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- (71) **Applicant: UNITED STATES ENDOSCOPY GROUP, INC.** [US/US]; 5976 Heisley Road, Mentor, Ohio 44060 (US).
- (72) **Inventors: STILL, Rapheal;** 23111 Rushmore Drive, Richmond Heights, Ohio 44143 (US). **MANN, Gary;** 6823 Rockport Lane, Mentor, Ohio 44060 (US). **KAYE, Christopher;** 36415 Sandy Knoll Drive, Eastlake, Ohio 44095 (US).
- (74) **Agent: LIU, Yizhou;** Calfee, Halter & Griswold LLP, The Calfee Building, 1405 East Sixth Street, Cleveland, Ohio 44114-1607 (US).
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(54) **Title:** SUCTION VALVE

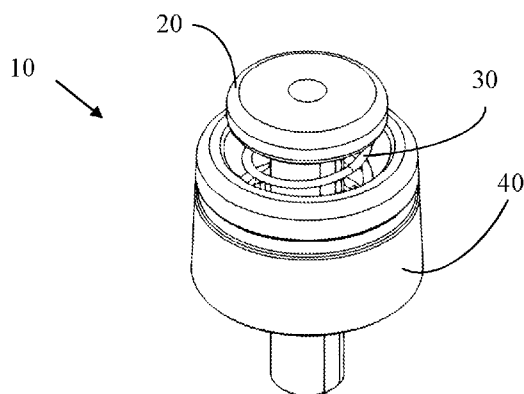


Figure 1A

(57) **Abstract:** A suction valve stem, a suction valve, an endoscopic valve kit, and a method for molding a stem are provided. The suction valve stem includes: a button head, and a stem body connecting to the button head. The stem body includes: an air passage through the center bore, a recessed slot, disposed on the stem body below the button head and above the side opening, a sealing area, disposed on the stem body below the side opening, and a flat, disposed on the stem body. The air passage includes a side opening disposed on side surface of the stem body and a bottom opening disposed at a bottom end of the stem body. The recessed slot is disposed 90 degrees from the side opening. The flat is disposed 90 degrees from the side opening and has a fluid communication to the bottom end of the stem body.



SUCTION VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and any benefit of U.S. Patent Application No. 62/346,847, filed June 7, 2016, the content of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates to endoscopic systems, more particularly, suction valves for endoscopes.

[0003] Suction valves are used to control the suction function of an endoscope during endoscopic procedures. For example, a suction valve for an endoscope may be inserted into a suction cylinder of the endoscope to provide suction to the endoscope. When the suction valve is in a normal position, suction to the distal tip of the endoscope is blocked by the valve. When suction is desired, an operator engages the suction valve (e.g. by depressing the valve) to open the suction channel to create negative pressure that draws air or fluid into the opening of the instrument channel of the endoscope. When the operator releases the suction valve, the valve returns to its normal position blocking air flow and stops the suctioning.

SUMMARY

[0004] Various embodiments of a suction valve for an endoscope are discussed herein.

[0005] In some embodiments, a suction valve stem comprises a button head, and a stem body connecting to the button head. The stem body comprises: an air passage through the center bore of the stem body, a recessed slot disposed on the stem body below the button head and above the side opening, a sealing area disposed on the stem body below the side opening, and a flat disposed on the stem body. The air passage comprises a side opening disposed on side surface of the stem body and a bottom opening disposed at a bottom end of the stem body. The recessed slot is disposed 90 degrees from the side opening. The flat is disposed 90 degrees from the side opening. The flat has a fluid communication to the bottom end of the stem body.

[0006] In some embodiments, a suction valve comprises a stem, a spring, a spring cup, and a boot, wherein the bottom end of the stem extends through the spring, the spring cup, and the boot.

[0007] In some embodiments, an endoscopic valve kit comprises a suction valve, an air/water valve, and a biopsy valve.

[0008] In some embodiments, a method for molding a suction valve stem comprises placing a mold parting line along the length of a non-sealing area.

[0009] In some embodiments, a method for molding a suction valve stem comprises pulling cross opening core pins in the same direction as the mold opening direction.

[0010] In some embodiments, a method for molding a suction valve stem comprises pulling the axial opening core pin in a direction that is perpendicular to the mold opening direction.

[0011] In some embodiments, a method for molding a suction valve stem comprises pulling the recessed slot cores in a direction that is perpendicular to the mold opening direction.

[0012] In some embodiments, a method for molding a suction valve stem comprises pulling the button head core pin in a direction that is perpendicular to the mold opening direction.

[0013] In some embodiments, a method for molding a suction valve stem comprises forming a sealing area in opposing halves of a mold cavity.

[0014] In some embodiments, a method for molding a suction valve stem comprises forming a sealing area without draft angle along the length of the sealing area.

[0015] In some embodiments, a method for molding a suction valve stem comprises ejecting the part from the mold in the same direction as the mold opening direction.

[0016] In some embodiments, a method for molding a suction valve stem comprises forming a recessed ejector pin mark near or on the sealing area.

[0017] Additional features and advantages of various embodiments will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practice of various embodiments. The objectives and other advantages of various embodiments will be realized and attained by means of the elements and combinations particularly pointed out in the description and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Features and advantages of the general inventive concepts will become apparent from the following detailed description made with reference to the accompanying drawings.

[0019] Figure 1A is a perspective view of an embodiment of a suction valve of the present subject matter;

[0020] Figure 1B is a cross sectional view of the suction valve in Figure 1A;

[0021] Figure 2A is a perspective view of an embodiment of a stem of the present subject matter;

[0022] Figure 2B is a side view of the stem in Figure 2A;

[0023] Figure 2C is a front view of the stem in Figure 2A;

[0024] Figure 2D is a front cross sectional view of the stem in Figure 2A;

[0025] Figure 3A is a cross sectional view at the distal end of an embodiment of a stem body of the present subject matter;

[0026] Figure 3B is a cross sectional view at the distal end of another embodiment of a stem body of the present subject matter;

[0027] Figure 3C is a cross sectional view at the distal end of a third embodiment of a stem body of the present subject matter;

[0028] Figure 3D is a cross sectional view at the distal end of a fourth embodiment of a stem body of the present subject matter;

[0029] Figure 3E is a cross sectional view at the distal end of a fifth embodiment of a stem body of the present subject matter;

[0030] Figure 4 is a side view of the stem of the present subject matter;

[0031] Figure 5 is a front view of the stem of the present subject matter;

[0032] Figure 6 is a perspective view of the stem of the present subject matter; and

[0033] Figure 7 shows a stem made by a molding method embodiment of the present subject matter.

DETAILED DESCRIPTION

[0034] This Detailed Description merely describes exemplary embodiments in accordance with the general inventive concepts and is not intended to limit the scope of the invention or the

claims in any way. Indeed, the invention as described by the claims is broader than and unlimited by the exemplary embodiment set forth herein, and the terms used in the claims have their full ordinary meaning.

[0035] The general inventive concepts will now be described with occasional reference to the exemplary embodiments of the invention. This general inventive concept may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the general inventive concepts to those skilled in the art.

[0036] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art encompassing the general inventive concepts. The terminology set forth in this detailed description is for describing particular embodiments only and is not intended to be limiting of the general inventive concepts. As used in this detailed description and the appended claims, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0037] Unless otherwise indicated, all numbers, such as for example, numbers expressing quantities of ingredients, percentages or proportions of materials, reaction conditions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about.” Accordingly, unless otherwise indicated, the numerical properties set forth in the specification and claims are approximations that may vary depending upon the suitable properties sought to be obtained in the embodiments of the invention. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the general inventive concepts are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical values, however, inherently contain certain errors necessarily resulting from error found in their respective measurements.

[0038] Aspects of the present disclosure relate to suction valves with improved fitment to endoscopes. The present invention also eliminates problems with leaks and leakage seen in other valves. Referring to Figures 1A-1B, an exemplary suction valve 10 comprises a stem 20, a spring 30, a boot 40, and a spring cup 50. The stem 20 extends through the spring 30 and the spring cup 50. In some embodiments, the boot 40 is placed over the spring cup 50. In some other

embodiments, the boot 40 is over-molded over the spring cup 50, and therefore the boot 40 and the spring cup 50 are one-piece. The boot 40 comprises a sealing ledge that seals off the suction port in the endoscope. In an additional embodiment it is possible to combine parts 50, 52, and 40 all into a single component (material).

[0039] Referring to Figures 1B, 2A-2D, the stem 20 comprises a top part 22 and a stem body 24. In some embodiments, the top part 22 of the stem 20 can also be referred to as a button head or button cap 22. The spring cup 50 comprises tabs 52. The stem 20 further comprises recessed slots 26. The tabs 52 reside in the recessed slots 26 of the stem 20. The recessed slots 26 allow the restricted movement of the stem 20 up and down on the spring cup 50. The spring 30 maintains the stem 20 in its upper position, but the recessed slots 26 and the tabs 52 prevent the stem 20 from being separated from the spring cup 50. When the suction valve 10 is actuated, the spring 30 is compressed and the stem 20 moves further down into the spring cup 50. The recessed slots 26 limit how far down the stem 20 may travel because the tabs 52 will eventually come in contact with the top part of the stem 20.

[0040] The stem 20 comprises the button head 22 and the stem body 24. The stem body comprises a side opening 28 and a bottom opening 32. In some embodiments, the stem body comprises a first side opening 28 at one side and a second side opening 281 at the opposite side. Fluid may pass horizontally through one of the first and second side openings 28, 281 and vertically through the bottom opening 32. The side openings 28, 281, and the bottom opening 32 may allow fluid to pass through the instrument channel of an endoscope when the suction valve 10 is actuated.

[0041] In some embodiments, the bottom opening 32 is disposed along a longitudinal axis of the stem body 24. The side openings are disposed transverse to the bottom opening 32. In some embodiments, one of the first and second side openings 28, 281 and the bottom opening 32 are perpendicular to each other.

[0042] The stem body 24 comprises recessed slots 26. In some embodiments, the stem body 24 comprises two recessed slots 26. In some embodiments, the recessed slots 26 are disposed at the top portion of the stem body 24. In some embodiments, the recessed slots 26 are disposed on the top portion of the opposite surfaces of the top portion of the stem body 24. In some embodiments, the recessed slots 26 are perpendicular to both the first and second side openings

28, 281. The recessed slot 26 orients the first or second side openings 28, 281 in the correct direction when the suction valve 10 is connected to the endoscope.

[0043] In some embodiments, the stem 20 functions as a tool the user (clinician) actuates to control vacuum (suction) to the patient. The stem 20 is depressed to allow vacuum suction through an endoscope and is released to stop vacuum suction.

[0044] In some embodiments, the interface between the endoscope and the stem 20 is important because the suction valve 10 must actuate smoothly while creating a sealing surface that does not allow suction to be lost during use. If there is a poor interface between the stem and endoscope, a loss of air within a patient will occur due to vacuum suction leaking around the stem. The fitment also needs to generate a hydraulic seal to mitigate fluids suctioned up an endoscope from going back down into a patient. In some embodiments of stem 20, the stem diameter may be precisely controlled to assure an air tight or nearly air tight seal within the suction cylinder/port of an endoscope.

[0045] Referring to Figures 4-6, in some embodiments, the stem body 24 comprises one seal area 34. In some embodiments, the stem body 24 comprises two seal areas 34. In some embodiments, the seal areas 34 are disposed on the bottom portion of the stem body 24 and below the side openings 28, 281. In some embodiments, the seal areas 34 are disposed on the opposite surfaces of the stem body 24.

[0046] In some embodiments, the seal area 34 may be disposed as high as the first or second side openings 28, 281. In some embodiments, the seal area 34 may be disposed as low as the bottom of the stem body 24. In some embodiments, the seal area 34 may be disposed as narrow as about the diameter of the first or second side openings 28, 281. In some embodiments, the seal area 34 may be disposed as wide as about a half of the perimeter of the stem body 24. In some embodiments, the minimum length of the seal area 34 is about 0.280 inches. In some embodiments, the maximum length of the seal area 34 is about 0.440 inches. In some embodiments, the minimum width of the seal area 34 is about 0.158 inches. In some embodiments, the maximum width of the seal area 34 is about 0.198 inches.

[0047] In some embodiments, the seal area 34 or the two seal areas 34 are ribbed and/or textured. However, the seal areas still are able to assure an air tight seal. The ribbed seal areas 34 may provide an easier movement of the stem 20.

[0048] In some prior art, however, the substantial air tight seal between the suction cylinder/port of an endoscope and the stem sometimes causes a hydraulic lock when the stem is depressed. Such hydraulic lock may prevent the stem from releasing back to the upper position.

[0049] Referring to Figures 2A, 2C, 5 and 6, in some embodiments, the stem body 24 further comprises flats 36. In some embodiments, the stem body 24 comprises one flat 36. In some embodiments, the stem body 24 comprises two flats 36. In some embodiments, the flats are disposed on the opposite surface of the stem body 24. In some embodiments, the flats 36 are disposed below the recessed slots 26 and on the bottom portion of the stem body 24. In some embodiments, the flats 36 extend to the bottom end of the stem body 24. In some embodiments, the flats 36 at least extend to the bottom level of the first or second openings 28, 281. In some embodiments, the flats 36 extend to the middle of the first or second openings 28, 281. In some embodiments, the flats 36 and the recessed slots 26 are separated and therefore prevent fluid communications from each other. In some embodiments, the flats 36 and the first and second side openings 28, 281 are separated and therefore prevent fluid communications from each other.

[0050] In some embodiments, the maximum length of the flat 36 is about 0.625 inches. In some embodiments, the minimum length of the flat 36 is about 0.450 inches. In some embodiments, the maximum width of the flat 36 is about 0.103 inches. In some embodiments, the minimum width of the flat 36 is about 0.020 inch.

[0051] Referring to Figure 6, in some embodiments, the sealing area 34 and the flat 36 do not overlap. In some embodiments, the sealing area 34 and the flat 36 are adjacent to each other.

[0052] Referring to Figure 3A, in some embodiments, the cross sectional view of the flat 36 is a plane shape. Referring to Figure 3B, in some embodiments, the cross sectional view of the flat 36 is a concave shape. Referring to Figure 3C, in some embodiments, the cross sectional view of the flat 36 is a pit shape. Referring to Figure 3D, in some embodiments, the cross sectional view of the flat 36 is a slot shape. Referring to Figure 3E, in some embodiments, the cross sectional view of the flat 36 is a four-flat shape. Referring to Figures 3A-3E, in some embodiments, the flat 36 and the internal channel 38 of the stem body are separated and therefore prevent fluid communications from each other. In some embodiments, the flat 36 helps to reduce noise while vacuum suction is in use.

[0053] The stem 20 may be formed from a suitable material or combination of material(s), such as plastic, polymeric material(s), metal, or the like. In some embodiments, the button head 22 of

the stem 20 is made of plastic or polymeric materials, while the rest part of the stem 20 is made of metal materials. In some other embodiments, the button head 22 is made of plastic or polymeric materials, and the recessed slot part of the stem 20 is made of plastic or polymeric materials; while the rest part of the stem 20 (including of the first and second openings and the flat 28) is made of metal materials. In some other embodiments, the stem 20 is made of metal materials.

[0054] In some embodiments, the stem 20 is formed from ABS. Comparing to polycarbonate material often used in prior art, ABS allows the stem 20 to be more compliant in tight tolerance sealing applications.

[0055] While the suction valve 10 shown is suitable for use with Olympus® endoscopes, other embodiments of suction valves may be suitable for use with other types of endoscopes, such as Pentax®, Fujinon®, or the like. As such, the embodiments discussed herein may be modified to accommodate other types and/or brands of endoscopes. The suction valve 10 shown here may be used as disposable suction valve. In some other embodiments, the suction valve 10 may be used as reusable/reprocessable suction valve.

[0056] In various embodiments, an endoscope valve kit is provided that may include additional parts along with the suction valve combined together to be used with the suction valve. The kit may further include an air/water valve. The endoscopic valve kit may further include a biopsy valve.

[0057] Referring to Figures 7A-7B, in some prior art molding method, the stem has no parting line on the sealing surface. The only parting line is in the non-critical area between the button head and the side openings. The parting line is the witness line of slide face shut offs that pull the retaining grooves. Directional drag marks near the side openings and at the bottom ends of the stem suggest that the stem was pushed out of a mold cavity going from the bottom of the stem to the top of the stem.

[0058] Continuing to address the prior art, the through side opening is likely pulled using a mechanical slide or a hydraulic core pull mechanism. This pin is “through the cavity block,” which means it operates through an opening in the cavity block below the parting line of the mold. This action can leave burrs on the opening in the cavity block that result in the drag marks seen in the center picture. These drag marks are essentially grooves in the surface of the plastic that prevent the stem from having a smooth sealing surface.

[0059] Referring to Figure 8, some embodiments of the present subject matter disclose molding approach to tooling the stem. In specific, the method comprises to place the mold parting line on the non-sealing surfaces such as the flats which are located 90 degrees from the critical sealing areas. In some embodiments, the mold parting line is placed along the length of a non-sealing area. This leaves the critical sealing areas completely free of the tooling marks and leaves no drag marks from ejection from the mold. It allows the sealing areas to stay uniform and smooth and be completely parallel (no draft or taper) to the mating surface of the endoscope. In some embodiments, the cross opening core pins now pull in the same direction as the mold opening direction, leaving no burrs around the side openings that can leave artifacts in the sealing areas that can promote leaks. In some embodiments, the axial opening core pin is pulled in a direction that is perpendicular to the mold opening direction. In some embodiments, the recessed slot cores are pulled in a direction that is perpendicular to the mold opening direction. In some embodiments, the button head core pin is pulled in a direction that is perpendicular to the mold opening direction. In some embodiments, a seal area is formed in opposing halves of a mold cavity. In some embodiments, a sealing area has no draft angle along the length of the sealing area. In some embodiments, the part is ejected from the mold in the same direction as the mold opening direction. In some embodiments, an ejector pin mark near or on the sealing area is recessed.

[0060] While various inventive aspects, concepts and features of the general inventive concepts are described and illustrated herein in the context of various exemplary embodiments, these various aspects, concepts and features may be used in many alternative embodiments, either individually or in various combinations and sub-combinations thereof. Unless expressly excluded herein all such combinations and sub-combinations are intended to be within the scope of the general inventive concepts. Still further, while various alternative embodiments as to the various aspects, concepts and features of the inventions (such as alternative materials, structures, configurations, methods, circuits, devices and components, alternatives as to form, fit and function, and so on) may be described herein, such descriptions are not intended to be a complete or exhaustive list of available alternative embodiments, whether presently known or later developed. Those skilled in the art may readily adopt one or more of the inventive aspects, concepts or features into additional embodiments and uses within the scope of the general inventive concepts even if such embodiments are not expressly disclosed herein. Additionally,

even though some features, concepts or aspects of the inventions may be described herein as being a preferred arrangement or method, such description is not intended to suggest that such feature is required or necessary unless expressly so stated. Still further, exemplary or representative values and ranges may be included to assist in understanding the present disclosure; however, such values and ranges are not to be construed in a limiting sense and are intended to be critical values or ranges only if so expressly stated. Moreover, while various aspects, features and concepts may be expressly identified herein as being inventive or forming part of an invention, such identification is not intended to be exclusive, but rather there may be inventive aspects, concepts and features that are fully described herein without being expressly identified as such or as part of a specific invention.

Claims

1. A suction valve stem, comprising:
 - a button head, and
 - a stem body connecting to the button head,
 - wherein the stem body comprises:
 - an air passage through the center bore of the stem body, wherein the air passage comprises a side opening disposed on side surface of the stem body and a bottom opening disposed at a bottom end of the stem body,
 - a recessed slot, disposed on the stem body below the button head and above the side opening, wherein the recessed slot is disposed 90 degrees from the side opening,
 - a sealing area, disposed on the stem body below the side opening, and
 - a flat, disposed on the stem body, wherein the flat is disposed 90 degrees from the side opening, further wherein the flat has a fluid communication to the bottom end of the stem body.
2. The suction valve stem of claim 1, wherein the sealing area extends to the bottom end of the stem body.
3. The suction valve stem of claim 1, wherein the sealing area extends to a lower edge of the side opening.
4. The suction valve stem of claim 1, wherein the minimum width of the sealing area is greater than the diameter of the side opening.
5. The suction valve stem of claim 1, wherein the maximum width of the sealing area is less than the perimeter of the stem body.
6. The suction valve stem of claim 1, wherein the cross sectional view of the flat is a plane shape.

7. The suction valve stem of claim 1, wherein the cross sectional view of the flat is a concave shape.
8. The suction valve stem of claim 1, wherein the cross sectional view of the flat is a slot shape.
9. The suction valve stem of claim 1, wherein the cross sectional view of the flat is a pit shape.
10. The suction valve stem of claim 1, wherein the cross sectional view of the flat is a four-flat shape.
11. A suction valve, comprising: a stem, a spring, a spring cup, and a boot, wherein the bottom end of the stem extends through the spring, the spring cup, and the boot, wherein the stem comprises:
 - a button head, and
 - a stem body connecting to the button head,
 - wherein the stem body comprises:
 - an air passage through the center bore of the stem body, wherein the air passage comprises a side opening disposed on side surface of the stem body and a bottom opening disposed at a bottom end of the stem body,
 - a recessed slot, disposed on the stem body below the button head and above the side opening, wherein the recessed slot is disposed 90 degrees from the side opening,
 - a sealing area, disposed on the stem body below the side opening, and
 - a flat, disposed on the stem body, wherein the flat is disposed 90 degrees from the side opening, further wherein the flat has a fluid communication to the bottom end of the stem body.
12. An endoscopic valve kit, comprising:
 - a suction valve,
 - an air/water valve, and
 - a biopsy valve,

wherein the suction valve comprises: a stem, a spring, a spring cup, and a boot, wherein the bottom end of the stem extends through the spring, the spring cup, and the boot, wherein the stem comprises:

a button head, and

a stem body connecting to the button head,

wherein the stem body comprises:

an air passage through the center bore of the stem body, wherein the air passage comprises a side opening disposed on side surface of the stem body and a bottom opening disposed at a bottom end of the stem body,

a recessed slot, disposed on the stem body below the button head and above the side opening, wherein the recessed slot is disposed 90 degrees from the side opening,

a sealing area, disposed on the stem body below the side opening, and

a flat, disposed on the stem body, wherein the flat is disposed 90 degrees from the side opening, further wherein the flat has a fluid communication to the bottom end of the stem body.

13. A method for molding a suction valve stem, comprising the following steps:

placing a mold parting line along the length of a non-sealing area.

14. The method of claim 13 further comprising:

pulling cross opening core pins in the same direction as the mold opening direction.

15. The method of claim 13 further comprising:

pulling the axial opening core pin in a direction that is perpendicular to the mold opening direction.

16. The method of claim 13 further comprising:

pulling the recessed slot cores in a direction that is perpendicular to the mold opening direction.

17. The method of claim 13 further comprising:

pulling the button head core pin in a direction that is perpendicular to the mold opening direction.

18. The method of claim 13 further comprising:

forming a sealing area in opposing halves of a mold cavity.

19. The method of claim 13 further comprising:

forming a sealing area without draft angle along the length of the sealing area.

20. The method of claim 13 further comprising:

ejecting the part from the mold in the same direction as the mold opening direction.

21. The method of claim 13 further comprising:

forming a recessed ejector pin mark near or on the sealing area.

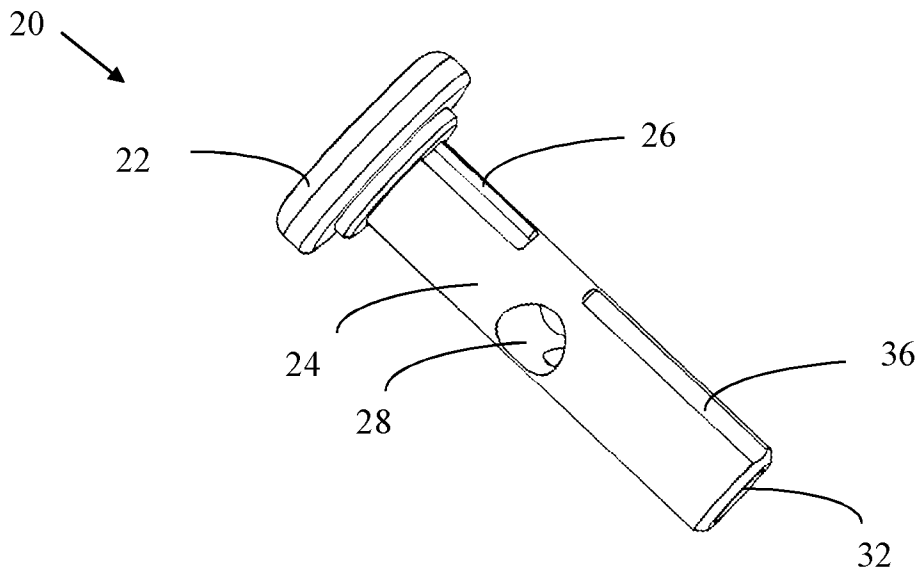


Figure 2A

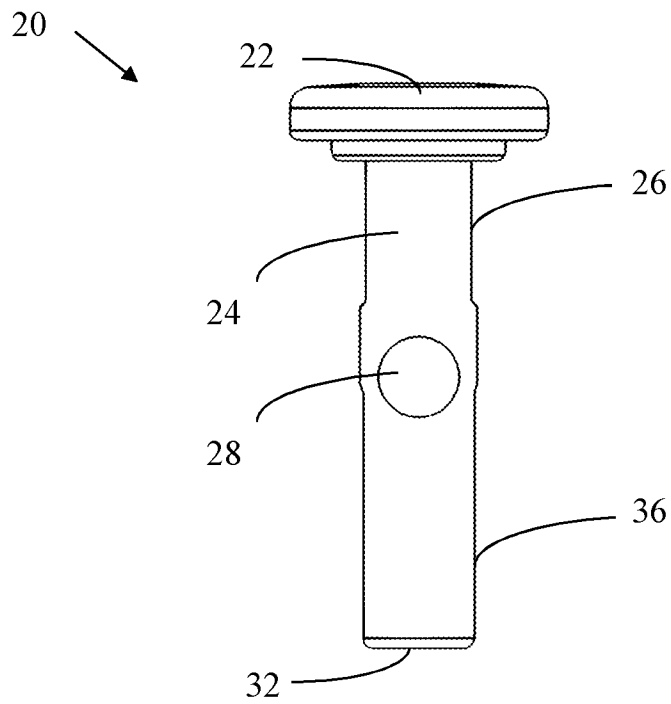


Figure 2B

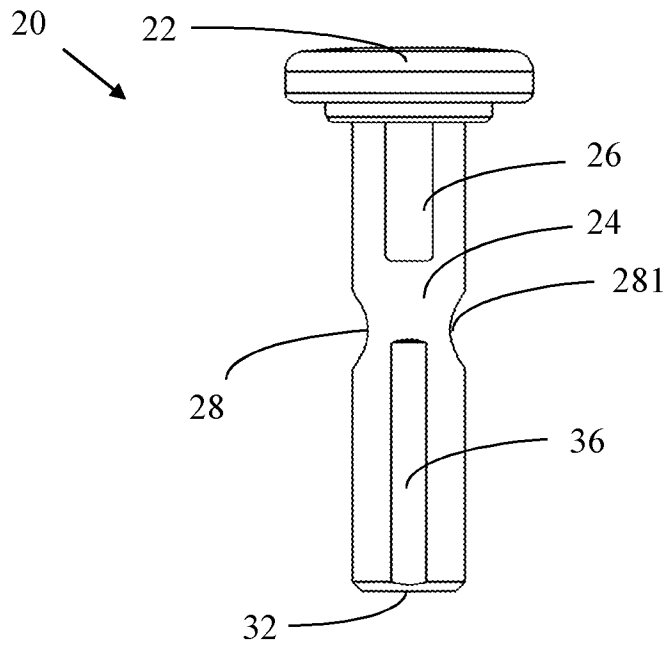


Figure 2C

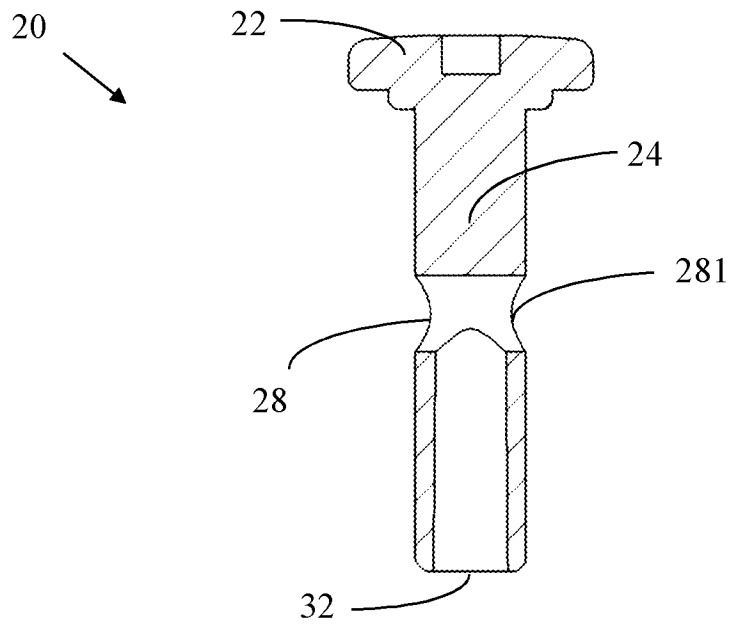


Figure 2D

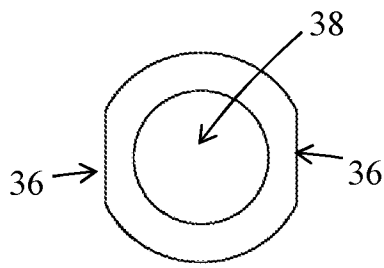


Figure 3A

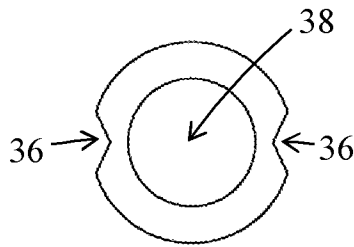


Figure 3B

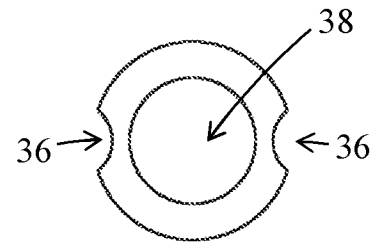


Figure 3C

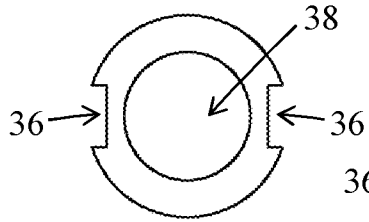


Figure 3D

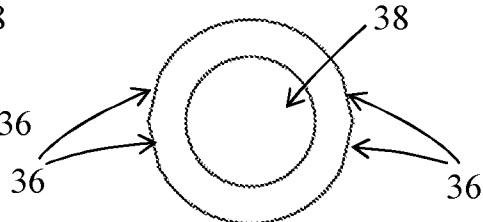


Figure 3E

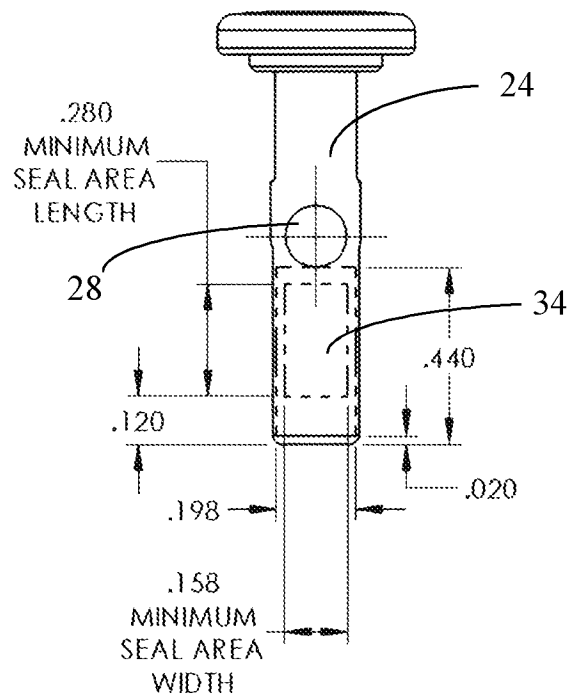


Figure 4

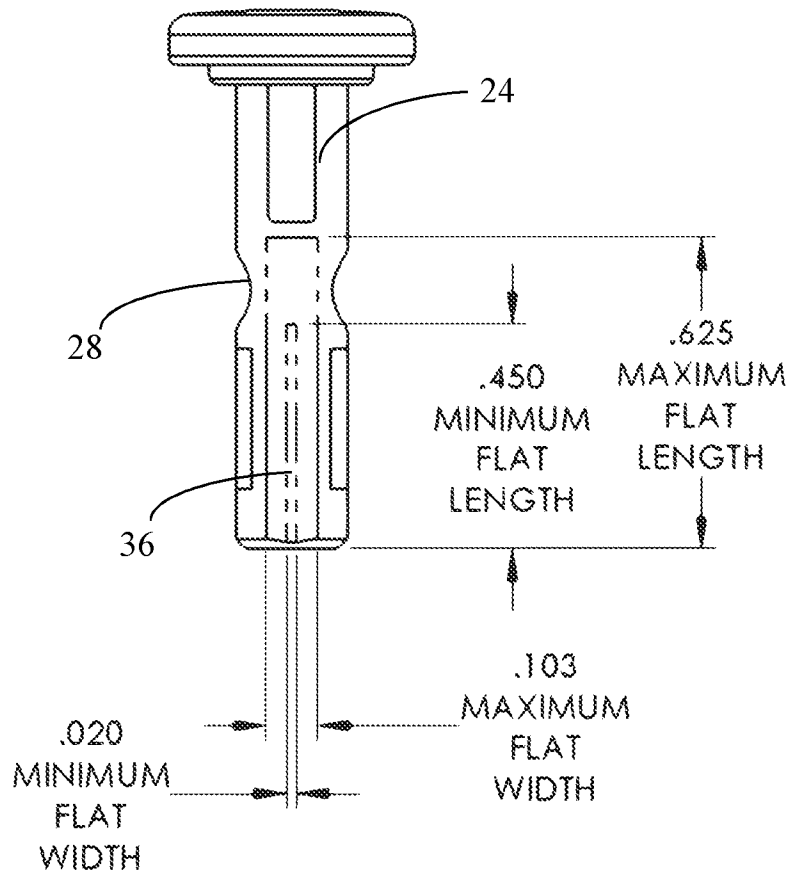


Figure 5

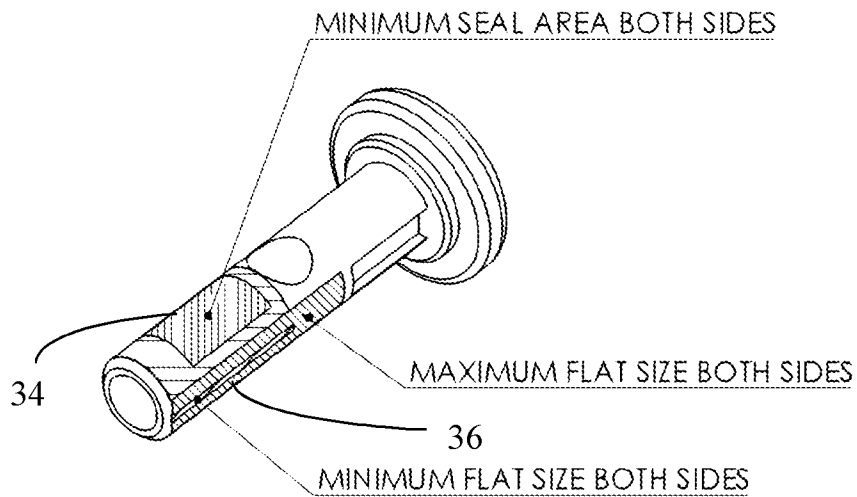


Figure 6

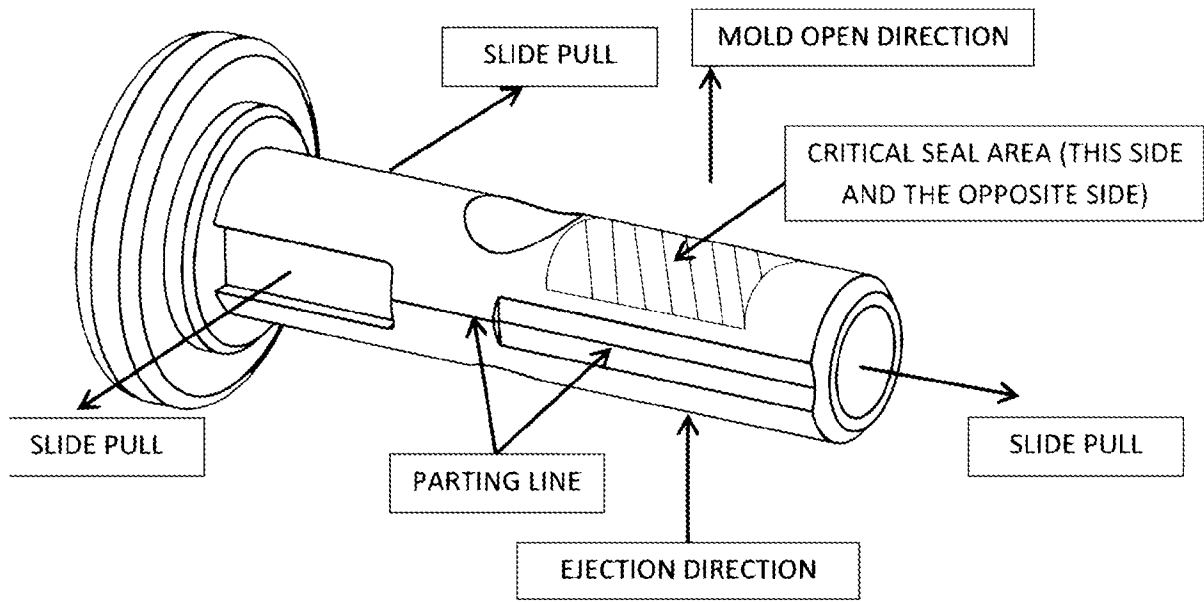


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/036398

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - A61B 1/00; A61B 1/015; A61B 1/04 (2017.01)
 CPC - A61B 1/00068; A61B 1/00094; A61B 1/0011; A61B 1/00137; A61B 1/015; B29C 45/26; B29C 45/261; B29C 45/2612; B29C 45/263; B29C 45/401; F16K 15/025 (2017.05)

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
 USPC - 29/890.127; 137/535; 251/336; 264/299; 264/328.1; 264/328.12; 264/890.123; 600/154; 600/159 (keyword delimited)

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.
X --- Y	US 2013/0338442 A1 (ANDERSON et al) 19 December 2013 (19.12.2013) entire document	1-4, 6-11 --- 12, 13, 18, 20
Y	US 2013/0302848 A1 (CONNOR et al) 14 November 2013 (14.11.2013) entire document	12
Y	CN 1133218 A (TONG JIANYAO) 16 October 1996 (16.10.1996) machine translation	13, 18, 20
Y	JP H1-192518 A (SHIN ETSU POLYMER CO LTD et al) 02 August 1989 (02.08.1989) machine translation	20
P,X	US 9,585,545 B2 (ANDERSON et al) 07 March 2017 (07.03.2017) entire document	1-21

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
 27 July 2017

Date of mailing of the international search report
16 AUG 2017

Name and mailing address of the ISA/US
 Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
 P.O. Box 1450, Alexandria, VA 22313-1450
 Facsimile No. 571-273-8300

Authorized officer
 Blaine R. Copenheaver
 PCT Helpdesk: 571-272-4300
 PCT OSP: 571-272-7774