIGS. **2**, **4**, and **6**-**13** show several examples intended to be non-limiting. FIGS. **2** and **4** show the key grooves **41** arranged as concentric rings on the dish **32**. FIGS. **6** and **7** depict key grooves **42**, **43** in straight orientations. FIG. **8** depicts the key grooves **44** in a "waffle" arrangement, having both concentric and radial orientations. In FIG. **9**, the key grooves **45** are circular nodes. In FIGS. **10**-**13**, several configurations of pocket-type key grooves **46**, **47**, **48**, **49** are shown. Such configurations may include wherein the pocket is "undercut" **46**, **47**, **49**, or wherein the pocket is dovetailed **48**. Any of these or more configurations may be individually or in combination.

[0040] In another embodiment of a reagent head **50** according to the disclosure, a polymer insert **52** may be machined to fit into a metallic substrate **54** (see, e.g., FIG. **14**). The insert **52** may be pressed into the metallic substrate **54** of the reagent head **50**. The insert **52** may be otherwise aligned inside the metallic substrate **54** or behind a plate. In such an embodiment, the internal structures (e.g., the dish **56**) of the reagent head **50** may be constructed entirely from polymer. As such, the metallic substrate **54** may provide the strength to the overall reagent head **50**, while the insert **52** may define structures where high strength materials are not necessary. The polymer-metal interface may be further strengthened by mechanical means, such as bolting the insert **52** to the metallic substrate **54**. In such an embodiment, the insert **52** may be of a thickness which provides structural qualities to the insert **52** and thereby lessens the forces on the polymer-metal interface.

[0041] In another embodiment of a reagent head **60** according to the disclosure, a bonding agent (not shown) may be used to enhance the strength of the polymer-metal interface (see, e.g., FIGS. **15***a* and **15***b*). Such bonding agents may allow a thinner polymer layer **62** to be deposited onto the metal layer **64** of the reagent head **60**. Such polymer layers may be as thin as 0.030" or thinner and may be sprayed on to the metal layer **64** (and bonding agent). The polymer layer **62** may be sprayed in several layers of 0.010"-0.020" each. The spray technique may include a statically-charged spray in order to better control the location and quality of the layer. The reagent head **60** may be baked to cure the polymer layer **62**.

[0042] FIGS. **15***a*-**15***c* show where the polymer layer **62** may cover the entire metallic portion of the reagent head **60**. Such a configuration may be incorporated in any of the aforementioned embodiments.

[0043] Reciprocating metering pumps employ corrosion resistant materials for components that come into contact with the fluid being pumped (herein after referred to as "process fluid"). The relative costs of these materials vary for a variety of reasons. Some exhibit extremely high relative costs (e.g., Stainless Steel versus Titanium). As the amount of fluid displaced by these pumps and discharge pressures increase—the size (diameter and thickness) of these pressure containing parts increase; this results in higher unit price. For large displacement, high pressure requirements, reciprocating metering pumps become increasingly more expensive. Reducing the cost of the pressure containing components (herein after referred to as the "wet end") is critical in this competitive situation.

[0044] A Reciprocating metering Pump including a reciprocating piston/plunger (herein after referred to only as "piston") that directly or indirectly moves the process fluid through the wet end via check valves (valves that only let fluid move in one direction). A primary component of the wet end being a cover that usually opposes the action/displacement caused by the piston and contains the pressure of the process

fluid (herein after referred to as the "reagent head"). The reagent head may be constructed of a semi-rigid material (e.g., iron, steel, stainless steel, etc). The reagent head may be covered, coated, lined, or otherwise contain a polymer/material in contact with the process fluid. Said polymer/material may be impervious and/or otherwise unaffected by the above mentioned process fluid (e.g., ETFE, PTFE, PVDF, PVC, etc . . .)

[0045] In one embodiment, the polymer/material portion (herein after referred to as the "coating") exhibits resistance to the process fluid and/or resistance to abrasion and/or superior adhesion. In another embodiment, the coating(s) includes fillers that enhance its machineability and/or resistance to compressive stresses and/or durability properties. In another embodiment, the coating(s) is applied through a spraying and/or rotary coating(s) and/or molding and/or melting/pouring and/or dunking/submerging process. In another embodiment, the coating(s) includes multiple layers thereby improving the coating's adhesion and/or mechanical and/or durability characteristics. In another embodiment, the coating (s) extends beyond the reagent head surfaces in direct contact with the process fluid up to and including the entire housing or where the coating(s) only extends through all or part of where the process fluid contacts.

[0046] In another embodiment, the coating(s) is modified by machining/cutting/EDM/etc. operation(s) and/or otherwise altering the initial configuration of the material. In another embodiment, mechanically separate components are coated individually. In another embodiment, mechanically separate components are sealed/pressed/fused/etc. or otherwise bonded/aligned/etc. together either permanently or temporarily through direct coating(s) to coating(s) contact, or direct contact between the coating and a/the-above-mentioned semi-rigid material.

[0047] In another embodiment, the coating is a separate part nested/pressed/aligned/fused/etc inside of a semi-rigid housing. Said housing can be one piece or multiple pieces welded or otherwise attached/mated/assembled together. In another embodiment, mechanically separate components are mated/aligned/nested together through an intermediate sealing component (e.g., o-ring), wherein the surface in contact with the sealing component may/may not represent the coating itself.

[0048] In another embodiment, the housing and/or coating (s)/sealing component(s) feature anti-rotation and/or alignment features. In another embodiment, the coating/sealing component(s) is/are sealed via o-rings, integral patterns of teeth/ridges/etc, and/or gaskets, etc. In another embodiment, two or more sealing components/coating(s) interface with o-rings, integral patterns of teeth/ridges/etc, and/or gaskets, etc. Said components mayor may not also seal to the housing via similar components.

[0049] In another embodiment, a coating(s) is adhered to the housing(s) via chemical bond and/or chemical coupling. In another embodiment, a coating(s) is adhered to the housing (s) via increased surface area, or roughness in the housing or supporting material, or permeation or protrusion from the housing/supporting material. The roughness can be accomplished through shot-peining, sand-blasting, roughness on a cast surface, etc/or similar method. The increased surface area can be accomplished via ribs, chamfers, waffles, etc or similar in which the overall surface area in contact with the coating(s)/sealing component(s) is increased. The permeations or protrusions can include cuts, slices, gouges, or otherwise negatively changing geometry ether formed in/cast in/machined in/etc. These can be undercut, over-cut, or straight/in-line with the opposing surface and can be cast/forged/machined/EDM'd/etc in. (e.g. milled slots, rings, circles, undercuts, knobs, recessed dots or holes, keyholes, etc).

[0050] In another embodiment, the coating(s) or sealed component(s) vary in thickness/geometry/etc to increase stiffness and/or performance. In another embodiment, the coating(s) involves a chemical/special-surface treatment either to the polymer or the housing. In another embodiment, the integrity of the coating is validated through use of an electrical potential measurement across the surface, and/or chemical and/or optical method.

[0051] While the invention has been described in connection with certain embodiments, it is not intended to limit the scope of the invention to the particular forms set forth, but, on the contrary, it is intended to cover such alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention.

What is claimed is:

1. A reagent head for a metering pump, comprising:

a housing having a pumping chamber, wherein the housing has a substrate layer; and

a polymer layer disposed on the housing in the pumping chamber.

* * * * *