Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2, 6, 7, 11, 14
	No:	Claims	1, 3-5, 8-10, 12, 13, 15-20
Inventive step (IS)	Yes:	Claims	6, 14
	No:	Claims	1-5, 7-13, 15-20
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

+++++

Reference is made to the following document:

D1: WO 2011/162772 A1 (CLEARVIEW PATIENT SAFETY TECHNOLOGIES LLC [US]; FISCHEL LLOYD [US]; BR) 29 December 2011.

+++++

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

+++++

1 INDEPENDENT CLAIMS 1, 8, 17

1.1 Claims 8 seeks to define a blood sequestration device by being connected with a blood sampling pathway having a patient needle and a sample collection device whereby said blood sampling pathway does not form part of the claimed blood sequestration device.

This would only be the case if e.g. claim 8 defined e.g. "A system of a blood sequestration device and a blood sampling pathway having a patient needle and a sample collection device, whereby the blood sequestration device is connected with the blood sampling pathway, said blood sequestration device comprising...".

The technical features and the related definitions of the blood sampling pathway can therefore not be used to render the subject-matter of claim 8 either novel or inventive.

Since the intended limitation does not belong to the subject-matter claimed, namely the blood sequestration device, this said limitation leads to uncertainty with regard to the actual protection sought, contrary to the requirements of Article 6 PCT.

The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claim 17, which therefore is also considered not meeting the requirements of Article 6 PCT.

1.2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT. The reason is the following:

Document D1 discloses (the references in parenthesis applying to this document) in figure 15 all the features of independent claim 1, namely:

"A blood sequestration device (see figure 15) comprising;

an inlet port (see ref. sign 117 "well");

an outlet port (see ref. sign 330 "sleeve connector");

a sequestration chamber (see ref. sign 117 "guide tube aperture") connected with the inlet port, the sequestration chamber having a vent (see ref. sign 117 "venting member") comprising an air permeable blood barrier;

a sampling channel (see the channel formed in the sleeve connector 330) having a proximal end connected with the inlet port and a distal end connected with the outlet port; and

a housing (see ref. sign 116 "guide tube") that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel".

1.3 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claims 8 an 17, which therefore are also considered not new (Article 33(1) and (2) PCT).

2 DEPENDENT CLAIMS 2-7, 9-16, 18-20

2.1 Dependent claims 2 to 5, 7, 9 to 13, 15, 16 and 18 to 20 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (Article 33(2) PCT) and/or inventive step (Article 33(3) PCT), the reasons being as follows:

As far as the features of these said dependent claims are not already explicitly anticipated by document D1 (for further details, see the relevant passages as cited in the International Search Report and in the above-mentioned paragraph 1), these features would be chosen by a person skilled in the art simply by routine trial and error or these said features are at least generally known by a person skilled in the art either to be one of several straightforward possibilities from which this said person would select or to be regarded by this said person as a normal design option and thus would not add any inventive merit to the subject-matter of the these said dependent claims.

2.2 The features of dependent claims 6 and 14 in combination with the features of any claim to which these said claims refer, seem neither to be known from, nor rendered obvious by, the available prior art.

+++++

Re Item VII

Certain defects in the international application

+++++

1 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT with those features known in combination from the prior art (e.g. one of the documents cited in the International Search Report) being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

2 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents cited in the International Search Report is not mentioned in the description, nor are at least some of these documents identified therein.

3 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

+++++

Re Item VIII

Certain observations on the international application

+++++

Claims 8 seeks to define a blood sequestration device by being connected with a blood sampling pathway having a patient needle and a sample collection device whereby said blood sampling pathway does not form part of the claimed blood sequestration device.

This would only be the case if e.g. claim 8 defined e.g. "A system of a blood sequestration device and a blood sampling pathway having a patient needle and a sample collection device, whereby the blood sequestration device is connected with the blood sampling pathway, said blood sequestration device comprising...".

The technical features and the related definitions of the blood sampling pathway can therefore not be used to render the subject-matter of claim 8 either novel or inventive.

Since the intended limitation does not belong to the subject-matter claimed, namely the blood sequestration device, this said limitation leads to uncertainty with regard to the actual protection sought, contrary to the requirements of Article 6 PCT.

The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claim 17, which therefore is also considered not meeting the requirements of Article 6 PCT.

+++++

EXHIBIT H

PTO/AIA/14 (11-15)
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Gregory	J.	Bullington	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	State/Province	Country of Residence
Bellevue	WA	US

Mailing Address of Inventor:

Address 1	5825 134th Place SE
Address 2	
City	Bellevue
State/Province	WA
Postal Code	98006
Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Richard	G.	Patton	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	State/Province	Country of Residence
Seattle	WA	US

Mailing Address of Inventor:

Address 1	2561 Magnolia Blvd. W
Address 2	
City	Seattle
State/Province	WA
Postal Code	98199
Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Shan	E.	Gaw	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

City	Seattle	State/Province	WA	Country of Residence	US

Mailing Address of Inventor:

Address 1	4027 Sunnyside Ave. N		
Address 2			
City	Seattle	State/Province	WA
Postal Code	98103	Country	US

Inventor 4 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jay	M.	Miazga	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Seattle	State/Province	WA	Country of Residence	US

Mailing Address of Inventor:

Address 1	4025 McKinley Pl. N		
Address 2			
City	Seattle	State/Province	WA
Postal Code	98103	Country	US

Inventor 5 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jed		McCann	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Seattle	State/Province	WA	Country of Residence	US

Mailing Address of Inventor:

Address 1	7321 22nd Ave. NW		
Address 2			
City	Seattle	State/Province	WA
Postal Code	98117	Country	US

Inventor 6 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Paul		Goldenbaum	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Antonio	State/Province	TX	Country of Residence	US

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Mailing Address of Inventor:

Address 1	4218 Black Rock		
Address 2			
City	San Antonio	State/Province	TX
Postal Code	78253	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	58249		
Email Address	zpatdcdocketing@cooley.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS		
Attorney Docket Number	MGMD-012/01US 316052-MGMD	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	36	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	68249		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
◉ Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Magnolia Medical Technologies, Inc.		
Mailing Address Information For Applicant:			
Address 1	2001 Sixth Avenue		
Address 2	Suite 1630		
City	Seattle	**State/Province**	WA
Country	US	Postal Code	98121
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		State/Province	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Michael D. Wintemitz/			Date (YYYY-MM-DD)	2016-11-18
First Name	Michael	Last Name	Wintemitz	Registration Number	73102

Additional Signature may be generated within this form by selecting the Add button. Add

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MGMD-012/01US 316052-MGMD
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

SYSTEMS AND METHODS FOR SAMPLE COLLECTION WITH REDUCED HEMOLYSIS

Background

[1001] Embodiments described herein relate generally to the parenteral procurement of bodily-fluid samples, and more particularly to systems and methods for parenterally procuring bodily-fluid samples, such as blood, with reduced hemolysis.

[1002] Health care practitioners routinely draw bodily-fluids from a patient for various testing and/or donation purposes. In some instances, the process of obtaining the bodily-fluids, and in particular, blood, can result in a degradation and/or breakdown of portions and/or constituents contained in the bodily-fluid. Specifically, hemolysis of red blood cells (i.e., a rupturing of the red blood cells and the release of cytoplasm) during blood draw is a known problem in the field of phlebotomy and/or medical testing. Hemolysis of blood is the most common pre-analytical source of error in clinical testing, accounting for nearly 60% of all rejected samples (Bonini P, Plebani M, Ceriotti F, Rubboli F (2002). Errors in laboratory medicine. *Clinical Chemistry*, 48, 691-698; and Plebani M, Carraro P (1997). Mistakes in a stat laboratory: types and frequency. *Clinical Chemistry*, 43, 1348-1351). Moreover, hemolyzed sample rates from hospital emergency rooms can be as high as 30% (Grant M (2003). The effect of blood drawing techniques and equipment on the hemolysis of ED laboratory blood samples. *Journal of Emergency Nursing*, 29 (2), 116-121, and Soderberg J, Jonsson PA, Wallin O, Grankvist K, Hultdin J (2009). Hemolysis index—an estimate of pre-analytical quality in primary health care. *Clinical Chemistry and Laboratory Medicine*, 47, 940-944). In some know blood draw systems, the arrangement and/or coupling of multiple devices to form a fluid flow path from a patient to, for example, a sample reservoir or container, shear stress exerted on or within the red blood cells, exposure time, and/or the like can lead to an increased likelihood of hemolysis within a sample volume.

[1003] Thus, a need exists for systems and methods for sample collection with reduced hemolysis.

Summary

[1004] Systems and methods for parenterally procuring bodily-fluid samples, such as blood, with reduced hemolysis are described herein. In some embodiments, a collection system has a proximal end portion, a distal end portion, and an inner surface defining a fluid flow path therethrough. The distal end portion is configured to be placed in fluid communication with a patient. The proximal end portion is configured to be placed in fluid communication with a fluid reservoir. The fluid flow path defined by the inner surface is associated with at least one flow characteristic configured to limit a stress within the flow of the bodily-fluid between the distal end portion and the proximal end portion.

Brief Description of the Drawings

[1005] FIG. 1 is a schematic illustration of a bodily-fluid collection device according to an embodiment.

[1006] FIG. 2 is a perspective view of a needle included in a bodily-fluid collection device according to an embodiment.

[1007] FIG. 3 is an enlarged view of a portion of the needle of FIG. 2, identified by the region A_1.

[1008] FIGS. 4-6 are illustrations of a needle used to deliver a cannula to a portion of the body according to an embodiment.

[1009] FIG. 7 is a perspective view of a portion of a needle included in a bodily-fluid collection device according to another embodiment.

[1010] FIG. 8 is a perspective view of a portion of a bodily-fluid collection device according to an embodiment.

[1011] FIG. 9 is a cross-sectional view of the bodily-fluid collection device of FIG. 8, taken along the line 9-9.

[1012] FIG. 10 is an enlarged view of a portion of the bodily-fluid collection device of FIG. 9, identified by the region A_2.

[1013] FIG. 11 is a front view of a portion of a bodily-fluid collection device according to an embodiment.

[1014] FIG. 12 is a cross-sectional view of the portion of the bodily-fluid collection device of FIG. 11, taken along the line 12-12.

[1015] FIG. 13 is an enlarged view of a portion of the bodily-fluid collection device of FIG. 12, identified by the region A_3.

[1016] FIG. 14 is a cross-sectional view of a portion of a bodily-fluid collection device according to another embodiment.

[1017] FIG. 15 is an enlarged view of a portion of the bodily-fluid collection device of FIG. 14, identified by the region A_4.

[1018] FIG. 16 is a cross-sectional view of a portion of a bodily-fluid collection device according to another embodiment.

[1019] FIG. 17 is a cross-sectional view of a portion of a bodily-fluid collection device according to another embodiment.

[1020] FIG. 18 is a perspective view of a portion of a bodily-fluid collection device according to an embodiment.

[1021] FIG. 19 is an exploded view of the portion of the bodily-fluid collection device of FIG. 18.

[1022] FIG. 20 is a cross-sectional view of the portion of the bodily-fluid collection device of FIG. 18, taken along the line 20-20.

[1023] FIG. 21 is a perspective view of a restrictor included in a bodily-fluid collection device according to an embodiment.

[1024] FIG. 22 is a cross-sectional view of the restrictor of FIG. 21, taken along the line 22-22.

[1025] FIG. 23 is a top view of a baffle included in the restrictor of FIG. 21.

[1026] FIG. 24 is a cross-sectional view of the baffle of FIG. 23, taken along the line 24-24.

[1027] FIG. 25 is a perspective view of a restrictor included in a bodily-fluid collection device according to an embodiment.

[1028] FIG. 26 is a cross-sectional view of the restrictor of FIG. 25, taken along the line 26-26.

[1029] FIG. 27 is a perspective view of an adapter included in a bodily-fluid collection device according to an embodiment.

[1030] FIG. 28 is a cross-sectional view of the adapter of FIG. 27, taken along the line 28-28.

[1031] FIG. 29 is a front view of a portion of the adapter of FIG. 27.

[1032] FIG. 30 is a cross-sectional view of the portion of the adapter illustrated in FIG. 29, taken along the line 30-30.

[1033] FIG. 31 is a perspective view of the portion of the adapter illustrated in FIG. 29 coupled to a fluid reservoir according to an embodiment.

[1034] FIG. 32 is an exploded view of the fluid reservoir of FIG. 31.

[1035] FIG. 33 is a cross-sectional view of the portion of the adapter and the fluid reservoir illustrated in FIG. 31, taken along the line 33-33.

[1036] FIG. 34 is a cross-sectional view of an adapter coupled to a fluid reservoir according to another embodiment.

[1037] FIG. 35 is a cross-sectional view of an adapter coupled to a fluid reservoir according to another embodiment.

[1038] FIG. 36 is a cross-sectional view of an adapter coupled to a fluid reservoir according to another embodiment.

[1039] FIG. 37 is a perspective view of an adapter coupled to a fluid reservoir according to another embodiment.

[1040] FIG. 38 is a cross-sectional view of the adapter and the fluid reservoir of FIG. 37, taken along the line 38-38.

[1041] FIG. 39 is a perspective view of an adapter coupled to a fluid reservoir according to another embodiment.

[1042] FIG. 40 is a perspective view of an adapter coupled to a fluid reservoir according to another embodiment.

[1043] FIGS. 41 and 42 are cross-sectional views of the adapter and the fluid reservoir of FIG. 40, taken along the line 41-41, in a first configuration and a second configuration, respectively.

[1044] FIG. 43 is a perspective view of an adapter and a fluid reservoir according to another embodiment.

[1045] FIG. 44 is a cross-sectional view of the adapter and the fluid reservoir of FIG. 43, taken along the line 44-44.

[1046] FIGS. 45-47 are cross-sectional views of an adapter and a fluid reservoir each according to a different embodiment.

[1047] FIG. 48 is a perspective of an adapter included in a bodily-fluid collection device according to another embodiment.

[1048] FIG. 49 is a cross-sectional view of the adapter of FIG. 48, taken along the line 49-49.

[1049] FIG. 50 is a perspective view of a fluid reservoir included in a bodily-fluid collection device according to an embodiment.

[1050] FIG. 51 is a cross-sectional view of the adapter illustrated in FIG. 49 coupled to the fluid reservoir illustrated in FIG. 50, taken along the line 51-51 in FIG. 50.

[1051] FIG. 52 is a perspective view of a fluid reservoir included in a bodily-fluid collection device according to another embodiment.

[1052] FIG. 53 is a cross-sectional view of the fluid reservoir of FIG. 52, taken along the line 53-53.

[1053] FIG. 54 is a perspective view of a fluid reservoir included in a bodily-fluid collection device according to another embodiment.

[1054] FIG. 55 is an exploded view of a plunger included in the fluid reservoir of FIG. 54.

[1055] FIG. 56 is a cross-sectional view of the fluid reservoir of FIG. 54, taken along the line 56-56.

[1056] FIG. 57 is a perspective view of a fluid reservoir included in a bodily-fluid collection device according to another embodiment.

[1057] FIG. 58 is a cross-sectional view of the fluid reservoir of FIG. 57, taken along the line 58-58.

[1058] FIG. 59 is a front view of a fluid reservoir included in a bodily-fluid collection device according to another embodiment.

[1059] FIG. 60 is a cross-sectional view of a fluid reservoir included in a bodily-fluid collection device according to another embodiment.

[1060] FIG. 61 is a perspective view of an adapter included in a bodily-fluid collection device according to another embodiment.

[1061] FIG. 62 is an exploded view of the adapter of FIG. 61.

[1062] FIG. 63 is a cross-sectional view of the adapter of FIG. 61, taken along the line 63-63.

[1063] FIG. 64 is a perspective view of an adapter included in a bodily-fluid collection device according to another embodiment.

[1064] FIG. 65 is an exploded view of the adapter of FIG. 64.

[1065] FIG. 66 is a cross-sectional view of the adapter of FIG. 65, taken along the line 66-66.

[1066] FIG. 67 is a perspective view of an adapter included in a bodily-fluid collection device according to another embodiment.

[1067] FIG. 68 is a cross-sectional view of the adapter of FIG. 67, taken along the line 68-68.

[1068] FIG. 69 is a perspective view of an adapter included in a bodily-fluid collection device according to another embodiment.

[1069] FIG. 70 is an exploded view of the adapter of FIG. 69.

[1070] FIG. 71 is a cross-sectional view of the adapter of FIG. 69, taken along the line 71-71.

Detailed Description

[1071] Systems and methods for parenterally procuring bodily-fluid samples, such as blood, with reduced hemolysis are described herein. In some embodiments, a collection system has a proximal end portion, a distal end portion, and an inner surface defining a fluid flow path therethrough. The distal end portion is configured to be placed in fluid communication with a patient. The proximal end portion is configured to be placed in fluid communication with a fluid reservoir. The fluid flow path defined by the inner surface is associated with at least one flow characteristic configured to limit a stress within the flow of the bodily-fluid between the distal end portion and the proximal end portion.

[1072] As used in this specification and the appended claims, the singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, the term "a member" is intended to mean a single member or a combination of members, "a material" is intended to mean one or more materials, or a combination thereof.

[1073] As used herein, "bodily-fluid" can include any fluid obtained from a body of a patient, including, but not limited to, blood, cerebrospinal fluid, urine, bile, lymph, saliva, synovial fluid, serous fluid, pleural fluid, amniotic fluid, and the like, or any combination thereof. Moreover, while the embodiments and/or devices herein are specifically described as reducing, limiting, inhibiting, and/or substantially preventing hemolysis of blood withdrawn therethrough, any of the embodiments and/or devices can be used for controlling a flow of any suitable bodily-fluid (e.g., such as those listed above) when withdrawn from the body of a patient through that device.

[1074] As used herein, the term "set" can refer to multiple features or a singular feature with multiple parts. For example, when referring to set of walls, the set of walls can be considered as one wall with distinct portions, or the set of walls can be considered as multiple walls. Similarly stated, a monolithically constructed item can include a set of walls. Such a set of walls can include, for example, multiple portions that are discontinuous from each other. A set of walls can also be fabricated from multiple items that are produced separately and are later joined together (e.g., via a weld, an adhesive, or any suitable method).

[1075] As used herein, the terms "proximal" and "distal" refer to the direction closer to and away from, respectively, a user who would place the device into contact with a patient. Thus, for example, the end of a device first touching the body of the patient would be the distal end, while the opposite end of the device (e.g., the end of the device being manipulated by the user) would be the proximal end of the device.

[1076] As used herein, the terms "about," "approximately," and "substantially" when used in connection with a numerical value is intended to convey that the value so defined is nominally the value stated. Said another way, the terms about, approximately, and substantially when used in connection with a numerical value generally include the value stated plus or minus a given tolerance. For example, in some instances, a suitable tolerance can be plus or minus 10% of the value stated; thus, about 0.5 would include 0.45 and 0.55, about 10 would include 9 to 11, about 1000 would include 900 to 1100. In other instances, a suitable tolerance can be plus or minus an acceptable percentage of the last significant figure in the value stated. For example, a suitable tolerance can be plus or minus 10% of the last significant figure; thus, about 10.1 would include 10.09 and 10.11, approximately 25 would include 24.5 and 25.5. Such variance can result from manufacturing tolerances or other practical considerations (such as, for example, tolerances associated with a measuring instrument, acceptable human error, or the like).

[1077] As used herein, the term "laminar" refers to an organized and/or orderly fluid flow in parallel layers without lateral mixing, crosscurrents, eddy currents, and/or the like. More generally, the term "laminar" is intended to convey a flow of fluid that is smooth and/or free of turbulence. Moreover, the term "substantially" when used in connection with "laminar" is intended to convey that a fluid flow so defined is nominally a laminar fluid flow. As one example, a portion of a fluid transfer device defining a lumen that is described as facilitating and/or otherwise causing a "substantially laminar" fluid flow therethrough is intended to

convey that, although laminar fluid flow is desirable, some non-laminar flow can occur. Such variances (e.g., turbulence or the like) can result from manufacturing tolerances, or other practical considerations. Thus, a fluid having a "substantially laminar" flow includes such non-laminar flow characteristics within an industry-accepted tolerance. For example, while it may be desirable that a bodily-fluid transfer device transfer a laminar flow of blood therethrough a "substantially laminar flow" of blood can be 99% laminar, 95% laminar, 90% laminar, or any other acceptable tolerance thereof.

[1078] The embodiments described herein can be formed or constructed of one or more biocompatible materials. Examples of suitable biocompatible materials include metals, glasses, ceramics, or polymers. Examples of suitable metals include pharmaceutical grade stainless steel, gold, titanium, nickel, iron, platinum, tin, chromium, copper, and/or alloys thereof. A polymer material may be biodegradable or non-biodegradable. Examples of suitable biodegradable polymers include polylactides, polyglycolides, polylactide-co-glycolides (PLGA), polyanhydrides, polyorthoesters, polyetheresters, polycaprolactones, polyesteramides, poly(butyric acid), poly(valeric acid), polyurethanes, and/or blends and copolymers thereof. Examples of non-biodegradable polymers include nylons, polyesters, polycarbonates, polyacrylates, polymers of ethylene-vinyl acetates and other acyl substituted cellulose acetates, non-degradable polyurethanes, polystyrenes, polyvinyl chloride, polyvinyl fluoride, poly(vinyl imidazole), chlorosulphonate polyolefins, polyethylene oxide, and/or blends and copolymers thereof.

[1079] In some current phlebotomy procedures, blood is drawn from a patient using multiple components that are physically and fluidically coupled to define a fluid flow path between the patient and a collection device and/or fluid reservoir used to capture the bodily-fluid sample. In some such systems, however, the physical and/or fluidic interfaces formed between the components can result in turbulent regions and/or eddy currents within the flow of the blood, which in turn, can result in a stress within the flow that is sufficient to sheer, rupture, and/or otherwise damage the red blood cells. In addition, the process of drawing blood from a patient often involves exposing the blood to a negative pressure differential produced, for example, by placing an evacuated container (e.g., a Vacutainer ™) in fluid communication with a portion of the body. In some instances, the pressure differential can increase an internal stress within a flow of blood to an extent that results in hemolysis of the red blood cells. In other instances, the pressure differential can be attributed to the physical

exertion associated with a clinician actuating, for example, a syringe with a force sufficient to rupture the red blood cells during the collection process. A number of factors (for example, small veins, dehydration, veins with scar tissue, presence of sclerosis, and/or the like) can make vascular access a challenge. In such cases, excess negative pressure exerted during the collection process can result in hemolysis.

[1080] While such a negative pressure differential often facilitates withdraw of the blood, it also can produce a relatively high shear stresses within the red blood cells and/or a relatively high flow velocity of the blood through a flow path defined between the patient and the fluid reservoir (e.g., evacuated container). As a result, the red blood cells contained within the flow of blood can be damaged as the cells pass through the physical and/or fluidic interfaces formed between different components of a transfer device. In some instances, the relatively high velocity of the blood flow as the blood enters the containers can result in the blood impacting an inner surface of the container with a force sufficient to damage the red blood cells and/or other components of the blood. In addition, exposure time of a needle and/or catheter within the vein can result in hemolysis of the red blood cells.

[1081] Thus, to mitigate the risk of hemolysis of a sample volume of blood, various portions of a fluid flow path between the patient and the sample reservoir can be optimized. Such optimization can be done holistically (i.e., a system wide optimization) or done piecemeal (i.e., optimization of at least one potential source of hemolysis). By way of example, in some instances, any of the embodiments described herein, can be used independently to mitigate the risk of hemolysis at a specific point along a fluid flow path between a patient and a sample reservoir. That is to say, the embodiments described herein can be characterized by the potential source of hemolysis that the embodiments, so characterized, mitigate. For example, the embodiments described herein generally address six potential categories, portions, and/or sources of hemolysis along a fluid flow path between a patient and a fluid reservoir. Namely, the embodiments described herein can be used to mitigate the risk of hemolysis otherwise associated with (1) blood flow from, for example, a vein into a puncture member, needle, cannula, and/or the like, (2) blood flow through changing geometries and/or physical and fluidic interfaces; (3) blood flow rates and/or velocity within the fluid flow path; (4) blood flow from an adapter, puncture member, needle, cannula, and/or the like into a fluid reservoir; (5) blood flow exposure to a negative

pressure differential within a fluid reservoir, and (6) blood flow through a multi-lumen adapter and/or the like.

[1082] FIG. 1 is a schematic illustration of a portion of a bodily-fluid collection device 100, according to an embodiment. Generally, the bodily-fluid collection device 100 (also referred to herein as "fluid collection device," "collection device," or "device") can be used to percutaneously withdraw bodily-fluid from a patient. In some instances, the device 100 can be used to withdraw a volume of blood from a patient that is to be used as a biological sample for testing and/or assays associated with medical diagnosis and/or treatment. In other instances, the device 100 can be used to withdraw a volume of blood for collection purposes such as, for example, blood donation or the like. More particularly, the device 100 is configured to limit, inhibit, and/or substantially prevent hemolysis of at least a portion of the blood drawn therethrough, as described in further detail herein.

[1083] The device 100 has a proximal end portion 101 and a distal end portion 102 and defines a lumen 104 therethrough. More specifically, the device 100 includes an inner surface 103 that defines the lumen 104. The device 100 can be any suitable device or group of devices (e.g., a system including multiple devices). In some embodiments, for example, the device 100 can be a needle, a cannula, a trocar, a catheter, and/or the like. In such embodiments, the distal end portion 102 of the device 100 can include a sharpened, angled, or beveled edge configured to puncture the cutaneous layer of the body to place the lumen 104 in fluid communication with, for example, a vascular structure and/or the like. The proximal end portion 101 of the device 100 can be physically and/or fluidically coupled to any other suitable device such as, for example, a collection reservoir (not shown in FIG. 1). As such, the lumen 104 defined by the device 100 defines fluid pathway through which blood can flow from the patient to an intermediary collection device and/or directly to the collection reservoir.

[1084] As described above, in some embodiments, the device 100 is configured to reduce, limit, inhibit, and/or substantially prevent hemolysis of blood withdrawn from the body and through the device. For example, in embodiments in which the device 100 is a needle, cannula, catheter, and/or the like, the distal end portion 102 of the device 100 can include rounded edges and/or a substantially smooth contour. As such, the constituents of the blood (e.g., the red blood cells or "erythrocytes") can flow relatively smoothly into the lumen

104 (e.g., in response to a negative pressure differential produced, for example, by a syringe and/or an evacuated container coupled thereto) substantially without being damaged.

[1085] Moreover, in some embodiments, the shape, size, and/or contour of the inner surface 103 can selectively control the flow of blood through the device 100. By way of example, in some embodiments, the inner surface 103 can form a substantially smooth contour, which can facilitate a laminar flow of the blood therethrough. In addition, the inner surface 103 can have a contour that can selectively control an amount of negative pressure within a region of the lumen 104. For example, in some embodiments, the inner surface 103 can have a diameter that is varied along the length of the device 100. That is to say, a first portion of the inner surface 103 can have a diameter that is different from a diameter of a second portion of the inner surface 103 and thus, can reduce, constrict, limit, and/or otherwise control a flow of blood therethrough. In some such embodiments, the first portion of the inner surface 103 can be disposed between the second portion of the inner surface 103 and a third portion of the inner surface 103 having a diameter greater than or equal to the diameter of the second portion of the inner surface 103. In such embodiments, a region of the lumen 104 having a relatively larger diameter can be associated with a larger pressure than a region of the lumen 104 having a relatively smaller diameter, while conversely, a velocity associated with the region of the lumen 104 having the relatively larger diameter is less than a velocity associated with the region of the lumen having the relatively smaller diameter based on the simplified Bernoulli's Equation mathematically represented by equation 1 below:

$$P_1 + {}^1/_2\,\rho V_1^2 = P_2 + {}^1/_2\,\rho V_2^2 \qquad \text{Equation 1}$$

wherein P is pressure within the lumen, ρ is density of the fluid, and V is velocity of the fluid.

[1086] While described above as being a needle, catheter, cannula, trocar, and/or the like, in other embodiments, the device 100 can be any suitable component included in a fluid transfer system. For example, the device 100 can be an adapter, a locking mechanism, a cannula, a coupling mechanism, a port, an inlet, and outlet, and/or the like. By way of example, in some embodiments, the device 100 can be an adapter configured to be physically and fluidically coupled to at least one other device such as, for example, a needle. Thus, the adapter (i.e., the device 100) can have an inner surface with a contour that can control a flow of bodily-fluid therethrough. Moreover, an interface between the device 100 and the needle

(and/or any other suitable device) can be arranged to reduce turbulence of a flow of bodily-fluid therebetween, as described in further detail herein.

[1087] In some embodiments, the device 100 can be coupled to a fluid reservoir or container (e.g., at the proximal end portion 101). As such, the contour of the inner surface 103 of the device 100 can control a flow of bodily-fluid therethrough (as described above), while the orientation of the device 100 relative to the fluid reservoir or container can control and/or direct the flow of bodily-fluid through the proximal end portion 101 toward an inner surface of the fluid reservoir to, for example, reduce a force associated with a portion of the flow of bodily-fluid impacting the inner surface. In some embodiments, the device 100 can be an insert or the like at least partially disposed within the fluid reservoir or container.

[1088] Although not shown in FIG. 1, in some embodiments, the device 100 can be used with (e.g., physically and fluidically coupled to) a device or mechanism configured to modulate a negative pressure within a fluid reservoir or container. For example, in some embodiments, the device 100 can be coupled to a syringe or the like configured to transition between a first configuration and a second configuration to produce a negative pressure within an inner volume. As such, a rate at which the syringe can be transitioned from the first configuration (e.g., associated with a plunger in a distal position) to the second configuration (e.g., associated with the plunger in a proximal position) can be constrained (e.g., limited, inhibited, slowed, governed, controlled, etc.), thereby reducing a negative pressure exerted through the lumen 104 of the device, as described in further detail herein.

[1089] While the device 100 is described above as including a surface, mechanism, portion, etc. configured to reduce hemolysis of a volume of blood in a mechanical manner (e.g., reducing pressure and/or turbulence within a flow path via a contour, restrictor, or the like; reducing forces associated with a portion of the volume of blood impacting a surface of a fluid reservoir via a coupling mechanism, interface, etc.; reducing damage to constituents in the volume of blood by limiting or eliminating sharp edges, corners, etc.; and/or the like), in other embodiments, the device can be configured to chemically modify one or more characteristics associated with the volume of blood. For example, in some embodiments, the inner surface 103 of the device 100 can be coated with a chemical configured to limit lysis of erythrocytes (red blood cells) by strengthening or weakening a cell wall of the erythrocytes. More specifically, in some embodiments, the device 100 can be configured to introduce a chemical into a flow of blood that can, for example, increase a rigidity of the cell wall of

erythrocytes (e.g., decrease flexibility), which in turn, can reduce a likelihood of lysis of the erythrocytes (e.g., hemolysis of the blood) as the blood flows through the device 100. In other embodiments, the device 100 can be configured to introduce a chemical into a flow of blood that can, for example, decrease a rigidity of the cell wall of erythrocytes (e.g., increase flexibility), which in turn, can reduce a likelihood of lysis of the erythrocytes as the blood flows through the device 100.

[1090] While described above as coating the inner surface 103 with the chemical configured to modify a characteristic of the cell wall of the erythrocytes, in other embodiments, the device 100 can include any suitable device, mechanism, and/or method for introducing such a chemical to the volume of blood flowing therethrough. For example, the device 100 can include a chamber containing such a chemical, a baffle impregnated with such a chemical, a dispensing or dispersing device (e.g., sprayer or the like) configured to dispense a volume of such a chemical, impregnation of the chemical directly into the material used to produce the device 100 and/or any other suitable means for introducing such a chemical.

[1091] FIGS. 2-7 illustrate embodiments configured to mitigate the risk of hemolysis as a volume of blood flows from the patient (e.g., a vein of a patient) and into a lumen-defining device such as a needle or the like. Specifically, FIGS. 2 and 3 illustrate a puncture member 210 coupled to an adapter 220 according to an embodiment. The puncture member 210 has a proximal end portion 211 and a distal end portion 212 and defines a lumen 213 therebetween. The proximal end portion 211 of the puncture member 210 is physically and fluidically coupled to a distal end portion 222 of the adapter 220, as described above with reference to FIG. 1. More specifically, the proximal end portion 211 of the puncture member 210 is coupled to the adapter 220 such that an interface therebetween forms a substantially smooth and/or continuous surface. Said another way, the interface between the puncture member 210 and the adapter 220 can be such that a transition between the lumen 213 of the puncture member 210 and a lumen (not shown in FIGS. 2-6) defined by the adapter is substantially smooth and/or continuous (i.e., does not introduce a discontinuity such as a change in alignment and/or diameter), as described in further detail herein.

[1092] The distal end portion 212 of the puncture member 210 is configured to be inserted through the cutaneous layer of the patient to transfer fluid to and/or from the patient. For example, the distal end portion 212 can be inserted into a vein of a patient and the adapter 220 can be coupled to a fluid reservoir and/or intermediary collection device configured to

receive a volume of blood from the patient via the lumen 213. More specifically, as shown in FIGS. 2 and 3, the distal end portion 212 of the puncture member 210 is sharpened, angled, and/or beveled, which facilitates the insertion of the puncture member 210 into the body. The lumen 213 of the puncture member 210 extends through the distal end portion 212, thereby defining an opening 214 that places the lumen 213 in fluid communication with, for example, a vascular structure (e.g., a vein) within which the distal end portion 212 is disposed. Furthermore, as shown in FIG. 3, a distal edge 215 of the puncture member 210 defining the opening 214 is substantially rounded, smoothed, contoured, blunted, and/or the like. In other words, the distal edge 215 defining the opening 214 forms a substantially round corner. Thus, blood drawn through the opening 214 and into the lumen 213 can flow past the distal edge 214 with reduced damage to, for example, the constituents of the blood (e.g., the erythrocytes) that would otherwise result from contact with a sharper, more abrupt, substantially orthogonal, and/or otherwise non-rounded distal edge 215.

[1093] In some instances, a puncture member can be used to deliver and/or place a portion of a catheter in a desired lumen within the body of a patient. For example, as shown in FIGS. 4-6, a puncture member 310 can be used to place a stented catheter and/or the like within a vein V. The puncture member 310 can be substantially similar to the puncture members 210 and/or 310 described above and thus, the puncture member is not described in further detail herein. As shown in FIG. 4, a user (e.g., a phlebotomist, nurse, technician, physician, doctor, etc.) can manipulate a portion of the puncture member 310 (e.g., either directly or indirectly) to place at least a distal end portion 312 of the puncture member 310 within a lumen defined by the vein V. Once disposed in the vein V, a guidewire 316 can be advanced through the lumen defined by the puncture member 310, as shown in FIG. 4. With the guidewire 316 positioned within the vein V, the user can advance an introducer catheter 317 and, for example, a stented catheter 318 along the guide wire 316 to dispose a distal end portion of at least the introducer catheter 317 within the lumen of the vein V, as indicated by the arrow AA in FIG. 5. In some instances, the stented catheter 318 can be inserted into the vein V concurrently with the introducer catheter 317. In other instances, the stented catheter 318 can be advanced within the introducer catheter 317 after the distal end portion of the introducer catheter 317 is disposed in the vein 317.

[1094] With the distal end portion of the stented catheter 318 disposed in the vein V, the guidewire 316 and the introducer catheter 317 can be moved in the proximal direction (i.e.,

withdrawn from the vein V), as indicated by the arrow BB in FIG. 6. In some embodiments, as the introducer catheter 317 is withdrawn from the vein V, the distal end portion of the stented catheter 318 can transition from a first configuration to a second configuration. For example, the stented catheter 318 can be in a collapsed configuration (e.g., the first configuration) when disposed in the introducer catheter 317 (FIG. 5) such that a diameter of the stented catheter 318 is substantially uniform. When the introducer catheter 318 is withdrawn from the vein (FIG. 6), the distal end portion of the stented catheter 318 can expand and/or otherwise reconfigure such that a diameter of the distal end portion of the stented catheter 318 is greater than a diameter of a portion of the stented catheter 318 still disposed in the introducer catheter 317.

[1095] In some embodiments, the distal end portion of the stented catheter 318 can expand to an extent that places an outer surface of the stented catheter 318 in close proximity to or directly in temporary contact with an inner surface of the vein V defining the lumen. As such, blood can be withdrawn from the vein V into a fluid reservoir (not shown in FIGS. 4-6) via a lumen defined by the stented catheter 318. Moreover, with the distal end portion of the stented catheter 318 in close proximity to or directly in contact with the inner surface of the vein, the stented catheter 318 can inhibit, limit, and/or substantially prevent a collapse of at least a portion of the vein V (e.g., in response to a negative pressure differential between the vein V and the fluid reservoir (not shown). In some embodiments, the arrangement of at least the distal end portion of the stented catheter 318, when in the second configuration, can allow a flow of blood to enter the stented catheter 318 substantially without damaging the constituents of the blood, as described above with reference to FIGS. 2 and 3. While the puncture member 310 is described above as being retracted once the stented catheter 318 is placed in a desired position with the vein, in other embodiments, the puncture member 310 need not be retracted. As such, the stented catheter 318 can be, for example, a sleeve or the like disposed about the distal end portion 312 of the puncture member 310 to control a flow of blood entering the lumen of the puncture member 310. Moreover, as described above with reference to the puncture member 210, a surface of the puncture member 310 and/or the stented catheter 318 defining a distal opening can be substantially rounded, smoothed, contoured, blunted, and/or the like. In other words, a distal edge of the puncture member 310 and/or stented catheter 318 defining the distal opening forms a substantially round corner. Thus, blood drawn through the opening can flow past the distal edge with reduced damage to

the erythrocytes that would otherwise result from contact with a sharper, more abrupt, substantially orthogonal, and/or otherwise non-rounded distal edge 215.

[1096] While described above as placing a stented catheter, in other embodiments, a puncture member can be used to place any suitable catheter and/or cannula. For example, FIG. 7 illustrates a puncture member 410 and a catheter 418 according to another embodiment. The puncture member 410 can be used, for example, to place at least a portion of the catheter 418 within a lumen defined by the body (e.g., a vein). As shown in FIG. 7, a distal end portion 412 of the puncture member 410 can include a substantially rounded distal edge 415, as described above with reference to the puncture member 210. In this manner, a flow of blood can flow past the distal edge 415 to enter a lumen 413 defined by the puncture member 410. Similarly, the catheter 418 can include a distal edge 418A that is substantially rounded. As shown in FIG. 7, the distal end portion 412 of the puncture member 410 extends beyond the distal edge 418A of the catheter 418. In some embodiments, the distal end portion 412 of the puncture member 410 can form and/or can define a recessed portion 419 or the like that corresponds with a position at or near the distal edge 418A of the catheter 418. In this manner, when the puncture member 410 is inserted into, for example, a vein of a patient, an opening in the vein defined by the puncturing can be a diameter that is substantially the same as an outer diameter of the catheter 418. As such, the catheter 418 can be positioned within the vein without rupturing and/or otherwise dilating the opening in the vein. In some instances, once the catheter 418 is disposed in the lumen defined by the vein, the puncture member 410 can be retracted through the catheter 418 while at least a distal end portion of the catheter 418 remains within the vein. In such instances, the substantially rounded distal edge 418A can reduce and/or can substantially prevent hemolysis of a volume of blood flowing to the catheter 418, as described above with reference to the puncture member 310 in FIGS. 2 and 3.

[1097] While the puncture members 210, 310, and 410 are particularly shown and described above, in other embodiments, any suitable puncture member can be coupled to any compatible adapter, which in turn, can place the puncture member in fluid communication with a fluid collection device. For example, FIGS. 8-17 illustrate embodiments configured to mitigate the risk of hemolysis as a volume of blood flows through changing geometries and/or physical and fluidic interfaces of one or more adapters. Specifically, FIGS. 8-10 illustrate a puncture member 510 coupled to an adapter 520, according to another

embodiment. In some embodiments, the puncture member 510 and the adapter 520 can be and/or can form, for example, a butterfly needle or the like. More specifically, the puncture member 510 has a proximal end portion 511 and a distal end portion 512 and defines a lumen 513 therethrough. The proximal end portion 511 is coupled to the adapter 520, as described in further detail herein. The distal end portion 512 of the puncture member 510 can be any suitable configuration. For example, the distal end portion 512 of the catheter 510 can be substantially similar to or the same as the distal end portion 212 of the catheter 210 described above with reference to FIGS. 2 and 3. That is to say, the arrangement of the distal end portion 512 of the catheter 510 can limit and/or substantially prevent damage (e.g., hemolysis) to blood as blood flow past the distal end portion 512 and into the lumen 513.

[1098] The adapter 520 has a proximal end portion 521, a distal end portion 522, and an inner surface 523. As described above, the adapter 520 can have an overall shape substantially similar to known butterfly needles. While shown in FIG. 8 as being substantially cylindrical with varying diameters, the adapter 520 can be any suitable shape, size, or configuration such as square, rectangular, polygonal, and/or any other non-cylindrical shape. In this manner, the overall shape of the adapter 520 can facilitate the handling of the transfer device 520 by including similar geometric features as known butterfly needles. The distal end portion 522 of the adapter 520 is physically and fluidically coupled to the proximal end portion 511 of the puncture member 510, as described in further detail herein. The proximal end portion 521 of the adapter 520 can be any suitable configuration. In some embodiments, the proximal end portion 521 can be a port and/or a portion of a locking mechanism. For example, in this embodiment, the proximal end portion 521 of the adapter 520 is a locking mechanism configured as a male portion of a Luer Lok ®. Moreover, in this embodiment, such a locking mechanism is disposed at a proximal end portion of a cannula configured to extend between the proximal end portion 521 and the distal end portion 522 of the adapter 520. In other embodiments, the adapter 520 is monolithically formed without a cannula between the proximal end portion 521 and the distal end portion 522. Although the proximal end portion 521 is described as including a locking mechanism, in other embodiments, the proximal end portion 521 can be any suitable configuration configured to interface with any suitable device such that blood flows in a substantially laminar, smooth, and/or non-turbulent flow between the adapter 520 and the device.

[1099] As shown in FIGS. 9 and 10, the inner surface 523 of the adapter 520 defines a lumen 524 extending through the proximal end portion 521 and the distal end portion 522. In some embodiments, the arrangement of the inner surface 523 can reduce, inhibit, and/or substantially prevent, for example, hemolysis of a volume of blood flowing within the lumen 524. More specifically, as shown in FIG. 10, the distal end portion 522 of the adapter 520 is coupled to the proximal end portion 511 of the puncture member 510 such that the lumen 513 of the puncture member 510 is substantially aligned with and substantially the same diameter as the lumen 524 of the adapter 520. That is to say, the proximal end portion 511 of the puncture member 510 is coupled to the distal end portion 522 of the adapter 520 such that a substantially smooth and/or continuous transition is defined between the lumen 513 of the puncture member 510 and the lumen 524 of the adapter 520. Similarly, in embodiments including the cannula extending between the end portions, a distal end portion of the cannula can be coupled to the distal end portion 522 of the adapter 520 in such a manner as to define a substantially smooth transition therebetween.

[1100] In addition, the inner surface 523 of the adapter 520 defines a tapered portion that extends between the puncture member 510 and the cannula. Expanding further, a first portion of the inner surface 523 (e.g., a more proximal portion) defines a first diameter that is substantially the same as an inner diameter defined by the cannula, while a second portion of the inner surface (e.g., a more distal portion) defines a second diameter, smaller than the first diameter, that is substantially the same as an inner diameter defined by the lumen 513 of the puncture member 510. As shown in FIG. 10, the tapered portion can form a substantially smooth transition between, for example, the first diameter and the second diameter. In some instances, such a smooth transition, for example, from the first diameter to the second diameter can facilitate, produce, encourage, and/or force a substantially laminar flow (e.g., consistent, uniform, non-turbulent, uninterrupted, smooth, etc.) of a volume of bodily-fluid (e.g., blood) through the lumen 524. Moreover, the smooth or substantially uniform transitions between the puncture member 510 and the adapter 520 and/or the smooth or substantially uniform transitions between the various components of the adapter 520 can reduce eddy currents (i.e., circulating currents often resulting from a discontinuity) or the like within the flow of blood. Thus, when the distal end portion 512 of the puncture member 510 is disposed in a vein or the like and the proximal end portion 521 (e.g., a locking mechanism) is physically and fluidically coupled to a fluid reservoir, a volume of blood can flow within the lumens 513 and 524 from the patient to the fluid reservoir with reduced damage to the

constituents of the blood (e.g., hemolysis of the erythrocytes) that might otherwise occur as a result of misaligned interfaces and/or discontinuities; abrupt changes in diameter; turbulence and/or eddy currents within a flow of blood therethrough; and/or the like.

[1101] While the adapter 520 is particularly shown and described above with reference to FIGS. 8-10, in other embodiments, an adapter can be any suitable configuration and can be arranged within a system of components to form a physical and/or fluidic interface therebetween. For example, FIGS. 11-13 illustrate a first adapter 620 coupled to a second adapter 630 according to an embodiment. The first adapter 620 has a proximal end portion 621, a distal end portion 622 and an inner surface 623. The inner surface 623 of the first adapter 620 defines a lumen 624 extending through its proximal end portion 621 and its distal end portion 622.

[1102] As shown in FIGS. 12 and 13, the inner surface 623 of the first adapter 620 includes and/or otherwise forms a shoulder 625. More specifically, the shoulder 625 formed by the inner surface 623 is associated with a change in diameter of the inner surface 623. As shown in FIG. 13, the shoulder 625 forms a substantially annular discontinuity that has substantially rounded corners or edges. In this manner, the transition from a diameter of the inner surface 623 proximal to the shoulder 625 to a diameter of the inner surface distal to the shoulder 625 can be relatively smooth rather than forming a relatively sharp, abrupt, and/or orthogonal corner (e.g., shoulder). As such, the arrangement of the shoulder 625 can limit, inhibit, and/or substantially prevent hemolysis of blood as the blood flows within the lumen 624 past the shoulder 625.

[1103] The second adapter 630 has a proximal end portion 631, a distal end portion 632, and an inner surface 633. The inner surface 633 of the second adapter 630 defines a lumen 624 extending through its proximal end portion 631 and its distal end portion 632. As shown in FIGS. 11-13, a portion of the second adapter 630 can be inserted into a portion of the lumen 624 defined by the first adapter 620 to couple the second adapter 630 to the first adapter 620. In some embodiments, the first adapter 620 and the second adapter 630 can form a friction fit and/or the like, which in turn, can define a substantially fluid tight seal therebetween. Thus, the second adapter 630 can be inserted into the first adapter 620 to couple the second adapter 630 thereto.

[1104] Similarly, the distal end portion 632 of the second adapter 630 is configured to reduce, limit, and/or substantially prevent hemolysis of blood as the blood flow therethrough. Specifically, as shown in FIG. 13, a distal most surface of the second adapter 630 and the inner surface 633 of the second adapter 630 form a rounded corner 635 and/or smooth transition therebetween. The rounded corner 635 formed by the second adapter 630 defines a relatively smooth transition from an outer diameter of the second adapter 630 (e.g., at the distal end) to an inner diameter of the second adapter 630 (e.g., at the distal end) rather than forming a relatively sharp, abrupt, and/or orthogonal corner. In some embodiments, a radius of curvature associated with the rounded corner 635 of the second adapter 630 can be substantially similar to a radius of curvature associated with the shoulder 625 of the first adapter 620. Thus, when the second adapter 630 is disposed within the first adapter 620, a volume of bodily-fluid (e.g., blood) can flow through the lumen 624 of the first adapter 620 and the lumen 634 of the second adapter 630 to be disposed within a fluid reservoir or the like. Moreover, the arrangement of the shoulder 625 of the first adapter 620 and the rounded corner 635 of the second adapter 630 can, for example, reduce, limit, and/or substantially prevent hemolysis of blood flowing therethrough that might otherwise result from contact substantially abrupt, sharp, and/or orthogonal corners or the like. In addition, the arrangement of the shoulder 625 of the first adapter 620 and the rounded corner 635 of the second adapter 630 can facilitate, produce, encourage, and/or otherwise result in a substantially laminar flow through the lumens 624 and 634, respectively (e.g., with little turbulence, eddy currents, etc.).

[1105] Although the first adapter 620 and the second adapter 630 are shown in FIGS. 11-13 as each forming substantially rounded corners and/or shoulders, in other embodiments, a first adapter and a second adapter can be coupled together to form an interface therebetween having any suitable arrangement and/or configuration. For example, FIGS. 14 and 15 illustrate a first adapter 720 coupled to a second adapter 730 according to another embodiment. The first adapter 720 has a proximal end portion 721, a distal end portion 722 and an inner surface 723. The inner surface 723 of the first adapter 720 defines a lumen 724 extending through its proximal end portion 721 and its distal end portion 722. Furthermore, the inner surface 723 includes and/or otherwise forms a shoulder 725. In this embodiment, the shoulder 725 is associated with a change in diameter of the inner surface 723. As shown in FIG. 15, the shoulder 725 forms a substantially annular discontinuity with a substantially orthogonal corner. Said another way, the shoulder 725 has a substantially non-rounded

corner (e.g., has no radius of curvature of a nominal radius of curvature) that defines an edge or the like.

[1106] The second adapter 730 has a proximal end portion 731, a distal end portion 732, and an inner surface 733. The inner surface 733 of the second adapter 730 defines a lumen 724 extending through its proximal end portion 731 and its distal end portion 732. As shown in FIGS. 14 and 15, a portion of the second adapter 730 can be inserted into a portion of the lumen 724 defined by the first adapter 720 to couple the second adapter 730 to the first adapter 720. As shown in FIG. 14, the distal most surface of the second adapter 730 and the inner surface 733 of the second adapter 730 form a substantially orthogonal corner 735 (e.g., a substantially non-rounded corner, as described above). In some embodiments, the first adapter 720 and the second adapter 730 can be substantially similar to known adapters (e.g., each adapter forms relatively abrupt and/or substantially orthogonal corners and/or edges).

[1107] While such corners, discontinuities, and/or edges are described above as a potential source of blood hemolyzation, in this embodiment, a gasket 726 is disposed between and in contact with the shoulder 725 of the first adapter 720 and the distal surface of the second adapter 730, as shown in FIG. 15. The gasket 726 can be, for example, an elastomeric gasket and/or the like that is in contact with the distal surface of the second adapter 730 and the shoulder 725 of the first adapter 720 to define a substantially fluid tight seal therebetween. Moreover, the gasket 726 defines an opening and/or lumen therethrough that can have a size and/or diameter substantially similar to the size and/or diameter of the lumens 724 and 734. Thus, the arrangement of the gasket 726 can reduce a magnitude of the discontinuities formed by the shoulder 725 of the first adapter 720 and the distal end of the second adapter 730. As a result, the gasket 726 disposed between the shoulder 725 of the first adapter 720 and the distal surface of the second adapter 730 can, for example, reduce, limit, and/or substantially prevent hemolysis of blood flowing therethrough that might otherwise result from relatively large changes and/or discontinuities in the diameters of the inner surfaces 723 and 733, respectively. In addition, the gasket 726 can facilitate, produce, encourage, and/or otherwise result in a substantially laminar flow of fluid through the lumens 724 and 734, respectively (i.e., with little to no turbulence, eddy currents, etc.).

[1108] In some embodiments, the gasket 726 can be configured to restrict, limit, reduce, and/or otherwise control a flow of blood and/or a pressure exerted therethrough. For example, while the gasket 726 is described above as having substantially the same size and/or

diameter as the lumens 724 and 734, in other embodiments, the gasket 726 can have a size and/or diameter that is greater than or less than the diameter of the lumens 724 and 734. Specifically, in some embodiments, the size and/or diameter of the gasket 726 can be less than the diameter of the lumens 724 and 734 and, as such, the gasket 726 can restrict, constrict, reduce, limit, and/or otherwise control a flow of blood therethrough. In some embodiments, such a reduction and/or restriction of the blood flowing through the gasket 726 can reduce a likelihood of hemolysis of the blood resulting from, for example, a flow rate and/or a large pressure differential between a volume having a relatively high pressure disposed on a first side of the gasket 726 and a volume having a relatively low pressure disposed on a second side of the gasket 726.

[1109] FIG. 16 illustrates a portion of a first adapter 820 coupled to a portion of a second adapter 830 according to another embodiment. The first adapter 820 has a proximal end portion 821 configured to be coupled to a distal end portion 832 of the second adapter 830, as described in further detail herein. Although only the proximal end portion 821 of the first adapter 820 is shown in FIG. 16, the first adapter 820 can be similar in size and/or shape as the first adapters 620 and/or 720, unless otherwise expressed. The first adapter 820 includes an inner surface 823 that defines a lumen 824 extending through at least its proximal end portion 821. As shown in FIG. 16, the inner surface 823 of the first adapter 820 includes and/or otherwise forms a shoulder 825. The shoulder 825 formed by the inner surface 823 is associated with a change in diameter of the inner surface 823. More specifically, the shoulder 825 is associated with and/or forms a tapered or chamfered portion of the inner surface 823, as described in further detail herein.

[1110] Although only the distal end portion 832 of the second adapter 830 is shown in FIG. 16, the second adapter 830 can be any suitable shape, size, or configuration. For example, the distal end portion 832 of the second adapter 830 can form and/or can include a locking mechanism or the like while a proximal end portion (not shown in FIG. 16) can be coupled to and/or can form any suitable portion of a fluid collection device such as, for example, a fluid reservoir, a conduit, a flow control mechanism, and/or the like. In this embodiment, the distal end portion 832 of the second adapter 830 includes and/or forms a locking mechanism configured to form a threaded coupling with, for example, the proximal end portion 821 of the first adapter 820. In other embodiments, the distal end portion 832 of the second adapter 830 can be any suitable configuration.

[1111] As shown in FIG. 16, the second adapter 830 includes an inner surface 833 that defines a lumen 834 extending through at least its distal end portion 832. Moreover, the distal end portion 832 of the second adapter 830 includes and/or forms a distal surface 835 that is substantially tapered or chamfered. In some embodiments, the distal surface 835 of the second adapter 830 can have a size, shape, angle, etc. that substantially corresponds with the shoulder 825 defined by the first adapter 820. Thus, when the first adapter 820 is coupled to the second adapter 830 (e.g., via a threaded coupling or the like), the distal surface 835 of the second adapter 830 can be brought into contact with the shoulder 825 of the first adapter 820. Moreover, the arrangement of the first adapter 820 and the second adapter 830 is such that when the distal surface 835 of the second adapter 830 is placed in contact with the shoulder 825 of the first adapter 820, the inner surfaces 833 and 823, respectively, are brought into alignment, as shown in FIG. 16. In this manner, the inner surfaces 823 and 833 can form a substantially continuous surface having, for example, a substantially constant diameter. Thus, by reducing and/or substantially eliminating a discontinuity otherwise associated with the physical and fluidic coupling of the first adapter 820 and the second adapter 830, blood can flow within the lumens 824 and 834 of the adapters 820 and 830, respectively, with little or substantially no hemolysis of the blood flowing therethrough.

[1112] Although the inner surfaces 823 and 833 of the first adapter 820 and the second adapter 830, respectively, are described above as having a substantially constant diameter, in other embodiments, a diameter of each inner surface 823 and 833 can be varied. Such arrangement, however, is such that the inner surfaces 823 and 833 form a substantially smooth transition between, for example, a smaller diameter and a larger diameter. Thus, the substantially smooth transition in the diameters of the inner surfaces 823 and 833 can still facilitate a substantially laminar flow therethrough, which in some instances, can limit and/or substantially prevent hemolysis of blood flowing from the first adapter 820 and through the second adapter 830.

[1113] While the flow of bodily-fluid (i.e., blood) is described above as first flowing through the first adapter 820 and then flowing through the second adapter 930, in other embodiments, the flow through a set of adapters can be reversed. For example, FIG. 17 illustrates a first adapter 920 and a second adapter 930 according to another embodiment. The first adapter 920 has a distal end portion 922 configured to be coupled to a proximal end portion 931 of the second adapter 930, as described in further detail herein. Although only

the distal end portion 922 of the first adapter 920 is shown in FIG. 17, the first adapter 920 can be similar in size and/or shape as the first adapters 620 and/or 720, unless otherwise expressed. The first adapter 920 includes an inner surface 923 that defines a lumen 924 extending through at least its distal end portion 922. As shown in FIG. 17, a portion of the second adapter 930 is inserted into the lumen 924, as described in further detail herein.

[1114] Although only the proximal end portion 931 of the second adapter 930 is shown in FIG. 17, the second adapter 930 can be any suitable shape, size, or configuration. For example, the proximal end portion 931 of the second adapter 930 can form and/or can include a locking mechanism or the like while a proximal end portion (not shown in FIG. 17) can be coupled to and/or can form any suitable portion of a fluid collection device such as, for example, a puncture member, a needle, a conduit, a flow control mechanism, and/or the like. In this embodiment, the proximal end portion 931 of the second adapter 930 includes and/or forms a locking mechanism configured to form a threaded coupling with, for example, the distal end portion 922 of the first adapter 920. In other embodiments, the proximal end portion 931 of the second adapter 930 can be any suitable configuration.

[1115] As shown in FIG. 17, the second adapter 930 includes an inner surface 933 that defines a lumen 934 extending through at least its proximal end portion 931. Moreover, a region of the proximal end portion 931 of the second adapter 930 is disposed within the lumen 924 of the first adapter 920. For example, the inner surface 923 of the first adapter 920 has a diameter that corresponds to an outer diameter associated with the region of the proximal end portion 931 of the second adapter 930. Thus, as shown in FIG. 17, the diameter defined by the inner surface 923 of the first adapter 920 is greater than a diameter defined by the inner surface 933 of the second adapter 930, as described in further detail herein.

[1116] The proximal end portion 931 of the second adapter 930 includes and/or forms a proximal surface 935 with a substantially rounded corner and/or smooth transition. For example, the proximal surface 935 formed by the second adapter 930 defines a relatively smooth transition from an inner diameter of the second adapter 930 (e.g., defined by the inner surface 933) to an outer diameter of the second adapter 930 (e.g., at the distal end) rather than forming a relatively sharp, abrupt, and/or orthogonal corner. When a portion of the second adapter 930 is disposed within the lumen 923 of the first adapter 920, a volume of bodily-fluid (e.g., blood) can flow through the lumen 934 of the second adapter 930 and into the lumen 924 of the first adapter 920. Thus, the arrangement of the proximal surface 935 of the

second adapter 930 can, for example, facilitate, produce, encourage, and/or otherwise result in a substantially laminar flow of a volume of bodily-fluid (i.e., blood) as the volume flows from the lumen 934 of the second adapter 930 into the lumen 924 of the first adapter 920. Specifically, the proximal surface 935 of the second adapter 930 allows for a gradual transition from the diameter associated with the lumen 934 of the second adapter 930 (i.e., the smaller diameter) to the diameter associated with the lumen 924 of the first adapter 920 (i.e., the larger diameter). Such a smooth transition can, for example, reduce eddy currents and/or other forms of turbulence that can otherwise result from a substantially abrupt change in diameter or the like. Thus, the arrangement of the first adapter 920 and the second adapter 930 can allow a volume of blood to expand as the flow of blood exits the lumen 934 of the second adapter 930, which in some instances, can reduce, limit, and/or substantially prevent hemolysis of blood flowing therethrough.

[1117] While the first adapters 620, 720, 820, and 920 are shown and described above as receiving and/or otherwise being directly coupled to the second adapters 630, 730, 830, and 930, respectively, in other embodiments, a first adapter can be indirectly coupled to a second adapter via an intervening structure. In such embodiments, the intervening structure can define a lumen that can place the first adapter in fluid communication with the second adapter. Moreover, the intervening structure can limit, modulate, and/or control a flow rate of a volume of fluid (i.e., blood) therethrough. For example, FIGS. 18-26 illustrate embodiments configured to mitigate the risk of hemolysis otherwise associated with a relatively high flow rate and/or velocity along a fluid flow path that exceeds known shear force and exposure time limits that can rupture red blood cells. Specifically, FIGS. 18-20 illustrate a first adapter 1020 indirectly coupled to a second adapter 1030 via a restrictor 1050, according to an embodiment. The first adapter 1020 includes a proximal end portion 1021, a distal end portion 1022, and an inner surface 1023. The inner surface 1023 defines a lumen 1024 extending through the proximal end portion 1021 and the distal end portion 1022 (see e.g., FIG. 20). In some embodiments, the first adapter 1020 can be substantially similar to and/or the same as the first adapter 720 described above with reference to FIGS. 14 and 15. Thus, aspects of the first adapter 1020 are not described in further detail herein.

[1118] The second adapter 1030 has a proximal end portion 1031, a distal end portion 1032, and an inner surface 1033. The inner surface 1033 of the second adapter 1030 defines a lumen 1024 extending through its proximal end portion 1031 and its distal end portion 1032

(see e.g., FIG. 20). In some embodiments, the second adapter 1030 can be substantially similar to and/or the same as the second adapter 730 described above with reference to FIGS. 14 and 15. Thus, aspects of the second adapter 1030 are not described in further detail herein.

[1119] The restrictor 1050 has a proximal end portion 1051, a distal end portion 1052, and an inner surface 1053. The inner surface 1053 of the restrictor 1050 defines a lumen 1054 extending through its proximal end portion 1051 and its distal end portion 1052 (see e.g., FIG. 20). In this embodiment, the restrictor 1050 is coupled between the first adapter 1020 and the second adapter 1030 to define a fluid pathway therebetween (e.g., via the lumen 1054). More specifically, the restrictor 1050 can include any suitable interface, locking mechanism, surface, etc. at or near the proximal end portion 1051 and the distal end portion 1052 configured to couple the restrictor 1050 to the first adapter 1020 or the second adapter 1030. As shown in FIGS. 18-20, the restrictor 1050 includes a locking mechanism or the like at its distal end portion 1052 that is configured to couple the distal end portion 1052 of the restrictor 1050 to the proximal end portion 1021 of the first adapter 1020. For example, in some embodiments, the distal end portion 1052 of the restrictor 1050 can include a threaded female Luer Lok ® configured to form a threaded coupling with a corresponding threaded male Luer Lok ® of the first adapter 1020, as shown in FIG. 20.

[1120] As shown in FIGS. 19 and 20, the proximal end portion 1051 of the restrictor 1050 receives the second adapter 1030. For example, as described above with reference to the first adapter 620 and the second adapter 630 in FIGS. 11-13, a portion of the second adapter 1030 is inserted through the proximal end portion 1051 of the restrictor 1050 to be disposed in the lumen 1054. In some embodiments, the restrictor 1050 and the second adapter 1030 can form a friction fit and/or the like, which in turn, can define a substantially fluid tight seal therebetween. In other embodiments, the proximal end portion 1051 of the restrictor 1050 and the distal end portion 1032 of the second adapter 1030 can include any suitable coupling and/or locking mechanism configured to couple the second adapter 1030 to the restrictor 1050 (e.g., as described above with reference to the coupling between the first adapter 1020 and the restrictor 1050).

[1121] As shown in FIGS. 19 and 20, the restrictor 1050 or the first adapter 1020 includes a gasket 1026 configured to minimize a discontinuity between the lumen 1024 of the first adapter 1020 and the lumen 1054 of the restrictor 1050 when coupled. Similarly, the

second adapter 1030 or the restrictor 1050 includes a gasket 1036. The gaskets 1026 and 1036 can be substantially similar in form and function to the gasket 726 shown and described above with reference to FIGS. 14 and 15. Thus, the gaskets 1026 and 1036 are disposed within the lumen 1024 of the first adapter 1020 and the lumen 1054 of the restrictor 1050, respectively. The arrangement of the gaskets 1026 and 1036 can reduce a magnitude of the discontinuities formed between the inner surfaces 1023, 1033, and 1053 of the first adapter 1020, the second adapter 1030, and the restrictor 1050, respectively, which in turn, can reduce, limit, and/or substantially prevent hemolysis of blood flowing therethrough, as described in detail above. In some embodiments, the gaskets 1026 and 1036 can be configured to restrict and/or reduce a pressure and/or a flow rate associated with the first adapter 1020, the second adapter 1030, and/or the restrictor 1050, as described above with reference to the gasket 726. In some instances, restricting and/or reducing the pressure and/or flow rate associated with the first adapter 1020, the second adapter 1030, and/or the restrictor 1050 (e.g., via the gaskets 1026 and 1036) can, for example, limit shear forces and/or exposure time experienced by red blood cells as the red blood cells flow through the first adapter 1020, the second adapter 1030, and the restrictor 1050, and/or the interfaces therebetween.

[1122] The inner surface 1053 of the restrictor 1050 is configured to control a flow of fluid through the lumen 1053. For example, as shown in FIG. 20, the inner surface 1053 of the restrictor 1050 includes a choke portion 1055 or the like. In some embodiments, the choke portion 1055 corresponds to a portion of the inner surface 1053 having a reduced diameter relative to the other portions of the inner surface 1053. More specifically, the choke portion 1055 forms a relatively smooth transition (e.g., a gradual change) from a region of the inner diameter 1053 associated with a first diameter to a region (i.e., the choke portion 1055) associated with a second diameter, smaller than the first diameter. Thus, the choke portion 1055 restricts, controls, and/or reduces a flow of fluid therethrough.

[1123] Expanding further, the reduction in the diameter of the inner surface 1053 at or along the choke portion 1055 selectively controls a pressure within the lumen 1054. For example, in some embodiments, the second adapter 1030 can be fluidically coupled (e.g., either directly or indirectly) to an evacuated container or the like, resulting in a negative pressure within the lumens 1034, 1054, and 1024. Thus, the reduced diameter associated with the choke portion 1055 results in a reduced pressure differential between the lumen 1024

of the first adapter 1020 (i.e., at a time directly before the exposure to the negative pressure) and a portion of the lumen 1054 of the restrictor 1050 that is distal to the choke portion 1055. As such, when the first adapter 1020 is in fluid communication with, for example, a vascular structure (e.g., via a needle, catheter, cannula, etc.), a magnitude of the negative pressure exerted on or in the vascular structure is reduced, thereby limiting, reducing, and/or substantially preventing hemolysis of blood as it flows into the lumen 1024 defined by the first adapter 1020. Moreover, the smooth transition in the diameter of the inner surface 1053 from the first diameter to the second diameter (associated with the choke portion 1055), facilitates, encourages, and/or otherwise results in a substantially laminar flow through the lumen 1054 of the restrictor 1050.

[1124] While the restrictor 1050 is particularly shown and described above with reference to FIGS. 18-20, in other embodiments, a restrictor, configured to control a flow of fluid therethrough, can be any suitable configuration. For example, FIGS. 21-24 illustrate a restrictor 1150 according to another embodiment. The restrictor 1150 has a proximal end portion 1151, a distal end portion 1152, and an inner surface 1153. The inner surface 1153 of the restrictor 1150 defines a inner volume 1154 extending through its proximal end portion 1151 and its distal end portion 1152 (see e.g., FIG. 22). Although not shown in FIGS. 21-24, the restrictor 1150 can be disposed between two components of a fluid transfer device to define a fluid flow path therethrough. For example, in some embodiments, the proximal end portion 1151 can be coupled to an adapter such as, for example, the second adapter 1030, described above with reference to FIGS. 18-20. Similarly, the distal end portion 1152 can be coupled to an adapter such as, for example, the first adapter 1020, described above. As such, the proximal end portion 1151 and the distal end portion 1152 can be substantially similar to or the same as the proximal end portion 1051 and the distal end portion 1052, respectively, of the restrictor 1050 and thus, are not described in further detail herein.

[1125] As shown in FIGS. 22-24, the restrictor 1150 includes a baffle 1156 disposed in the inner volume 1154. The baffle 1156 can be any suitable shape, size, or configuration. For example, in this embodiment, the baffle 1156 is substantially rectangular (see e.g., FIG. 20) with a size that substantially corresponds to the inner volume 1154 of the restrictor 1150, as described in further detail herein. The baffle 1156 includes an inner surface 1157 that defines an inner volume 1158. As shown in FIG. 24, the inner surface 1157 of the baffle 1156 defines a gradual bow toward the center of the baffle 1156. More specifically, the

arrangement of the inner surface 1157 is such that a distance between opposite sides of the baffle 1156 gradually varies as the inner surface 1157 extends outward from a longitudinal centerline CL (shown in FIG. 22) of the baffle 1156. For example, in this embodiment, a distance between opposite portions of the inner surface 1157 gradually increases from a first distance, at a first position associated with a perimeter of the inner surface 1157, to second distance, at a second position disposed between the perimeter of the inner surface 1157 and the longitudinal centerline CL, and then gradually decreases from the second distance to a third distance, at a position associated with and/or near the longitudinal center CL. In this manner, the baffle 1156 can selectively control a flow of fluid through the inner volume 1158, as described in further detail herein.

[1126] Referring back to FIG. 22, in this embodiment, an outer surface of the baffle 1156 is in contact with the inner surface 1153 of the restrictor 1150 when disposed in the inner volume 1154. In some embodiments, the outer surface of the baffle 1156 and the inner surface 1153 of the restrictor 1150 define a friction fit or the like that forms a substantially fluid tight seal. As such, the arrangement of the baffle 1156 and the inner surface 1153 of the restrictor 1150 can limit, inhibit, and/or substantially prevent a flow of fluid between the outer surface of the baffle 1156 and the inner surface 1153 of the restrictor 1150. More specifically, the inner volume 1158 of the baffle 1156 defines a fluid flow path that places a first portion of the inner volume 1154, which is distal to the baffle 1156, in fluid communication with a second portion of the inner volume 1154, which is proximal to the baffle 1156. In this manner, the arrangement of the inner surface 1157 of the baffle 1156 can restrict, inhibit, guide, limit, choke, and/or otherwise control a flow of fluid through the restrictor 1150. Moreover, the smooth or gradual change in distance between opposite portions of the inner surface 1157 of the baffle (as described above) facilitates, encourages, and/or otherwise results in a substantially laminar flow through the inner volume 1154 of the restrictor 1150.

[1127] Although not shown in FIGS. 21-24, in some embodiments, the inner volume 1158 of the baffle 1156 can include a medium disposed therein. For example, in some embodiment, the baffle 1156 can include a substantially porous material or the like that can slow and/or filter a flow of fluid (e.g., blood) therethrough. In other embodiments, the user can manipulate the restrictor 1150 to modify and/or control a flow of fluid through the restrictor 1150. For example, in some instances, the user can exert a force on a portion of the

restrictor 1150 sufficient to deform that portion. As such, a portion of the force can correspondingly deform the baffle 1156, which in turn, can change a contour of the inner surface 1157. Thus, the user can exert a force on the restrictor 1150 to, for example, increase, decrease, or otherwise control a flow of fluid through the baffle 1156. By way of example, a user can exert a force of the restrictor 1150 to reduce a distance between opposite portions of the inner surface 1157, which in turn, can reduce a negative pressure differential produced by an evacuated container being placed in fluid communication with the restrictor 1150.

[1128] FIGS. 25 and 26 illustrate a restrictor 1250 according to another embodiment. The restrictor 1250 has a proximal end portion 1251, a distal end portion 1252, and an inner surface 1253. The inner surface 1253 of the restrictor 1250 defines a inner volume 1254 extending through its proximal end portion 1251 and its distal end portion 1252 (see e.g., FIG. 26). As described above, the restrictor 1250 can be physically and fluidically coupled between, for example, a pair of components of a fluid transfer device to restrict and/or otherwise control a flow of fluid therebetween. For example, although not shown in FIGS. 25-26, the proximal end portion 1251 can be coupled to an adapter such as, for example, the second adapter 1030, described above with reference to FIGS. 18-20. Similarly, the distal end portion 1252 can be coupled to an adapter such as, for example, the first adapter 1020, as described above. In this manner, the proximal end portion 1251 and the distal end portion 1252 can be substantially similar to or the same as the proximal end portion 1051 and the distal end portion 1052, respectively, of the restrictor 1050 and thus, are not described in further detail herein.

[1129] The restrictor 1250 includes and/or defines a set of chambers 1259, as shown in FIG. 26. More specifically, the restrictor 1250 includes a set of walls that can form, for example, a set of semi-spherical portions, which in turn, result in the inner surface 1253 defining the set of chambers 1259. Thus, the chambers 1259 are, for example, a set of semi-spherical portions of the inner volume 1254. As shown in FIG. 26, the chambers 1259 are serially arranged along a longitudinal centerline CL of the restrictor 1250. In some embodiments, the size and/or shape of each chamber 1259 can vary. For example, as shown in FIG. 26, the chamber 1259 disposed at or near the proximal end portion 1251 of the restrictor 1250 is smaller than the adjacent chamber 1259. In other embodiments, the size and/or shape of each chamber 1259 can be substantially uniform. With the inner surface 1253 defining the semi-spherical chambers 1259, a diameter of the inner volume 1254 (e.g.,

associated with a cross-sectional shape of the inner surface 1253) is varied along a length of the longitudinal centerline CL. For example, a diameter of the inner volume 1254 gradually increases or decreases in an alternating manner between a relatively smaller diameter, associated with a position along the longitudinal centerline substantially between adjacent chambers 1259 and a relatively larger diameter, associated with a position along the longitudinal centerline substantially in the center of a given chamber 1259.

[1130] In some embodiments, the arrangement of the chambers 1259 selectively controls a pressure within the inner volume 1254. For example, in some embodiments, the proximal end portion 1251 of the restrictor 1250 can be fluidically coupled (e.g., either directly or indirectly) to an evacuated container or the like, resulting in a negative pressure within the inner volume 1254. Thus, the alternating increase and decrease corresponding to each chamber 1259 results in a changing pressure differential along the longitudinal centerline CL. In some embodiments, such an alternating arrangement can, for example, act as a peristaltic pump or the like. Thus, the restrictor 1250 can draw a fluid through the inner volume 1254 via a pressure differential that is at least partially controlled by the arrangement of the inner surface 1253. That is to say, while an evacuated container is the source of a negative pressure, the arrangement of the chambers 1259 at least partially controls a pressure differential between the proximal end portion 1251 and the distal end portion 1252. In this manner, hemolysis of blood can be reduced and/or substantially prevented, which might otherwise occur in response to a shear force produced by a relatively rapid and/or relatively large pressure drop associated with placing an evacuated container in fluid communication with a vascular structure. Moreover, the smooth and/or gradual transitions in the diameter of the inner surface 1253 associated with the chambers 1259, facilitates, encourages, and/or otherwise results in a substantially laminar flow through the inner volume 1254 of the restrictor 1250.

[1131] Although not shown, any of the restrictors 1050, 1150, and/or 1250 can be fluidically coupled (either directly or indirectly) to and/or monolithically formed with an adapter configured to engage a fluid reservoir such as an evacuated container. In some embodiments, such adapters can include an inner surface configured to reduce discontinuities or the like within a portion of a fluid flow path and/or otherwise configured to facilitate a substantially laminar fluid flow therethrough, as described in detail above. Moreover, the adapters can engage any suitable fluid reservoir or container. For example, FIGS. 27-44

illustrate embodiments (i.e., adapters and fluid reservoirs) configured to mitigate the risk of hemolysis as blood flow from an adapter, a puncture member, a needle, a cannula, and/or the like into a fluid reservoir. Specifically, FIGS. 27-33 illustrate an adapter 1330 configured to engage a fluid reservoir 1360 (FIGS. 29-33) according to an embodiment. The adapter 1330 has a proximal end portion 1331, a distal end portion 1332, and an inner surface 1333. The inner surface 1333 defines a lumen 1334 extending through the proximal end portion 1331 and the distal end portion 1332 (see e.g., FIG. 27). As shown in FIGS. 27 and 28, in some embodiments, the adapter 1330 can include and/or can be coupled to a shroud 1343. In such embodiments, the shroud 1343 can define an inner volume 1344 within which a portion of a fluid reservoir can be disposed. In other embodiments, the adapter 1330 need not include and/or need not be coupled to the shroud 1343.

[1132] The adapter 1330 can be any suitable shape, size, or configuration. For example, as shown in FIGS. 29 and 30, the distal end portion 1332 of the adapter 1330 includes and/or is coupled to a lock mechanism or the like. In this embodiment, the distal end portion 1332 includes and/or forms a female portion of a Luer Lok ® or the like. Thus, the distal end portion 1332 of the adapter 1330 can be coupled to a corresponding male portion of a Luer Lok ® or the like, as described above with reference to the distal end portion 1052 of the restrictor 1050 shown in FIG. 20. The proximal end portion of the adapter 1330 includes and/or is coupled to a puncture member 1338 defining a lumen 1339 in fluid communication with the lumen 1334 of the adapter 1330. The puncture member 1338 can be any suitable configuration. For example, in some embodiments, the puncture member 1338 is a needle. As shown in FIG. 30, the puncture member 1325 is disposed within a sheath 1341. More specifically, the sheath 1341 is at least temporarily disposed about the puncture member 1338 and is configured to limit and/or substantially prevent an accidental contact with the puncture member 1338. Furthermore, the sheath 1341 can maintain the puncture member 1338 in a substantially sterile environment prior to use and can selectively control a flow of bodily-fluid through the puncture member 1338, as described in further detail herein.

[1133] As shown in FIG. 30, a diameter of the inner surface 1333 at or near the distal end portion 1332 is larger than a diameter of the puncture member 1338. In this manner, the inner surface 1333 forms and/or defines a smooth transition from a larger diameter at or near the distal end portion 1332 to a smaller diameter at or near the puncture member 1338. In some instances, such a smooth transition from the larger diameter to the smaller diameter can

facilitate, produce, encourage, and/or force a substantially laminar flow of a volume of bodily-fluid (e.g., blood) through the lumen 1334. Moreover, the smooth transition can reduce eddy currents or the like within the flow of blood that can otherwise result from a relatively abrupt change in diameter or the like. Thus, a volume of blood can flow within the lumens 1334 and 1339 with reduced damage to the constituents of the blood (e.g., hemolysis of the erythrocytes) that might otherwise occur as a result of misaligned interfaces and/or discontinuities; abrupt changes in diameter; turbulence and/or eddy currents within a flow of blood therethrough; and/or the like.

[1134] As described above, the adapter 1330 is configured to couple to and/or otherwise engage a fluid reservoir 1360. The fluid reservoir 1360 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 1360 is an evacuated container such as a Vacutainer™, a BacT/ALERT® SN, a BacT/ALERT® FA, and/or any other type of container, vial, bottle, reservoir, etc. As shown in FIGS. 31-33, the fluid reservoir 1360 includes a proximal end portion 1361 and a distal end portion 1362, and defines an inner volume 1364. The distal end portion 1362 includes a port 1363 through which the puncture member 1338 can be inserted to place the inner volume 1364 of the fluid reservoir 1360 in fluid communication with the lumen 1334 of the adapter 1330. For example, in some embodiments, the port 1363 can be a self-healing septum or the like. Thus, the port 1363 can be substantially in a sealed configuration prior to insertion of, for example, the puncture member 1338 and subsequently, can transition from an open configuration to the sealed configuration when, for example, the puncture member 1338 is removed from the port 1363.

[1135] In some embodiments, a fluid reservoir can include a flow control member or the like disposed in its inner volume. For example, as shown in FIGS. 32 and 33, the fluid reservoir 1360 includes a flow control member 1367 disposed within the inner volume 1364. In this embodiment, the flow control member 1367 can be, for example, an insert or funnel that defines a channel 1368 configured to receive a flow of fluid from the lumen 1339 of the puncture member 1338. More specifically, as shown in FIG. 33, a first end of the flow control member 1367 can be disposed adjacent to and/or can be coupled to the port 1363 and a second end, opposite the first end, can extend toward an inner surface of the fluid reservoir 1360. In this manner, the second end of the flow control member 1367 can be adjacent to the inner surface of the fluid reservoir 1360 such that an axis associated with a portion of the

channel 1368 at or near the second end is substantially parallel to and/or otherwise directed toward the inner surface of the fluid reservoir 1360.

[1136] In use, the adapter 1330 and/or the fluid reservoir 1360 can be manipulated to insert the puncture member 1338 through the port 1363 of the fluid reservoir 1360. As such, the sheath 1341 disposed about the puncture member 1338 can deform to allow the puncture member 1338 to be inserted through the port 1363. With the fluid reservoir 1360 being an evacuated container, the insertion of the puncture member 1338 is such that a negative pressure within the fluid reservoir 1360 is exerted through the lumen 1334 of the adapter 1330 (e.g., via the lumen 1339 of the puncture member 1338). Thus, when the distal end portion 1332 is fluidically coupled (either directly or indirectly) to a device or member in fluid communication with the body of a patient, the negative pressure draws a volume of bodily-fluid (e.g., blood) from the patient and into the fluid reservoir 1360. More specifically, the distal end portion 1332 of the adapter 1330 can be coupled (either directly or indirectly) to any suitable adapter, restrictor, and/or needle described herein to receive a flow of, for example, blood from the patient with reduced or substantially no hemolyzation of the blood. Furthermore, by disposing the flow control member 1367 in the inner volume 1364, a flow of blood can be directed within the channel 1338 toward the inner surface, which in turn, can decrease a force otherwise associated with an impact of the volume of blood contacting the inner surface. Thus, hemolysis of the blood associated with such a contact is reduced or substantially prevented.

[1137] While the adapter 1330 is shown in FIGS. 31-33 as not including and/or not be coupled to the shroud 1343, in other embodiments, the adapter 1330 can be coupled to the shroud 1343 when engaging the fluid reservoir 1360. Furthermore, while the flow control member 1367 is particularly shown in FIG. 33, in some embodiments, a second end of a flow control member can extend within the inner volume 1364 to a position adjacent to and/or substantially abutting a bottom or proximal surface (i.e., a surface opposite the port 1363). In other embodiments, a flow control member can extend in a spiral or helical manner from the port 1363. As such, a second end of the flow control member can be substantially tangential to the inner surface of the fluid reservoir and thus, fluid exiting a channel defined by the flow control member can flow along a circumference of the inner surface (e.g., tangent to the inner surface).

[1138] In other embodiments, a fluid reservoir can include any suitable flow control member. For example, FIG. 34 illustrates a fluid reservoir 1460 according to another embodiment. The fluid reservoir 1460 includes a proximal end portion 1461 and a distal end portion 1462, and defines an inner volume 1464. The distal end portion 1462 includes a port 1463 configured to receive, for example, a puncture member 1438 of an adapter 1430, as described in detail above with reference to FIGS. 31-33. The inner volume 1464 of the fluid reservoir 1460 includes and/or houses a flow control member 1467 operable to control a flow of fluid from, for example, the adapter 1430 into the inner volume 1464, as described in further detail herein. The fluid reservoir 1460 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 1460 is an evacuated container such as a Vacutainer™, a BacT/ALERT® SN, a BacT/ALERT® FA, and/or any other type of container, vial, bottle, reservoir, etc. In some embodiments, the fluid reservoir 1460 can be substantially similar to or the same as the fluid reservoir 1360 described above with reference to FIGS. 31-33. Thus, such similar aspects of the fluid reservoir 1460 are not described in further detail herein.

[1139] The fluid reservoir 1460 can differ from the fluid reservoir 1360, however, in the arrangement of the flow control member 1467. More specifically, while the flow control member 1367 is shown in FIG. 33 as tapering to a substantially uniform diameter as the flow control member 1367 extends away from the port 1363, in this embodiment, the flow control member 1467 has a varying diameter as the flow control member 1467 extends away from the port 1463. In this manner, a channel 1468 defined by the flow control member 1467 has a cross-sectional area and/or diameter that is dependent on, for example, a position along a longitudinal centerline CL defined by the flow control member 1467. For example, the channel 1468 can have a first diameter at a first end portion nearest to the port 1463, a second diameter at an end portion opposite the first end portion, and a third diameter at a portion disposed therebetween. As shown in FIG. 34, the end portions of the flow control member 1467 can be flared or the like such that the first diameter and the second diameter are each greater than the third diameter. Said another way, the diameter of the channel 1468 can taper along the longitudinal centerline CL from a larger diameter associated with the end portions of the flow control member 1467 to a smaller diameter at or near a center portion of the flow control member 1467.

[1140] With the fluid reservoir 1460 being an evacuated container or the like, a pressure (i.e., a negative pressure) within the channel 1468 is dependent on a position along the longitudinal centerline CL. That is to say, the pressure within the channel 1468 is dependent on the diameter of the channel 1468, in which a larger diameter is associated with a larger pressure. In a similar manner, the velocity of a flow of bodily-fluid (e.g., blood) within the channel 1468 is also dependent on the diameter of the channel 1468, however, such dependency is inverse to that associated with the pressure (i.e., a larger diameter is associated with less velocity). Thus, as blood (or other bodily-fluid) flows through the channel 1468, the increase in diameter at the end portion of the flow control member 1467 opposite the port 1463 results in a decrease in velocity associated with the flow of bodily-fluid therethrough. As such, a force otherwise associated with a volume of blood contacting an inner surface of the fluid reservoir 1460 is reduced, which in turn, can reduce and/or substantially prevent hemolysis of the volume of blood. Moreover, the diameter of the channel 1468 can be such that a pressure within the channel 1468 is maintained below a threshold that can otherwise result in hemolysis of blood flowing therethrough.

[1141] While the flow control members 1367 and 1467 are shown and described above as controlling a flow of, for example, blood through the channels 1368 and 1468, respectively, in other embodiments, a fluid reservoir can include a flow control member having any suitable configuration. For example, FIG. 35 illustrates a fluid reservoir 1560 according to another embodiment. The fluid reservoir 1560 includes a proximal end portion 1561 and a distal end portion 1562, and defines an inner volume 1564. The distal end portion 1562 includes a port 1563 configured to receive, for example, a puncture member 1538 of an adapter 1530, as described in detail above with reference to FIGS. 31-33. The inner volume 1564 of the fluid reservoir 1560 includes and/or houses a flow control member 1565 operable to control a flow of fluid from, for example, the adapter 1530 into the inner volume 1564, as described in further detail herein. The fluid reservoir 1560 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 1560 is an evacuated container such as a Vacutainer™, a BacT/ALERT® SN, a BacT/ALERT® FA, and/or any other type of container, vial, bottle, reservoir, etc. In some embodiments, the fluid reservoir 1560 can be substantially similar to or the same as the fluid reservoir 1360 described above with reference to FIGS. 31-33. Thus, such similar aspects of the fluid reservoir 1560 are not described in further detail herein.

[1142] As shown in FIG. 35, the flow control member 1565 is disposed within the inner volume 1564 at or near the port 1563. In this embodiment, the flow control member 1565 is a baffle insert or the like. Specifically, the flow control member 1565 forms and/or includes an angled baffle having a set of substantially parallel angled surfaces configured to direct a flow of blood or other bodily-fluid. For example, the puncture member 1538 of the adapter 1530 can be inserted through the port 1563 to place a distal end portion of the puncture member 1538 within the flow control member 1565. As such, when a flow of blood is expelled and/or drawn through a lumen defined by the puncture member 1538 (e.g., via a negative pressure differential produced by the evacuated container), the flow of blood contacts at least one angled surface of the flow control member 1565. Thus, the blood can flow along the angled surface toward an inner surface of the fluid reservoir 1560. By diverting, guiding, and/or otherwise directing the flow of blood to the inner surface, a force is reduced, which can otherwise result from an impact of the volume of blood contacting the inner surface. Thus, hemolysis of the blood associated with such a contact is reduced or substantially prevented.

[1143] While the flow control member 1565 is shown and described as forming and/or including a set of parallel angled surfaces configured to direct a flow of bodily-fluid toward the inner surface of the fluid reservoir 1560, in other embodiments, a flow control member can be any suitable baffle or the like. For example, in some embodiments, a flow control member can be an angled baffle or the like having a set of angled surfaces with an alternating orientation or the like. By way of example, a flow control member can include a first set of angled surfaces with a cross-sectional orientation (as shown in FIG. 35) that forms a 30° with a given plane and a second set of angled surfaces with a cross-sectional orientation that forms a 150° orientation with the given plane (i.e., a mirrored orientation), with each angled surface of the first set being disposed between two angled surfaces of the second set (or vice versa). In some embodiments, a baffle can include a set of surfaces that are each substantially V-shaped or U-shaped.

[1144] In other embodiments, a flow control member can be an absorbent or porous baffle or the like that can fill at least a portion of an inner volume of a fluid reservoir. In this manner, a flow of blood can be expelled or drawn from a lumen of an adapter (e.g., a lumen of a puncture member or the like) and absorbed by the absorbent baffle. In such embodiments, a volume of blood can be subsequently released or expelled from the absorbent

baffle via a centripetal or centrifugal action and/or the like. In some embodiments, a flow control member can be a baffle including a set of angled surfaces with an absorbent material disposed therebetween.

[1145] While the flow control members 1367, 1467, and 1565 are shown as independent components disposed within the fluid reservoirs 1360, 1460, and 1560, respectively, in other embodiment, a fluid reservoir can include a flow control member that is integral with another portion of the fluid reservoir such as, for example, a port. For example, FIG. 36 illustrates a fluid reservoir 1660 according to another embodiment. The fluid reservoir 1660 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 1660 is an evacuated container such as a Vacutainer™, a BacT/ALERT® SN, a BacT/ALERT® FA, and/or any of type of container, vial, bottle, reservoir, etc. In some embodiments, the fluid reservoir 1660 can be substantially similar to or the same as the fluid reservoir 1360 described above with reference to FIGS. 31-33. Thus, such similar aspects of the fluid reservoir 1660 are not described in further detail herein.

[1146] The fluid reservoir 1660 includes a proximal end portion 1661 and a distal end portion 1662, and defines an inner volume 1664. The distal end portion 1662 includes a port 1663 configured to receive, for example, a puncture member 1638 of an adapter 1630, as described in detail above with reference to FIGS. 31-33. The port 1663 in this embodiment, however, includes an inner surface 1665 configured to control a flow of fluid into the inner volume 1664 of the fluid reservoir 1660. As shown in FIG. 36, the inner surface 1665 of the port 1663 has a varied diameter that forms a constriction disposed between a proximal end portion and a distal end portion of the port 1663. For example, in some embodiments, the inner surface 1665 can form a constriction or otherwise can have a reduced diameter at or near a center of the port 1663 (i.e., at or near a midpoint between the proximal end portion and the distal end portion of the port).

[1147] In some embodiments, the inner surface 1665 can have a reduced diameter at a position that is proximal to the puncture member 1638 when the adapter 1630 is engaged with the fluid reservoir 1660. Similarly stated, the arrangement of the fluid reservoir 1660 and the adapter 1630 is such that when the adapter 1630 engages the fluid reservoir 1660, the puncture member 1638 is disposed in a distal position relative to a portion of the inner surface 1665 associated with the smallest diameter. Thus, the arrangement of the inner surface 1665 of the port 1663 can, for example, result in a venturi effect within a volume of

bodily-fluid as the volume of bodily-fluid flows from the puncture member 1638 into the port 1663. In other words, with the inner surface 1665 forming a constriction and/or reduction in diameter, a pressure associated with a volume on opposite sides of the constriction and/or reduction in diameter can be controlled. For example, the fluid reservoir 1660, being an evacuated container, defines a negative pressure within a portion of the inner volume 1664 proximal to the portion of the inner surface 1665 having the reduced diameter. In some embodiments, the constriction and/or reduced diameter formed by the inner surface 1665 results in a corresponding decrease in pressure associated with the reduced diameter. Thus, by selectively controlling a portion of the inner surface 1665 that is distal to the reduced diameter (i.e., selectively increasing the diameter of the inner surface 1665) a pressure within a volume distal to the reduced diameter can be less than, for example, the pressure within the volume proximal to the reduced diameter. Thus, hemolysis within a flow of blood is reduced or substantially prevented that might otherwise result from a rapid exposure to the negative pressure differential produced by the fluid reservoir 1660.

[1148] While the flow control members 1367, 1467, 1565, and the port 1663 are shown and described above as receiving and/or otherwise guiding a flow of bodily-fluid (e.g., blood) into the inner volumes 1364, 1464, 1564, 1664, respectively, in some embodiments, an adapter can be arranged to selectively direct a flow of bodily-fluid into a fluid reservoir. For example, FIGS. 37 and 38 illustrate an adapter 1760, according to another embodiment. The adapter 1760 is configured for selective engagement with a fluid reservoir 1760 to deliver a flow of bodily-fluid into an inner volume 1764. The adapter 1760 includes at least a shroud 1743 and a puncture member 1768. Although not shown in FIGS. 37 and 38, an inner surface of the adapter 1760 can be substantially similar to or the same as the inner surface 1363 of the adapter 1360 described above with reference to FIG. 30. That is to say, the adapter 1760 can include an inner surface that defines a substantially smooth transition between, for example, a lumen associated with an inlet of the adapter 1760 (e.g., a catheter, cannula, and/or locking mechanism) and a lumen of the puncture member 1768, thereby reducing and/or substantially preventing hemolysis of blood flowing therethrough.

[1149] As shown in FIG. 38, the arrangement of the adapter 1760 is such that the puncture member 1768 is disposed at non-orthogonal orientation relative to the shroud 1743. More specifically, at least a portion of the puncture member 1768 extends within an inner volume 1744 of the shroud 1743 and toward an inner surface. Thus, when the fluid reservoir

1760 is inserted into the inner volume 1744 of the shroud 1743, the puncture member 1768 punctures a port 1763 of the fluid reservoir 1760 (e.g., substantially similar to the port 1363 of the fluid reservoir 1360 described above with reference to FIGS. 31-33) at a substantially non-orthogonal angle. For example, the fluid reservoir 1760 can be inserted into the inner volume 1743 of the shroud 1744 with a substantially parallel or orthogonal orientation relative thereto. As the fluid reservoir 1760 is moved in the distal direction, the port 1763 is brought into contact with the puncture member 1768 and with the fluid reservoir 1760 parallel or orthogonal to the shroud 1743, the puncture member 1768 punctures the port 1763 at an angle associated with the orientation of the puncture member 1768 relative to the shroud (e.g., non-orthogonal). Therefore, as shown in FIG. 38, an end portion of the puncture member 1768 can be adjacent to, in contact with, and/or otherwise near an inner surface of the reservoir 1760 defining the inner volume 1764. In this manner, directing the flow of blood to the inner surface reduces a force, which can otherwise result from an impact of the volume of blood contacting the inner surface. Thus, hemolysis of the blood associated with such a contact is reduced or substantially prevented.

[1150] In some embodiments, the adapter 1730 can be configured to engage, for example, a standard fluid reservoir such as, for example, a Vacutainer ™ or the like. That is to say, in some embodiments, the adapter 1730 is configured to be compatible with existing fluid reservoirs without modifications being made thereto. In other embodiments, a fluid reservoir can have any suitable configuration. For example, FIG. 39 illustrates an adapter 1830 physically and fluidically coupled to a fluid reservoir 1860 according to another embodiment. The adapter 1830 can be any suitable adapter such as, for example, the adapter 1330 described above with reference to FIGS. 29 and 30. In this manner, the adapter 1830 includes a puncture member 1838 configured to puncture a port or the like of the fluid reservoir 1860, as described in further detail herein.

[1151] The fluid reservoir 1860 includes a proximal end portion 1861 and a distal end portion 1862, and defines an inner volume (not shown in FIG. 39). The distal end portion 1862 includes a port 1863 configured to receive, for example, the puncture member 1838 of the adapter 1830, as described in detail above with reference to FIGS. 31-33. The port 1863 in this embodiment, however, is disposed in a substantially horizontal position. More specifically, in some embodiments, the port 1863 can be disposed in a substantially tangential arrangement relative to, for example, an inner surface of the fluid reservoir 1860. Thus,

when the puncture member 1838 is inserted through the port 1863, an end portion of the puncture member 1838 can be placed adjacent to, at, or substantially near a portion of the inner surface of the fluid reservoir 1860, as described above with reference to the adapter 1730 and fluid reservoir 1760. Similarly stated, the arrangement of the port 1863 can be such that when the puncture member 1838 is inserted therethrough, at least the end portion of the puncture member 1838 (not shown in FIG. 39) is in a tangential orientation relative to the inner surface of the fluid reservoir 1860. In this manner, directing a flow of blood to the inner surface reduces a force, which can otherwise result from an impact of the volume of blood contacting the inner surface. Thus, hemolysis of the blood associated with such a contact is reduced or substantially prevented.

[1152] While a flow of bodily-fluid (e.g., blood) into the fluid reservoirs 1360, 1460, 1560, 1660, 1760, and 1860 is described above as being passively controlled by, for example, the flow control members 1367, 1467, 1565, the port 1663, the adapter 1730, and/or the port 1863, respectively, in other embodiments, a flow of bodily-fluid into a fluid reservoir can be actively controlled. That is to say, while the flow of bodily-fluid into the fluid reservoirs 1360, 1460, 1560, 1660, 1760, 1860 is controlled without user intervention (i.e., beyond the intervention of coupling the adapters 1330, 1430, 1530, 1660, 1760, and 1860 to the fluid reservoirs 1360, 1460, 1560, 1660, 1760, and 1860 respectively), in other embodiments, a user can manipulate an adapter and/or fluid reservoir to actively control a flow of fluid into the fluid reservoir. For example, FIGS. 40-42 illustrate an adapter 1930 and a fluid reservoir 1960, according to another embodiment. The fluid reservoir 1960 can be any suitable reservoir that defines an inner volume 1964 configured to receive a flow of bodily-fluid such as, for example, an evacuated container or the like. More specifically, as described above with reference to the fluid reservoir 1360 in FIGS. 31-33, the fluid reservoir 1960 includes a port 1963 through which a portion of the adapter 1930 can be inserted to gain access to the inner volume 1964, as described in further detail herein.

[1153] As shown in FIGS. 40-42, the adapter 1930 includes a proximal end portion 1931 and a distal end portion 1932, and defines an inner volume 1934. Although not shown, the distal end portion 1932 of the adapter 1930 can be coupled to any suitable lumen-defining device such as a needle, cannula, catheter, and/or sterile flexible tubing. In some embodiments, the distal end portion 1932 can include a locking mechanism or the like that can physically and fluidically couple the adapter 1930 to any suitable corresponding device

and/or component. The proximal end portion 1931 of the adapter 1930 receives a portion of the fluid reservoir 1960. For example, as shown in FIGS. 41 and 42, at least a portion of the port 1963 is inserted through the proximal end portion 1931 of the adapter 1930 to be disposed within a portion of the inner volume 1934.

[1154] As shown in FIGS. 41 and 42, the adapter 1930 further includes a cannula 1935 and an actuator 1945. Specifically, the cannula 1935 extends through the proximal end portion 1931 and the distal end portion 1932 of the adapter 1930, thereby defining a fluid pathway through the adapter 1930. The cannula 1935 can be any suitable shape, size, or configuration. For example, in some embodiments, the cannula 1935 is a substantially flexible tube formed of a biocompatible plastic or the like. In this manner, at least a portion of the cannula 1935 can be manipulated (e.g., by the actuator 1945) to bend, flex, kink, and/or otherwise reconfigure the cannula 1935, as described in further detail herein. The arrangement of the cannula 1935 can be such that when the fluid reservoir 1960 is inserted into the inner volume 1934 of the adapter 1930, an end portion of the cannula 1935 punctures the port 1963 of the fluid reservoir 1960 and thus, places the inner volume 1964 of the fluid reservoir 1960 in fluid communication with a lumen defined by the cannula 1935. Thus, a negative pressure within the fluid reservoir 1960 (e.g., the fluid reservoir 1960 is an evacuated container) exerts or draws suction through the lumen defined by the cannula 1935, as described in further detail herein.

[1155] The actuator 1945 of the adapter 1930 can be any suitable configuration. For example, as shown in FIGS. 41 and 42, the actuator 1945 can be a trigger or the like coupled to the adapter 1930 via a pivot point, pin, axle, etc. More specifically, a first portion of the actuator 1945 extends from and/or beyond an outer surface of the adapter 1930 and a second portion is disposed within the inner volume 1934 defined by the actuator 1930. Thus, a user (e.g., a phlebotomist, doctor, technician, nurse, etc.) can actuate the actuator 1945 by pivoting the actuator 1945 relative to the adapter 1930. In this manner, a portion of the actuator 1945 disposed in the inner volume 1934 of the adapter 1930 can be increased or decreased, for example, by exerting a force or removing a force, respectively, on the actuator 1945 (i.e., pivoting the actuator 1945 relative to the adapter 1930).

[1156] As shown, the portion of the actuator 1945 disposed within the inner volume 1934 of the adapter 1930 defines an opening 1946 through which the cannula 1935 can extend. Therefore, actuating the actuator 1945 (e.g., pivoting the actuator 1945 relative to the adapter

1930) results in a corresponding manipulation of a portion of the cannula 1935. For example, in some instances, while the actuator 1945 is in a first configuration, the position of the opening 1946 relative to the adapter 1930 can be such that the cannula 1935 (disposed therein) is pulled, bent, bowed, deformed, kinked, etc. Such deformation of the cannula 1935 can result in, for example, a constriction and/or pinching of the cannula 1935, which in turn, can constrict and/or at least partially obstruct the lumen defined by the cannula 1935, as shown in FIG. 41.

[1157] Conversely, a force can be exerted to actuate the actuator 1945, thereby pivoting the actuator 1945 relative to the adapter 1930. As described above, such pivoting motion can, for example, increase a portion of the actuator 1945 disposed in the inner volume 1934, which in turn, can change the position and/or orientation of the opening 1946 relative to the adapter 1930. Thus, the repositioning and/or reorienting of the opening 1946 actively (e.g., by exerting a force) or passively (e.g., by removing or reducing an existing force) reconfigures at least the portion of the cannula 1935 disposed therein. For example, as shown in FIG. 42, when the actuator 1945 is placed in the second configuration, the cannula 1935 can be substantially straight or substantially undeformed. Thus, the lumen defined by the cannula 1935 is substantially unobstructed and/or otherwise not constricted by the actuator 1945.

[1158] In use, when the fluid reservoir 1960 is placed in fluid communication with the lumen defined by the cannula 1935 (see e.g., FIGS. 41 and 42), the negative pressure and/or suction (described above) within the lumen of the catheter 1935 can be modulated by actuating the actuator 1945 between its first configuration, associated with a smaller amount of suction, and its second configuration, associated with a larger amount of suction. Moreover, when the distal end portion 1932 of the adapter 1930 is placed in fluid communication with the body of a patient (e.g., either directly or indirectly via a lumen-defining device, a needle, etc.), the negative pressure within the fluid reservoir 1960 draws blood, or other bodily-fluids, through the lumen defined by the cannula 1935 and into the inner volume 1964. In this manner, actuating the actuator 1945 to control or modulate the amount of suction or negative pressure within the lumen of the cannula 1935 can reduce a magnitude of negative pressure that would otherwise be exerted on the flow of blood. Thus, hemolysis of the blood is reduced or substantially prevented that might otherwise result from a rapid exposure to a negative pressure differential produced by the fluid reservoir 1960.

[1159] Although the lumen of the cannula 1935 is shown in FIG. 41 as being partially constricted when the actuator 1945 is in its first configuration, in other embodiments, the actuator 1945 can deform the cannula 1935 a sufficient amount to result in a substantially complete constriction of the lumen. Moreover, while not shown in FIGS. 40-42, in some embodiments, the actuator 1945 can include and/or can be operably coupled to a bias member such as a spring or the like. As such, the bias member can exert a force that at least temporarily maintains the actuator 1945 in, for example, the first configuration until an actuating force is exerted on the actuator 1945, which is sufficient to overcome the force of the bias member.

[1160] While the adapter 1930 is shown and described above as controlling a flow of bodily-fluid into the fluid reservoir 1960 by manipulating the cannula 1935, in other embodiments, an adapter can control a flow of bodily-fluid into a fluid reservoir in any suitable manner. For example, FIGS. 43 and 44 illustrate an adapter 2030 and a fluid reservoir 2060, according to another embodiment. The fluid reservoir 2060 can be any suitable reservoir that defines an inner volume 2064 configured to receive a flow of bodily-fluid such as, for example, an evacuated container or the like. More specifically, as described above with reference to the fluid reservoir 1360 in FIGS. 31-33, the fluid reservoir 2060 includes a port 2063 through which a portion of the adapter 2030 can be inserted to gain access to the inner volume 2064, as described in further detail herein.

[1161] As shown in FIGS. 43 and 44, the adapter 2030 includes a proximal end portion 2031 and a distal end portion 2032. The proximal end portion 2031 of the adapter 2030 is open and/or defines an opening configured to receive at least a portion of the port 2063 of the fluid reservoir 2060. The distal end portion 2032 of the adapter 2030 includes a port 2033 or the like that can be coupled to any suitable lumen-defining device such as a cannula, catheter, and/or sterile flexible tubing (not shown in FIGS. 43 and 44). In some embodiments, the distal end portion 2032 can include a locking mechanism or the like fluidically coupled to the port 2033 and configured to physically and fluidically couple the adapter 2030 to any suitable corresponding device and/or component.

[1162] As shown in FIG. 44, the adapter 2030 includes a puncture member 2038 that extends from a surface of the adapter 2030 to, for example, puncture the port 2063 of the fluid reservoir 2060. Furthermore, the adapter 2030 defines a lumen 2036 that extends through a portion of the adapter 2030 to fluidically couple the port 2033 to the puncture

member 2038. Thus, the puncture member 2038 can puncture the port 2063 of the fluid reservoir 2060 to place the inner volume 2064 of the fluid reservoir 2060 in fluid communication with, for example, the port 2033 of the adapter 2030, which in turn, can be in fluid communication (e.g., either directly or indirectly via an intervening structure) a portion of the body of a patient. Moreover, a negative pressure within the fluid reservoir 2060 (e.g., the fluid reservoir 2060 is an evacuated container) exerts or draws suction through the lumen 2036 and the port 2033 of the adapter 2030 to, for example, draw a flow of bodily-fluid from the patient through the adapter 2030 and into the inner volume 2064 of the fluid reservoir 2060.

[1163] As shown in FIGS. 43 and 44, the arrangement of the adapter 2030 is such that the fluid reservoir 2060 is in a substantially vertical orientation when coupled to the adapter 2030. Thus, when a volume of bodily-fluid (e.g., blood) is expelled from the puncture member 2038, in response to the negative pressure within the fluid reservoir 2060, the bodily-fluid flows in a substantially vertical direction from a lower position to an upper position. While the fluid reservoir 2060 defines a negative pressure that produces a suction force operable in drawing a flow of bodily-fluid from the puncture member 2038, the bodily-fluid expelled therefrom is also exposed to a substantially opposing force associated with gravitational acceleration (i.e., approximately 9.81 meters-per-second-squared ($^{m}/_{s^2}$)). Thus, when a volume of blood is drawn through the adapter 2030 and into the inner volume 2064 of the fluid reservoir 2060, the force associated with gravity acts to slow a velocity of the flow of blood within the inner volume 2064. As such, hemolysis of blood is reduced and/or substantially prevented that can otherwise result from a force associated with a volume of blood impacting an inner surface of the fluid reservoir 2060 defining the inner volume 2064.

[1164] While the adapters and fluid reservoirs described above with reference to FIGS. 27-44 control and/or direct a flow of fluid (i.e., blood) into a fluid reservoir to, for example, reduce hemolysis, in some embodiments, the arrangement of a fluid reservoir and/or an adapter can be such that a negative pressure operable in drawing a volume of blood into the fluid reservoir can be configured modulated and/or controlled. For example, FIGS. 45-60 illustrate embodiments configured to mitigate the risk of hemolysis associated with blood flow to a negative pressure differential within a fluid reservoir. Specifically, FIG. 45 illustrates an adapter 2130 and a fluid reservoir 2160 according to another embodiment. The adapter 2130 can be any suitable adapter such as, for example, the adapter 1330 described

above with reference to FIGS. 29 and 30. In this manner, the adapter 2130 includes a puncture member 2138 configured to puncture a port or the like of the fluid reservoir 2160, as described in further detail herein. The fluid reservoir 2160 includes a proximal end portion 2161 and a distal end portion 2162, and defines an inner volume 2164. The proximal end portion 2161 includes a port 2163A configured to receive, for example, an output member (e.g., a needle, puncture member, cannula, etc.) from, for example, a vacuum source or the like, as described in further detail herein. Similarly, the distal end portion 2162 includes a port 2163 configured to receive, for example, the puncture member 2138 of the adapter 2130, as described in detail above with reference to FIGS. 31-33. In some embodiments, the ports 2163A and 2163 can be substantially similar in form and/or function. In some embodiments, the port 2163A disposed at or near the proximal end portion 2161, for example, can include a frangible seal, a self-healing port, a one-way valve, and/or the like.

[1165] As shown in FIG. 45, the fluid reservoir 2160 includes an elastomeric member 2178 (and/or any other suitable member or material) disposed within the inner volume 2164. The elastomeric member 2178 is in contact with an inner surface of the fluid reservoir 2160 (defining at least a portion of the inner volume 2164) to form a substantially fluid tight seal therebetween. Thus, a portion of the inner volume 2164 that is proximal to the elastomeric member 2178 is substantially fluidically isolated from a portion of the inner volume 2164 that is distal to the elastomeric member 2178. In some embodiments, the portion of the inner volume 2164 disposed between the elastomeric member 2178 and the port 2163 (i.e., disposed at the distal end portion 2162 of the fluid reservoir 2160) can define, for example, a negative pressure, prior to the insertion of the puncture member 2138 through the port 2163. In other embodiments, both portions of the inner volume 2164 (e.g., on either side of the elastomeric member 2178) define a negative pressure, prior to the insertion of the puncture member 2138 through the port 2163. In still other embodiments, the inner volume 2164, in its entirety, need not define a negative pressure, prior to the insertion of the puncture member 2138 through the port 2163.

[1166] As shown in FIG. 45, the plunger 2145 can "float" and/or otherwise be disposed in a substantially fixed position within the inner volume 2164 prior to the port 2163A being fluidically coupled to a vacuum source (not shown in FIG. 45). Moreover, the arrangement of the fluid reservoir 2160 is such that when the actuator 2130 engages the fluid reservoir 2160, the puncture member 2138 is in a distal position relative to the elastomeric member

2178 and thus, substantially fluidically isolated from the portion of the inner volume 2164 that is proximal to the elastomeric member 2178. In a similar manner, the fluid reservoir 2160 can be manipulated such that an outlet of a vacuum source (not shown in FIG. 45) punctures and/or is otherwise inserted through the port 2163A to be placed in fluid communication with the portion of the inner volume 2164 proximal to the elastomeric member 2178. Thus, a user can actuate the vacuum source (e.g., via an electric switch, a pre-charged negative pressure created in a manufacturing process, mechanical actuation, and/or the like), such that the vacuum source draws a vacuum (e.g., a suction force) through its output and into the portion of the inner volume 2164 proximal to the elastomeric member 2178.

[1167] In some instances, the suction force and/or negative pressure can be sufficient to overcome a friction force between the elastomeric member 2178 and the inner surface, thereby resulting in a movement of the elastomeric member 2178 within the inner volume 2164 towards the port 2163A. The movement of the elastomeric member 2178 results in a change in volume associated with the portions of the inner volume 2164 disposed on either side of the elastomeric member 2178. In some instances, the increase in volume of the portion of the inner volume 2164 distal to the elastomeric member 2178 results in a negative pressure that is sufficient to draw a flow of bodily-fluid through the puncture member 2138 and into the inner volume 2164. As such, in some instances, a rate and/or magnitude of the vacuum drawn by the vacuum source can be controlled to, for example, change a characteristic associated with a pressure difference within the inner volume 2164 of the fluid reservoir 2160 and, for example, the adapter 2130. Thus, hemolysis of the blood is reduced or substantially prevented that might otherwise result from a rapid exposure to a negative pressure differential produced by the fluid reservoir 2160.

[1168] While the elastomeric member 2178 is shown and described above as "floating" within the inner volume 2164, in other embodiments, a fluid reservoir can include an elastomeric member and/or the like that is coupled to a plunger. For example, FIG. 46 illustrates an adapter 2230 and a fluid reservoir 2260 according to another embodiment. The adapter 2230 can be any suitable adapter such as, for example, the adapter 1330 described above with reference to FIGS. 29 and 30. In this manner, the adapter 2230 includes a puncture member 2238 configured to puncture a port or the like of the fluid reservoir 2260, as described in further detail herein.

[1169] The fluid reservoir 2260 includes a proximal end portion 2261 and a distal end portion 2262, and defines an inner volume 2264. The proximal end portion 2261 includes a port 2263A configured to be coupled to, for example, a vacuum source or the like, as described in further detail herein. Similarly, the distal end portion 2262 includes a port 2263 configured to receive the puncture member 2238 of the adapter 2230, as described in detail above with reference to FIGS. 31-33. In some embodiments, the ports 2263A and 2263 can be substantially similar in form and/or function. In some embodiments, the port 2263A disposed at or near the proximal end portion 2261, for example, can include a frangible seal, a self-healing port, a one-way valve, a locking mechanism, and/or the like. Thus, the port 2263A can physically and fluidically couple to a corresponding outlet port of a vacuum source (not shown in FIG. 46). For example, in some embodiments, an outlet port of a vacuum source and the port 2263A can form a threaded coupling or the like. In such embodiments, when the vacuum source is actuated, the port 2263A can be transitioned from a first, substantially sealed configuration to a second, substantially open configuration.

[1170] As shown in FIG. 46, the fluid reservoir 2260 includes a plunger 2275 disposed within the inner volume 2264. The plunger 2275 includes and/or is coupled to an elastomeric member 2278 disposed within the inner volume 2264. The elastomeric member 2278 is in contact with an inner surface of the fluid reservoir 2260 (defining at least a portion of the inner volume 2264) to form a substantially fluid tight seal therebetween. Thus, a portion of the inner volume 2264 that is proximal to the elastomeric member 2278 is substantially fluidically isolated from a portion of the inner volume 2264 that is distal to the elastomeric member 2278, as described above with reference to the elastomeric member 2178 in FIG. 46. In this embodiment, at least a portion of the plunger 2275 is movably disposed within a support member 2264A extending from a surface of the fluid reservoir 2260. As shown, the support member 2264A can, for example, divide the inner volume into a first portion and a second portion. Moreover, the support member 2264A can include a seal or the like that is in contact with an outer surface of the plunger to form a substantially fluid tight seal therebetween. Thus, the first portion of the inner volume 2264 can be substantially isolated from the second portion of the inner volume 2264.

[1171] The arrangement of the fluid reservoir 2260 is such that when the actuator 2230 engages the fluid reservoir 2260, the puncture member 2238 is in a distal position relative to the elastomeric member 2278 and thus, substantially fluidically isolated from the portion of

the inner volume 2264 that is proximal to the elastomeric member 2278. A user can similarly manipulate the fluid reservoir to couple the port 2263A to an outlet of a vacuum source (not shown in FIG. 46). In this manner, the portion of the inner volume 2264 that is proximal to the support member 2264A is placed in fluid communication with the vacuum source. Thus, a user can actuate the vacuum source (e.g., via an electric switch, a pre-charged negative pressure created in a manufacturing process, mechanical actuation, and/or the like) such that the vacuum source draws a vacuum (e.g., a suction force) through its output and into the portion of the inner volume 2264 proximal to the support member 2264A.

[1172] In some instances, the suction force and/or negative pressure can be sufficient to move the plunger 2275 within the inner volume 2264 towards the port 2263A. The movement of the plunger 2275 results in a corresponding movement of the elastomeric member 2278 and thus, changes a volume associated with the portions of the inner volume 2264 disposed on either side of the elastomeric member 2278. In some instances, the increase in volume of the portion of the inner volume 2264 distal to the elastomeric member 2278 results in a negative pressure that is sufficient to draw a flow of bodily-fluid through the puncture member 2238 an into the inner volume 2264. As such, in some instances, a rate and/or magnitude of the vacuum drawn by the vacuum source can be controlled to, for example, change a characteristic associated with a pressure difference within the inner volume 2264 of the fluid reservoir 2260 and, for example, the adapter 2230. Thus, hemolysis of the blood is reduced or substantially prevented that might otherwise result from a rapid exposure to a negative pressure differential produced by the movement of the plunger 2375 within the fluid reservoir 2260.

[1173] In some embodiments, the arrangement of the plunger 2275 and the support member 2264A can, for example, maintain a sterility of a portion of the inner volume 2264 distal to the support member 2264A. Specifically, as described above, the support member 2264A can include the seal that engages the outer surface of the plunger 2275 to fluidically isolate a portion of the inner volume 2264 proximal to the support member 2264A from a different portion of the inner volume 2264 distal to the support member 2264A. As such, when the port 2263A is placed in fluid communication with the vacuum source (not shown in FIG. 46), the portion of the inner volume 2264 proximal to the support member 2264A can be exposed, for example, to a non-sterile environment (e.g., associated with the vacuum source), while the sterility of the portion of the inner volume 2264 is maintained.

[1174] FIG. 47 illustrates an adapter 2330 and a fluid reservoir 2360 according to another embodiment. The adapter 2330 can be any suitable adapter such as, for example, the adapter 1330 described above with reference to FIGS. 29 and 30. In this manner, the adapter 2330 includes a puncture member 2338 configured to puncture a port or the like of the fluid reservoir 2360, as described in further detail herein.

[1175] The fluid reservoir 2360 includes a proximal end portion 2361 and a distal end portion 2362, and defines an inner volume 2364. The proximal end portion 2361 includes a port 2363A configured to be coupled to, for example, a vacuum source or the like, as described in further detail herein. Similarly, the distal end portion 2362 includes a port 2363 configured to receive the puncture member 2338 of the adapter 2330, as described in detail above with reference to FIGS. 31-33. As shown in FIG. 47, the fluid reservoir 2360 includes a plunger 2375 disposed within the inner volume 2364. The plunger 2375 includes and/or is coupled to an elastomeric member 2378 disposed within the inner volume 2364. The elastomeric member 2378 is in contact with an inner surface of the fluid reservoir 2360 (defining at least a portion of the inner volume 2364) to form a substantially fluid tight seal therebetween. As such, the fluid reservoir 2360 can be substantially similar to the fluid reservoir 2260 described above with reference to FIG. 46.

[1176] The fluid reservoir 2360 can differ from the fluid reservoir 2260, however, by including a bias member 2377 (e.g., a linear spring, a torsion spring, a leaf spring, a compression member, and/or the like) disposed about and in contact with a portion of the plunger 2375. In this manner, when the port 2363A is physically and fluidically coupled to an outlet of a vacuum source (not shown in FIG. 47) and the vacuum source is actuated, the vacuum source draws a vacuum (e.g., a suction force) through its output and into the portion of the inner volume 2364. Thus, the vacuum source can exert a suction force within a portion of the inner volume 2364 that results in a proximal movement of the plunger 2375. The arrangement of the bias member 2377, however, is such that the bias member 2377 exerts a reaction force in response to the movement of the plunger 2375. As such, the bias member 2377 can at least partially control a movement of the plunger 2375 within the inner volume 2364, for example, to reduce speed at which the plunger 2375 is moved. Thus, hemolysis of the blood is reduced or substantially prevented that might otherwise result from a rapid exposure to a negative pressure differential produced by the movement of the plunger 2375 within the fluid reservoir 2360.

[1177] While the adapters in the embodiments above have been shown and described as being physically and/or fluidically coupled to a corresponding fluid reservoir configured as an evacuated container, in other embodiments, an adapter can be configured to physically and/or fluidically couple to any suitable fluid reservoir and/or any suitable intervening structure. For example, FIGS. 49 and 50 illustrate an adapter 2430 according to another embodiment. The adapter 2430 can be any suitable shape or size and can be configured to be placed in fluid communication with any suitable fluid reservoir. For example, as described in further detail herein with reference to FIGS. 51 and 52, in some instances, the adapter 2430 can be physically and fluidically coupled to a fluid reservoir 2460 configured as, for example, a syringe or the like.

[1178] As shown in FIGS. 49 and 50, the adapter 2430 has a proximal end portion 2431 and a distal end portion 2432. In this embodiment, the distal end portion 2432 of the adapter 2430 includes, for example, a locking mechanism (e.g., a Luer Lok® or the like) that can physically and fluidically couple the adapter 2430 to a corresponding locking mechanism of any other suitable device such as, for example, an extension set or the like. In other embodiments, the distal end portion 2432 can be any suitable configuration such as, for example, a port, a septum, and/or the like. In a similar manner, the proximal end portion 2431 of the adapter 2430 includes, for example, a locking mechanism (e.g., a Luer Lok® or the like) that can physically and/to fluidically couple the adapter 2430 to, for example, the fluid reservoir 2460, as described in further detail herein.

[1179] The adapter 2430 includes a delivery member 2438 that extends from a portion of adapter 2430 toward the proximal end portion 2431. The delivery member 2438 defines a lumen 2439 extending at least partially through the delivery member 2438. More specifically, in this embodiment, the lumen 2439 extends through the distal end portion 2432 of the adapter 2430 but does not extend through the proximal end portion 2431. Similarly stated, the lumen 2439 does not extend through a proximal surface of the delivery member 2438. For example, as shown in FIGS. 49 and 50, the delivery member 2438 can have a substantially rounded or hemispherical proximal surface that is substantially closed and/or continuous. Alternatively, the delivery member 2438 defines at least one opening 2440 disposed along a circumference of the delivery member 2438 at a position distal to, for example, the proximal surface. Thus, while the delivery member 2438 does not define an

opening though a proximal most surface, opening(s) 2440 place a proximal end portion of the lumen 2439 in fluid communication with a volume outside of the delivery member 2438.

[1180] As described above, the adapter 2430 can be physically and fluidically coupled to the fluid reservoir 2460 (see e.g., FIG. 52). The fluid reservoir 2460 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 2460 is a syringe or the like, as shown in FIG. 51. The fluid reservoir 2460 has a proximal end portion 2461 and a distal end portion 2462 and defines an inner volume 2464. The distal end portion 2462 is configured to be physically and fluidically coupled to an adapter such as, for example, the adapter 2430. For example, the distal end portion 2462 can include a locking mechanism (e.g., a Luer Lok® or the like) configured to be physically and fluidically coupled to the proximal end portion 2431 (e.g., the corresponding locking member included therein) of the adapter 2430. Moreover, when the adapter 2430 is coupled to the fluid reservoir 2460, the delivery member 2438 is at least partially disposed in the inner volume 2464 of the fluid reservoir 2460 and as such, the opening(s) 2440 defined by the delivery member 2438 place the lumen 2439 of the adapter 2430 in fluid communication with the inner volume 2464 of the fluid reservoir 2460, as described in further detail herein.

[1181] As shown in FIGS. 51 and 52, the proximal end portion 2461 movably receives a plunger 2475 that is at least partially disposed in the inner volume 2464, as described in further detail herein. As shown in FIG. 52, the fluid reservoir 2460 includes a seal member 2479 disposed within the inner volume 2464. More specifically, the seal member 2479 is disposed within a proximal portion of the inner volume 2464 and about a portion of the plunger 2475. As such, the seal member 2479 forms a substantially fluid tight seal between an inner surface of the fluid reservoir 2460 and an outer surface of the seal member 2479 and an outer surface of the plunger 2475 and an inner surface of the seal member 2479. Furthermore, the seal member 2479 defines an opening 2479A extending therethrough that can place a portion of the inner volume 2464 proximal to the seal member 2479 in fluid communication with a portion of the inner volume 2464 distal to the seal member 2479. The arrangement of the fluid reservoir 2460 is such that the seal member 2479 is maintained in a substantially fixed position when the plunger 2475 is moved within the inner volume 2464, as described in further detail herein.

[1182] As shown in FIG. 52, the plunger 2475 has a proximal end portion 2476 and a distal end portion 2477. The distal end portion 2477 of the plunger 2475 includes and/or is

coupled to an elastomeric member 2478 or the like. For example, in some embodiments, the elastomeric member 2478 can form a substantially fluid tight seal with an inner surface of the fluid reservoir 2460. As described above, the plunger 2475 is movably disposed within the inner volume 2464 of the fluid reservoir 2460. More specifically, the plunger 2475 can be moved within the inner volume 2464 in an axial direction between a first position (e.g., a distal position) and a second position (e.g., a proximal position) relative to the fluid reservoir 2460. For example, in some embodiments, the plunger 2475 can be disposed in a distal position relative to the fluid reservoir 2460 prior to use. A user can then manipulate the fluid reservoir 2460 and/or the plunger 2475 to move the plunger 2474 in a proximal direction within the inner volume 2464. With the elastomeric member 2478 in contact with the inner surface of the fluid reservoir 2460, the proximal movement of the plunger 2475 relative to the fluid reservoir 2460 produces a negative pressure within a portion of the inner volume 2464 that is distal to the elastomeric member 2478.

[1183] When the adapter 2430 is coupled to the fluid reservoir 2460 (as shown in FIG. 52), the negative pressure within the portion of the inner volume 2464 results in a suction through the lumen 2439 of the delivery member 2438. Thus, when the distal end portion 2431 of the adapter 2430 is coupled to a device or other intervening structure, which in turn, is in fluid communication with a portion of the body and/or intervening device (e.g. catheter, fluid reservoir, etc.), the suction force within the lumen 2439 can draw a bodily-fluid (e.g., blood) through the lumen 2439 and into the inner volume 2464 of the fluid reservoir 2460. Moreover, the arrangement of the seal member 2479 within the inner volume 2464 can reduce, limit, modulate, and/or otherwise at least partially control a rate at which the plunger 2479 can be moved within the inner volume 2464. For example, with the elastomeric member 2478 forming a substantially fluid tight seal with the inner surface of the fluid reservoir 2460, the proximal movement of the plunger 2464 reduces and/or compresses a volume defined between the elastomeric member 2478 and the seal member 2479, which in turn, increases a pressure within that volume. Therefore, with the seal member 2479 similarly forming a substantially fluid tight seal with the inner surface of the fluid reservoir 2460 and with an outer surface of the plunger 2475, air within the volume between the seal member 2479 and the elastomeric member 2478 is forced through the opening 2479A defined by the seal member 2479, thereby limiting the rate at which the plunger 2479 is moved within the inner volume 2464. As such, a negative pressure and/or a suction force drawn through the lumen 2439 of the adapter 2430 is correspondingly controlled and/or modulated.

[1184] As described above, in some embodiments, the arrangement of the delivery member 2438 can also limit and/or otherwise modulate a pressure and/or a suction force within the lumen 2439. In this manner, when withdrawing a volume of blood, hemolysis of the blood flowing through the lumen 2439 and into the inner volume 2464 of the fluid reservoir 2460 is reduced or substantially prevented. Specifically, the arrangement opening(s) 2440 and the lumen 2439 of the delivery member 2438 can, for example, reduce a negative pressure within the lumen 2439 and/or can slow a flow of blood delivered to the inner volume 2464 of the fluid reservoir 2460 to an extent that can reduce and/or substantially prevent hemolysis of the blood that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like. In addition, the arrangement of an inner surface defining the lumen 2439 can, for example, reduce turbulence, eddy currents, and/or any other disturbance that can otherwise result from a discontinuity or the like.

[1185] While the fluid reservoir 2460 is particularly shown and described above with reference to FIGS. 51 and 52, in other embodiments, any suitable fluid reservoir can be coupled to, for example, the adapter 2430 to receive a volume of blood with reduced hemolysis of its constituents. For example, FIGS. 53 and 54 illustrate a fluid reservoir 2560 according to another embodiment. In this embodiment, the fluid reservoir 2560 is, for example, a syringe or the like having a proximal end portion 2561 and a distal end portion 2562 and defining an inner volume 2564. The distal end portion 2562 is configured to be physically and fluidically coupled to an adapter such as, for example, the adapter 1530, as described in detail above.

[1186] The proximal end portion 2561 of the fluid reservoir 2560 is substantially open and receives at least a portion of a plunger 2575. Moreover, the proximal end portion 2561 of the fluid reservoir 2560 includes an actuator 2570 that is operable in moving the plunger 2575 within the inner volume 2564. For example, as shown in FIGS. 53 and 54, the fluid reservoir 2560 includes a protrusion 2569 to which the actuator 2570 is pivotally coupled. More specifically, the actuator 2570 includes a first end portion 2571, a second end portion 2572, and a pivot portion 2573 disposed therebetween. The second end portion 2572 of the actuator 2570 is coupled to a portion of the plunger 2575, as described in further detail herein. The pivot portion 2573 is coupled to the protrusion 2569 via, for example, a pin, an axle, a rod, and/or the like configured to allow the actuator 2570 to pivot about the protrusion

2569 (e.g., about an axis defined by the protrusion 2569) in response to a force exerted on the first end portion 2571. In this manner, the actuator 2570 can be arranged, for example, as a trigger or the like which when actuated, is operable in moving the plunger 2575 relative to the fluid reservoir 2560, as described in further detail herein.

[1187] As shown in FIG. 54, the plunger 2575 has a proximal end portion 2576 and a distal end portion 2577. The distal end portion 2577 of the plunger 2575 includes and/or is coupled to an elastomeric member 2578 or the like. For example, in some embodiments, the elastomeric member 2578 can form a substantially fluid tight seal with an inner surface of the fluid reservoir 2560. As described above, the plunger 2575 is movably disposed within the inner volume 2564 of the fluid reservoir 2560. More specifically, the proximal end portion 2576 of the plunger 2575 is coupled to the second end portion 2572 of the actuator 2570 such that an actuation of the actuator 2570 results in a movement of the plunger 2570 within the inner volume 2564.

[1188] For example, a user can exert a force on the first end portion 2571 (e.g., with his or her thumb or finger) of the actuator 2570, which in turn, results in a pivoting motion about the protrusion 2569 that places the first end portion 2571 in a position closer to an outer surface of the fluid reservoir 2560 and places the second end portion 2572 in a corresponding position farther away from the fluid reservoir 2560. In other words, the pivoting of the actuator 2570 about the protrusion 2569 moves the second end portion 2572 in a proximal direction. Moreover, the trigger arrangement of the actuator 2570 (as described above) defines a range of motion through which the actuator 2570 can pivot and thus, defines a range of motion through which the plunger 2575 is moved in the proximal direction (i.e., a stroke length). As such, the user can serially actuate the actuator 2570 to move the plunger 2575 a desired distance in the proximal direction.

[1189] With the elastomeric member 2578 of the plunger 2575 forming a substantially fluid tight seal with the inner surface of the fluid reservoir 2560, the proximal movement of the plunger 2575 relative to the fluid reservoir 2560 produces a negative pressure within a portion of the inner volume 2564 that is distal to the elastomeric member 2578. Thus, when the fluid reservoir is coupled to an adapter and/or any other suitable lumen-defining device in fluid communication with the body of a patient, the negative pressure results in a suction force within that lumen that can draw a bodily-fluid (e.g., blood) through the lumen and into the inner volume 2564 of the fluid reservoir 2560. Moreover, by limiting the stroke length

(as described above) of the plunger 2575, a rate at which the plunger 2575 can be moved within the inner volume 2564 is reduced, limited, modulated, and/or otherwise at least partially controlled. As a result, a negative pressure and/or a suction force drawn through, for example, the lumen of the lumen-defining device is correspondingly controlled and/or modulated. Therefore, by limiting the stroke of the plunger 2575, a negative pressure within the inner volume 2564 of the fluid reservoir 2560 and/or a rate at which blood (or other bodily-fluid) flows into the inner volume 2564 can be controlled to an extent that can reduce and/or substantially prevent hemolysis of the blood that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like.

[1190] While the actuator 2570 is particularly shown in FIGS. 52 and 53, in other embodiments, the actuator 2570 can be any suitable device, mechanism, and/or member that is operative in moving the plunger 2575 within the fluid reservoir 2560. For example, while actuator 2570 is described above as being actuated by a user's thumb or finger, in other embodiments, and actuator can include a first end portion that extends a given length of the fluid reservoir as to be engaged by a user's palm or more than one finger (e.g., each finger excluding the thumb of the user). In other embodiments, a fluid reservoir can include an actuator that is a switch, a push button, a toggle, and/or the like configured to close an electric circuit or the like when actuated. Thus, when the electric circuit is closed, a current can flow through the electric circuit, for example, to a mechanism (e.g., including an electric motor) configured to move a plunger within the fluid reservoir.

[1191] FIGS. 54-56 illustrate a fluid reservoir 2660 according to another embodiment. The fluid reservoir 2660 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 2660 is a syringe or the like, as shown in FIG. 54. The fluid reservoir 2660 has a proximal end portion 2661 and a distal end portion 2662 and defines an inner volume 2664 (see e.g., 56). The distal end portion 2662 is configured to be physically and fluidically coupled to an adapter (not shown in FIGS. 54-56) such as, for example, the adapter 2430 described above with reference to FIGS. 48-51.

[1192] The proximal end portion 2661 of the fluid reservoir 2660 movably receives a plunger 2675 that is at least partially disposed in the inner volume 2664. As shown in FIGS. 55 and 56, the plunger 2675 has a proximal end portion 2676 and a distal end portion 2677. The distal end portion 2677 of the plunger 2675 includes and/or is coupled to an elastomeric member 2678 or the like. For example, in some embodiments, the elastomeric member 2678

can form a substantially fluid tight seal with an inner surface of the fluid reservoir 2660, as described in detail above. The proximal end portion 2676 of the plunger 2675 is coupled to an actuator 2670. For example, in some embodiments, at least a portion of the actuator 2670 can be hollow and configured to be movably disposed (e.g., in an axial direction) about the proximal end portion 2676 of the plunger 2675. Expanding further, the proximal end portion 2676 of the plunger 2675 includes a set of protrusions 2676A or the like (e.g., tabs, pins, bumps, etc.) configured to engage and/or otherwise disposed in a corresponding set of openings 2670A when the actuator 2670 is disposed about the proximal end portion 2676. In some embodiments, each protrusion 2676A can include an indicator or the like that can be viewable when disposed in a corresponding opening 2670A of the actuator 2670, as described in further detail herein.

[1193] As shown in FIGS. 55 and 56, the plunger 2675 includes a bias member 2674 (e.g., a linear spring, a torsion spring, and/or the like) disposed between the proximal end portion 2676 and the actuator 2670. In this manner, the bias member 2674 can, for example, maintain the actuator 2670 is a substantially fixed position relative to the proximal end portion 2676 until a force is exerted on the actuator 2670 or the plunger 2675 that is sufficient to overcome a force exerted by the bias member 2674. For example, in some embodiments, a user can manipulate the fluid reservoir 2660 to fluidically couple the distal end portion 2662, for example, to an adapter (e.g., the adapter 2430), which in turn can be directly or indirectly coupled to a device in fluid communication with a portion of the body. Thus, the inner volume 2664 of the fluid reservoir 2660 is placed in fluid communication with the portion of the body. With the fluid reservoir 2660 in fluid communication with the portion of the body, the user can manipulate the actuator 2670, for example, to move the plunger 2675 within the inner volume 2664. For example, a user can exert a force on the actuator 2670 to move the actuator 2670 and the plunger 2675 in the proximal direction relative to the fluid reservoir 2660. The arrangement of the bias member 2674 can be such that at least a portion of the force exerted by the user on the actuator 2670 transitions the bias member 2674 from a first configuration (e.g., a compressed configuration) to a second configuration (e.g., an extended configuration). Thus, the bias member 2674 can absorb at least a portion of the force (e.g., an excess portion of force above a predetermined threshold), exerted by the user, that would otherwise be exerted on the plunger 2675. In this manner, a rate at which the plunger 2675 is moved within the inner volume 2664 can be at least partially controlled and/or otherwise limited, which in turn, can reduce and/or substantially prevent hemolysis of the blood drawn

into the inner volume 2664 that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like.

[1194] In some embodiments, the arrangement of the protrusions 2676A of the proximal end portion 2676 within the openings 2670A of the actuator 2670, for example, can define a range of motion of the actuator 2670 relative to the plunger 2675 (e.g., can prevent a movement of the actuator 2675 beyond a predetermined threshold relative to the plunger 2675. In some embodiments, the protrusions 2676A can each include an indicator or the like that are viewable through the openings 2670A and therefore, can provide an indication to the user associated with the movement of the actuator 2670 relative to the plunger 2675. For example, in some embodiments, when a force is exerted on the actuator 2670 that is greater than a predetermined threshold, the actuator 2670 can be moved relative to the plunger 2675 and at least a portion of the force can transition the bias member 2674 from its first configuration to its second configuration. Thus, when the bias member 2674 is in its second configuration (e.g., an extended configuration), the actuator 2670 can be in a position relative to the plunger 2675 that is associated with at least a portion of the indicator of the protrusions 2676A being viewable through the openings 2670A. As such, the indicators can provide a visual indication of when a force exerted by the user exceeds a predetermined threshold. In some embodiments, the arrangement of the protrusions 2676A and the openings 2670A can be such that when a force exerted on the actuator 2670 exceeds the predetermined threshold, the plunger 2675 and/or the actuator 2670 also provide an auditory (e.g., a clicking sound) or a haptic indication.

[1195] While the actuators 2570 and 2670 are particularly shown and described above, in other embodiments, a fluid reservoir can include any suitable actuator operable in moving a plunger within an inner volume of the fluid reservoir. For example, FIGS. 57 and 58 illustrate a fluid reservoir 2760 according to another embodiment. The fluid reservoir 2760 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 2760 is a syringe or the like, as shown in FIG. 57. The fluid reservoir 2760 has a proximal end portion 2761 and a distal end portion 2762 and defines an inner volume 2764 (see e.g., 56). The distal end portion 2762 is configured to be physically and fluidically coupled to an adapter (not shown in FIGS. 57 and 58) such as, for example, the adapter 2430 described above with reference to FIGS. 48-51. The proximal end portion 2761 of the fluid reservoir 2760 movably receives a plunger 2775 that is at least partially disposed in the inner

volume 2764. As shown in FIG. 58, the plunger 2775 has a proximal end portion 2776 and a distal end portion 2777. The distal end portion 2777 of the plunger 2775 includes and/or is coupled to an elastomeric member 2778 or the like, as described in detail herein. The proximal end portion 2776 of the plunger 2775 is coupled to an actuator 2770 operable in moving the plunger 2775 relative to the fluid reservoir 2760.

[1196] The actuator 2770 can be any suitable shape, size, or configuration. For example, as shown in FIGS. 57 and 58, the actuator 2770, in this embodiment, is a dial rotatably coupled to the fluid reservoir 2760 and the plunger 2775. More specifically, the actuator 2770 can be disposed about the proximal end portion 2761 of the fluid reservoir 2760 such that the actuator 2770 can rotate relative thereto without, for example, unthreading or removing the actuator 2770 from the fluid reservoir 2760. In other words, the actuator 2770 can be coupled to the proximal end portion 2761 of the fluid reservoir 2760 for rotational motion while substantially preventing a linear motion of the actuator 2770 relative to the fluid reservoir 2760. As shown in FIG. 58, an outer surface of the plunger 2775 includes and/or otherwise forms a set of continuous threads 2775A arranged in a helical manner along a length of the plunger 2775 (e.g., substantially the entire length). Moreover, a portion of the plunger 2775 is configured to extend through, for example, a threaded opening defined by the actuator 2770. Thus, the set of threads 2775A engage a surface of the actuator 2770 to define a threaded coupling therebetween, which can allow the plunger 2775 to be moved in an axial direction within the inner volume 2764 of the fluid reservoir 2760.

[1197] Specifically, in use, the fluid reservoir 2760 can be manipulated to couple the distal end portion 2762 to an adapter or other device in fluid communication with a portion of the body, thereby placing the inner volume 2764 of the fluid reservoir 2760 in fluid communication with the portion of the body and/or intervening device (e.g. catheter, etc.). With the inner volume 2764 in fluid communication with the portion of the body, the actuator 2770 can be rotated relative to the fluid reservoir 2760, which in turn, results in the threads 2775A being advanced along a surface of the actuator 2770. Thus, the plunger 2775 is moved in an axial direction (e.g., a proximal direction) within the inner volume 2764, which in turn, increases a portion of the inner volume 2764 that is distal to the elastomeric member 2778. Such an increase results in, for example, a negative pressure within the portion of the inner volume 2764 distal to the elastomeric member 2778 and therefore, a suction force is exerted that is operable in drawing a bodily-fluid (i.e., blood) into the inner volume 2764 of

the fluid reservoir 2760. In some embodiments, the arrangement of the actuator 2770 and the plunger 2775 (i.e., the threaded coupling) limits a rate at which the plunger 2775 is moved within the inner volume 2764. In this manner, limiting the rate at which the plunger 2775 is moved within the inner volume 2764 can reduce and/or substantially prevent hemolysis of the blood drawn into the inner volume 2764 that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like.

[1198] While the actuator 2770 is shown and described above as forming a threading coupling with the plunger 2775, in other embodiments, a fluid reservoir can include an actuator that is monolithically formed with a plunger. For example, FIG. 59 illustrates a fluid reservoir according to another embodiment. The fluid reservoir 2860 has a proximal end portion 2861 and a distal end portion 2862 and defines an inner volume 2864. The distal end portion 2862 is configured to be physically and fluidically coupled to an adapter (not shown in FIG. 59) such as, for example, the adapter 2430 described above with reference to FIGS. 48-51. In this embodiment, the fluid reservoir 2860 includes an outer surface that defines a set of continuous threads arranged in a helical manner along a length of the fluid reservoir 2860, as described above with reference to the plunger 2775 in FIG. 58.

[1199] The fluid reservoir 2860 is rotatably coupled to an actuator 2870. The actuator 2870 includes a proximal end portion 2871, a distal end portion 2872, and a plunger 2875. The actuator 2870 further includes an inner surface that defines a set of continuous threads 2899 (e.g., female threads or grooves) arranged in a helical manner along a length of the inner surface. In this manner, the actuator 2870 can be disposed about the fluid reservoir 2860 such that the set of threads 2860A of the fluid reservoir 2860 are disposed within the corresponding set of threads 2899 of the actuator 2870, while the plunger 2875 extends from the proximal end portion 2871 of the actuator 2870 within the inner volume 2864 of the fluid reservoir 2860. Moreover, as shown in FIG. 59, a distal end portion 2877 of the plunger 2875 includes and/or is coupled to an elastomeric member 2878 configured to form a substantially fluid tight seal with an inner surface of the fluid reservoir 2860, as described in detail herein.

[1200] Thus, in use, the fluid reservoir 2860 can be manipulated to couple the distal end portion 2862 to an adapter or other device in fluid communication with a portion of the body, thereby placing the inner volume 2864 of the fluid reservoir 2860 in fluid communication with the portion of the body. With the inner volume 2864 in fluid communication with the

portion of the body, the actuator 2870 can be rotated relative to the fluid reservoir 2860, which in turn, results in the threads 2899 of the actuator 2870 being advanced along the corresponding threads 2860A of the fluid reservoir 2860. Thus, the actuator 2870 can be moved in the proximal direction relative to the fluid reservoir 2860, which results in the plunger 2875 being moved in an axial direction (e.g., a proximal direction) within the inner volume 2864. As such, a portion of the inner volume 2864 that is distal to the elastomeric member 2878 is increased. Such an increase results in, for example, a negative pressure within the portion of the inner volume 2864 distal to the elastomeric member 2878 and therefore, a suction force is exerted that is operable in drawing a bodily-fluid (i.e., blood) into the inner volume 2864 of the fluid reservoir 2860. In some embodiments, the arrangement of the actuator 2870 and the fluid reservoir 2860 (i.e., the threaded coupling) limits a rate at which the plunger 2875 is moved within the inner volume 2864. In this manner, limiting the rate at which the plunger 2875 is moved within the inner volume 2864 can reduce and/or substantially prevent hemolysis of the blood drawn into the inner volume 2864 that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like.

[1201] FIG. 60 illustrates a fluid reservoir 2960 according to another embodiment. The fluid reservoir 2960 can be any suitable shape, size, or configuration. For example, in this embodiment, the fluid reservoir 2960 can be configured to receive a portion of an actuator 2970 (e.g., arranged as a syringe or the like), as described in further detail herein. The fluid reservoir 2960 has a first chamber 2990 and a second chamber 2991, which are formed unitarily (e.g., joined at a proximal end portion of the fluid reservoir 2960. The first chamber 2990 includes a proximal end portion 2961 and a distal end portion 2962 and defines an inner volume 2964. The distal end portion 2962 is configured to be physically and fluidically coupled to an adapter such as, for example, the adapter 2430 described above with reference to FIGS. 48-51. The proximal end portion 2961 movably receives a first plunger 2975 of the actuator 2970, which is at least partially disposed in the inner volume 2964, as described in further detail herein. In this manner, the first chamber 2990 is configured to receive and at least temporarily store a volume of bodily-fluid, as described in further detail herein.

[1202] Similarly, the second chamber 2991 includes a proximal end portion 2992 and a distal end portion 2993 and defines an inner volume 2994. The distal end portion 2993 of the second chamber 2991 is closed (i.e., does not define a port or other opening). The proximal

end portion 2992 movably receives a second plunger 2995 of the actuator 2970, which is at least partially disposed in the inner volume 2994, as described in further detail herein. As shown in FIG. 60, the second chamber 2991 has a size and/or shape that are/is smaller than the first chamber 2990. Thus, in some embodiments, the second chamber 2991 can be an auxiliary chamber or the like. For example, with the distal end portion 2993 of the second chamber 2991 being closed and/or sealed, in this embodiment, the second chamber 2991 can act as a dampener or the like configured to dampen a movement of the actuator 2970 relative to the fluid reservoir 2960.

[1203] As described above, the actuator 2970 includes the first plunger 2975 movably disposed in the inner volume 2964 of the first chamber 2990 and the second plunger 2995 movably disposed in the inner volume 294 of the second chamber 2991. As shown in FIG. 60, the first plunger 2975 has a proximal end portion 2976 and a distal end portion 2977. The proximal end portion 2976 of the first plunger 2975 is coupled to and/or otherwise unitarily formed a proximal end portion 2996 of the second plunger 2995. The distal end portion 2977 of the first plunger 2975 includes and/or is coupled to an elastomeric member 2978 or the like. In some embodiments, the elastomeric member 2978 can form a substantially fluid tight seal with an inner surface of the first chamber 2990, as described in detail above. Similarly, the second plunger 2995 has the proximal end portion 2996 and a distal end portion 2997. The proximal end portion 2996 of the second plunger 2995 is coupled to and/or otherwise unitarily formed with the proximal end portion 2976 of the first plunger 2975. The distal end portion 2997 of the second plunger 2995 includes and/or is coupled to an elastomeric member 2998. As described above with reference to the elastomeric member 2978, the elastomeric member 2998 of the second plunger 2995 can form a substantially fluid tight seal with an inner surface of the second chamber 2991. In this manner, the actuator 2970 can be moved relative to the fluid reservoir 2960 to move the first plunger 2975 within the inner volume 2964 of the first chamber 2990 and the second plunger 2995 within the inner volume 2994 of the second chamber 2991 in a substantially concurrent movement, as described in further detail herein.

[1204] In use, for example, the fluid reservoir 2960 can be manipulated to couple the distal end portion 2962 to an adapter or other device in fluid communication with a portion of the body, thereby placing the inner volume 2964 of the fluid reservoir 2960 in fluid communication with the portion of the body and/or intervening device (e.g. catheter, etc.).

Once the inner volume 2964 is placed in fluid communication with the portion of the body, the actuator 2970 can be moved in the proximal direction relative to the fluid reservoir 2960, which in turn, moves the first plunger 2975 within the inner volume 2964. More specifically, with the elastomeric member 2978 of the plunger 2975 forming a substantially fluid tight seal with the inner surface of the fluid reservoir 2960, the proximal movement of the first plunger 2975 relative to the fluid reservoir 2960 produces a negative pressure within a portion of the inner volume 2964 that is distal to the elastomeric member 2978. Thus, when the fluid reservoir is coupled to an adapter and/or any other suitable lumen-defining device in fluid communication with the body of a patient, the negative pressure results in a suction force within that lumen that can draw a bodily-fluid (e.g., blood) through the lumen and into the inner volume 2964 of the fluid reservoir 2960.

[1205] In a similar manner, the proximal movement of the actuator 2970 moves the second plunger 2995 within the inner volume 2994 of the second chamber 2991 substantially concurrently with the first plunger 2975, thereby increasing a portion of the inner volume 2994 that is distal to the elastomeric member 2998. With the elastomeric member 2998 of the second plunger 2995 forming a substantially fluid tight seal with the inner surface of the second chamber 2991, such an increase in the portion of the inner volume 2994 that is distal to the elastomeric results in a negative pressure within that portion of the inner volume 2994. Moreover, with the distal end portion 2993 of the second chamber 2991 being closed and/or sealed, the movement of the second plunger 2995 within the second chamber 2991, for example, can act to dampen the movement of the actuator 2970 relative to the fluid reservoir 2960. Specifically, the increase of the portion of the inner volume 2994 distal to the elastomeric member 2998 produces, for example, a suction force therein that resists the proximal movement of the second plunger 2995. Thus, an effective force exerted on the actuator 2970 to move the first plunger 2975 within the first chamber 2990 and the second plunger 2995 within the second chamber 2991 can be modulated, reduced, limited, and/or otherwise controlled, which in turn, can limit a rate at which the actuator 2970 is moved relative to the fluid reservoir 2960. In other words, the arrangement of the second chamber 2991 and the second plunger 2995 dampen the force exerted on the actuator 2970 and thus, the movement of the actuator 2970 relative to the fluid reservoir 2960. Therefore, by limiting the rate at which the actuator 2970 is moved relative to the fluid reservoir 2960, a negative pressure within the inner volume 2964 of the first chamber 2991 and/or a rate at which blood (or other bodily-fluid) flows into the inner volume 2964 can be controlled to an extent that

can reduce and/or substantially prevent hemolysis of the blood that can otherwise result from, inter alia, a volume of blood being exposed to a rapid pressure drop or the like.

[1206] While the embodiments are shown and described above as defining a single flow path from the patient to a fluid reservoir, in some embodiments, a fluid transfer device and/or system can include, for example, any suitable extension set, Y-adapter, T-adapter, junction, split, and/or the like configured to define more than one fluid flow path. Moreover, in such embodiments, a fluid transfer device and/or system can include any suitable coupling mechanism, lock mechanism, hub, and/or the like configured to couple, for example, a first lumen-defining device to a second lumen-defining device such that hemolysis of a flow of blood therethrough is limited and/or substantially prevented. For example, FIGS. 61-71 illustrate embodiments configured to mitigate the risk of hemolysis as blood flows through a multi-lumen adapter and/or the like. Specifically, FIGS. 61-63 illustrate a hub 3020 configured to receive a lumen-defining device 3080 according to an embodiment.

[1207] The hub 3020 has a proximal end portion 3021, a distal end portion 3022 and an inner surface 3023 defining a lumen 3024 therethrough (see e.g., FIG. 63). The distal end portion 3022 of the hub 3020 includes and/or is coupled to a cannula 3022A and/or other suitable lumen-defining device. Although not shown in FIGS. 61-63, in some embodiments, the cannula 3022A can be coupled to an adapter, a restrictor, locking mechanism, and/or the like. In some embodiments, the cannula 3022A can be, for example, an indwelling cannula with a distal end portion disposed within the body of a patient. In other embodiments, the distal end portion 3022 of the hub 3020 can include and/or can form a locking mechanism configured to physically and fluidically couple the hub 3020 to any suitable device. The proximal end portion 3021 of the hub 3020 includes and/or is coupled to a proximal cap 3027 and an actuator 3045. For example, in some embodiments, the proximal cap 3027 can be coupled to the proximal end portion 3021 via a press fit, a snap fit, a friction fit, a threaded coupling, an adhesive, ultrasonic welding and/or the like. Moreover, the proximal cap 3027 defines an opening 3028 that is, for example, substantially aligned with the lumen 3024 defined by the inner surface 3023. In this manner, a portion of the lumen-defining device 3080 can be inserted through the opening 3028 of the proximal cap 3027 to be disposed within the hub 3020, as described in further detail herein.

[1208] As shown in FIGS. 62 and 63, the actuator 3045 is disposed between the proximal end portion 3021 and the proximal cap 3027. More specifically, the actuator 3045 forms a

substantially annular ring or the like that is movably disposed within a space defined between a proximal surface of the hub 3020 and a distal surface of the proximal cap 3027. In this manner, the actuator 3045 defines an opening 3046 that can be selectively aligned with the opening 3028 of the proximal cap 3027 and the inner surface 3023 of the hub 3020. Moreover, the actuator 3045 includes and/or is coupled to a bias member 3047 (see e.g., FIG. 62), which can exert a force to temporarily maintain the actuator 3045 in a predetermined position relative to the hub 3020, for example, until a force is exerted on the actuator 3045 sufficient to overcome the force exerted by the bias member 3047, as described in further detail herein.

[1209] As shown in FIG. 63, the inner surface 3023 of the hub 3020 defines the lumen 3024 extending through its proximal end portion 3021 and its distal end portion 3022, which is configured to receive a portion of the lumen-defining device 3080. Furthermore, the inner surface 3023 includes and/or otherwise forms a shoulder 3025. In this embodiment, the shoulder 3025 is associated with a change in diameter of the inner surface 3023. For example, a first portion of the inner surface 3023 (e.g., a proximal portion) can have a first diameter that is larger than a diameter of a second portion of the inner surface (e.g., a distal portion). In this manner, the shoulder 3025 can be placed in contact with a surface of the lumen-defining device 3080 when inserted therein, as described in further detail herein.

[1210] The hub 3020 further includes a valve 3026 disposed within the lumen 3024. The valve 3026 can be, for example, a one-valve, a port, and/or the like, which can be transitioned between a first, substantially closed configuration and a second, substantially opened configuration. Thus, when in the first configuration, the valve 3026 can fluidically isolate a portion of the lumen 3024 that is proximal to the valve 3026 from a portion of the lumen 3024 that is distal to the valve 3026. Conversely, when the valve 3026 is in the second configuration, the lumen 3024 can define a fluid flow path substantially through the hub 3020. In some embodiments, the insertion of the portion of the lumen-defining device 3080 can be operable in transitioning the valve 3026 from the first configuration to the second configuration, as described in further detail herein.

[1211] The lumen-defining device 3080 has a proximal end portion 3031, a distal end portion 3032, and a flange 3086. The lumen-defining device 3080 also defines a notch 3085 and a lumen 3083 extending through the proximal end portion 3081 and the distal end portion 3082, as described in further detail herein. As shown in FIGS. 62 and 63, the distal end

portion 3082 of the lumen-defining device 3080 is configured to be inserted through the proximal cap 3027 and the actuator 3045 to be disposed within the hub 3020, as described in further detail herein. Moreover, the lumen-defining device 3080 includes a seal member 3087 disposed about an outer surface of the distal end portion 3082, which is placed in contact with the inner surface 3023 of the hub 3020 which the lumen-defining device 3080 is disposed therein.

[1212] As shown, for example, in FIGS. 61 and 63, the proximal end portion 3081 of the lumen-defining device 3080 is physically and fluidically coupled to a cannula 3088. The cannula 3088 can be any suitable configuration. For example, in this embodiment, the cannula 3088 is a bifurcated cannula having a first portion 3088A and a second portion 3088B (also referred to herein as a "first cannula" and a "second cannula," respectively). The first portion 3088A and second portion 3088B can be physically and fluidically coupled to any suitable device (e.g., at a proximal end). For example, as shown in FIG. 61, the second portion 3088B includes a port or locking mechanism that can physically and fluidically couple the second portion 3088B to, for example, a fluid source and/or the like. Although not shown, the first portion 3088A can include a port or the like substantially similar to that of the second portion 3088B that can physically and fluidically couple the first portion 3088A to, for example, a fluid reservoir and/or the like. In other embodiments, the first portion 3088A and the second portion 3088B can be arranged in any suitable manner and can each be physically and fluidically coupled to any suitable device, mechanism, and/or member included in a fluid transfer system.

[1213] In use, a portion of the lumen-defining device 3080 can be inserted into the hub 3020 to define a fluid flow path between the cannula 3022A, coupled to the distal end portion 3022 of the hub 3020, and the cannula 3088 coupled to the proximal end portion 3081 of the lumen-defining device 3080. More specifically, in some instances, a user can manipulate the hub 3020 by exerting a force on the actuator 3045, thereby moving the actuator 3045 from a first position, in which the opening 3046 of the actuator 3045 is substantially unaligned with the opening 3028 of the proximal cap 3027, to a second position, in which the opening 3046 is aligned with the opening 3028. Thus, with the actuator 3045 in the second position, the opening 3028 of the proximal cap 3027, the opening 3046 of the actuator 3046, and the lumen 3024 of the hub 3020 are sufficiently aligned to allow the distal end portion 3082 of the lumen-defining device 3080 to be inserted through the proximal cap 3027, the actuator

3045, and into the lumen 3024. As shown in FIG. 63, the lumen-defining device 3080 can be inserted into the hub 3020 by a predetermined amount that places the distal end portion 3082 extends through the valve 3026, thereby transitioning the valve 3026 from its first, substantially closed configuration to its second, substantially open configuration. Moreover, a distal surface of the lumen-defining device 3080 in contact with the shoulder 3025, as shown in FIG. 63.

[1214] With the distal surface of the lumen-defining device 3080 in contact with the shoulder 3025, the flange 3086 of the lumen-defining device 3080 is disposed within a recessed surface defined by the proximal cap 3027. In some embodiments, the shape and/or size of the recessed surface and the flange 3086 can be such that the lumen-defining device 3080 is placed into a predetermined radial position such that the lumen 3024 of the hub 3020 and the lumen 3083 of the lumen-defining device 3080 are substantially aligned, as shown in FIG. 63. Moreover, the seal member 3087 disposed about the outer surface at or near the distal end portion 3082 of the lumen-defining device 3080 is placed in contact with the inner surface 3023 of the hub 3020. In this manner, the arrangement of the flange 3086 disposed within the recessed surface of the proximal cap 3027 and the seal member 3087 in contact with the inner surface 3023 of the hub 3020, the lumen-defining device 3080 is placed in a predetermined radial position relative to the hub 3020. For example, in this embodiment, the lumen 3083 of the lumen-defining device 3080 and the lumen 3024 of the hub 3020 form a substantially continuous transition therebetween. That is to say, the lumens 3083 and 3024 are substantially aligned and/or a discontinuity defined therebetween is sufficiently minimized or obviated so as to not produce turbulence within a flow of bodily-fluid therethrough.

[1215] In addition, once the lumen-defining device 3080 is disposed in the desired and/or predetermined position within the hub 3020, the user can remove the force exerted on the actuator 3045. As such, the bias member 3047 can exert a force to move the actuator 3045 from its second position to its first position (e.g., a biased position). Thus, as shown in FIG. 63, the actuator 3045 is moved out of alignment with the hub 3020, resulting in a portion of the actuator 3045 being disposed in the notch 3085 defined by the lumen-defining device 3080, which in turn, can maintain the lumen-defining device 3080 in a substantially fixed position within the hub 3020. In this manner, a user can couple the first portion 3088A or the second portion 3088B of the cannula 3088 to, for example, a fluid reservoir such as those

described herein, which in turn, can exert a suction force (e.g., in response to a negative pressure differential) through the lumen-defining device 3080 and the hub 3020. Therefore, when the cannula 3022A is in fluid communication with the body of a patient (e.g., either directly or indirectly via an intervening structure), a volume of, for example, blood can be withdrawn with a reduced amount of hemolysis. Specifically, the alignment of the lumen 3024 defined by the hub 3020 and the lumen 3083 of the lumen-defining device 3080, for example, can reduce turbulence, eddy currents, and/or any other disturbance that can otherwise result from a discontinuity or the like. Thus, the flow of blood therethrough can be substantially laminar and substantially free of hemolysis.

[1216] Although the valve 3026 is particularly shown and described above with reference to FIGS. 62 and 63, in other embodiments, a hub can include any suitable valve. For example, FIGS. 64-66 illustrate a hub 3120 configured to receive a lumen-defining device 3180 according to another embodiment. The hub 3120 and the lumen-defining device 3080 can be substantially similar in form and/or function as the hub 3020 and the lumen-defining device 3080 described above with reference to FIGS. 61-63. Thus, such similar aspects are not described in further detail herein.

[1217] As shown in FIGS. 64-66, the hub 3120 has a proximal end portion 3121, a distal end portion 3122, and an inner surface 3123 defining a lumen 3124 therethrough (see e.g., FIG. 66). The distal end portion 3122 of the hub 3120 includes and/or is coupled to a cannula 3122A and/or other suitable lumen-defining device. While the hub 3020 is shown and described as being coupled to a single cannula and/or a cannula defining a single lumen, in this embodiment, the hub 3120 is coupled to a bifurcated cannula having a first portion (also referred to herein as "first cannula" or "cannula 3122A") and a second portion 3122B. In other embodiments, the hub 3120 can be coupled to a single cannula and/or a cannula defining a single lumen. The proximal end portion 3121 of the hub 3120 includes and/or is coupled to a proximal cap 3127 and an actuator 3145, as described in detail above. The proximal cap 3127 defines an opening 3128 that is, for example, substantially aligned with the lumen 3124 defined by the inner surface 3123. In this manner, a portion of the lumen-defining device 3180 can be inserted through the opening 3128 of the proximal cap 3127 to be disposed within the hub 3120, as described in further detail herein.

[1218] As shown in FIGS. 65 and 66, the actuator 3145 is disposed between the proximal end portion 3121 and the proximal cap 3128. The actuator 3145 forms a substantially annular

ring or the like that is movably disposed within a space defined between a proximal surface of the hub 3120 and a distal surface of the proximal cap 3127. In addition, the actuator 3145 includes and/or is coupled to a bias member 3147, which can exert a force to temporarily maintain the actuator 3145 in a predetermined position relative to the hub 3120, for example, until a force is exerted on the actuator 3145 sufficient to overcome the force exerted by the bias member 3147. In this manner, the arrangement of the proximal end portion 3121 of the hub 3120, the proximal cap 3127, and the actuator 3145 can be substantially similar to the proximal end portion 3021 of the hub 3020, the proximal cap 3027, and the actuator 3045 described above with reference to FIGS. 62 and 63.

[1219] As shown in FIG. 66, the inner surface 3123 of the hub 3120 defines the lumen 3124 extending through its proximal end portion 3121 and its distal end portion 3122, which is configured to receive a portion of the lumen-defining device 3180. Furthermore, the inner surface 3123 includes a valve and a sealing surface 3125. As shown in FIG. 66, in this embodiment, the valve is a ball valve 3126, which can be transitioned between a first, substantially closed configuration and a second, substantially opened configuration. More specifically, the hub 3120 includes a bias member 3148 in contact with the ball valve 3126. In this manner, the bias member 3148 can exert a force on the ball valve 3126 that places the ball valve 3126 in contact with the sealing surface 3125. Thus, a contact sufficient to maintain a substantially fluid tight seal can be maintained when the ball valve 3126 is in contact with the sealing surface 3125 (e.g., in the first configuration) via a force exerted by the bias member 3148. Conversely, when a force exerted on the ball valve 3126, opposite the force exerted by the bias member 3148, is sufficient to overcome the force exerted by the bias member 3148, the ball valve 3126 can be removed from contact with the sealing surface 3125 and thus, a fluid flow path can be defined therethrough. In some embodiments, the insertion of the portion of the lumen-defining device 3180 can be operable in transitioning the ball valve 3126 from the first configuration to the second configuration, as described in further detail herein.

[1220] The lumen-defining device 3180 has a proximal end portion 3181, a distal end portion 3182, and a flange 3186. The lumen-defining device 3180 also defines a notch 3185 and a lumen 3183 extending through the proximal end portion 3181 and the distal end portion 3182, as described in further detail herein. As shown, for example, in FIGS. 64-66, the proximal end portion 3181 of the lumen-defining device 3180 is physically and fluidically

coupled to a cannula 3188. The cannula 3188 can be any suitable configuration. For example, in this embodiment, the cannula 3188 is a single cannula and/or a cannula that defines a single lumen. In other embodiments, the cannula 3188 can be a bifurcated cannula, as described in detail above with reference to the cannula 3088 in FIG. 61. Moreover, although not shown in FIGS. 64-66, the cannula 3188 can include any suitable port, locking mechanism, and/or the like, as described above.

[1221] As shown in FIGS. 65 and 66, the distal end portion 3182 of the lumen-defining device 3180 is configured to be inserted through the proximal cap 3127 and the actuator 3145 to be disposed within the hub 3120, as described in further detail herein. Moreover, the lumen-defining device 3180 includes a seal member 3187 disposed about an outer surface of the distal end portion 3182, which is placed in contact with the inner surface 3123 of the hub 3120 which the lumen-defining device 3180 is disposed therein. As shown in FIG. 66, the lumen 3183 of defined by the lumen-defining device 3080 at or near the distal end portion 3182 is diverted, for example, into one or more channels and defining a substantially smooth transition therebetween. In some embodiments, the one or more channels, for example, can be offset from the lumen 3183 (e.g., non-coaxial). In other words, each channel is radially offset from a longitudinal centerline CL, as shown in FIG. 66. Thus, when a distal surface of the lumen-defining device 3180 is placed in contact with, for example, the ball valve 3126, the channels and/or the lumen 3183 are/is substantially unobstructed, as described in further detail herein.

[1222] In use, a portion of the lumen-defining device 3180 can be inserted into the hub 3120 to define a fluid flow path between the cannula 3122A, coupled to the distal end portion 3122 of the hub 3120, and the cannula 3188 coupled to the proximal end portion 3181 of the lumen-defining device 3180. More specifically, in some instances, a user can manipulate the hub 3120 by exerting a force on the actuator 3145, thereby moving the actuator 3145 from a first position, in which the opening 3146 of the actuator 3145 is substantially unaligned with the opening 3128 of the proximal cap 3127, to a second position, in which the opening 3146 is aligned with the opening 3128, as described in detail above. As shown in FIG. 66, the lumen-defining device 3180 can be inserted into the hub 3120 by a predetermined amount that places a distal surface of the lumen-defining device 3180 in contact with the ball valve 3126. In this manner, the lumen-defining device 3180 can be inserted into the hub 3180 until the flange 3186 of the lumen-defining device 3180 is disposed within a recessed surface

defined by the proximal cap 3127, thereby aligning the lumen-defining device 3180, as described in detail above. Moreover, the seal member 3187 disposed about the outer surface at or near the distal end portion 3182 of the lumen-defining device 3180 is placed in contact with the inner surface 3123 of the hub 3120. In this manner, the lumen-defining device 3180 can be inserted into a position that removes the ball valve 3126 from the sealing surface 3125, thereby defining a fluid flow path between the lumen 3124 of the hub 3120 and the lumen 3183 (and/or channels) of the lumen-defining device 3180.

[1223] Once the lumen-defining device 3180 is disposed in the desired and/or predetermined position within the hub 3120, the user can remove the force exerted on the actuator 3145. As such, the bias member 3147 can exert a force to move the actuator 3145 from its second position to its first position (e.g., a biased position), resulting in a portion of the actuator 3145 being disposed in the notch 3185 defined by the lumen-defining device 3180. Thus, the actuator 3145 can maintain the lumen-defining device 3180 in a substantially fixed position within the hub 3120, as described in detail above. In this manner, a user can couple the cannula 3188, for example, to a fluid reservoir such as those described herein. Therefore, when the cannula 3122A is in fluid communication with the body of a patient (e.g., either directly or indirectly via an intervening structure), a volume of, for example, blood can be withdrawn with a reduced amount of hemolysis, as described in detail above. Specifically, the alignment of the lumen 3124 defined by the hub 3120 and the channels and/or lumen 3183 of the lumen-defining device 3180, for example, can reduce turbulence, eddy currents, and/or any other disturbance that can otherwise result from a discontinuity or the like. Thus, the flow of blood therethrough can be substantially laminar and substantially free of hemolysis.

[1224] Although the hubs 3020 and 3120 have a proximal end portion including an actuator, in other embodiments, a hub can have any suitable configuration and need not include an actuator. For example, FIGS. 67 and 68 illustrate a hub 3320 configured to receive a lumen-defining device 3280 according to another embodiment. The hub 3220 and the lumen-defining device 3280 can be substantially similar in form and/or function as the hub 3020 and the lumen-defining device 3080 and/or the hub 3120 and the lumen-defining device 3180, described in detail above. Thus, such similar aspects are not described in further detail herein. As shown in FIGS. 67 and 68, the hub 3220 has a proximal end portion 3221, a distal end portion 3222, a secondary port 3289, and an inner surface 3223 defining a

lumen 3224 therethrough (see e.g., FIG. 68). The hub 3220 further includes a valve 3226 disposed within the lumen 3224, as described in further detail herein.

[1225] The distal end portion 3222 of the hub 3220 includes and/or is coupled to a cannula 3222A and/or other suitable lumen-defining device, as described above with reference to the hub 3020 in FIGS. 61-63. The proximal end portion 3221 of the hub 3220 includes and/or is coupled to a proximal cap 3227. As shown in FIGS. 67 and 68, in this embodiment, the proximal cap 3237 can be, for example, a locking mechanism or the like configured to form a treaded coupling with a portion of the lumen-defining device 3280, as described in further detail herein.

[1226] As shown in FIG. 68, the inner surface 3223 of the hub 3220 defines the lumen 3224 extending through its proximal end portion 3221 and its distal end portion 3222, which is configured to receive a portion of the lumen-defining device 3280. Furthermore, the inner surface 3223 includes and/or otherwise forms a shoulder 3225. In this embodiment, the shoulder 3225 is associated with a change in diameter of the inner surface 3223. For example, a first portion of the inner surface 3223 (e.g., a proximal portion) can have a first diameter that is larger than a diameter of a second portion of the inner surface (e.g., a distal portion). In this manner, the shoulder 3225 can be placed in contact with a surface of the lumen-defining device 3280 when inserted therein, as described in detail above with reference to the hub 3020. In some embodiments, the shoulder 3225 can form, for example, a seat or a recessed portion configured to receive a portion of the lumen-defining device 3280.

[1227] The valve 3226 of the hub 3220 can be, for example, a one-valve, a port, and/or the like, which can be transitioned between a first, substantially closed configuration and a second, substantially opened configuration. Thus, when in the first configuration, the valve 3226 can fluidically isolate a portion of the lumen 3224 that is proximal to the valve 3226 from a portion of the lumen 3224 that is distal to the valve 3226. Conversely, when the valve 3226 is in the second configuration, the lumen 3224 can define a fluid flow path substantially through the hub 3220. In some embodiments, the insertion of the distal end portion 3282 of the lumen-defining device 3280 can be operable in transitioning the valve 3226 from the first configuration to the second configuration, as described in further detail herein.

[1228] The secondary port 3289 of the hub 3280 can be any suitable port or the like. For example, in some embodiments, the hub 3220 can be arranged as a T-adapter or the like, in

which the proximal end portion 3221 defines a first port and the secondary port 3289 extends in a substantially perpendicular direction from the first port. In this manner, the secondary port 3289 is in fluid communication with the lumen 3224 defined by the hub 3220 and can be configured to receive and/or deliver a fluid from and/or to the lumen 3224 of the hub 3220. Moreover, the arrangement of the secondary port 3289 is such that when the valve 3226 is in its closed configuration, the secondary port 3289 is fluidically isolated from a portion of the lumen 3224 proximal to the valve 3226.

[1229] The lumen-defining device 3080 has a proximal end portion 3031, a distal end portion 3032, and a flange 3086. The lumen-defining device 3080 also defines a notch 3085 and a lumen 3083 extending through the proximal end portion 3081 and the distal end portion 3082, as described in further detail herein. As shown in FIGS. 62 and 63, the distal end portion 3082 of the lumen-defining device 3080 is configured to be inserted through the proximal cap 3027 and the actuator 3045 to be disposed within the hub 3020, as described in further detail herein. Moreover, the lumen-defining device 3080 includes a seal member 3087 disposed about an outer surface of the distal end portion 3082, which is placed in contact with the inner surface 3023 of the hub 3020 which the lumen-defining device 3080 is disposed therein.

[1230] The lumen-defining device 3280 has a proximal end portion 3281 and a distal end portion 3282, and defines a lumen 3283 therethrough. As shown, for example, in FIG. 68, the proximal end portion 3281 of the lumen-defining device 3280 is physically and fluidically coupled to a cannula 3288. The cannula 3288 can be any suitable configuration. For example, in this embodiment, the cannula 3288 is a single cannula and/or a cannula that defines a single lumen. In some embodiments, the cannula 3288 can be substantially similar to the cannula 3188 described above wither reference to FIGS. 64-66.

[1231] As shown in FIG. 68, the distal end portion 3282 of the lumen-defining device 3280 is configured to be inserted through the proximal cap 3227 to be disposed within the hub 3220. More specifically, a portion of the lumen-defining device 3280 can be inserted into the proximal cap 3227 and configured to form, for example, a threaded coupling or the like. For example, in some embodiments, a portion of an outer surface of the lumen-defining device 3280 can include a set of treads or the like configured to engage a corresponding set of threads included in and/or defined by the proximal cap 3227. Thus, in use, as the lumen-defining device 3280 is inserted through the proximal cap 3227, the proximal cap 3227

and/or the lumen-defining device 3280 can be rotated to form the threaded coupling therebetween. Moreover, the arrangement of the lumen-defining device 3280 can be such that when coupled to the proximal cap 3227, the distal end portion 3282 of the lumen-defining device 3280 extends through the valve 3226. Thus, the valve 3226 is transitioned from its first, substantially closed configuration to its second, substantially open configuration. In some embodiments, the valve 3226 can be configured to form a substantially fluid tight seal about a portion of the lumen-defining device 3280, which in turn, can maintain the secondary port 3289 in fluid isolation from, for example, the lumen 3283 of the lumen-defining device 3280. Moreover, the lumen-defining device 3280 is advanced such that a distal surface of the lumen-defining device 3280 is in contact with the shoulder 3225, as shown in FIG. 68.

[1232] In this embodiment, the arrangement of the lumen-defining device 3280 and the proximal cap 3227 (i.e., the coupling therebetween) is such that the lumen 3283 of the lumen-defining device 3280 and the lumen 3224 of the hub 3220 form a substantially continuous transition therebetween. That is to say, the lumens 3283 and 3224 are substantially aligned and/or a discontinuity defined therebetween is sufficiently minimized or obviated so as to not produce turbulence within a flow of bodily-fluid therethrough. Therefore, when the cannula 3222A is in fluid communication with the body of a patient (e.g., either directly or indirectly via an intervening structure), a volume of, for example, blood can be withdrawn with a reduced amount of hemolysis. Specifically, the alignment of the lumen 3224 defined by the hub 3220 and the lumen 3283 of the lumen-defining device 3280, for example, can reduce turbulence, eddy currents, and/or any other disturbance that can otherwise result from a discontinuity or the like. Thus, the flow of blood therethrough can be substantially laminar and substantially free of hemolysis.

[1233] While the hubs 3020, 3120, and 3220 are shown and described above as receiving the lumen-defining devices 3080, 3180, and 3280 (e.g., a connector), respectively, in other embodiments, a hub can be configured to receive a terminated end of a cannula or the like (e.g., without a connector or other lumen-defining device). For example, FIGS. 69-71 illustrate a hub 3320 configured to receive a cannula 3388 according to another embodiment. The hub 3320 and the lumen-defining device 3080 can be substantially similar in form and/or function as the hub 3020 and the lumen-defining device 3080 and/or the hub 3120 and the

lumen-defining device 3180, described in detail above. Thus, such similar aspects are not described in further detail herein.

[1234] As shown in FIGS. 69-71, the hub 3320 has a proximal end portion 3321, a distal end portion 3322, and an inner surface 3323 defining a lumen 3324 therethrough (see e.g., FIG. 71). The distal end portion 3322 of the hub 3320 includes and/or is coupled to a cannula 3322A and/or other suitable lumen-defining device. In some embodiments, the distal end portion 3322 of the hub 3320 can be substantially similar to the distal end portion 3322 of the hub 3020 described above with reference to FIGS. 61-63. The proximal end portion 3321 of the hub 3320 includes and/or is coupled to a proximal cap 3327, as described in detail above. The proximal cap 3327 defines an opening 3328 that is, for example, substantially aligned with the lumen 3324 defined by the inner surface 3323. In this manner, a portion of the cannula 3388 can be inserted through the opening 3328 of the proximal cap 3327 to be disposed within the hub 3320, as described in further detail herein.

[1235] As shown in FIGS. 70 and 71, the proximal end portion 3321 of the hub 3320 further includes and or is coupled to a first coupling member 3345 and a second coupling member 3349. As described above with reference to the actuator 3145, the first coupling member 3345 is disposed between the proximal end portion 3321 and the proximal cap 3327. The first coupling member 3345 is configured to selective receive a portion of the second coupling member 3349. The second coupling member 3349 is configured to be disposed about a portion of the cannula 3388. Thus, the second coupling member 3349 can be inserted substantially concurrently with the cannula 3388. Moreover, the second coupling member 3349 is configured to engage the first coupling member 3345 disposed within the hub 3320, for example, to at least temporarily maintain the cannula 3388 in a fixed position. For example, in some embodiments, the second coupling portion 3349 can form a snap fit, a press fit, a friction fit, and/or the like when placed in contact with the first coupling member 3345, as described in further detail herein.

[1236] As shown in FIG. 71, the inner surface 3323 of the hub 3320 defines the lumen 3324 extending through its proximal end portion 3321 and its distal end portion 3322, which is configured to receive a portion of the cannula 3388. Furthermore, the inner surface 3323 includes and/or otherwise forms a shoulder 3325. In this embodiment, the shoulder 3325 is associated with a change in diameter of the inner surface 3323. For example, a first portion of the inner surface 3323 (e.g., a proximal portion) can have a first diameter that is larger than

a diameter of a second portion of the inner surface (e.g., a distal portion). In this manner, the shoulder 3325 can be placed in contact with a surface of the cannula 3388 when inserted therein, as described in detail above with reference to the hub 3020.

[1237] The hub 3320 further includes a valve 3326 disposed within the lumen 3324. The valve 3326 can be, for example, a one-valve, a port, and/or the like, which can be transitioned between a first, substantially closed configuration and a second, substantially opened configuration. Thus, when in the first configuration, the valve 3326 can fluidically isolate a portion of the lumen 3324 that is proximal to the valve 3326 from a portion of the lumen 3324 that is distal to the valve 3326. Conversely, when the valve 3326 is in the second configuration, the lumen 3324 can define a fluid flow path substantially through the hub 3320. In some embodiments, the insertion of the portion of the cannula 3388 can be operable in transitioning the valve 3326 from the first configuration to the second configuration, as described in further detail herein.

[1238] In use, a portion of the cannula 3388 can be inserted into the hub 3320 to define a fluid flow path between the cannula 3322A, coupled to the distal end portion 3322 of the hub 3320, and the cannula 3388 coupled to the proximal end portion 3381 of the cannula 3388. More specifically, in some instances, a user can insert an end portion of the cannula 3388 through the second coupling member 3349. Once the second coupling member 3349 is disposed about the cannula 3380, the cannula 3388 can be inserted into the hub 3320 by a predetermined amount that extends, for example, a distal end portion of the cannula 3388 through the valve 3326, thereby transitioning the valve 3326 from its first, substantially closed configuration to its second, substantially open configuration. Moreover, a distal surface of the cannula 3388 in contact with the shoulder 3325, as shown in FIG. 71. As the cannula 3388 is moved into its desired position within the hub 3320, the second coupling member 3349 is inserted through the opening 3328 defined by the proximal cap 3327 and into contact with the first coupling member 3345. Thus, the second coupling member 3349 can engage the first coupling member 3345 to define, for example, a snap fit or the like. In some embodiments, the arrangement of the second coupling member 3349 can be such that when it engages the first coupling member 3349, a space through which the cannula 3388 extends is reduced. As such, the second coupling member 3349 can clamp the cannula 3388 and with the second coupling member 3349 being coupled to the first coupling member 3345, the first coupling member 3345 and the second coupling member 3349 can act to at least

temporarily maintain the cannula 3388 in a substantially fixed position relative to the hub 3320. Although described above as being moved substantially concurrently with the cannula 3388, in other embodiments, the second coupling member 3349 can be moved after the distal surface of the cannula 3388 is placed in contact with the shoulder 3325.

[1239] In some embodiments, the arrangement of the hub 3320 and the cannula 3388 is such that when the cannula 3388 is maintained in the substantially fixed position, the lumen 3324 of the hub 3320 is substantially aligned with a lumen defined by the cannula 3388. For example, in this embodiment, the lumen of the cannula 3388 and the lumen 3324 of the hub 3320 form a substantially continuous transition therebetween. That is to say, the lumens are substantially aligned and/or a discontinuity defined therebetween is sufficiently minimized or obviated so as to not produce turbulence within a flow of bodily-fluid therethrough. In this manner, a user can couple the cannula 3388 to, for example, a fluid reservoir such as those described herein, which in turn, can exert a suction force (e.g., in response to a negative pressure differential) through the cannula 3388 and the hub 3320. Therefore, when the cannula 3322A is in fluid communication with the body of a patient (e.g., either directly or indirectly via an intervening structure), a volume of, for example, blood can be withdrawn with a reduced amount of hemolysis. Specifically, the alignment of the lumen 3324 defined by the hub 3320 and the lumen of the cannula 3388, for example, can reduce turbulence, eddy currents, and/or any other disturbance that can otherwise result from a discontinuity or the like. Thus, the flow of blood therethrough can be substantially laminar and substantially free of hemolysis.

[1240] Although the embodiments are shown and described above as mitigating the risk of hemolysis of a volume of blood at a given point along a fluid flow path between a patient and a fluid reservoir, any embodiment configured to mitigate the risk of hemolysis at a given point along the fluid flow path can be used in conjunction with any suitable embodiment(s) configured to mitigate the risk of hemolysis at a different point along the fluid flow path. In some instances, a fluid transfer device can include any combination of the embodiments described herein, for example, to mitigate the risk of hemolysis otherwise associated with (1) blood flow from, for example, a vein into a puncture member, needle, cannula, and/or the like; (2) blood flow through changing geometries and/or physical and fluidic interfaces; (3) blood flow rates, pressures, and/or velocities within the fluid flow path; (4) blood flow from an adapter, puncture member, needle, cannula, and/or the like into a fluid reservoir; (5) blood

flow exposure to a negative pressure differential within a fluid reservoir; and/or (6) blood flow through a multi-lumen adapter and/or the like.

[1241] While the embodiments are shown and described above as mitigating the risk of hemolysis of a volume of blood during, for example, aspiration, blood draw, and/or any other procedure in which blood is withdrawn from the body, in other instances, any embodiment configured to mitigate the risk of hemolysis described herein, and/or any combination thereof, can be used in any suitable medical device and/or procedure in which it is desirable to reduce hemolysis. For example, any of the embodiments or combinations of the embodiments described herein such as the adapters, puncture members, restrictors, fluid reservoirs, gaskets, etc., and/or characteristics, geometries, and/or features thereof can be used to mitigate the risk of hemolysis in any suitable device and/or during any suitable medical procedure. Such devices and/or procedures can include but are not limited to, mechanical hearts and/or other organs, perfusion machines used, for example, during open-heart surgery, dialysis machines, and/or the like. In some instances, the embodiments and/or combination of embodiments described herein can be used to modulate pressure within such devices, produce a laminar flow through at least a portion of such devices, reduce and/or limit shear stress and/or exposure time experienced by red blood cells, and/or the like.

[1242] Although not shown or described herein, any of the embodiments can be used in a fluid transfer device configured to, for example, divert a predetermined pre-sample volume of bodily-fluid that can contain, for example, externally residing microbes prior to collection of a sample volume of bodily. For example, in some embodiments, the predetermined pre-sample volume can be about a drop or a few drops of blood, about 0.1 mL, about 0.3 mL, about 0.5 mL, about 1.0 mL, about 2.0 mL, about 3.0 mL, about 4.0 mL, about 5.0 mL, about 11.0 mL, about 20 mL, about 50 mL, and/or any volume or fraction of a volume therebetween. In other embodiments, the pre-sample volume can be greater than 50 mL or less than 0.1 mL. In other embodiments, the predetermined pre-sample volume can be between about 2 mL and about 5 mL. In one embodiment, the predetermined pre-sample volume can be about 3 mL. In some instances, a venipuncture event can result in trauma to the blood flowing within the punctured vein that can at least temporarily hemolyze a portion of the blood. Thus, in some embodiments, the diverted pre-sample volume of blood can include, for example, the hemolyzed portion of the blood. Furthermore, by collecting the

predetermined pre-sample volume, the predetermined sample volume disposed in one or more sample reservoirs can be substantially free-from externally residing microbes.

[1243] Fluid transfer devices configured to divert a predetermined pre-sample volume of bodily-fluid can be any suitable configuration. For example, in some embodiments, such a fluid transfer device can be substantially similar to or the same as the fluid transfer devices described in U.S. Patent No. 8,535,241 entitled, "Fluid Diversion Mechanism for Bodily-Fluid Sampling," filed October 12, 2012; U.S. Patent No. 9,060,724 entitled, "Fluid Diversion Mechanism for Bodily-Fluid Sampling," filed May 29, 2013; U.S. Patent No. 9,155,495 entitled, "Syringe-Based Fluid Diversion Mechanism for Bodily-fluid Sampling," filed December 2, 2013; and/or U.S. Patent Publication No. 2014/0155782 entitled, "Sterile Bodily-Fluid Collection Device and Methods," filed December 4, 2012, the disclosures of which are incorporated herein by reference in their entireties and attached hereto as Exhibit A, Exhibit B, Exhibit C, and Exhibit D, respectively. Moreover, in some embodiments, such transfer devices can be configured to selectively obstruct a needle to prevent hemolyzed blood from entering a lumen defined by the needle during a venipuncture event. Such devices can be substantially similar to and/or the same as those described in U.S. Patent Publication No. 2014/0276578, entitled, "Methods and Apparatus for Selectively Occluding the Lumen of a Needle," filed September 18, 2014, the disclosure of which is incorporated herein by reference in its entirety and attached hereto as Exhibit E.

[1244] In some embodiments, the bodily-fluid transfer devices described herein can include and/or can be partially formed from antisepsis-saturated materials. For example, any of the valves, gaskets, seals, ports, and/or the like can be saturated with, for example, isopropyl alcohol. As such, when various components of a fluid transfer device are coupled and/or otherwise collectively form an interface, the components can be contemporaneously sterilized. In some embodiments, such a device can be substantially similar to or the same as those described in U.S. Patent Publication No. 2015/0246352 entitled, "Apparatus and Methods for Disinfection of a Specimen Container," filed March 3, 2015, the disclosure of which is incorporated herein by reference in its entirety and attached as Exhibit F.

[1245] While the device 100 is described above as including a surface, mechanism, portion, etc. configured to reduce hemolysis of a volume of blood in a mechanical manner (e.g., by mechanically changing one or more characteristics of a flow of blood within a fluid flow path), in other embodiments, any of the devices can be configured to chemically modify

one or more characteristics associated with the volume of blood. For example, in some embodiments, an inner surface of any of the embodiments described herein can be coated with a chemical configured to limit lysis of erythrocytes (red blood cells) by strengthening or weakening a cell wall of the erythrocytes. More specifically, in some embodiments, a can be configured to introduce a chemical into a flow of blood that can, for example, increase a rigidity of the cell wall of erythrocytes (e.g., decrease flexibility), which in turn, can reduce a likelihood of lysis of the erythrocytes (e.g., hemolysis of the blood) as the blood flows through the device. In other embodiments, a device can be configured to introduce a chemical into a flow of blood that can, for example, decrease a rigidity of the cell wall of erythrocytes (e.g., increase flexibility), which in turn, can reduce a likelihood of lysis of the erythrocytes as the blood flows through the device.

[1246] While described above as coating an inner surface of a device with the chemical configured to modify a characteristic of the cell wall of the erythrocytes, in other embodiments, any of the embodiments described herein can include any suitable device, mechanism, and/or method for introducing such a chemical to the volume of blood flowing therethrough. For example, a device can include a chamber containing such a chemical (e.g., a chamber within a Luer lock or the like), a baffle, wipe, valve, porous material (e.g., sintered glass or plastic), etc. impregnated with such a chemical, a dispensing or dispersing device (e.g., sprayer or the like) configured to dispense a volume of such a chemical, and/or any other suitable means for introducing such a chemical. Moreover, a device can include any suitable combination of devices, interfaces, members, mechanisms, etc. included in the embodiments described herein as well as any suitable means for introducing a chemical into a volume of blood flowing through such a device.

[1247] As described above, in some instances, introducing a chemical into a volume of blood (e.g., whole blood) can result in a strengthening of an erythrocyte membrane or outer structure, or in other words, can modify a magnitude of stability associated with the erythrocyte membrane. In some instances, such stabilization can result in an increased resistance to hemolysis caused by mechanical stress, osmotic stress, peroxyl radicals attack, heat, and/or the like. Examples of chemicals that can modify a characteristic associated with an erythrocyte membrane include phloridzin, cremophore (glycerol polyethylene glycol ricinoleate, lidocaine, antioxidants such as reduced glutathione (GSH), N-acetylcysteine, ebselen (2-phenyl-1, 2-benzoselenazol-3-one) and/or albumin, papaya leaf and/or other plant

extracts, tranquilizers and/or antihistamines such as phenothiazine, reserpine, and/or haloperidol, saponins and/or sapogenins, polyamines, anti-inflammatory drugs such as phenylbutazone, methylsergide, and/or indomethacin, and/or any other suitable chemical.

[1248] While various embodiments have been particularly shown and described, various changes in form and details may be made. While embodiments have been described above, it should be understood that they have been presented by way of example only, and not limitation. Although various embodiments have been described as having particular features and/or combinations of components, other embodiments are possible having any combination or sub-combination of any features and/or components from any of the embodiments described herein. For example, in some embodiments, a restrictor such as, for example, the restrictor 650 can be used when collecting a bodily-fluid using any of the fluid reservoirs described herein. Similarly, the hub 3020 and lumen-defining device 3080 described above with reference to FIGS. 61-63 can be used with any of the adapters described herein. Moreover, any suitable combination of components described herein can be physically and/or fluidically coupled together to form a bodily-fluid collection device configured, for example, to reduce hemolysis in a withdrawn volume of blood.

[1249] The specific configurations of the various components can also be varied. For example, the size and specific shape of the various components can be different from the embodiments shown, while still providing the functions as described herein. More specifically, the size and shape of the various components can be specifically selected for a desired rate of bodily-fluid flow into a fluid reservoir. While various components have been described above a being physically and fluidically coupled, in other embodiments, any of the devices and/or embodiments can be, for example, monolithically formed with and/or otherwise joined to any other suitable device and/or embodiment. For example, while the first adapter 1020, the second adapter 1030, and the restrictor 1050 are described above with reference to FIGS. 18-20 as being formed separately and subsequently coupled, in other embodiments, the first adapter 1020 and/or the second adapter 1030 can be monolithically formed with the restrictor 1050. In some instances, such a monolithically formed component can be included in, for example, a pre-assembled and sterile blood collection device and/or the like.

[1250] Where methods and/or events described above indicate certain events and/or procedures occurring in certain order, the ordering of certain events and/or procedures may

be modified. Additionally, certain events and/or procedures may be performed concurrently in a parallel process when possible, as well as performed sequentially as described above.

Abstract

A collection system has a proximal end portion, a distal end portion, and an inner surface defining a fluid flow path therethrough. The distal end portion is configured to be placed in fluid communication with a patient. The proximal end portion is configured to be placed in fluid communication with a fluid reservoir. The fluid flow path defined by the inner surface is associated with at least one flow characteristic configured to limit a stress within the flow of the bodily-fluid between the distal end portion and the proximal end portion.

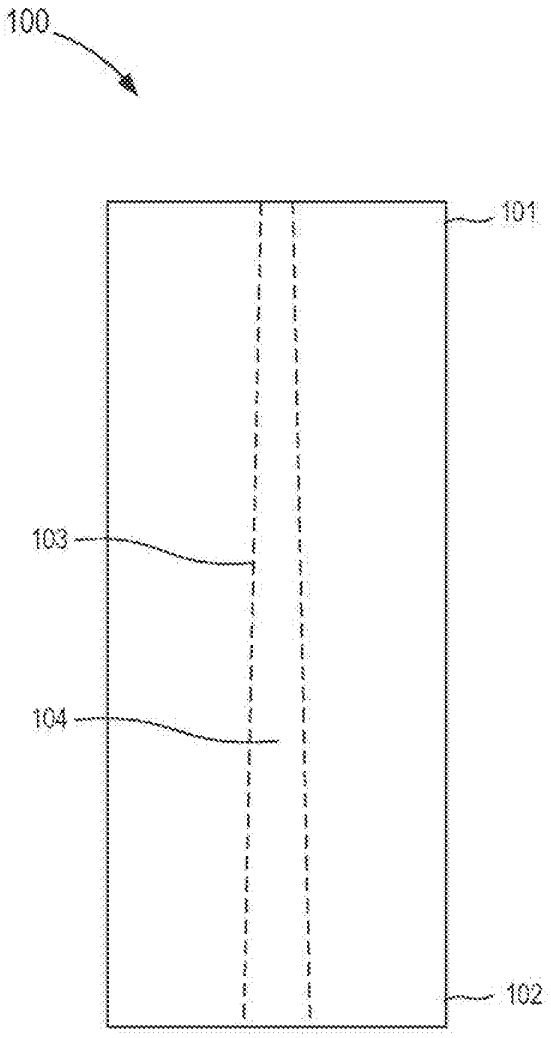


FIG. 1

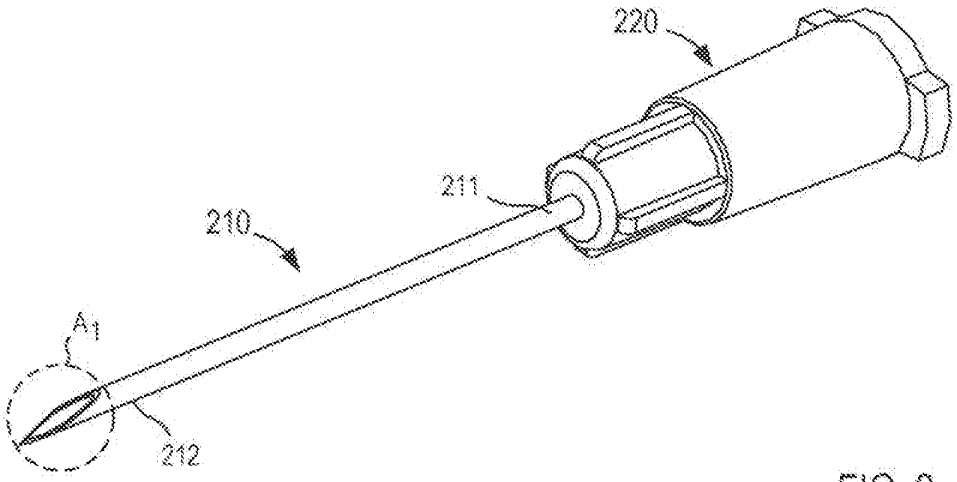


FIG. 2

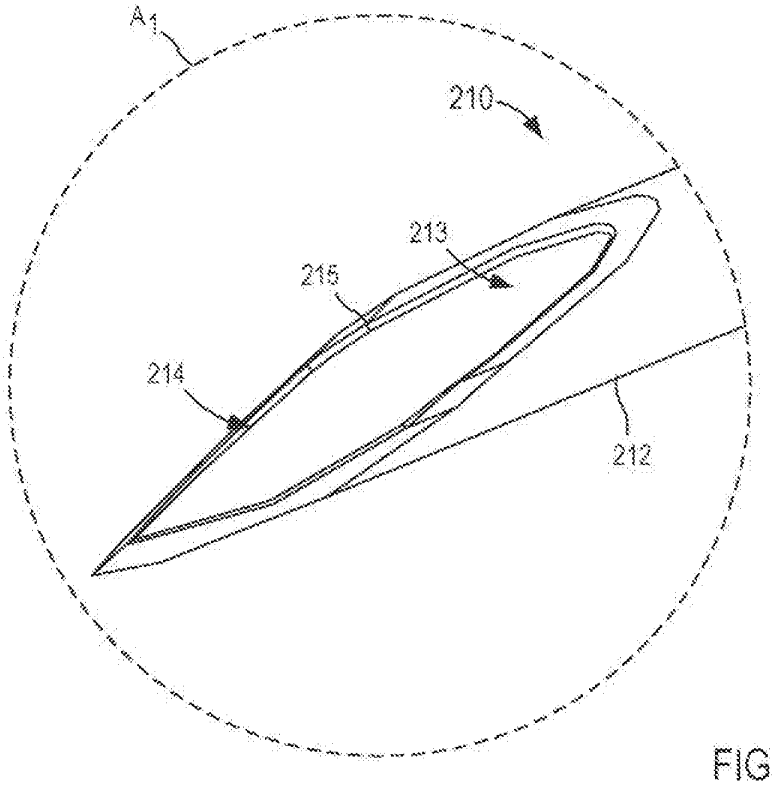


FIG. 3

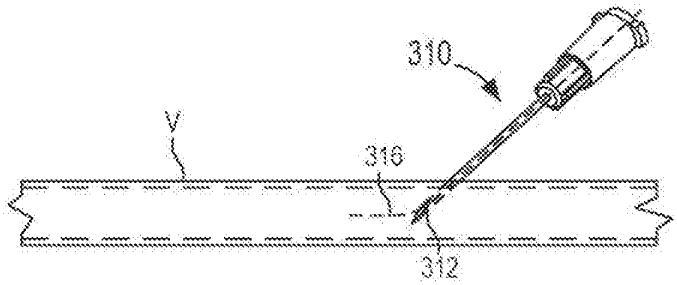


FIG. 4

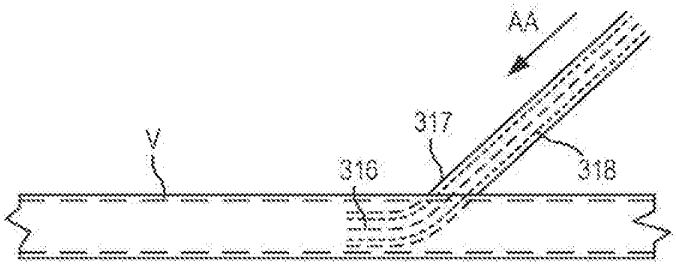


FIG. 5

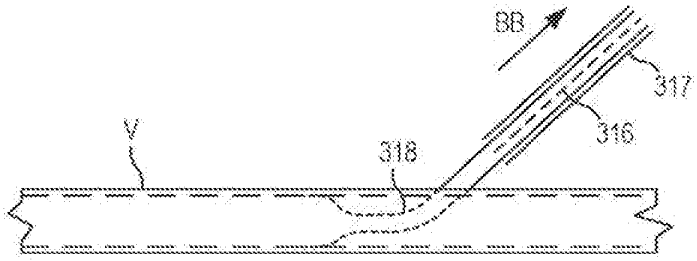


FIG. 6

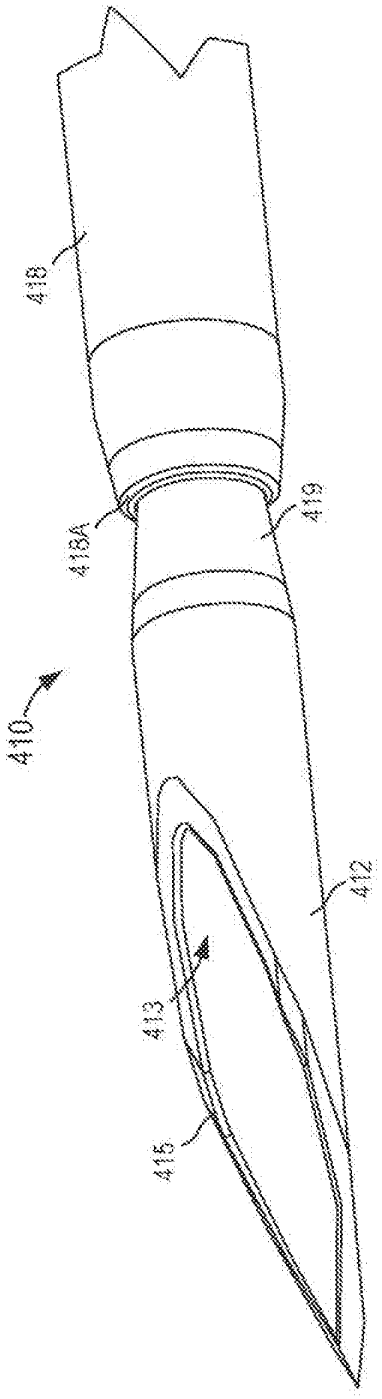


FIG. 7

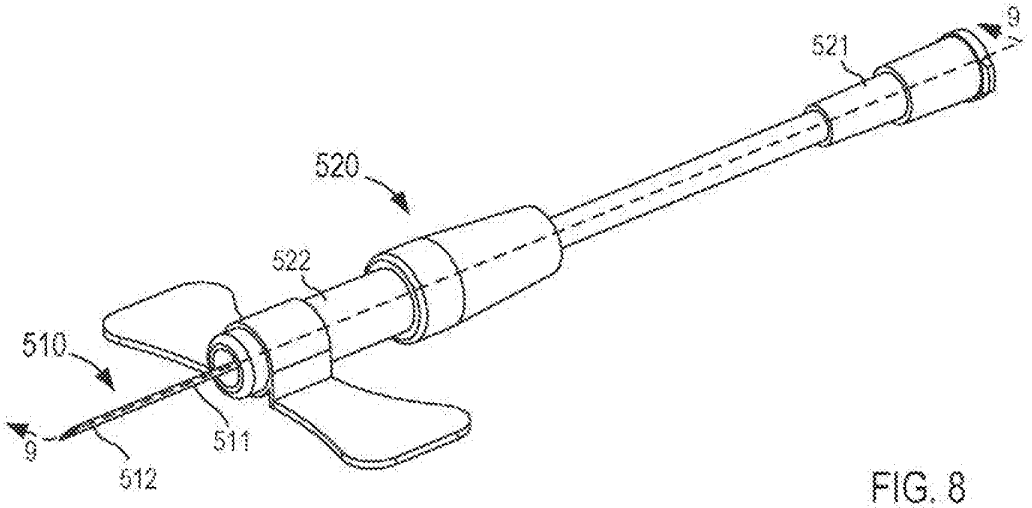


FIG. 8

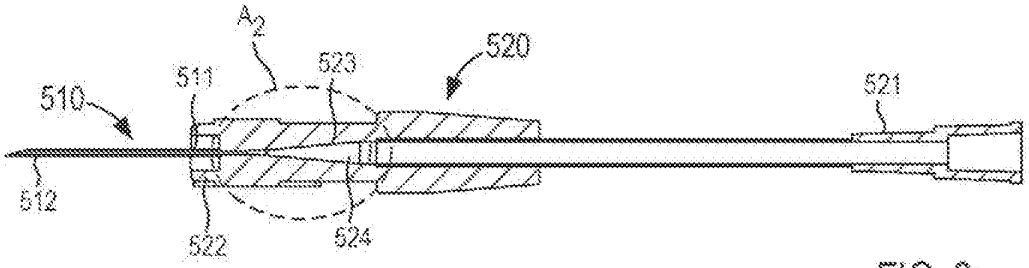


FIG. 9

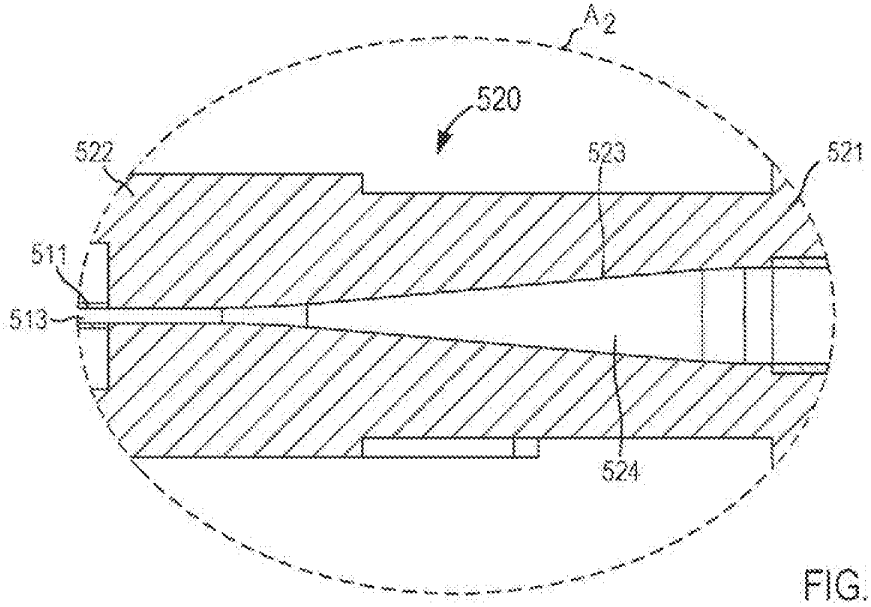


FIG. 10

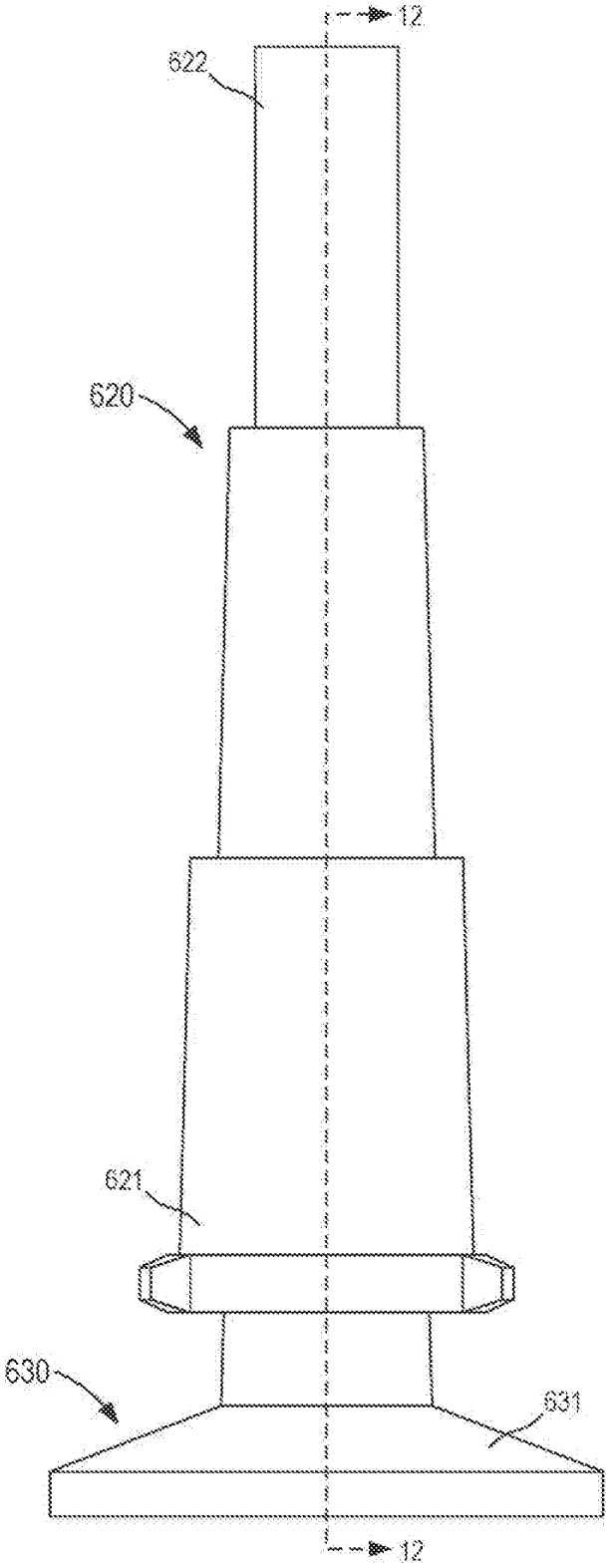


FIG. 11

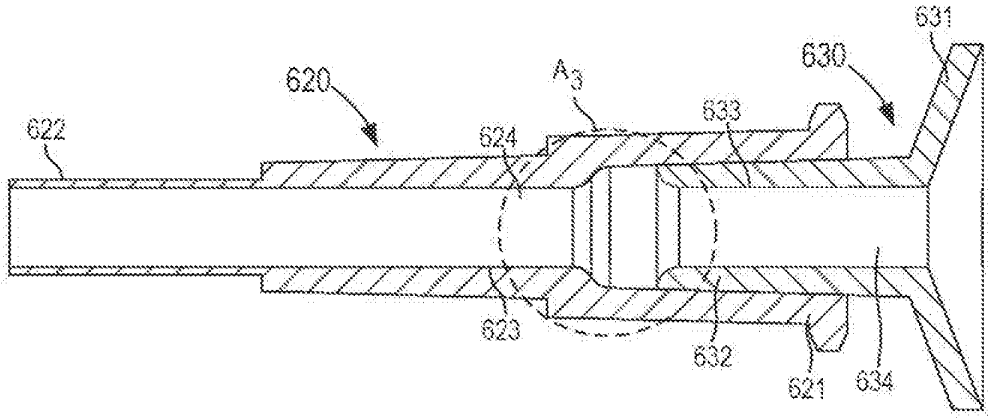

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FIG. 12

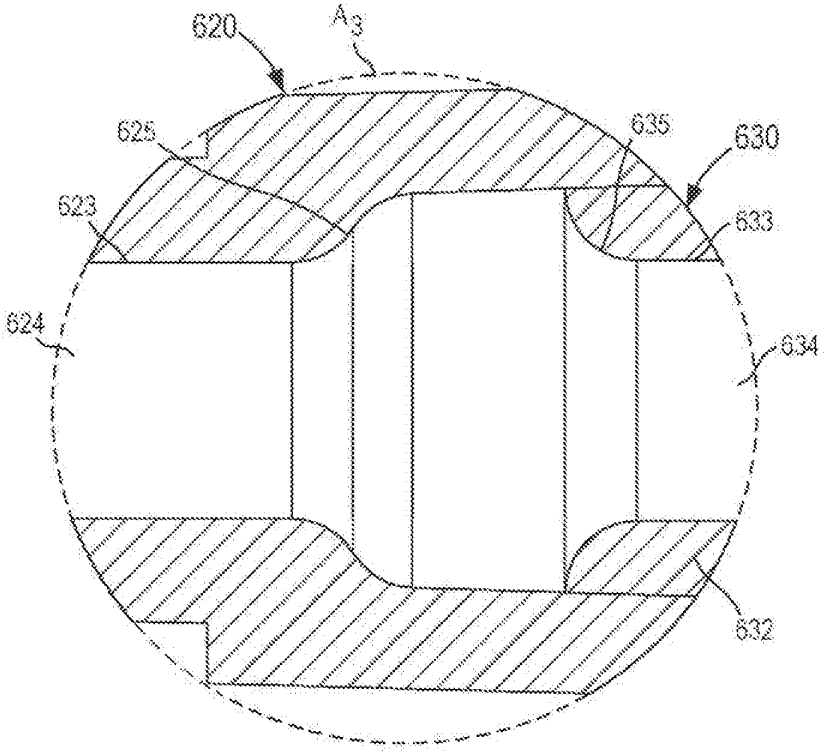

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FIG. 13

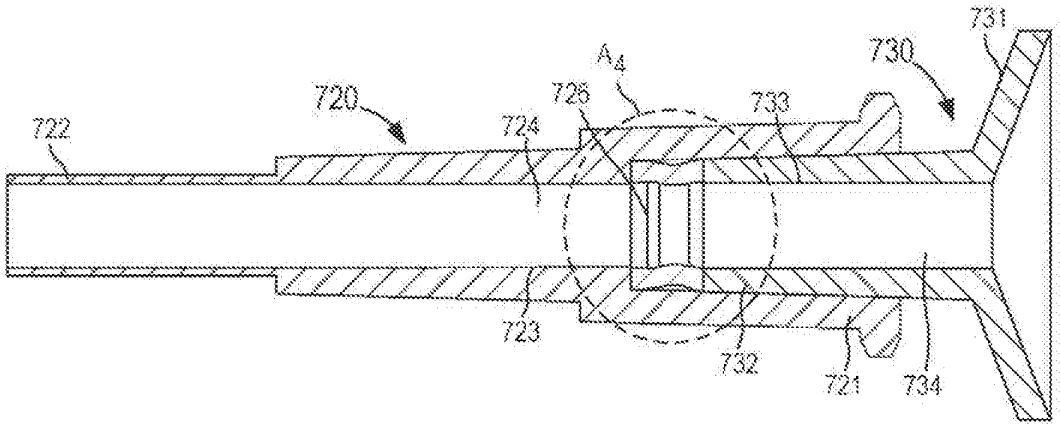

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FIG. 14

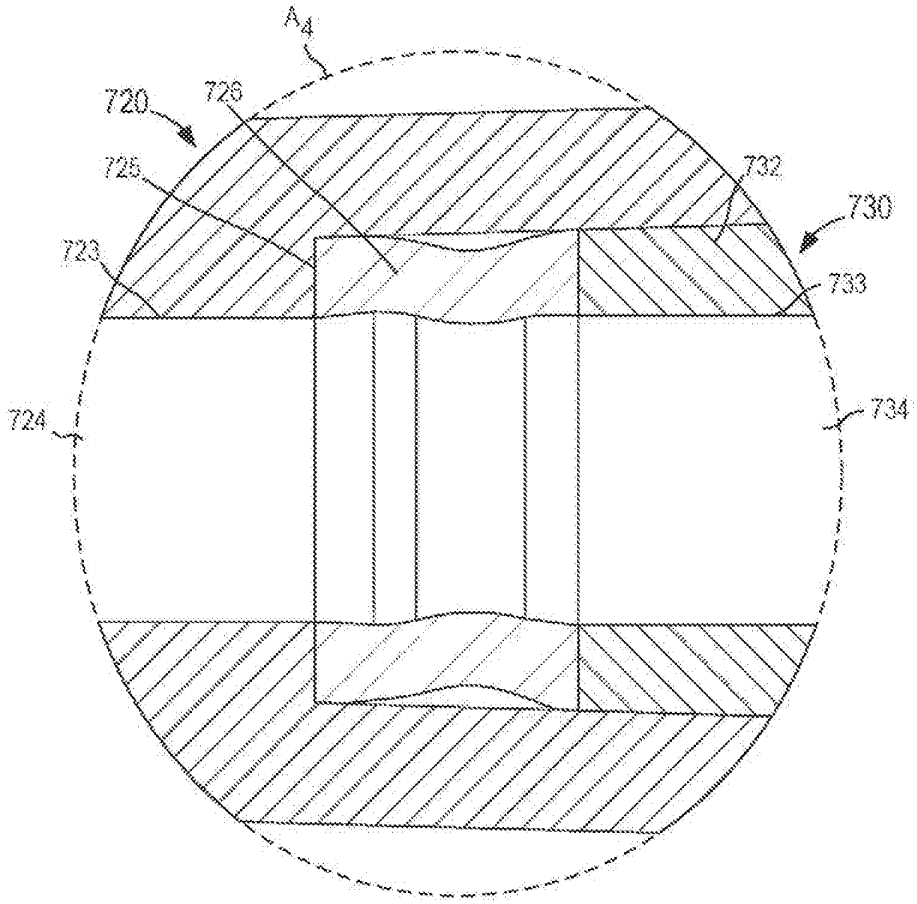

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FIG. 15

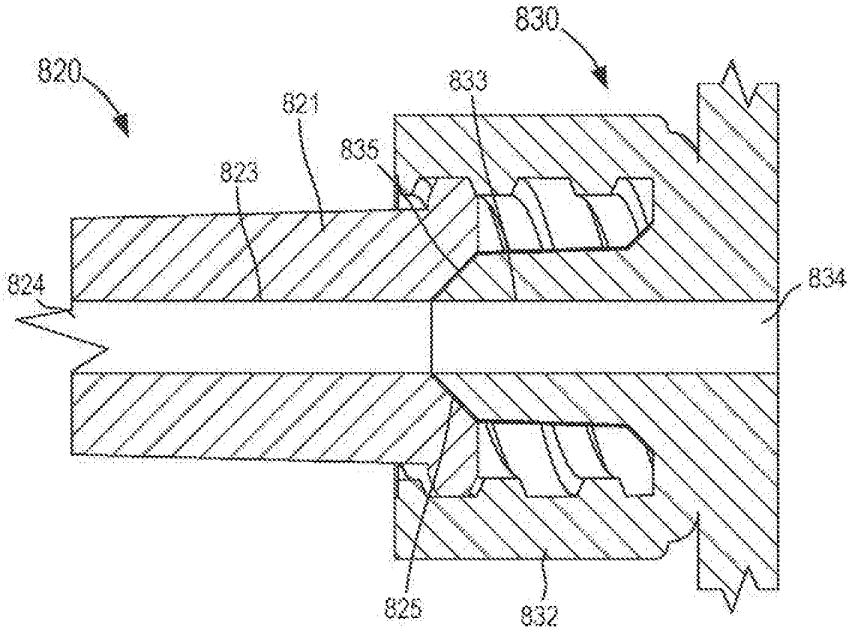

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FIG. 16

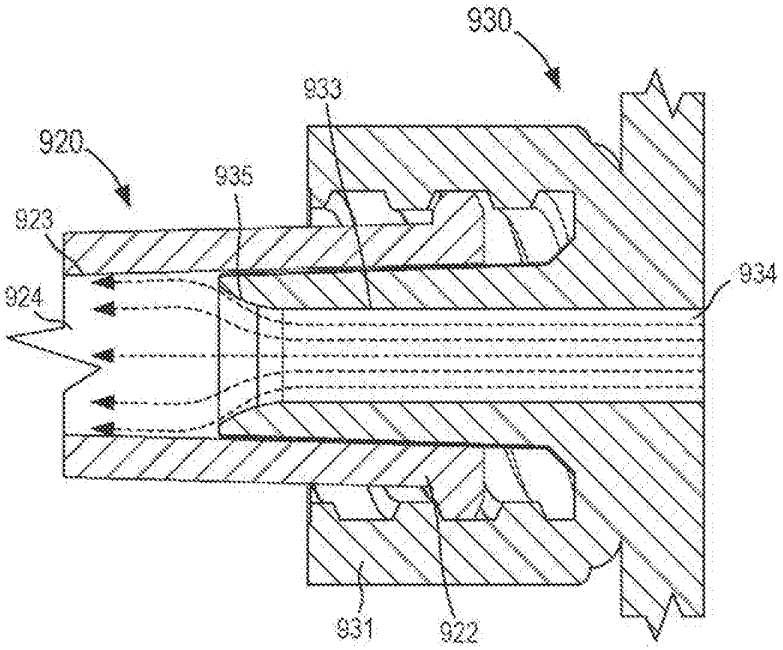

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FIG. 17

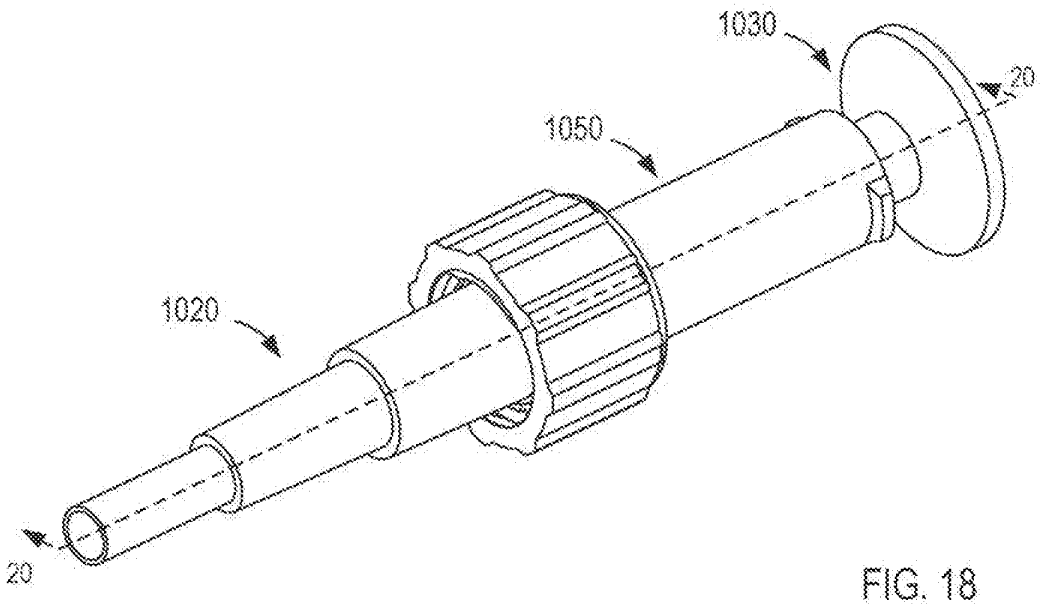

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FIG. 18

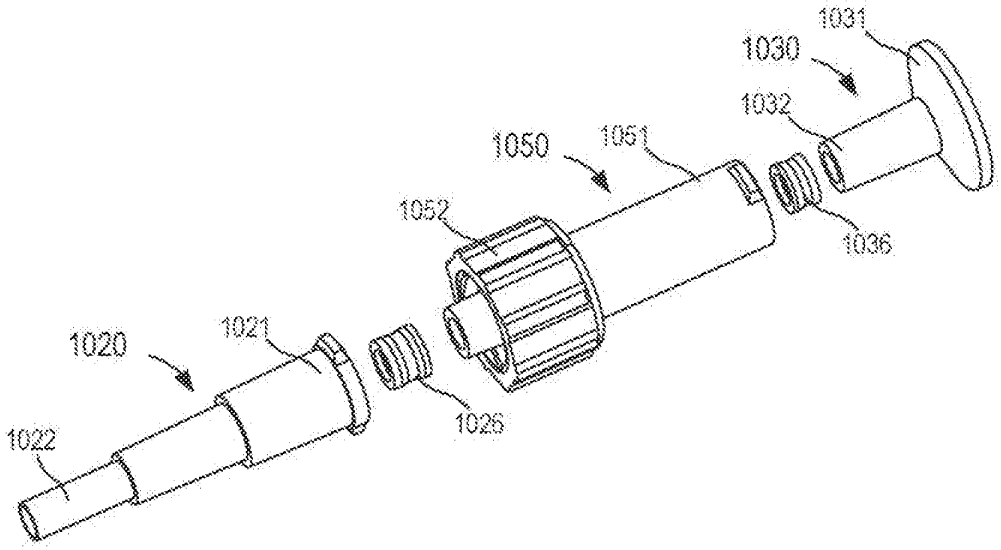

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FIG. 19

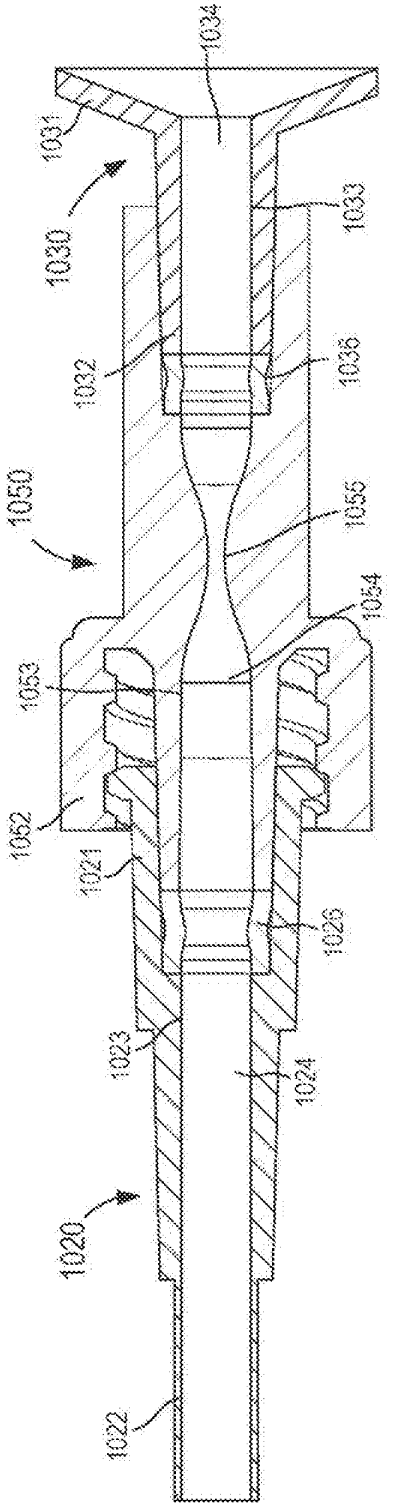

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FIG. 20

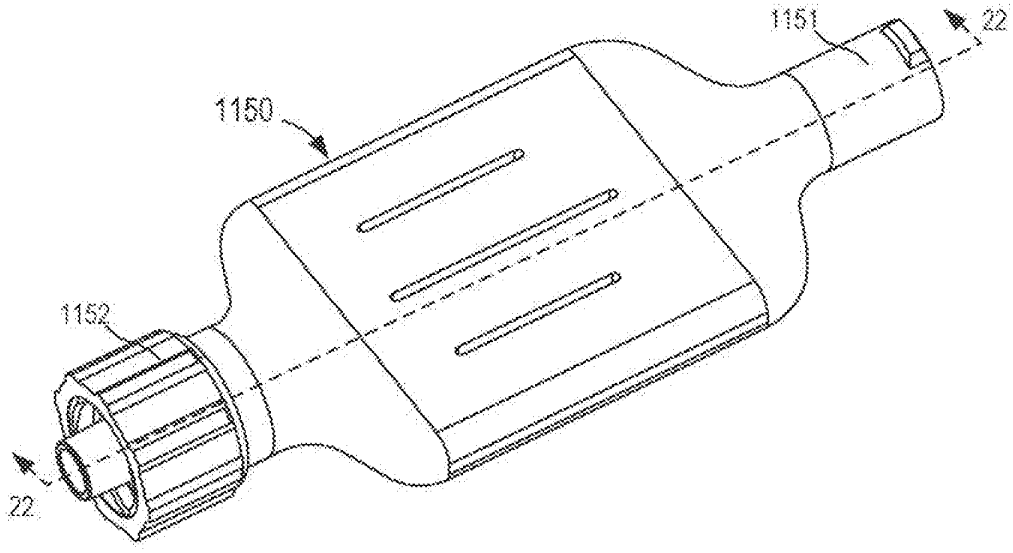


FIG. 21

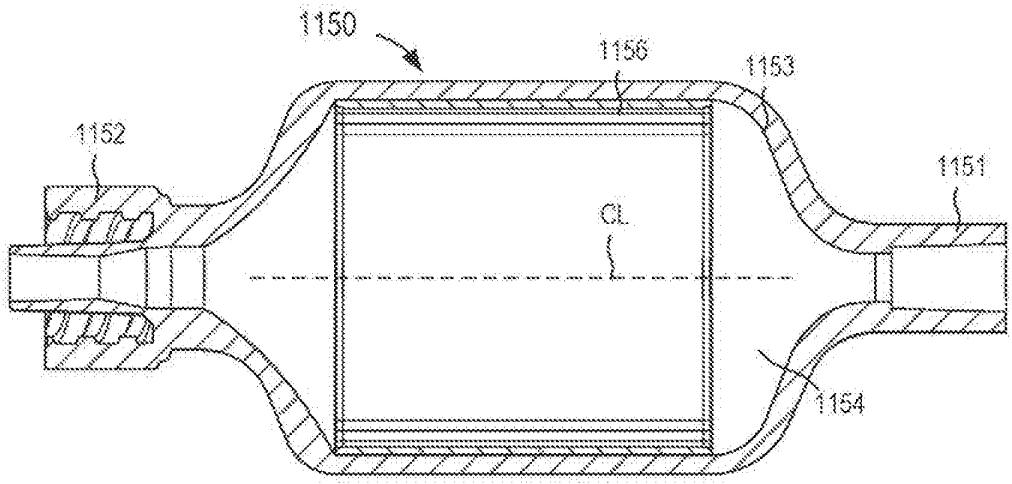


FIG. 22

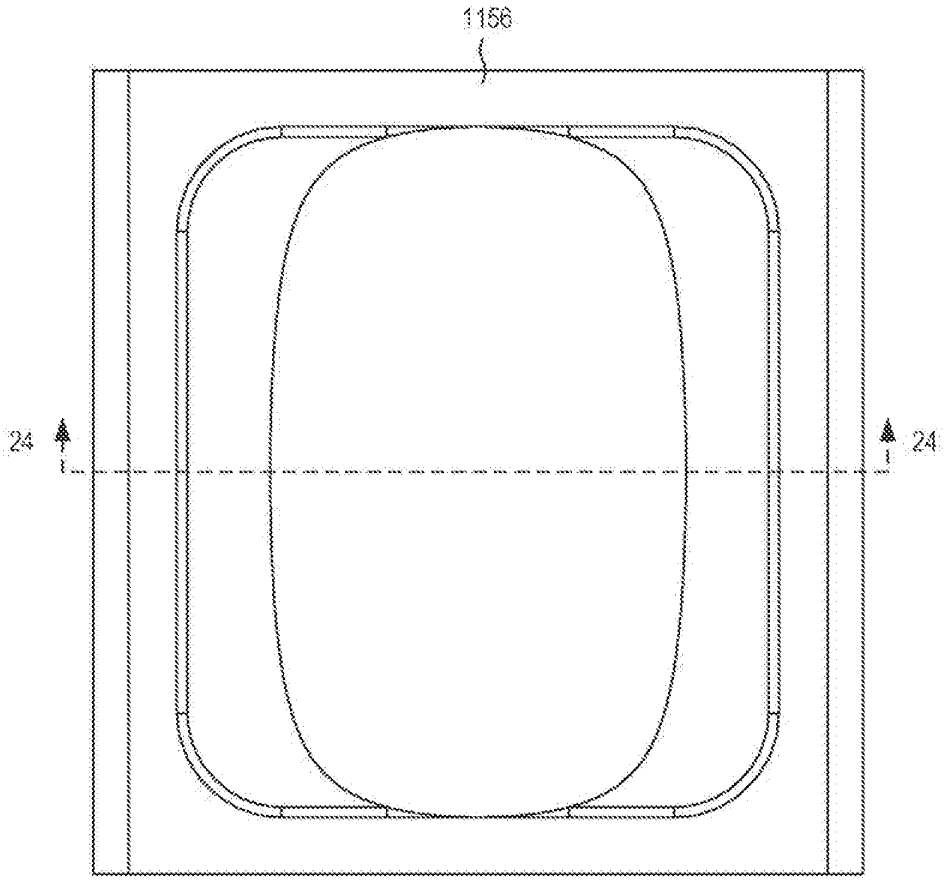


FIG. 23

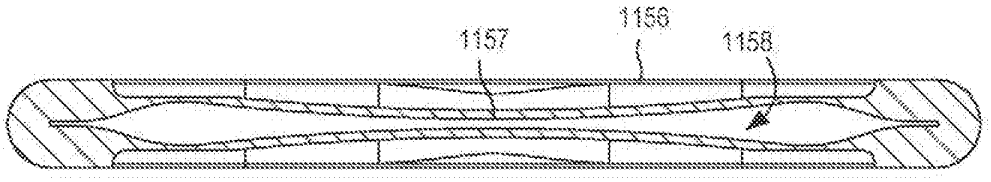


FIG. 24

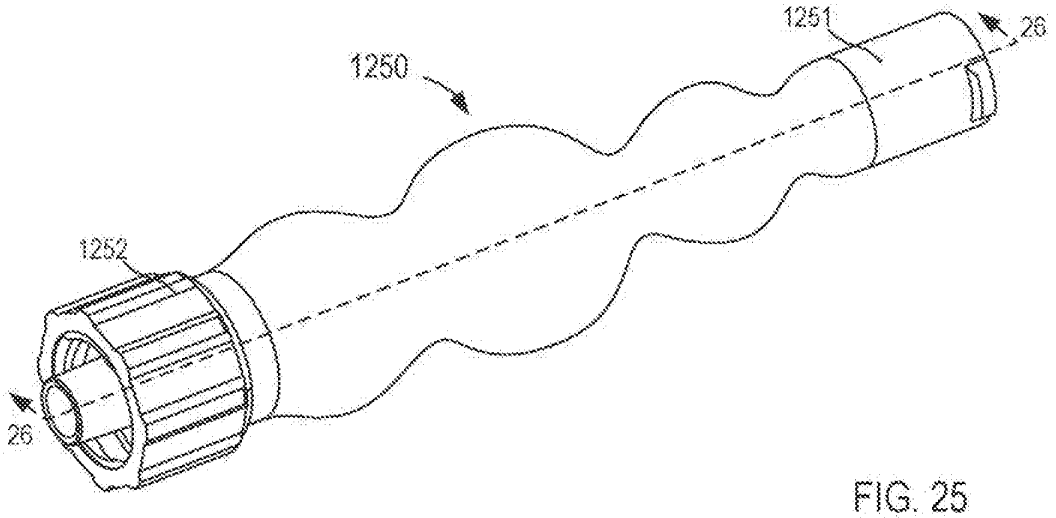

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FIG. 25

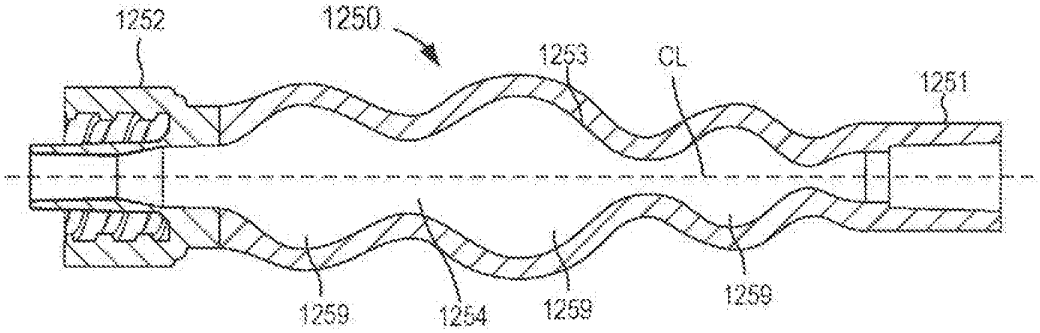

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FIG. 26

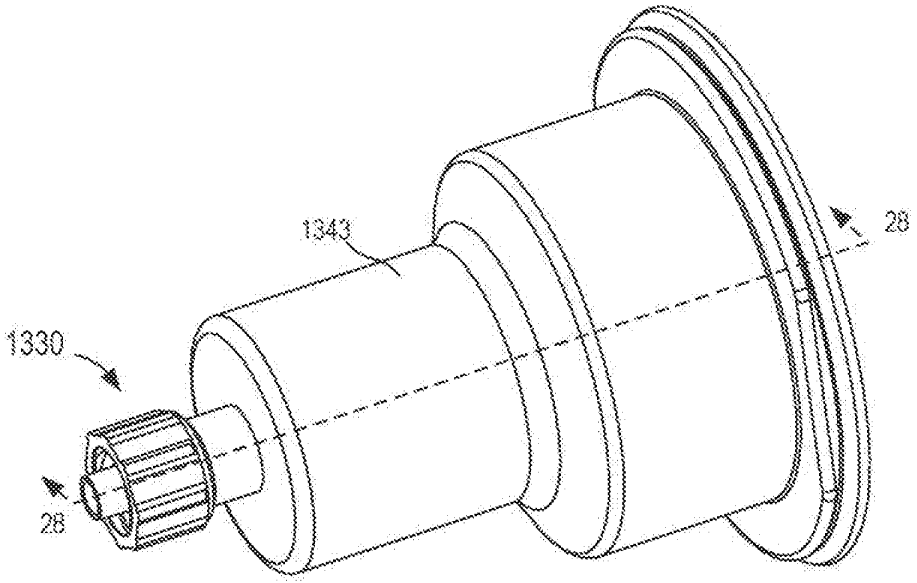


FIG. 27

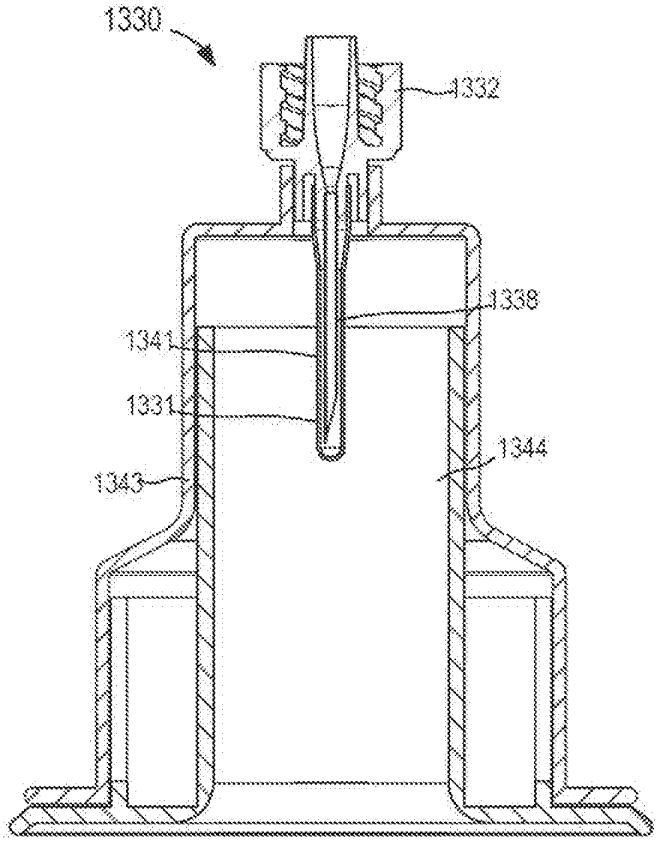


FIG. 28

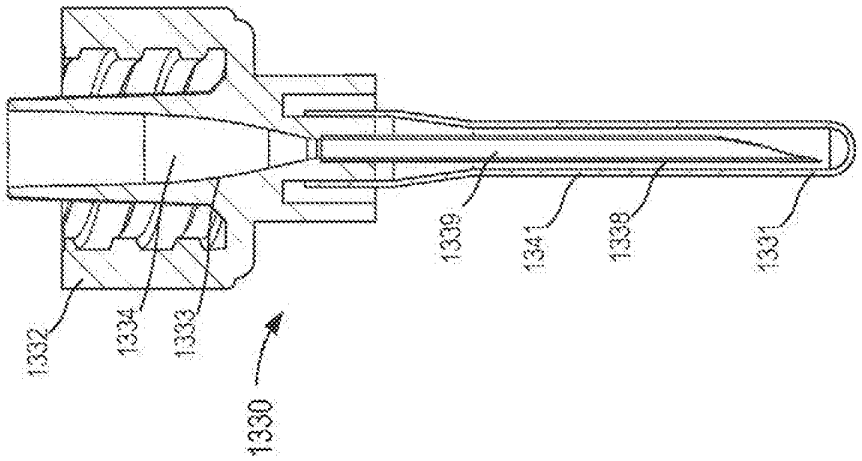


FIG. 30

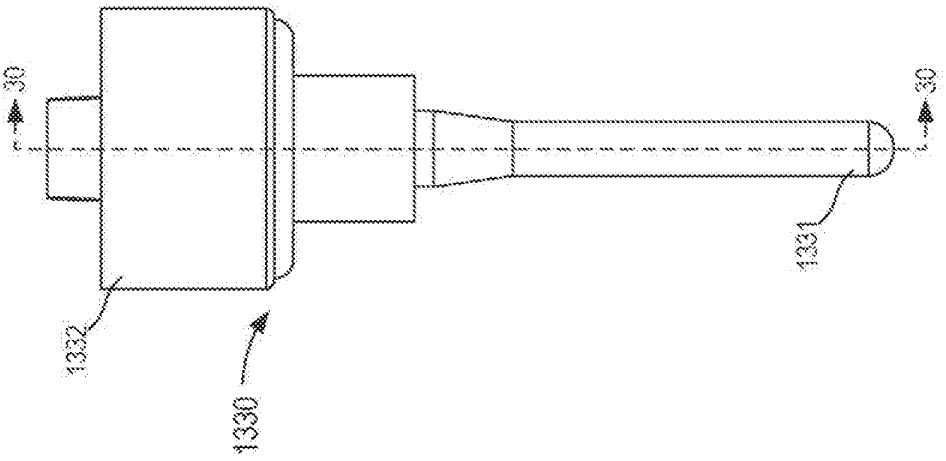


FIG. 29

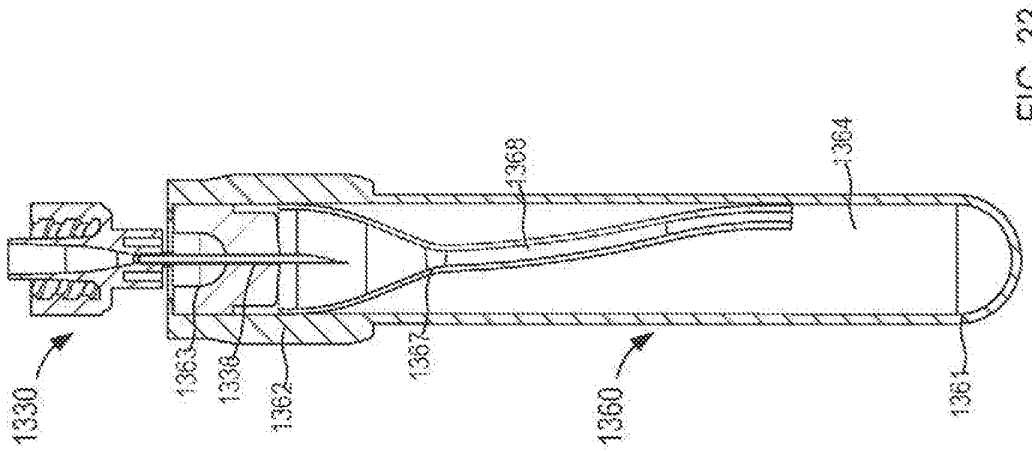


FIG. 33

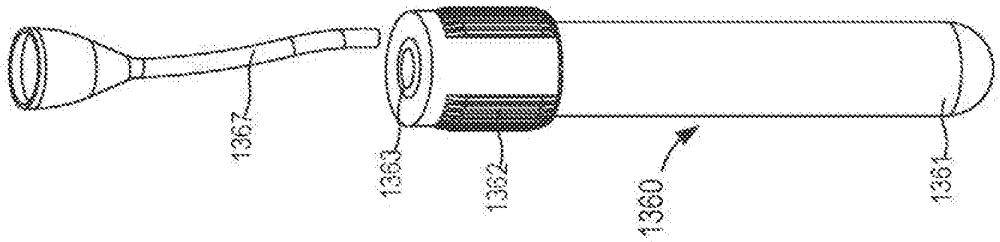


FIG. 32

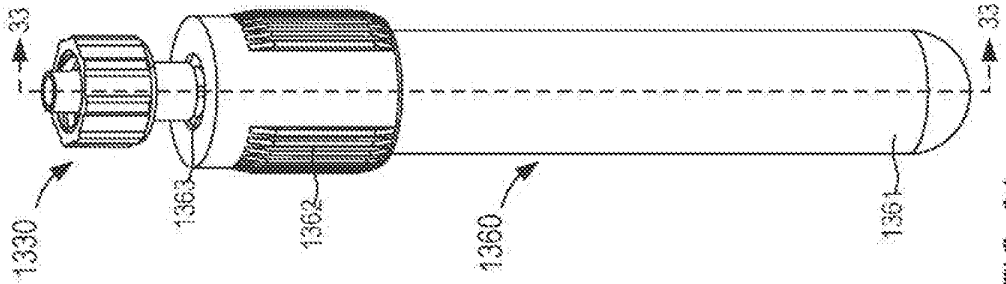


FIG. 31

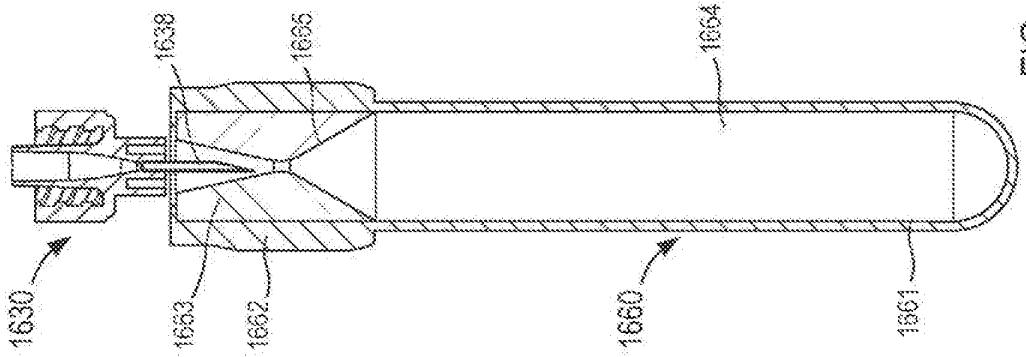


FIG. 36

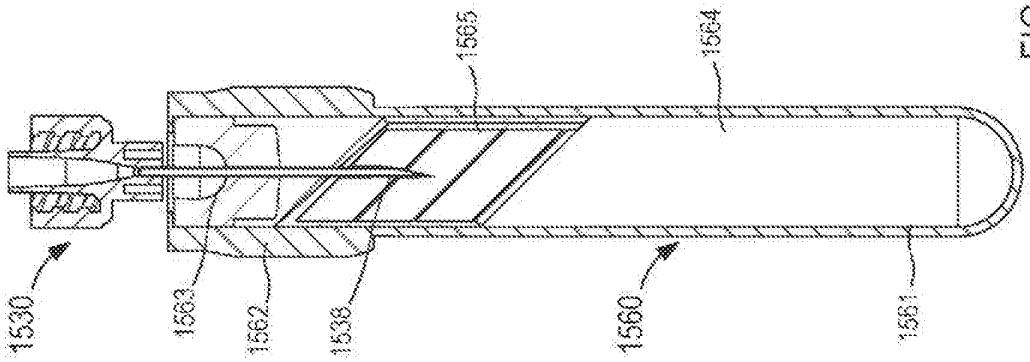


FIG. 35

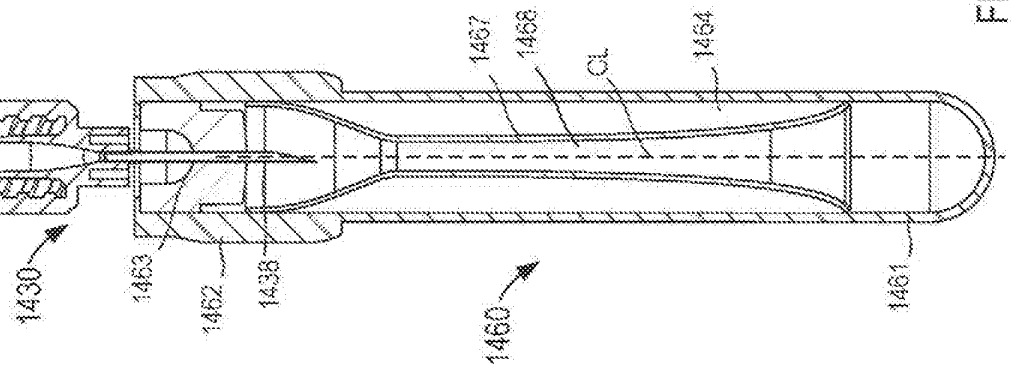


FIG. 34

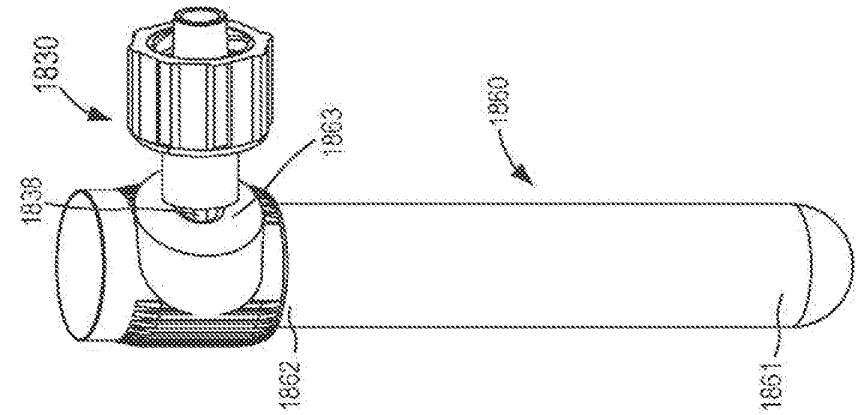


FIG. 39

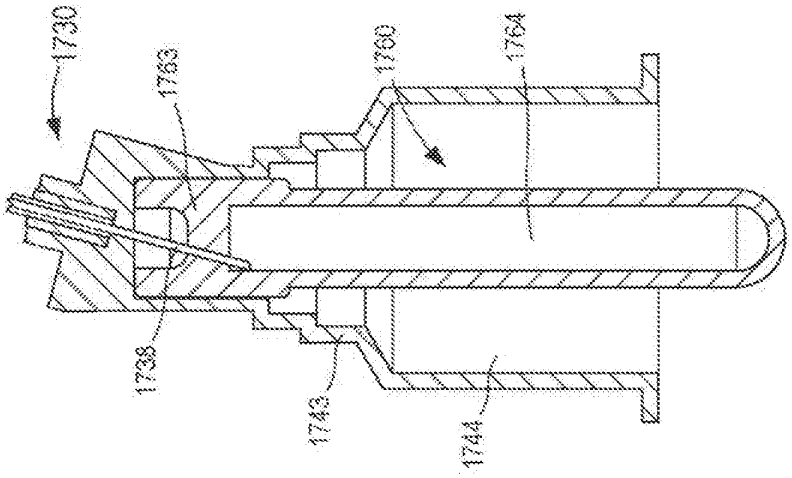


FIG. 38

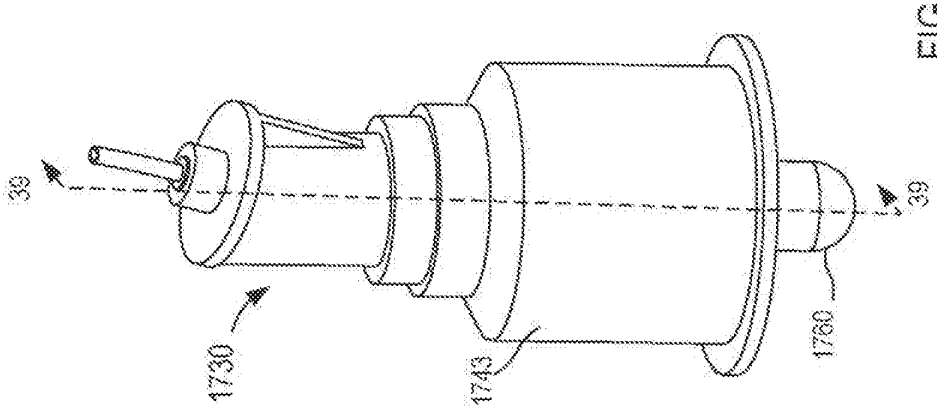


FIG. 37

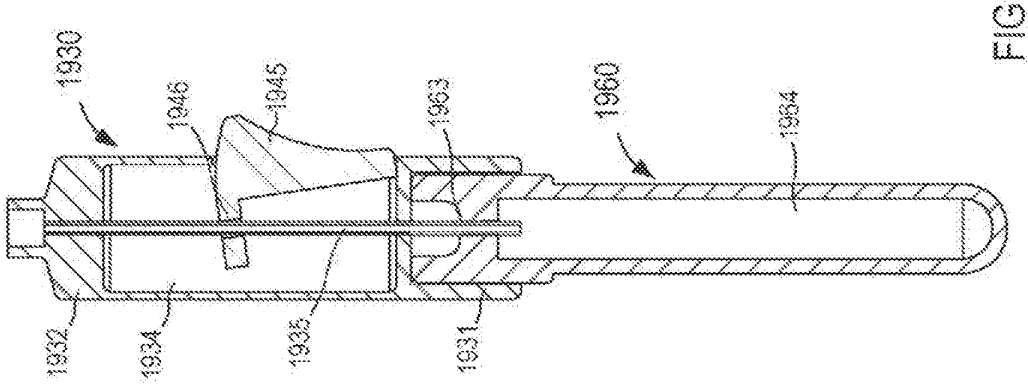


FIG. 42

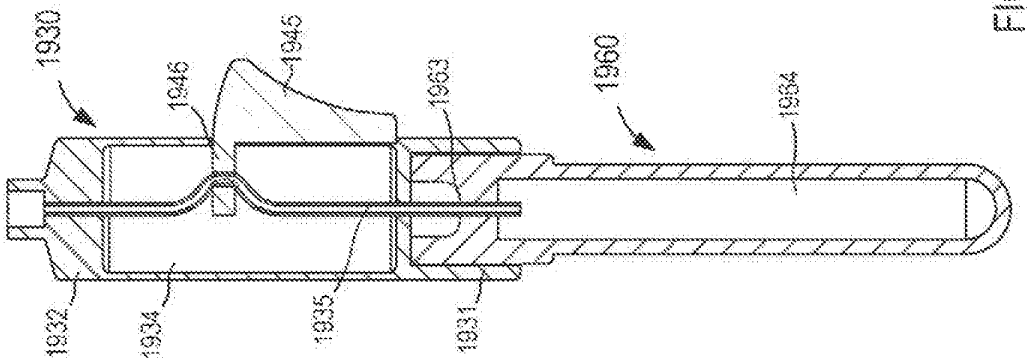


FIG. 41

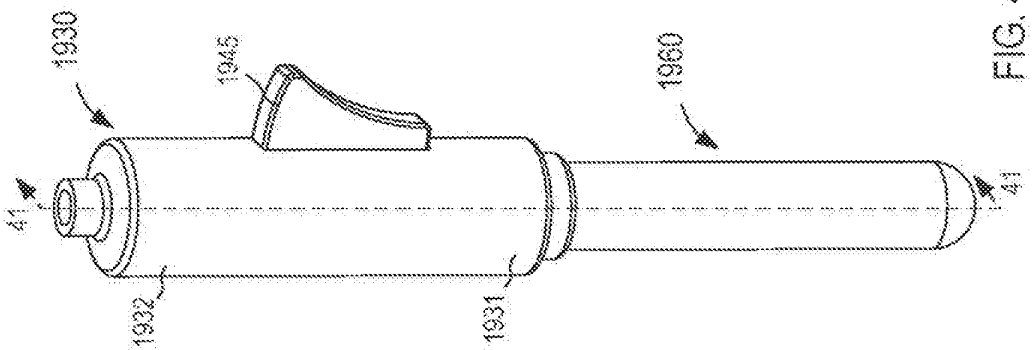


FIG. 40

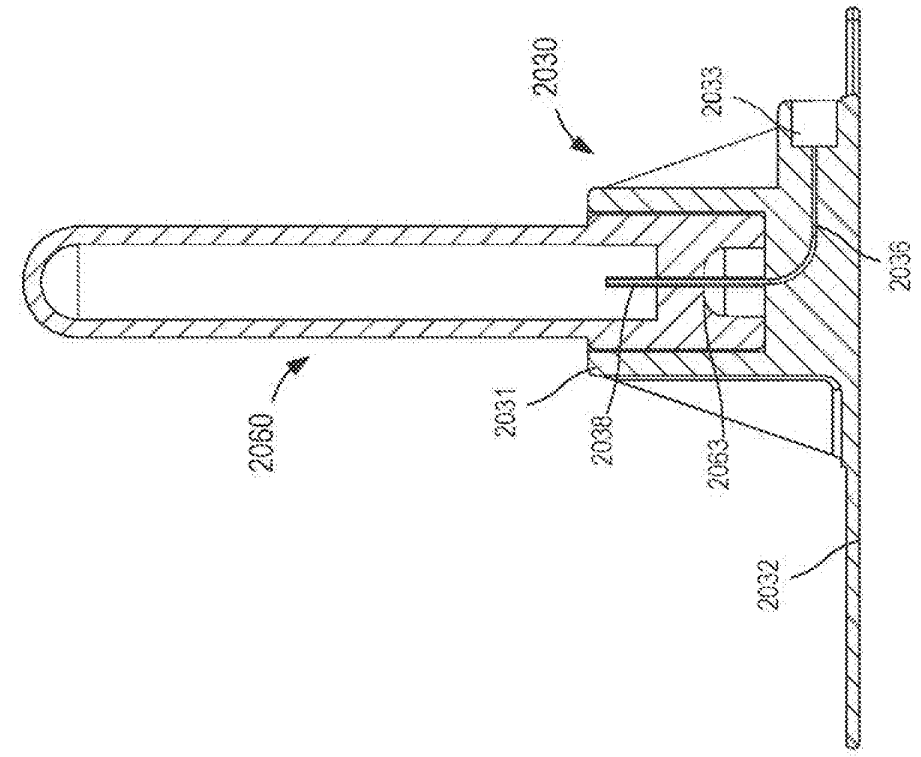

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FIG. 44

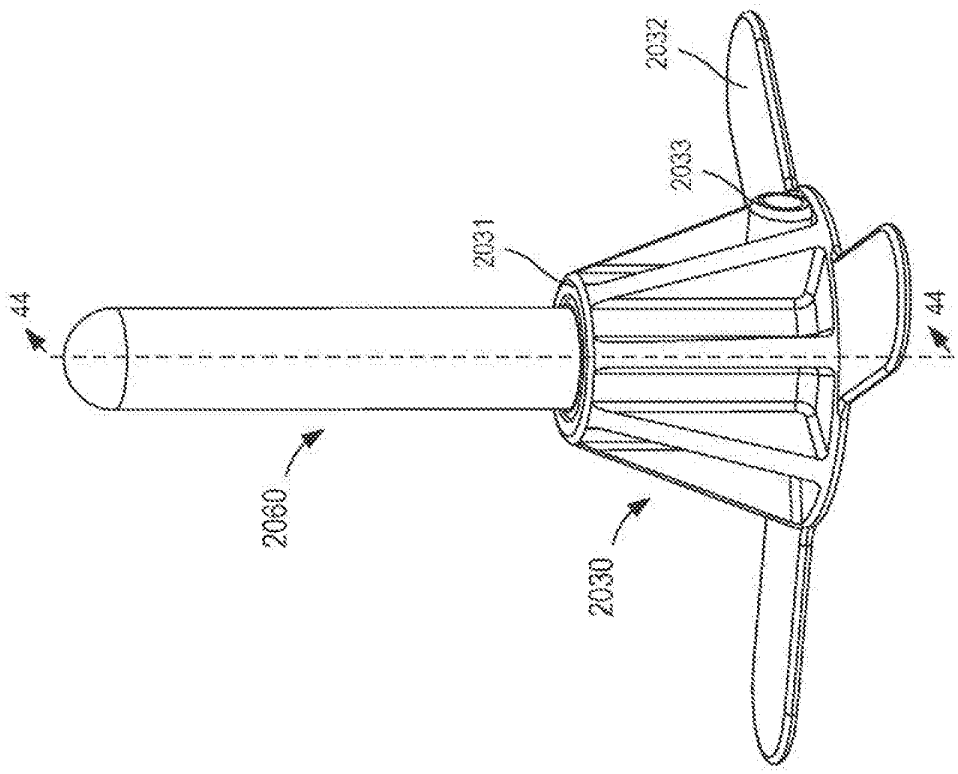

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FIG. 43

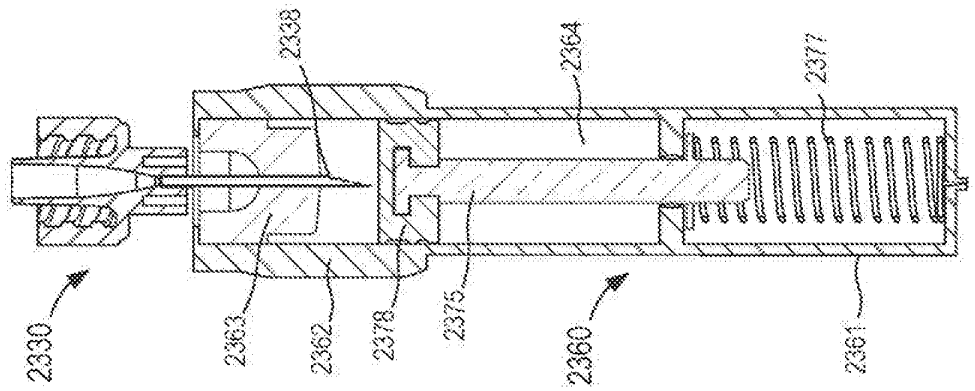


FIG. 47

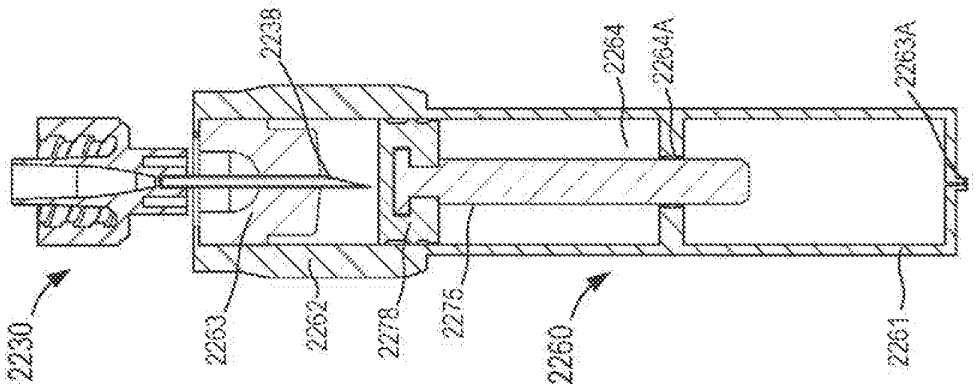


FIG. 46

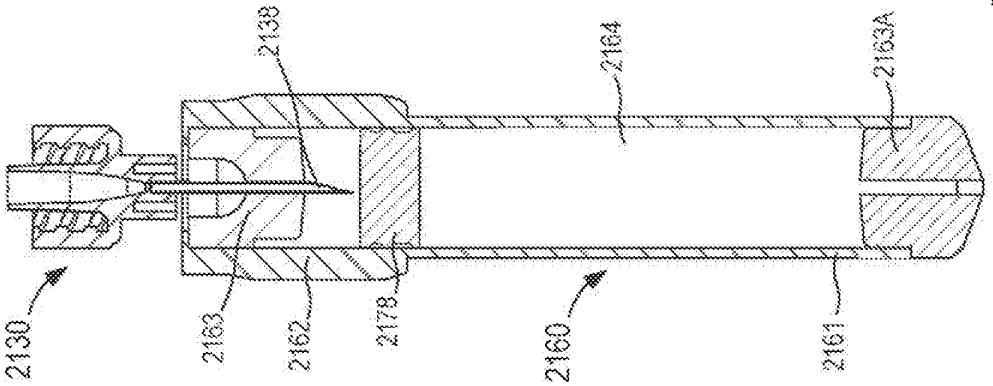


FIG. 45

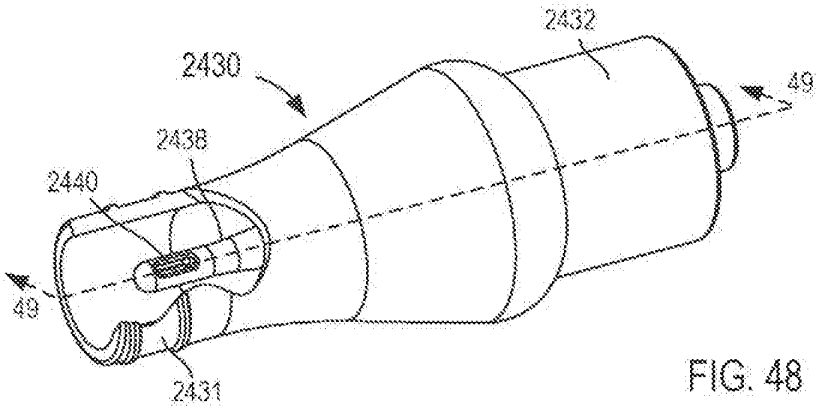


FIG. 48

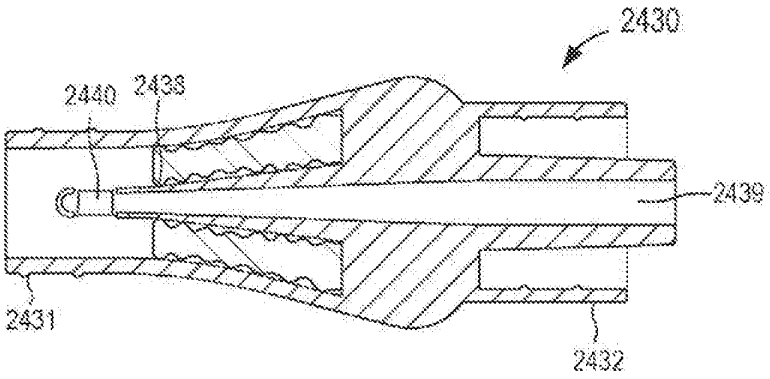


FIG. 49

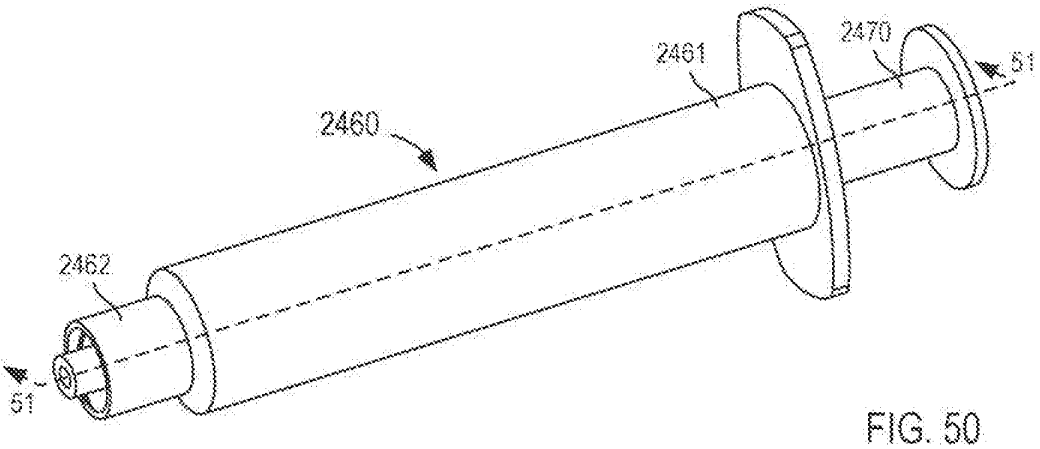


FIG. 50

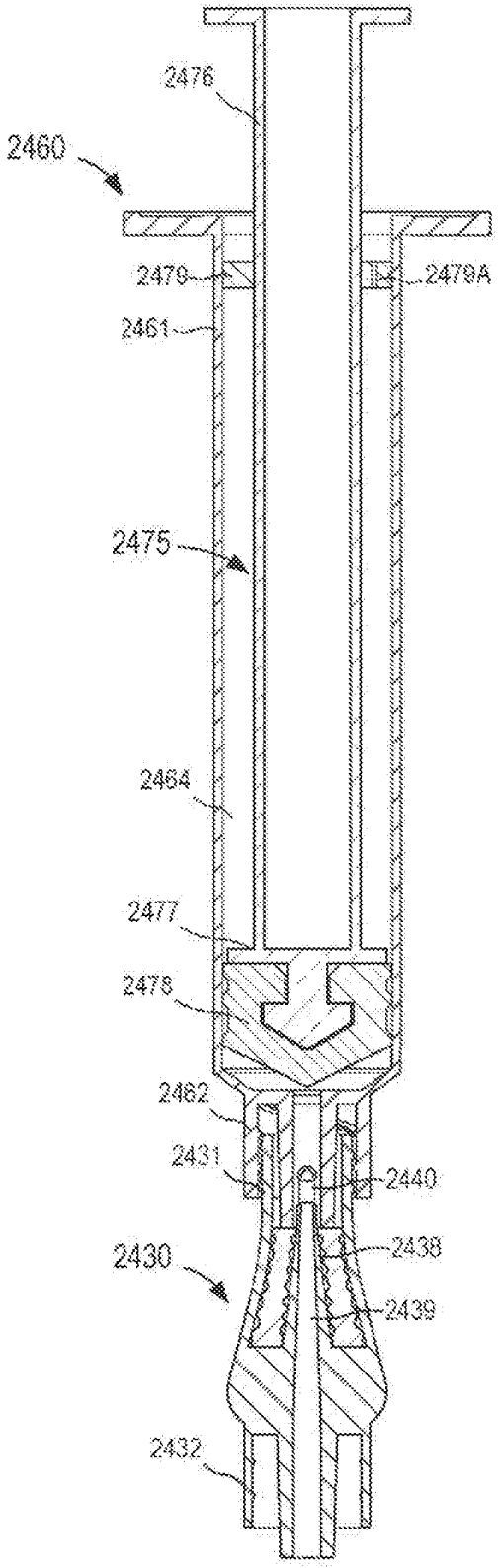

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FIG. 51

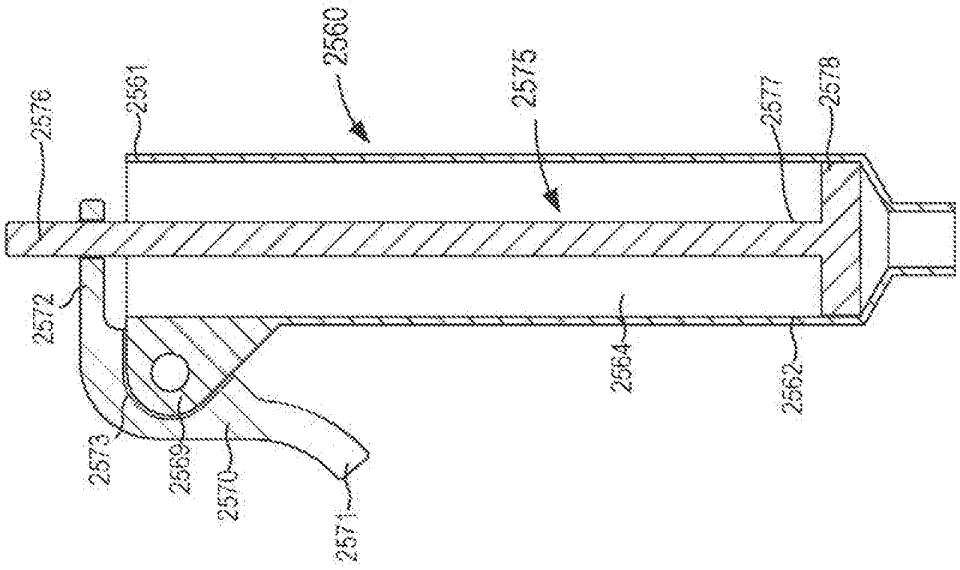

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FIG. 53

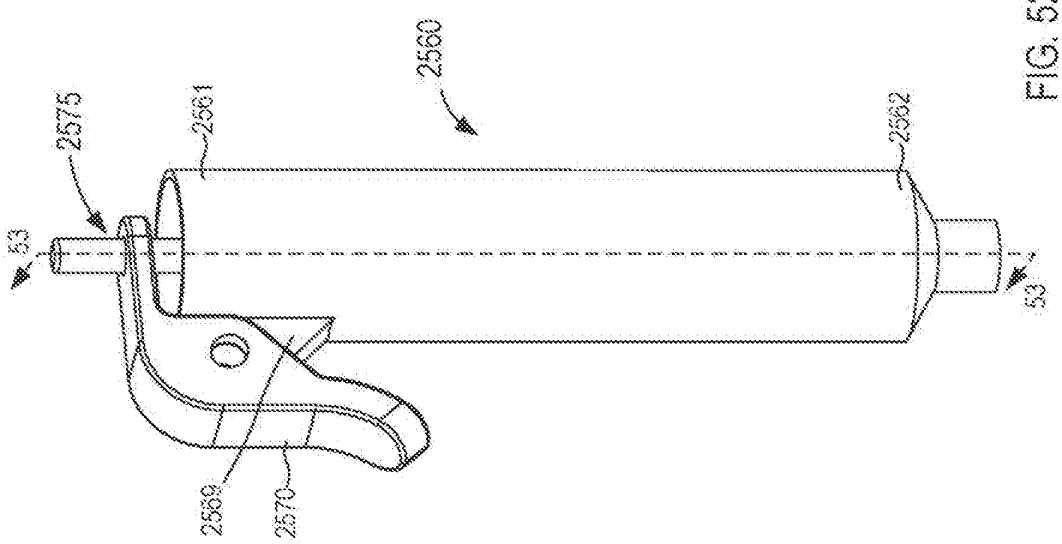

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FIG. 52

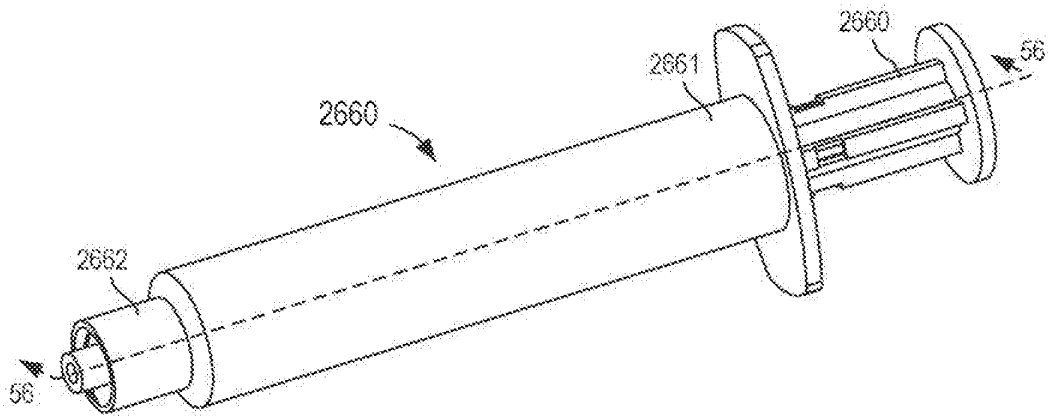

2660
2661
2660
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2662
56

FIG. 54

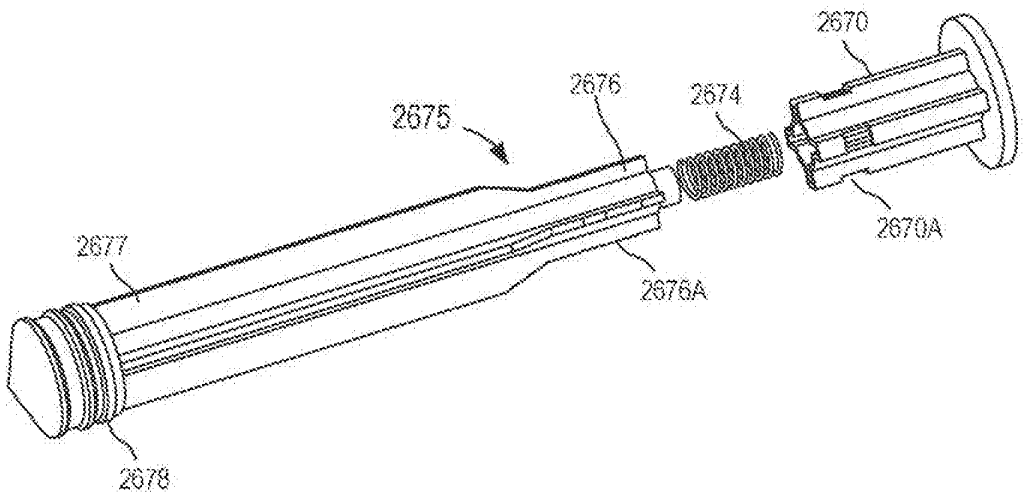

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2670A
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2676A
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FIG. 55

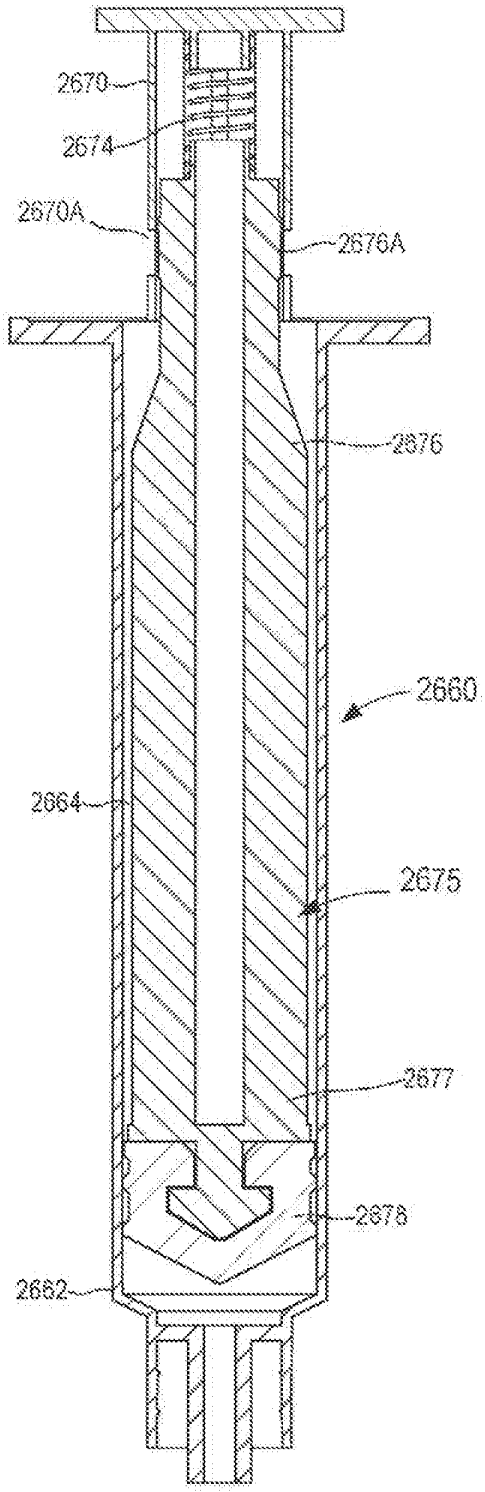


FIG. 56

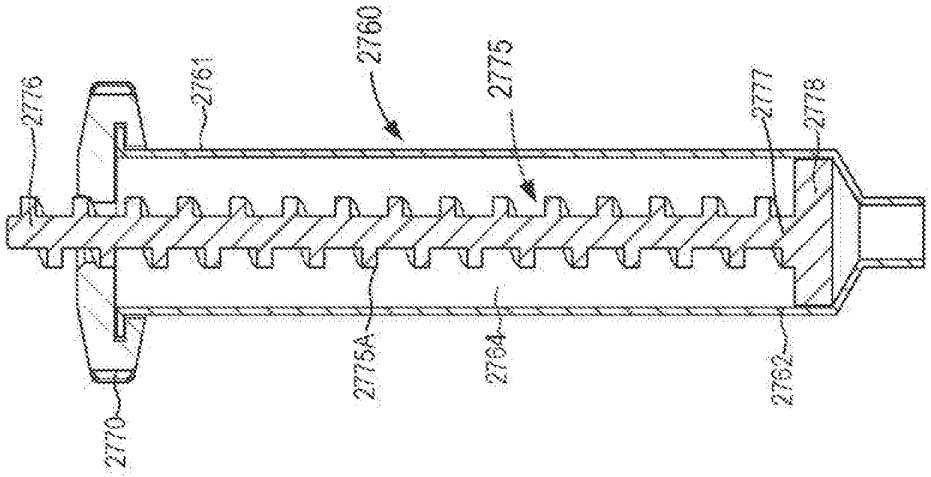

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FIG. 58

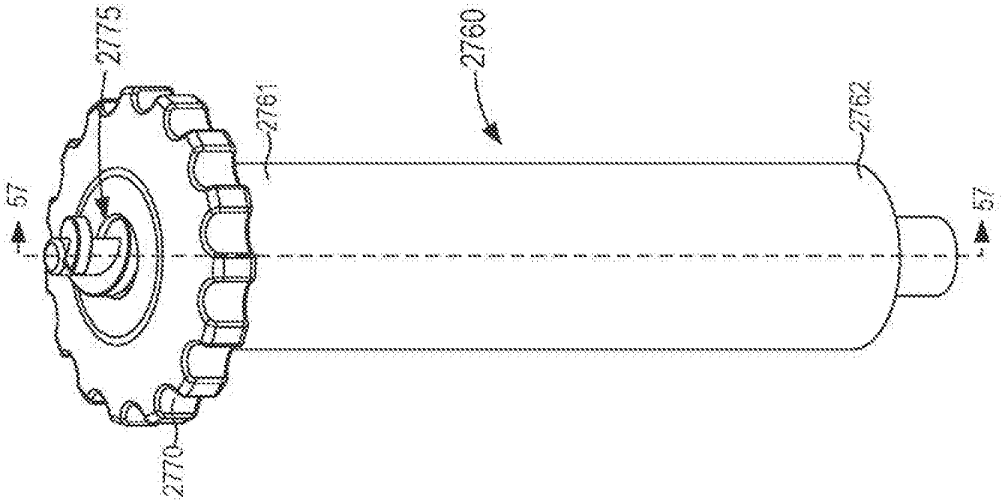

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FIG. 57

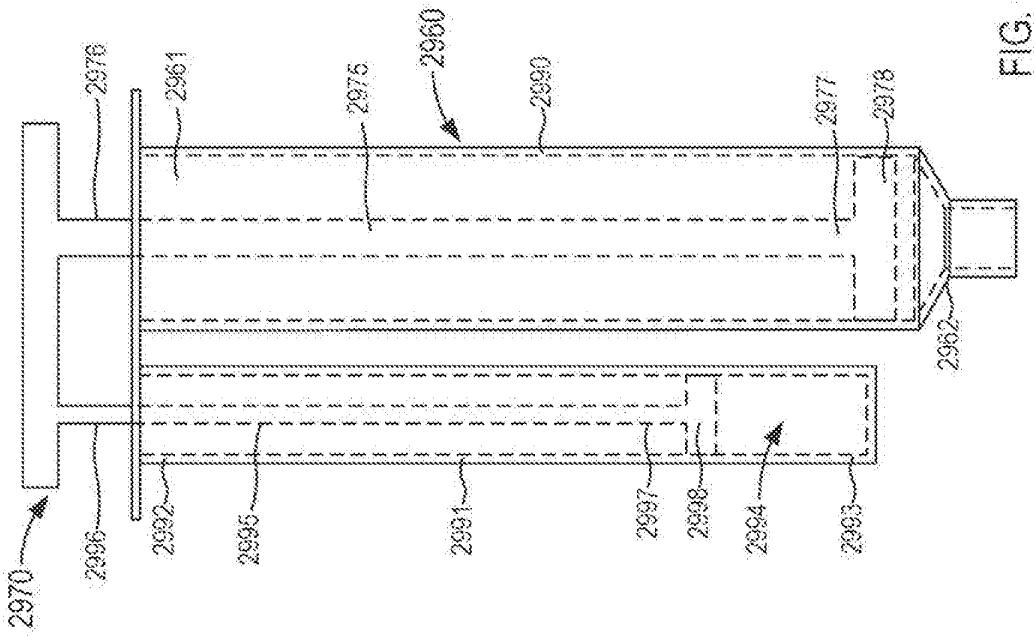

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FIG. 60

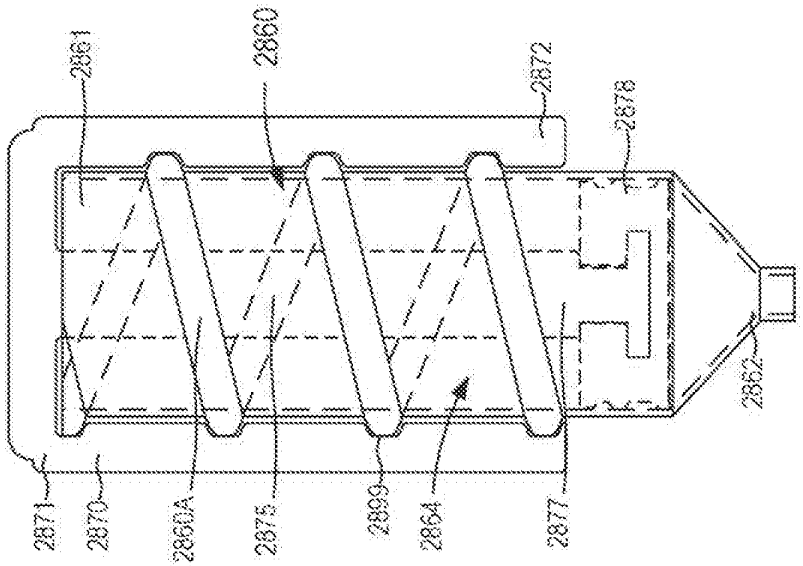

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FIG. 59

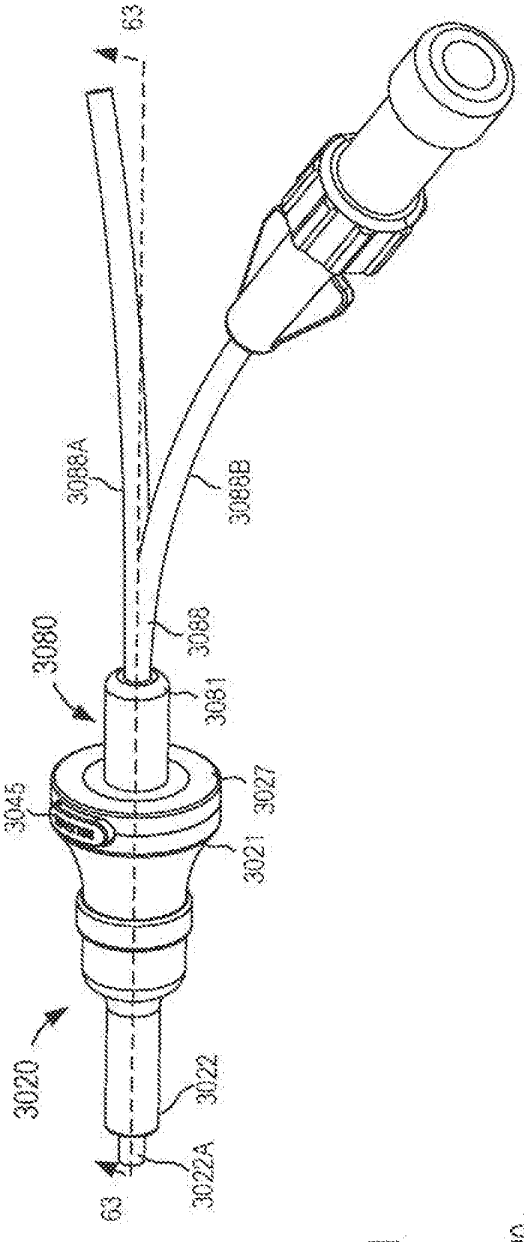

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3088A
3088B
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3022A
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FIG. 61

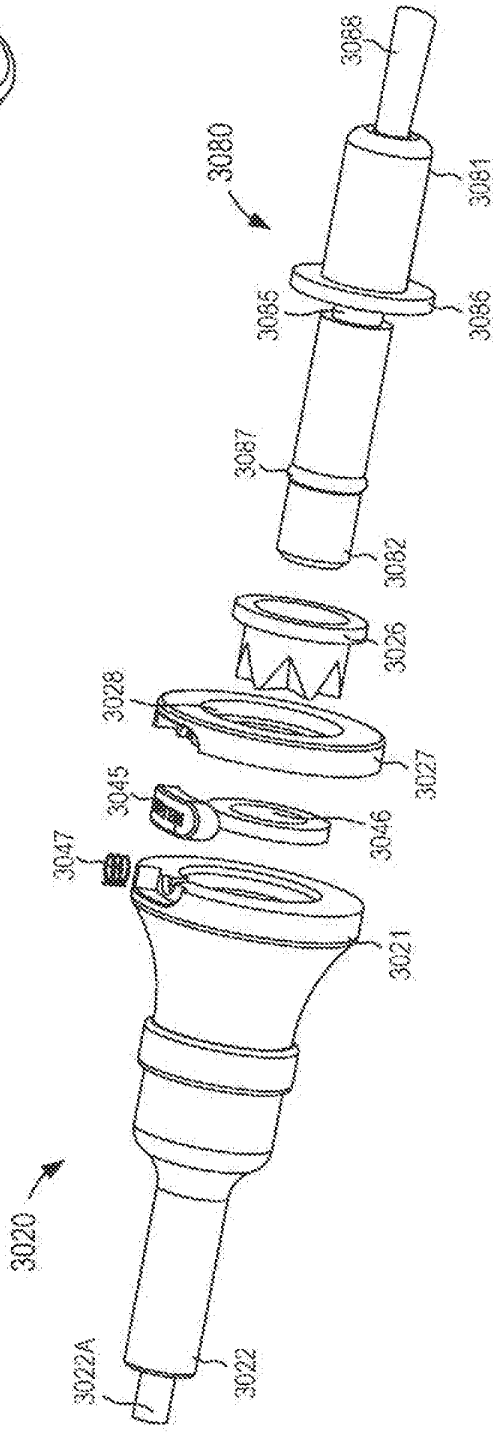

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FIG. 62

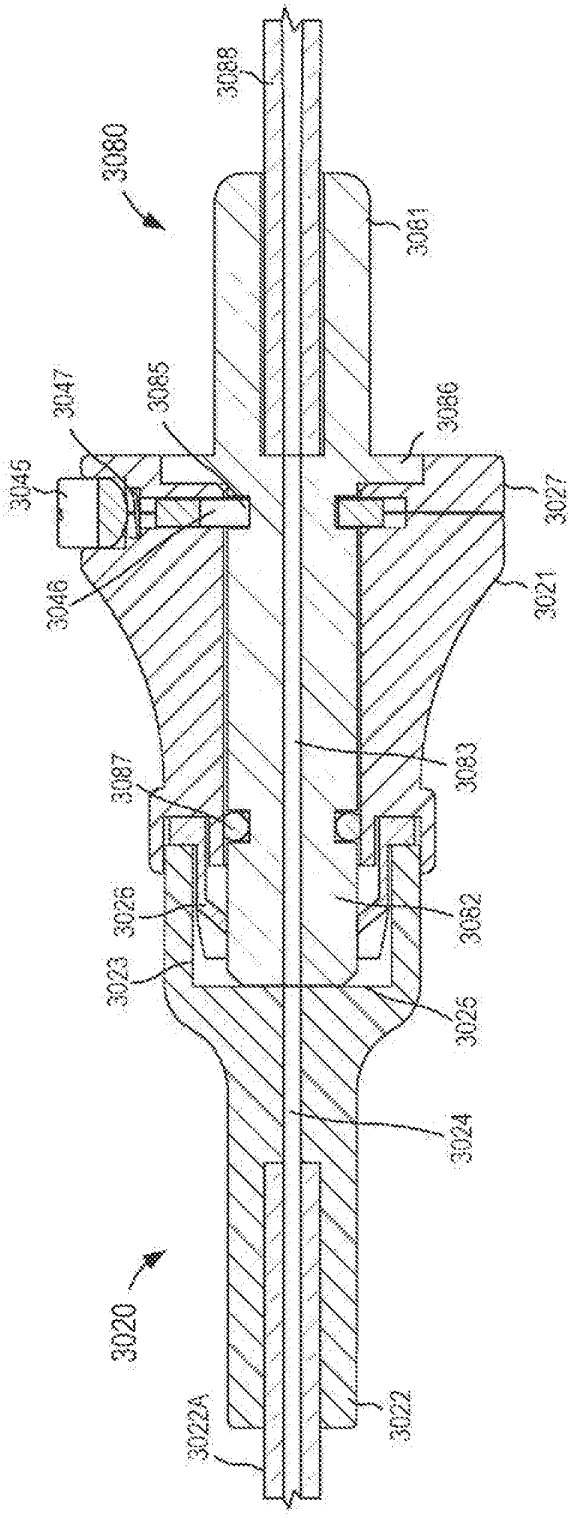

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FIG. 63

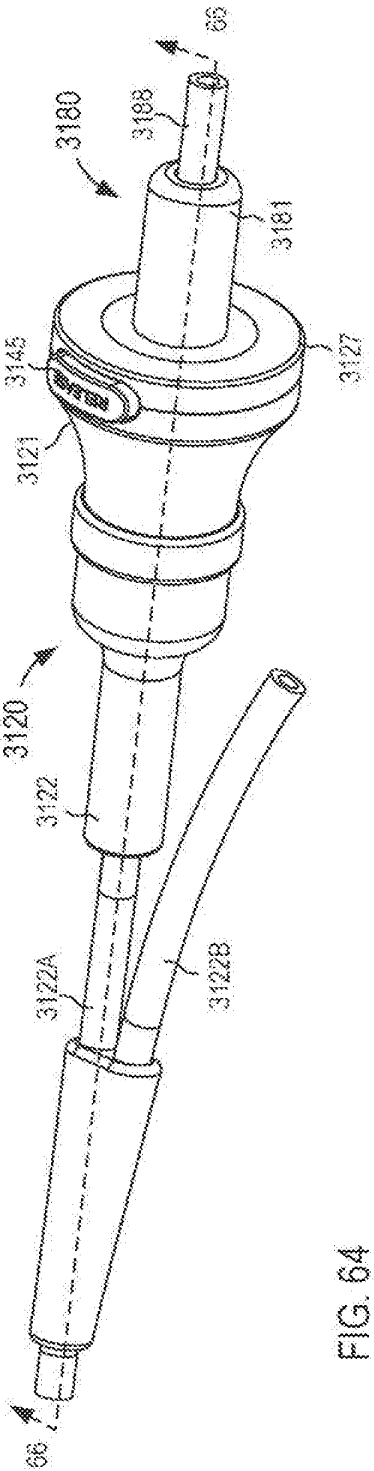

66
3188
3180
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3127
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3121
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3122A
3122B
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FIG. 64

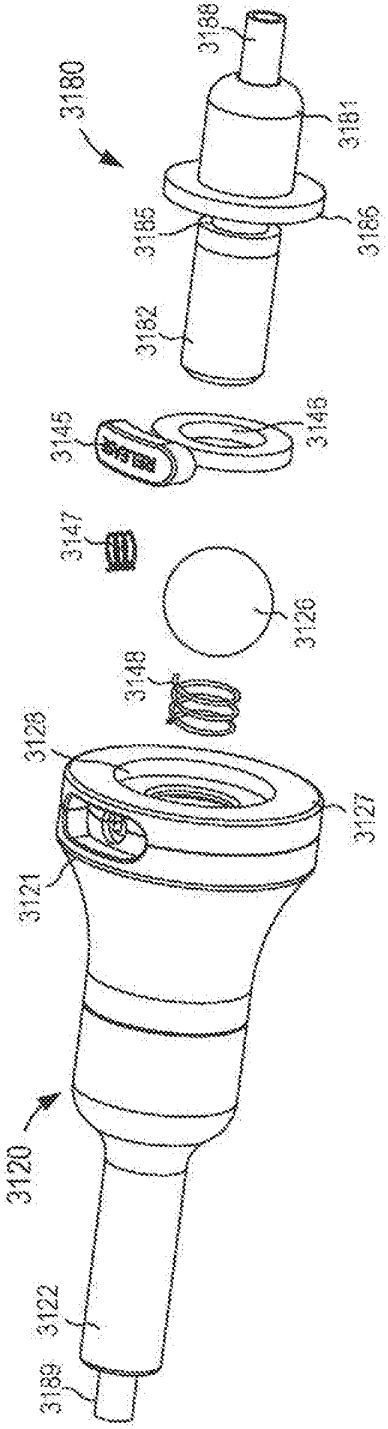

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FIG. 65

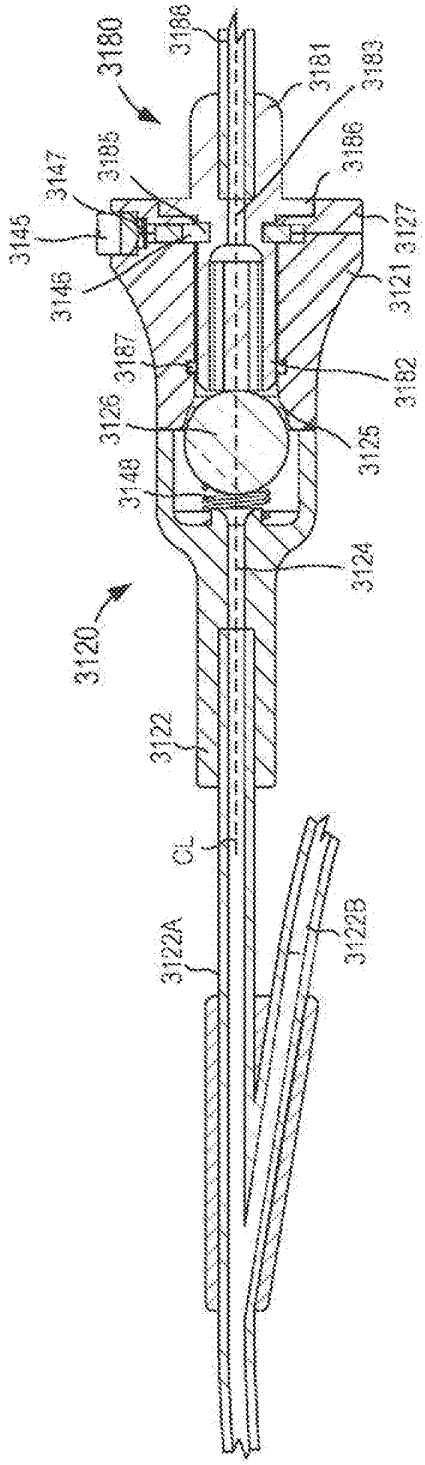

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FIG. 66

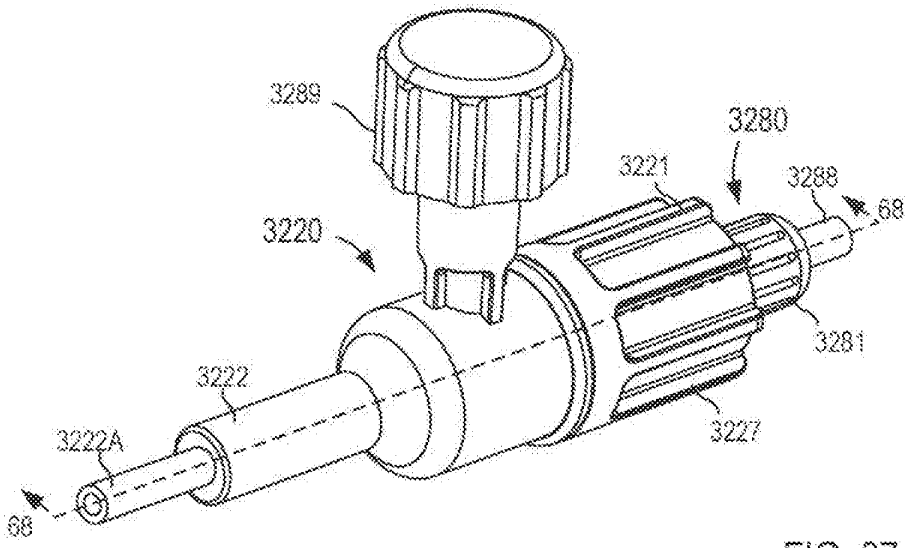

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FIG. 67

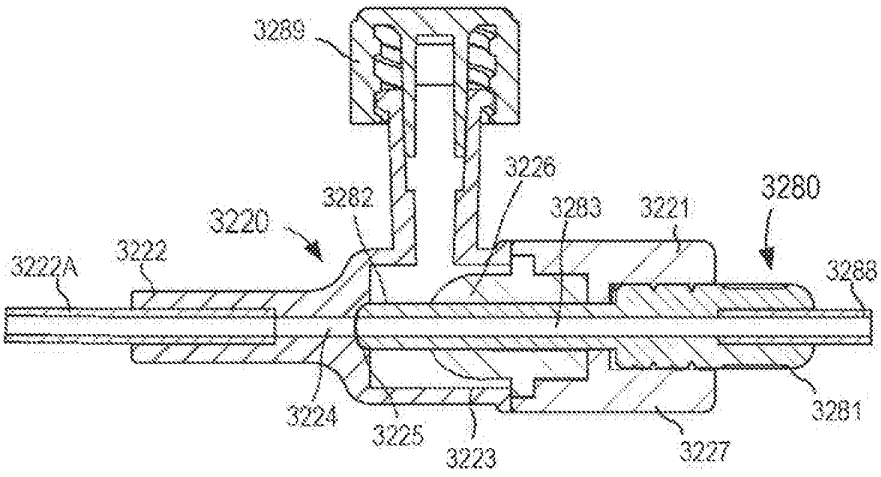

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FIG. 68

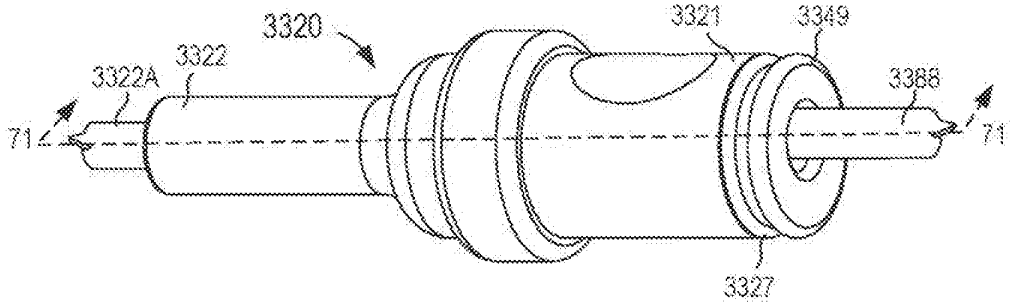

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FIG. 69

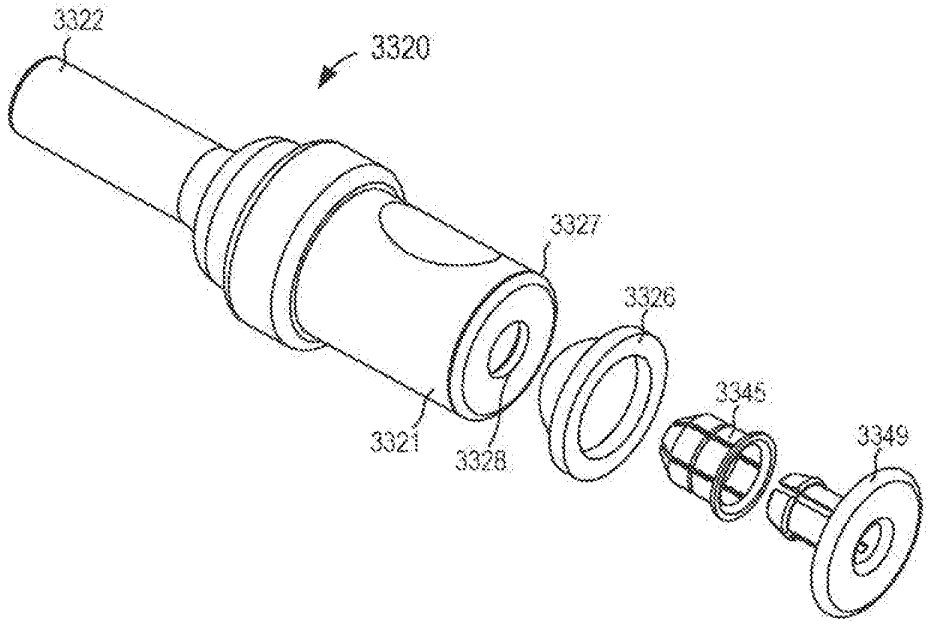

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FIG. 70

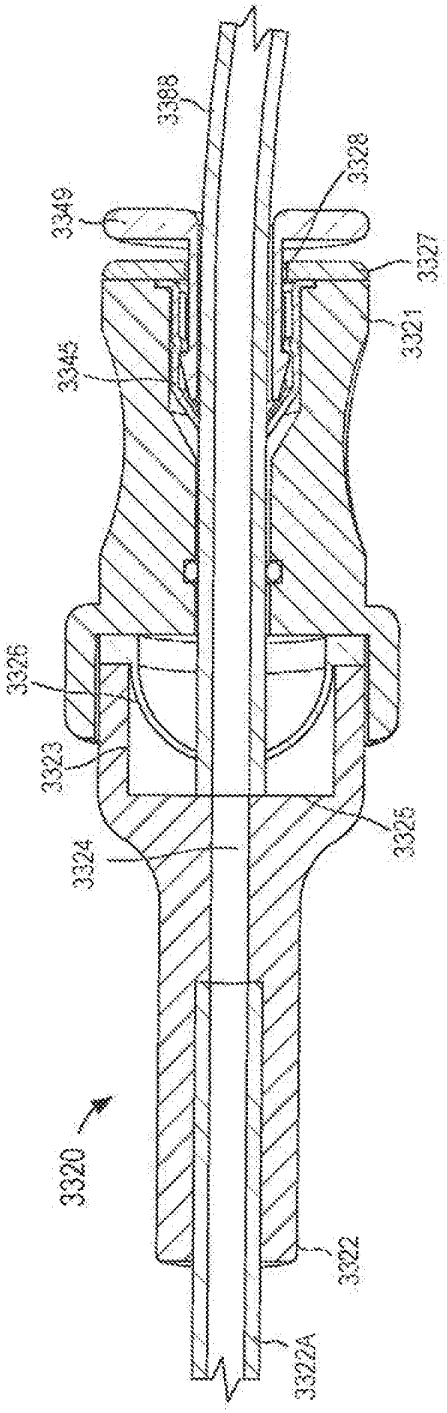

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FIG. 71

The Clinical Significance of Positive Blood Cultures in the 1990s: A Prospective Comprehensive Evaluation of the Microbiology, Epidemiology, and Outcome of Bacteremia and Fungemia in Adults

Melvin P. Weinstein, Michael L. Towns, Seth M. Quartey, Stanley Mirrett, Larry G. Reimer, Giovanni Parmigiani, and L. Barth Reller

From the Departments of Medicine and Pathology, University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School, New Brunswick, New Jersey; Clinical Microbiology Laboratory, Duke University Medical Center, Departments of Medicine and Pathology, Duke University School of Medicine, and Institute of Statistics and Decision Sciences, Duke University, Durham, North Carolina; and Departments of Pathology and Medicine, Salt Lake City Veterans Administration Medical Center and University of Utah Medical School, Salt Lake City, Utah

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To assess changes since the mid-1970s, we reviewed 843 episodes of positive blood cultures in 707 patients with septicemia. The five most common pathogens were *Staphylococcus aureus, Escherichia coli,* coagulase-negative staphylococci (CNS), *Klebsiella pneumoniae,* and *Enterococcus* species. Although CNS were isolated most often, only 12.4% were clinically significant. Half of all episodes were nosocomial, and a quarter had no recognized source. Leading identifiable sources included intravenous catheters, the respiratory and genitourinary tracts, and intraabdominal foci. Septicemia-associated mortality was 17.5%. Patients who received appropriate antimicrobial therapy throughout the course of infection had the lowest mortality (13.3%). Multivariate analysis showed that age (relative risk [RR], 1.80), microorganism (RR, 2.27), source of infection (RR, 2.86), predisposing factors (RR, 1.98), blood pressure (RR, 2.29), body temperature (RR, 2.04), and therapy (RR, 2.72) independently influenced outcome. Bloodstream infections in the 1990s are notable for the increased importance of CNS as both contaminants and pathogens, the proportionate increase in fungi and decrease in anaerobes as pathogens, the emergence of *Mycobacterium avium* complex as an important cause of bacteremia in patients with advanced human immunodeficiency virus infection, and the reduction in mortality associated with infection.

The presence of living microorganisms in blood has substantial clinical importance. From the diagnostic standpoint, a positive blood culture yielding a clinically important microorganism represents either failure of host defenses to contain an infection at its primary focus or failure of the physician to effectively eradicate, drain, excise, or otherwise remove that focus of infection. The presence of bacteremia or fungemia also is an indicator of disseminated infection and, as such, generally indicates a poorer prognosis than that associated with localized disease. A positive blood culture, however, is not always clinically significant, since contamination may occur or the positive result might represent the transient and self-limited presence of microorganisms in the blood [1].

Our current understanding of the clinical significance of positive blood cultures has been enhanced by studies reported over several decades [2–21]. In recent years there have been many changes in medical practice, influenced in part by technologic advances and in part by the increased incidence of diseases not recognized previously. Just a few examples include the more frequent use of invasive or prosthetic devices; the increase in solid-organ and bone marrow transplantation as well as improvements in posttransplantation medical management; the introduction of HIV infection and AIDS as a scourge on late 20th century society; and therapeutic advances in the form of improved imaging techniques, less invasive methods of draining pus from closed spaces, and availability of broader spectrum antiinfective therapy.

We therefore undertook a comprehensive analysis of positive blood cultures in the 1990s. As a template for this project, we used an earlier review of bacteremia and fungemia [10, 11] authored by two of the current investigators (M.P.W. and L.B.R.). Although the earlier work has been widely recognized, the aforementioned changes in medicine and its practice argued for the need to reevaluate the clinical and prognostic importance of positive blood cultures. The primary goal of this study, therefore, was to determine the current microbiology, epidemiology, and prognostic importance of positive blood cultures, with special reference to similarities with and differences from the earlier reports from our group [10, 11, 22, 23].

Materials and Methods

For a 12-month period, February 1992 through January 1993, all inpatients ≥18 years of age with culture-positive blood

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were evaluated at Duke University Medical Center (DUMC), in Durham, NC; Robert Wood Johnson University Hospital (RWJUH), in New Brunswick, NJ; and the Salt Lake City Veterans Administration Medical Center (SLCVAMC), in Salt Lake City. Each patient was observed prospectively from the time the blood culture became positive, unless the patient had been discharged or had died before review of the hospital records by one of the investigators, in which case the review of the medical record was retrospective. Charts were evaluated according to the method of Feinstein et al. [24, 25], such that if the presence or absence of a particular finding was not clearly indicated, that case was excluded from analysis for that finding.

During the study period, 20 mL or more of blood was obtained for each culture and inoculated into media for processing on the BACTEC NR660 (Becton Dickinson Diagnostic Instrument Systems, Sparks, MD) or BacT/Alert (Organon Teknika, Durham, NC) blood culture system or both systems at all three centers. Blood was obtained at the bedside by house officers, medical students, or other trained health care personnel (nurses, phlebotomists, etc.) using 70% isopropyl alcohol and then 10% povidone-iodine. Although most of the blood culture specimens were obtained by peripheral venipuncture, it was not possible to determine specifically which ones were obtained in this manner and which were obtained through access devices.

Bottles were transported to the laboratory and incubated until flagged as positive or for 7 days in either BACTEC nonradiometric instruments (NR6 and NR7 bottles) or BacT/Alert continuous-monitoring instruments (BacT/Alert aerobic and anaerobic bottles). Broth from positive bottles was gram-stained and subcultured with use of standard techniques [26]. Susceptibility testing of isolates was done according to guidelines established by the National Committee on Clinical Laboratory Standards [27, 28].

All information obtained from patients' records was recorded on data worksheets and then transferred to a database software program for analysis.

Definitions

Definitions for this study for the most part were identical to those of Weinstein et al. [10, 11]. Only a few will be detailed here. New or modified definitions also will be detailed.

True septicemia vs. contamination. Each positive blood culture was assessed critically by one of the investigators, each an infectious disease physician. All isolates were categorized as true-positives, contaminants, or of unknown clinical significance. The categorical decision was made after the following factors were taken into account: the patient's clinical history, physical findings, body temperature at the time of the blood culture, leukocyte count and differential cell counts, number of positive blood cultures out of the total number performed, results of cultures of specimens from other sites, imaging results, histopathologic findings, and clinical course and response to therapy. If the clinical significance of the positive culture was not clear on the basis of the available information, the isolate was categorized as being of unknown significance.

Episode. An episode of bacteremia, fungemia, or mycobacteremia was defined by the first positive blood culture in a series or by any new positive blood culture result that occurred >48 hours after the previous positive result, unless it was clear to the investigator that the new positive culture was part of the same episode. For example, a positive blood culture for *Staphylococcus aureus* on the fifth day of antibiotic therapy for *S. aureus* endocarditis was considered part of the original bacteremic episode.

Community- vs. hospital-acquired septicemia. Each episode was classified as either community- or hospital-acquired septicemia, according to guidelines of the Centers for Disease Control and Prevention [29]. Septicemia in nursing home patients with positive blood cultures was always classified as hospital-acquired, whereas that in patients transferred from other outside facilities was classified according to their total period of hospitalization at both institutions.

Antimicrobial Therapy

Data on antimicrobial therapy were obtained at four chronologic points for each episode. These points were as follows: (1) at the time the first positive blood culture specimen was obtained, (2) after the blood culture was performed but before positive culture results were reported (i.e., empirical therapy), (3) after the blood culture was reported to be positive and gram-stained smear results were made known to the primary physician(s) but before organism identification and susceptibility test results were available, and (4) after organism identification and susceptibility test results were reported to the physicians.

Therapy was assessed critically at each time point on the basis of the clinical information available (time points 1–3) or the identification of the isolate and susceptibility test results (time point 4).

Treatment was judged to be the first choice if it was in accordance with the recommendations of a standard reference for antimicrobial therapy [30] and an alternative choice if the etiologic microorganism(s) was (were) susceptible to the agent administered but that agent was not considered the first choice. For purposes of judging the adequacy of therapy, both first-choice and alternative-choice agents were considered appropriate. Therapy was designated as the wrong choice if the causative microorganism was resistant to the antibiotic given. Superfluous therapy was defined as either the administration of unnecessary antibiotics in addition to a first- or alternative-choice agent or the administration of antibiotics for contaminant isolates. Ineffective or superfluous agents given for infections elsewhere in the body were recorded separately.

If a patient died before susceptibility results became available, that fact was recorded. When no therapy was given after the report of a positive blood culture to the physician, one of

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three assessments was made: (1) appropriate, if the isolate was a contaminant; (2) appropriate, if the episode was judged to represent true but transient bacteremia or fungemia that resolved spontaneously without adversely affecting the patient; or (3) inappropriate, if the culture represented true sepsis and the patient's status deteriorated because of the infection.

Outcome

The outcome of each episode was categorized as follows. The patient was (1) discharged alive, (2) alive but still hospitalized 30 days or longer after the onset of bacteremia or fungemia, (3) dead from causes attributable to the septicemic episode, or (4) dead from causes unrelated to septicemia. For the purposes of this study, mortality is termed associated or nonassociated in the subsequent text and tables.

Statistical Methods

For univariate analyses, statistical significance was calculated with the χ^2 test as described by O'Brien and Shampo [31]. The multivariate analysis and the resulting significance calculations were based on the logistic regression model [32], as implemented by the function "glm" in the statistical package S+ [33].

Results

During the study period, 1,585 blood culture–positive episodes occurred in 1,267 patients and yielded 1,844 microorganisms. Nine hundred forty-four microorganisms were isolated from 707 patients who had 843 episodes of true bacteremia or fungemia. There were 658 contaminant episodes and 84 episodes of unknown clinical significance.

Microbiological Features

The microorganisms isolated from positive blood cultures and the frequency with which they caused true bacteremia or fungemia are shown in table 1. The most common isolates from blood were coagulase-negative staphylococci. *S. aureus* was the microorganism most frequently causing true bacteremia; 87.2% of isolates were judged clinically significant. In contrast, only 12.4% of the coagulase-negative staphylococci were clinically significant, but they ranked as the third most frequent cause of bacteremia by virtue of their high prevalence.

Given the frequency with which coagulase-negative staphylococci were isolated from blood and the difficulty in determining their clinical significance, we analyzed *Staphylococcus epidermidis* isolates on the basis of the number of culture sets positive vs. the number of sets performed for each episode. The results are shown in table 2. When only a single culture set yielded *S. epidermidis,* the culture result almost always was judged to be of indeterminate significance or to represent contamination. When all of two or three culture sets yielded *S. epidermidis,* the isolates usually were judged clinically significant, but a substantial minority were of unknown (i.e., indeterminate) significance.

Whereas pneumococci always represented real infection, enterococcal isolates did so only 70% of the time, and viridans streptococci more often were contaminants (49%) than clinically significant isolates (38%) (table 1). Among the gram-negative aerobic and facultative bacteria, *Escherichia coli* was the most common isolate, and this microorganism was second only to *S. aureus* as a cause of septicemia. Overall, the Enterobacteriaceae and *Pseudomonas aeruginosa* represented true bacteremia >95% of the time when isolated.

Anaerobic bacteria were not common blood pathogens, accounting for only 3.9% of clinically important isolates. The isolation of a member of the *Bacteroides fragilis* group, however, almost always indicated true bacteremia (89%). *Clostridium perfringens* usually represented contamination when isolated from the blood, whereas the isolation of other *Clostridium* species usually represented true bacteremia.

Yeasts were relatively common isolates from blood cultures and almost always represented true fungemia when detected (91.7%). These organisms were present as clinically important pathogens almost twice as often as anaerobic bacteria, and *Candida albicans* ranked among the top 10 microorganisms causing septicemia. All mycobacteria and all but one *Cryptococcus neoformans* isolate were isolated from HIV-infected patients.

Of the 843 episodes of bacteremia and fungemia, 764 (90.6%) were unimicrobial and 79 (9.4%) were polymicrobial. Two microorganisms were isolated in 57 (72.2%) of the polymicrobial episodes, and ⩾3 microorganisms were isolated in 22 episodes (27.8%).

Epidemiological Features

Age and sex. Patients ranged in age from 17 to 103 years (mean, 56.2 years). Patients with HIV infection were younger (mean age, 36.9 years). Four hundred ninety of the episodes (58.1%) occurred in men. Ninety-nine percent of the episodes at the SLCVAMC, vs. 54% at both DUMC and RWJUH, were in men.

Community- vs. hospital-acquired infection. Of the 843 episodes, 404 (47.9%) were of community-acquired infection and 439 (52.1%) were of nosocomial infection. The microorganisms isolated in these episodes, categorized according to place of acquisition, are shown in table 3. Microorganisms more often associated with nosocomial acquisition were coagulase-negative staphylococci, enterococci, Enterobacteriaceae other than *E. coli, P. aeruginosa, Clostridium* species, *Bacteroides* species, and yeasts other than *C. neoformans.* A somewhat surprising finding was that nearly 40% of *P. aeruginosa* bacteremias were community-acquired.

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Table 1. Microorganisms isolated from blood of patients at Duke University Medical Center, Robert Wood Johnson University Hospital, and the Salt Lake City VA Medical Center, February 1992 through January 1993.

Microorganism (no. of isolates)	No. (%) of isolates per indicated category		
	True pathogen	Contaminant	Unknown
Aerobic and facultative bacteria			
Gram-positive			
Staphylococcus aureus (204)	178 (87.2)	13 (6.4)	13 (6.4)
Coagulase-negative staphylococci (703)	87 (12.4)	575 (81.9)	41 (5.8)
Enterococcus species (93)	65 (69.9)	15 (16.1)	13 (14.0)
Viridans streptococci (71)	27 (38.0)	35 (49.3)	9 (12.7)
Streptococcus pneumoniae (34)	34 (100)	0	0
Group A streptococci (3)	3 (100)	0	0
Group B streptococci (15)	10 (66.7)	3 (20.0)	2 (13.3)
Other streptococci (13)	8 (61.5)	3 (23.1)	2 (15.4)
Bacillus species (12)	1 (8.3)	11 (91.7)	0
Corynebacterium species (53)	1 (1.9)	51 (96.2)	1 (1.9)
Listeria monocytogenes (2)	1 (50.0)	0	1 (50.0)
Lactobacillus species (15)	6 (54.5)	2 (18.2)	3 (27.3)
Other gram-positive bacteria (15)	2 (13.3)	12 (80)	1 (6.7)
Gram-negative			
Escherichia coli (143)	142 (99.3)	0	1 (0.7)
Klebsiella pneumoniae (65)	65 (100)	0	0
Enterobacter cloacae (25)	25 (100)	0	0
Serratia marcescens (22)	22 (100)	0	0
Proteus mirabilis (16)	16 (100)	0	0
Other Enterobacteriaceae (45)	41 (91)	1 (2.2)	3 (6.7)
Pseudomonas aeruginosa (55)	53 (96.4)	1 (1.8)	1 (1.8)
Pseudomonas species (8)	6 (75)	0	2 (25)
Stenotrophomonas maltophilia (7)	5 (71.4)	0	2 (28.6)
Acinetobacter baumanii (16)	13 (81.2)	1 (6.2)	2 (12.5)
Haemophilus influenzae (3)	3 (100)	0	0
Other gram-negative bacteria (16)	10 (62.5)	3 (18.8)	3 (18.8)
Anaerobic bacteria			
Clostridium perfringens (13)	3 (23.1)	10 (76.9)	0
Clostridium species (15)	12 (80)	3 (20)	0
Propionibacterium species (48)	0	48 (100)	0
Other gram-positive anaerobic bacteria (7)	4 (57.1)	2 (28.6)	1 (14.3)
Bacteroides fragilis group (18)	16 (88.9)	0	2 (11.1)
Other gram-negative anaerobic bacteria (5)	2 (40)	2 (40)	1 (20)
Yeasts and fungi			
Candida albicans (30)	27 (90)	0	3 (10)
Other *Candida* species (15)	15 (100)	0	0
Cryptococcus neoformans (8)	8 (100)	0	0
Torulopsis glabrata (15)	14 (93.3)	0	1 (6.7)
Other yeasts and fungi (4)	2 (50)	1 (25)	1 (25)
Mycobacteria			
Mycobacterium avium complex (16)	16 (100)	0	0
M. tuberculosis (1)	1 (100)	0	0
All microorganisms (1,844)	944 (51.2)	791 (42.9)	109 (5.9)

Hospital service. Six hundred twenty of the 843 bacteremic and fungemic episodes (73.5%) occurred in patients hospitalized on the medical services of our institutions. Patients hospitalized on the nontransplantation surgical services accounted for 21.3% of total episodes, with the remaining 5.2% of episodes distributed among the transplantation surgery, obstetric and gynecologic services, and emergency and outpatient departments. Pneumococcal bacteremia, not surprisingly, was seen almost exclusively in patients on the medical service.

Proportionately, enterococcal and pseudomonas bacteremias were twofold more common on the general and transplantation surgical services than on the medical service. Indeed, *P. aeruginosa* accounted for only 4.4% of septicemias on the medical service. Fungemia was proportionately most common on the

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Table 2. Clinical significance of *Staphylococcus epidermidis* isolates (unimicrobial episodes only).

No. of culture sets		Clinical significance: no. (%) of isolates		
Positive	Performed	Significant	Contaminant	Indeterminate
1	1	0	33 (97.1)	1 (2.9)
1	2	3 (2.2)	129 (94.8)	4 (3.0)
2	2	18 (60.0)	1 (3.3)	11 (36.7)
1	3	0	2 (100)	0
2	3	3 (75.0)	0	1 (25)
3	3	4 (100)	0	0

transplantation surgical service, accounting for nearly 25% of septicemic episodes. Anaerobic bacteremia, which was uncommon in general, was seen most frequently in patients on the general surgery service (6.6% of episodes) and obstetric and gynecologic service (11.1% of episodes).

Sources of infection. The sources of bacteremia and fungemia were identifiable in 627 (74.4%) of episodes and are listed in table 4. Intravenous catheters were the most common primary foci for septicemia. Despite the availability of increasingly sophisticated imaging techniques, the sources for nearly one-fourth of episodes could not be determined.

The relationship between microorganism and sources of unimicrobial bacteremia and fungemia are presented in table 5, which also delineates those episodes confirmed by cultures of specimens other than blood or by clinical evidence. The majority of *S. aureus* and coagulase-negative staphylococcal bacteremias were associated with intravascular devices. Not surprisingly, pneumococcal bacteremia was most often associated with pneumonia, but in 7 of 34 episodes (20.6%) a primary source could not be determined. Among the Enterobacteriaceae, primary foci of infection below the diaphragm predominated (table 5), as would be expected given the normal habitat of these bacteria. In contrast, the most common focus for bacteremia due to *P. aeruginosa* was the respiratory tract, which was the focus more than twice as frequently as the next most common focus, the genitourinary tract.

Several microorganisms or microorganism groups were associated at a particularly high frequency with bacteremia or fungemia in which a primary focus for infection could not be determined. These included the viridans streptococci (44.4%), *Enterobacter cloacae* (58.3%), *Klebsiella pneumoniae* (33.3%), *Candida* species (37.5%), *Torulopsis glabrata* (41.7%), and *Mycobacterium avium* complex (100%). All of the *E. cloacae* bacteremias and many of the fungemias and *K. pneumoniae* bacteremias with unknown sources occurred in patients with underlying malignancies.

Table 3. Community-acquired and hospital-acquired microorganisms and major microorganism groups involved in episodes of bacteremia and fungemia.

	No. (%) of isolates per place of acquisition of infection	
Microorganisms	Community	Hospital
Staphylococcus aureus	90 (50.6)	88 (49.4)
Coagulase-negative staphylococci	27 (31.0)	60 (69.0)
Streptococcus pneumoniae	31 (91.2)	3 (8.8)
Other streptococci	32 (68.1)	15 (31.9)
Enterococcus species	15 (23.1)	50 (76.9)
Escherichia coli	87 (61.3)	55 (38.7)
Other Enterobacteriaceae	61 (36.1)	108 (63.9)
Pseudomonas aeruginosa	21 (39.6)	32 (60.4)
Other nonfermentative gram-negative rods	16 (51.6)	15 (49.4)
Clostridium species	5 (33.3)	10 (66.7)
Bacteroides species	7 (38.9)	11 (61.1)
Candida species	7 (16.7)	35 (83.8)
Cryptococcus neoformans	8 (100)	0
Torulopsis glabrata	2 (14.3)	12 (85.7)
Mycobacterium avium complex	16 (100)	0

Clinical Observations

In order to determine whether certain indicators might assist in assessing the clinical significance of positive blood cultures, we examined the relationship between positive cultures and the peripheral leukocyte count, absolute neutrophil count, blood pressure, and body temperature at the time the first positive blood culture specimen was obtained for a given episode. We also examined the relationship between each of these variables and the microorganisms isolated from true positive cultures. In addition, we critically assessed the antimicrobial therapy as described in the Materials and Methods section.

Leukocyte count and absolute neutrophil count. Patients with culture-positive blood and a peripheral leukocyte count of $<4{,}000/\mu L$ or $\geq 20{,}000/\mu L$ were significantly more likely

Table 4. Sources of bacteremia and fungemia.

	No. of episodes confirmed by		
Source	Culture	Clinical evidence	Total no. (%) of episodes
Intravascular catheter	29	97	161 (19.1)
Genitourinary tract	115	28	147 (17.4)
Respiratory tract	56	46	104 (12.3)
Bowel and peritoneum	22	21	45 (5.3)
Biliary tract	9	21	33 (3.9)
Intraabdominal abscess	9	15	24 (2.8)
Skin	11	29	42 (5.0)
Bone and joint	11	5	16 (2.0)
Surgical wound	7	2	11 (1.3)
Other	25	18	44 (5.2)
Unknown	0	0	216 (25.6)

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Table 5. Sources and confirmatory evidence for episodes of unimicrobial bacteremia and fungemia, according to microorganism.

Microorganism(s) (no. of episodes)	No. of sources confirmed by		Common source(s) (no. of episodes)*
	Culture	Clinical evidence	
Staphylococcus aureus (159)	56	74	IV (56), skin (19), respiratory (18), bone/joint (10)
Coagulase-negative staphylococci (73)	16	45	IV (59), skin (5)
Streptococcus pneumoniae (34)	5	22	Respiratory (26)
Group B streptococci (8)	4	3	Skin (3), GU (3)
Viridans group streptococci (24)	3	10	Respiratory (3), skin (2)
Enterococcus species (38)	13	9	GU (15), IV (3)
Escherichia coli (116)	70	30	GU (67), biliary (11), peritoneal (10)
Klebsiella pneumoniae (48)	15	15	Biliary (10), GU (8), peritoneal (5)
Enterobacter cloacae (12)	3	2	Biliary (2), respiratory (2)
Serratia marcescens (20)	11	6	GU (4), respiratory (4), IV (3)
Proteus mirabilis (13)	10	2	GU (9)
Pseudomonas aeruginosa (48)	25	12	Respiratory (19), GU (9)
Acinetobacter baumanii (12)	4	0	Respiratory (3)
Bacteroides fragilis group (9)	3	4	Abscess (6)
Candida albicans (21)	7	2	IV (5), peritoneal (2)
Candida tropicalis (7)	1	4	IV (1), GU (1), peritoneal (1)
Torulopsis glabrata (12)	1	4	GU (4)
Mycobacterium avium (15)	0	0	No sources identified

NOTE. The list of microorganisms includes all those isolated ≥5 times as causes of unimicrobial bacteremia or fungemia.

* Abscess = intraabdominal abscess; GU = genitourinary tract; IV = intravascular device; respiratory = respiratory tract.

($P < .001$) to have true bacteremia or fungemia episodes (62.5% and 60.3%, respectively) than contaminant episodes when compared with patients who had peripheral leukocyte counts between 4,000 and 19,999/μL (proportion of true bacteremias, 49.2%). Similarly, patients with absolute neutropenia were significantly more likely ($P < .001$) than nonneutropenic patients to have a positive blood culture represent true bacteremia or fungemia (70.2% vs. 51.4% of positive cultures, respectively).

The distribution of microorganisms causing septicemia in neutropenic and nonneutropenic patients is shown in table 6. Neutropenic patients were significantly less likely to have bacteremia due to *S. aureus* ($P < .0001$; RR, 0.33) but were significantly more likely to have fungemia ($P < .01$; RR, 1.81) and polymicrobial bacteremia ($P < .0001$; RR, 2.63) than were nonneutropenic individuals.

Blood pressure. Approximately 14% of patients were hypotensive at the time the first positive blood culture specimen was obtained. The positive blood cultures of these patients were more likely to represent true bacteremia than were positive blood cultures of patients with normal blood pressure at the time cultures were performed (72.7% vs. 51.1% of positive cultures, respectively; $P < .0001$). The distribution of microorganisms causing bacteremia and fungemia in these patients is shown in table 7. There were no statistically significant differences in microorganisms or microorganism groups in hypotensive vs. normotensive patients. However, polymicrobial episodes occurred significantly more often in hypotensive patients than in patients whose blood pressure was normal at the time of blood culture ($P < .05$; RR, 1.58).

Temperature. Cultures of patients who were hypothermic (temperature, <36°C) or who had marked fever (temperature, ≥40°C) were more likely to be true-positives (67.7% and 69.6% of positive cultures, respectively) than were those of patients whose temperatures were normal (39.2% of positive cultures) or moderately elevated (55.9% of positive cultures) at the time the positive blood culture specimen was obtained.

Endocarditis. Of 31 episodes (in 31 patients) of endocarditis, 11 were due to *S. aureus,* 10 to viridans streptococci, and 3 to enterococci. All episodes were unimicrobial; 30 of the 31 were due to gram-positive bacteria, and one was caused by *K. pneumoniae.* Twenty-one patients presented following <1 week of symptoms, 8 following 1–3 weeks of symptoms, and 2 following >3 weeks of symptoms. Seven of 11 patients with endocarditis due to *S. aureus* and 7 of 10 patients with endocarditis caused by viridans streptococci presented following <1 week of symptoms.

Antibiotic therapy. Of the 1,585 episodes of positive blood cultures, 454 (28.6%) involved patients receiving antimicrobial agents at the time the first positive blood culture specimen was obtained. The proportion of patients who were receiving antibiotics was the same regardless of whether growth repre-

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Table 6. Microorganisms recovered from and types of episodes in patients with bacteremia and fungemia, according to absolute neutrophil count.

Variable	No. (%) of isolates from patients with indicated neutrophil count	
	<1,000/μL	≥1,000/μL
Microorganisms		
Staphylococcus aureus	9 (6.0)*	169 (21.1)*
Coagulase-negative staphylococci	12 (8.1)	75 (9.4)
Streptococci	9 (6.0)	78 (9.7)
Enterococcus species	13 (8.7)	52 (6.5)
Enterobacteriaceae	58 (38.9)	253 (31.6)
Pseudomonas aeruginosa	11 (7.4)	42 (5.2)
Other nonfermentative gram-negative rods	2 (1.3)	29 (3.6)
Anaerobic bacteria	9 (6.1)	29 (3.6)
Yeasts and fungi	17 (12.1)†	48 (6.0)†
Type of episode: total no. (%)		
Unimicrobial	96 (69.6)	668 (87.4)
Polymicrobial	24 (30.4)*	55 (12.6)*

* $P < .0001$.
† $P < .01$.

sented true bacteremia or contamination. Of the 843 episodes of true bacteremia or fungemia, 71 (8.4%) occurred in patients who were receiving therapy that was effective against the microorganism(s) that grew in the blood culture. This proportion was the same at all three hospitals (range, 8.0%–9.1%).

Appropriate antimicrobial therapy was administered to a substantial majority of patients at all of the time points assessed. Excluding the 48 patients who died prior to the availability of susceptibility test results, 620 of 795 patients (78%) received appropriate therapy at all time points. In addition, 111 patients (14%) were given appropriate therapy after susceptibility test results were available, regardless of whether they had received inappropriate empirical therapy at an earlier time point.

Patients with unimicrobial septicemia were more likely than those with polymicrobial septicemia to be treated with appropriate therapy, especially after susceptibility test results were available (92.7% vs. 83.6%, respectively). At all time points assessed, medical patients were somewhat more likely than surgical patients to receive appropriate therapy. Among medical patients, the proportion who received appropriate therapy at the different time points ranged from 89.4% to 91.0%, versus a range of 83.0% to 87.1% among surgical patients.

After susceptibility test results were available, approximately one-quarter of all patients were receiving antimicrobial agents judged to be superfluous for the infecting microorganism(s) and clinical setting. Twenty-six patients (3.3%) were receiving agents to which their infecting organisms were resistant in vitro, and nine patients (1.1%) received no antimicrobials despite a clinical setting that should have mandated therapeutic intervention.

Outcome and Factors Influencing Prognosis

One hundred forty-eight patients (17.5%) died of causes directly or indirectly attributable to an episode of septicemia (associated mortality). Five hundred thirty-five patients (63.5%) were discharged alive, 118 (14.0%) were alive but remained hospitalized 30 days after onset of the septicemic episode, and 42 (5.0%) died from causes that were judged by the investigators not to be associated with the bacteremia or fungemia. There were no significant differences in mortality at the three collaborating hospitals.

Univariate Analyses

Age and sex. The effect of age on outcome of bacteremia and fungemia was assessed according to the decade of life of the infected patients. As shown in figure 1, septicemia-associated mortality gradually increased with age and was especially notable after the age of 70 years. The infection-associated mortality for septicemic patients over 70 years of age was 24.2% compared with 15.2% for patients 70 years of age or less. In comparison with other patients, the relative risks of death from bacteremia and fungemia for patients between 71 and 80 years of age and >80 years of age were 2.58 and 3.4, respectively. There were no significant differences in infection-associated mortality between septicemic men and women.

Hospital service. The septicemia-associated mortality rates ranged from zero among obstetric and gynecologic patients to 19% and 23% among medical and cardiovascular surgery patients, respectively. However, none of the differences in mortality, when sorted according to hospital service, were statistically significant.

Table 7. Microorganisms recovered from and types of episodes in hypotensive and normotensive patients with bacteremia and fungemia.

Variable	No. (%) of isolates from patients with indicated blood pressure status	
	Hypotensive	Normotensive
Microorganism		
Staphylococcus aureus	21 (16.0)	157 (19.3)
Coagulase-negative staphylococci	6 (4.6)	81 (10.0)
Streptococcus pneumoniae	8 (6.1)	26 (3.2)
Other streptococci	6 (4.6)	41 (5.0)
Enterococcus species	13 (10.0)	52 (6.4)
Enterobacteriaceae	46 (35.1)	265 (32.6)
Pseudomonas aeruginosa	7 (5.3)	46 (5.7)
Other nonfermentative gram-negative rods	1 (0.8)	30 (3.7)
Anaerobic bacteria	5 (3.8)	33 (4.1)
Yeasts and fungi	12 (9.2)	54 (6.6)
Type of episode: total no. (%)		
Unimicrobial	96 (85.7)	668 (91.4)
Polymicrobial	16 (14.3)*	63 (8.6)*

* $P < .05$.

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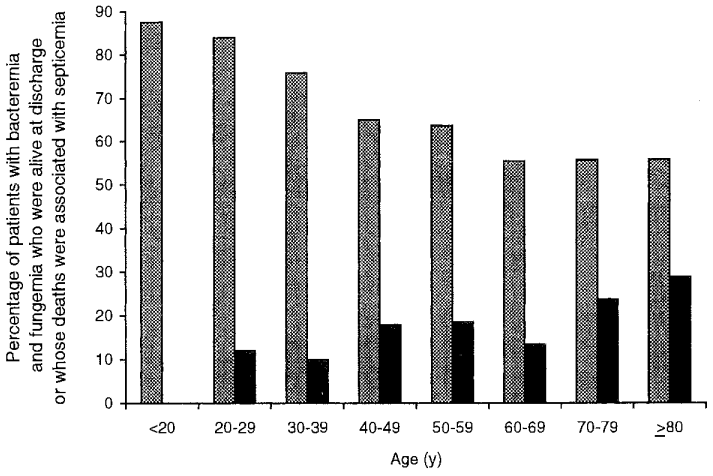


Figure 1. Outcome of bacteremia or fungemia, according to age group of patients (▩ = alive at discharge; ■ = death, associated with septicemia).

Place of acquisition of bacteremia and fungemia. Patients who developed bacteremia or fungemia during the course of hospitalization had an infection-associated mortality rate of 20.3%, vs. 14.6% for patients with community-acquired disease. The relative risk of death associated with nosocomial septicemia was 1.39 ($P < .05$).

Table 8. Associated mortality in episodes of bacteremia and fungemia and relative risk of death, as related to etiologic microorganisms in unimicrobial episodes and to the type of episode.

Variable	Associated mortality: no. (%) of deaths per no. of episodes	Relative risk of death
Microorganisms		
Staphylococcus aureus	19/159 (11.9)	2.18
Coagulase-negative staphylococci	4/73 (5.5)*	1.0
Streptococcus pneumoniae	6/34 (17.6)	3.22
Other streptococci	5/38 (13.1)	2.40
Enterococcus species	5/38 (13.1)	2.40
Other gram-positive aerobic bacteria	1/9 (11.1)	2.03
Escherichia coli	14/116 (12.1)	2.20
Other Enterobacteriaceae	31/125 (24.8)†	4.53
Pseudomonas aeruginosa	8/48 (16.7)	3.04
Other nonfermentative gram-negative rods	3/25 (12.0)	2.19
Other gram-negative aerobic bacteria	0/6	0.04
Gram-negative anaerobic bacteria	2/14 (14.3)	2.61
Gram-positive anaerobic bacteria	2/8 (25.0)	3.65
Yeasts and fungi	19/53 (35.8)‡	6.54
Mycobacteria	2/16 (12.5)	2.28
Type of episode		
Unimicrobial	120/764 (15.7)	1.0
Polymicrobial	27/79 (34.2)‡	2.16

* $P < .05$.
† $P < .01$.
‡ $P < .001$.

Microorganism. The microorganism isolated and type of bacteremia or fungemia (i.e., unimicrobial or polymicrobial) influenced outcome (table 8). Among the common etiologic agents of bacteremia and fungemia, the lowest associated mortality occurred with coagulase-negative staphylococci (5.5%) and the highest with yeasts and fungi (35.8%). Infection-associated mortality was lower with gram-positive unimicrobial bacteremia (11.1%) than with gram-negative bacteremia (17.6%), anaerobic bacteremia (18.2%), or fungemia (35.8%).

The mortality associated with pneumococcal bacteremia was greater than that associated with enterococcal or *S. aureus* bacteremia (table 8). Also noteworthy was the mortality rate with *P. aeruginosa* bacteremia, which was less than that with bacteremia due to enteric gram-negative rods other than *E. coli* (table 8). The mortality associated with polymicrobial bacteremia was more than twice that associated with unimicrobial episodes.

Table 9. Associated mortality in episodes of bacteremia and fungemia, according to source of infection.

Source of infection	Associated mortality: no. (%) of deaths per no. of episodes	Relative risk of death
Intravascular catheter	12/161 (7.4)*	1.0
Genitourinary tract	16/147 (10.8)†	1.46
Respiratory tract	26/104 (25.0)†	3.35
Bowel and peritoneum	23/45 (51.1)‡	6.86
Biliary tract	4/33 (12.1)	1.63
Intraabdominal abscess	3/24 (12.5)	1.68
Skin	6/42 (14.3)	1.92
Bone and joint	1/16 (6.25)	0.84
Surgical wound	0/11	0.01
Other	3/44 (6.8)	0.91
Unknown	54/216 (25.0)*	3.35

* $P < .01$.
† $P < .05$.
‡ $P < .001$.

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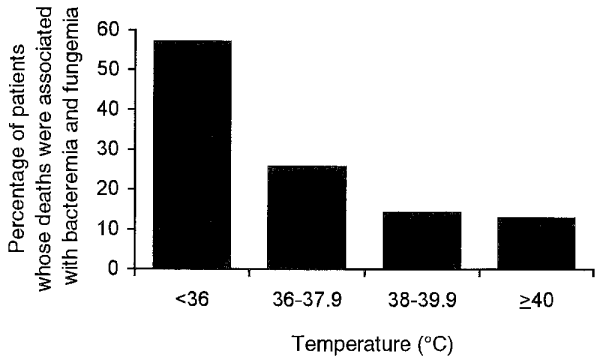


Figure 2. Septicemia-associated mortality as related to temperature of patients at the time the first positive blood culture specimen was obtained.

Source of infection. The outcome of bacteremia and fungemia was affected by the primary source of infection (table 9). For risk factor analysis, we assigned a risk of 1.0 to septicemia associated with iv catheters in order to maintain consistency with our earlier work [11]. Significantly increased septicemia-associated mortality and relative risk of death occurred with respiratory tract sources ($P < .05$), with bowel and peritoneal sources ($P < .01$), and when a primary focus of infection could not be found ($P < .05$).

Body temperature. The mortality associated with bacteremia and fungemia was inversely related to the body temperature of patients at the time the first positive blood culture specimen was obtained (figure 2). Risk factor analysis showed significantly increased mortality ($P < .05$) among the patients who were hypothermic at the onset of septicemia.

Blood pressure. Septic shock, as evidenced by the presence of hypotension at the time the first positive blood culture specimen was obtained, was associated with increased mortality. Table 10 reveals that this relationship was a virtually uniform finding, regardless of the etiologic microorganism or the type of septic episode.

Leukocyte count and absolute neutrophil count. The relationship between septicemia-associated mortality and total leukocyte count or absolute neutrophil count is shown in table 11. Patients who had leukocyte counts of $<4{,}000/\mu L$ or $\geq 20{,}000/\mu L$ had a twofold increase in relative risk of death from septicemia. Patients with absolute neutropenia had a significantly increased relative risk of death in comparison with that for nonneutropenic patients.

Predisposing factors. The influence of predisposing factors on the outcome of septicemia was analyzed both when individual factors were present alone and when multiple factors were present (table 12). Nearly one-quarter of the patients had no predisposing factors, and these patients had the lowest septicemia-associated mortality (8.2%; RR, 1.0). The greatest mortality was associated with moderate renal failure (61.5%; RR, 7.54).

Table 10. Associated mortality in episodes of bacteremia and fungemia, as related to etiologic microorganism in unimicrobial episodes, type of episode, and blood pressure status at the time of onset of septicemia.

Variable	Associated mortality: no. (%) of deaths per no. of episodes in indicated group	
	Hypotensive	Normotensive
Microorganisms		
Staphylococcus aureus	5/18 (27.8)*	14/141 (9.9)*
Coagulase-negative staphylococci	1/4 (25)	3/69 (4.3)
Streptococcus pneumoniae	1/8 (12.5)	5/26 (19.2)
Other streptococci	1/3 (33.3)	3/35 (8.6)
Enterococcus species	1/5 (20)	4/33 (12.1)
Escherichia coli	4/13 (30.8)*	10/103 (9.7)*
Other Enterobacteriaceae	12/23 (52.2)†	19/104 (18.3)†
Pseudomonas aeruginosa	3/6 (50)*	5/42 (11.9)*
Other nonfermentative gram-negative rods	0/1	3/28 (10.7)
Anaerobic bacteria	1/2 (50)	3/24 (12.5)
Yeasts and fungi	5/7 (71.4)*	14/46 (30.4)*
Type of episode		
Unimicrobial	35/96 (36.4)‡	85/668 (12.7)
Polymicrobial	10/16 (62.5)†	17/63 (27.0)

* $P < .05$.
† $P < .01$.
‡ $P < .001$.

Although the relative risk of death was high in the presence of severe renal failure and biopsy-proven cirrhosis, statistical significance was not achieved because of the relative infrequency of each of these predisposing factors as the sole underlying problem. Not surprisingly, there was a direct relationship between septicemia-associated mortality and the number of predisposing factors present. Thus, mortality was greater among the patients with multiple predisposing factors than among patients with only a single factor.

Table 11. Associated mortality in episodes of bacteremia and fungemia, as related to leukocyte count and absolute neutrophil count.

Variable	Associated mortality: no. (%) of deaths per no. of episodes	Relative risk of death
Total leukocyte count (per μL)		
$<4{,}000$	42/177 (23.7)	2.11*
4,000–10,999	28/249 (11.2)	1.0
11,000–19,999	48/293 (16.4)	1.46
20,000–49,999	27/115 (23.5)	2.09*
$\geq 50{,}000$	2/8 (25)	2.22
Absolute neutrophil count (per μL)		
$<1{,}000$	31/120 (25.8)	1.58*
$\geq 1{,}000$	115/702 (16.4)	1.0

* $P < .05$.

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Table 12. Influence of predisposing factors on associated mortality in episodes of bacteremia and fungemia.

Factor(s)	Associated mortality: no. (%) of deaths* per no. of episodes	Relative risk of death
None	16/196 (8.2)	1.0
Hematologic malignancy	14/70 (20.0)	2.45†
Other neoplasm	27/150 (18.0)	2.20†
Corticosteroids	3/28 (10.7)	1.31
AIDS	11/51 (21.6)	2.64†
Trauma	1/11 (9.1)	1.11
Recent surgery	7/49 (14.3)	1.75
Diabetes mellitus	6/59 (10.2)	1.25
Creatinine level, 2–5 mg/dL	16/26 (61.5)	7.54‡
Creatinine level, >5 mg/dL	4/16 (25)	3.06
Cirrhosis	2/6 (33.3)	4.08
One factor	91/477 (19.1)	2.34†
Two or more factors	41/168 (24.4)	2.99†

* No. of deaths among patients in whom listed predisposing factor was the only one present.
† $P < .05$.
‡ $P < .01$.

Antibiotic and other therapy. The mortality associated with bacteremia and fungemia clearly was affected by the type of antimicrobial therapy administered (table 13). The great majority (78%) of patients received appropriate therapy at all three time points at which assessments were made, and this group of patients had the lowest septicemia-associated mortality. Patients who received inappropriate empirical therapy but whose physicians administered appropriate therapy once the blood culture was reported to be positive also had low mortality. By contrast, among the small group of patients who received inappropriate therapy at all three time points, three of nine (33%) died of causes attributable to sepsis.

Indeed, the data shown in table 13 clearly indicate that septicemia-associated mortality increased in proportion to the duration of inappropriate antimicrobial therapy. Since our definition of appropriate empirical therapy allowed for the possibility that the organism(s) grown in blood culture might not be susceptible to the agents given, we also assessed outcome in terms of whether the infecting organisms were susceptible to therapy being administered at each time point. The results of this analysis were very similar; that is, associated mortality was lowest (9.8%) when the organism was susceptible at all three time points and also was low (12.6%) when patients received effective antimicrobial therapy after blood cultures were reported to be positive.

When mortality following the availability of susceptibility test results was analyzed alone, the mortality rates when first-choice or alternative-choice agents were given were identical (8.3%), but the rate was 24% when superfluous therapy was given. Since superfluous therapy included at least one agent with in vitro activity against the infecting microorganism, other factors that may have influenced outcome were assessed. Patients receiving superfluous therapy were twofold to threefold more likely to have absolute granulocytopenia, fungemia, or polymicrobial episodes than were patients who received first-choice or alternative-choice agents.

The removal, excision, or drainage of a primary focus of infection, if feasible, often has a salutary effect on the outcome of septicemia. Therefore, we assessed outcome when such therapeutic maneuvers were undertaken. The results confirmed the beneficial effect of these interventions. Among patients who survived until susceptibility test results were available, associated mortality was 6.2% (14 of 224) when an infected focus was excised, drained, or removed, vs. 15.6% (87 of 557) when no additional interventions were (or could be) undertaken ($P < .001$). Among patients with catheter-associated bacteremia or fungemia, removal of the catheter was associated with death due to septicemia in only 3.9%.

Table 13. Associated mortality in episodes of bacteremia and fungemia, as related to appropriateness of antimicrobial therapy at different time points during septicemia.

Assessment of therapy at indicated time point*				
Initial empirical therapy	After culture reported positive	After susceptibility results available	Associated mortality: no. (%) of deaths per no. of patients	RR
A	A	A	65/620 (10.5)	1.0
I	A	A	6/45 (13.3)	1.27
A	I	A	7/35 (20.0)	1.91
A	A	I	7/35 (20.0)	1.91
I	I	A	8/31 (25.8)	2.46
A	I	I	4/14 (28.6)	2.73
I	A	I	0/2	0.05
I	I	I	3/9 (33.3)	3.18

* A = appropriate; I = inappropriate. Therapy was considered appropriate after susceptibility test results became available if the microorganism(s) were susceptible (on the basis of in vitro testing) to at least one agent administered, whereas therapy was considered appropriate at the earlier time points it if was appropriate for the clinical situation.

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Multivariate Analysis

Based on the results of univariate analysis, high- and low-risk categories were established for each variable assessed. When there was more than one high-risk component for a variable (e.g., microorganism, source, or predisposing factor), these components were grouped and assigned a univariate relative risk for the purpose of multivariate analysis. Then, with use of logistic regression, the relative risk of death was determined for each variable in the presence of all others.

The results of this analysis are shown in table 14. Those variables associated with a significantly increased risk of death in multivariate analysis were advanced age (>70 years); isolation of fungi or Enterobacteriaceae other than *E. coli;* a primary source of infection in the respiratory tract, bowel, or peritoneum or that was unknown; underlying malignancy, AIDS, or renal failure; shock, as manifested by hypotension; inability to mount a febrile response to sepsis; and inappropriate antibiotic therapy at two or more of the time points assessed.

Discussion

It was our hypothesis that the many changes in medicine since the mid-1970s, when two of us and other investigators [10, 11] comprehensively reviewed a large series of patients with bacteremia and fungemia, would lead to substantive changes in the microbiology, epidemiology, and clinical and prognostic significance of positive blood cultures in the 1990s. Indeed, the more aggressive and widespread use of prosthetic materials and intravascular devices, the occurrence of syndromes such as AIDS not known 2 decades ago, and therapeutic advances in imaging, interventional radiology, and antimicrobial therapy virtually ensured the presence of important differences and underscored the need for this update.

In order to best compare the differences and similarities of bacteremia and fungemia in the 1990s versus the mid-1970s, we used definitions, including clinical and diagnostic criteria, that were similar to those in our earlier work [10, 11]. However, we performed this study prospectively, gathering data concurrently on patients with culture-positive blood, to better assess the ways in which physicians used laboratory results for therapeutic decisions.

Laboratory Observations

True septicemia vs. contamination. The observations from this study suggest that contaminants in blood cultures are more frequent in the 1990s than they were 2 decades ago. Of 1,585 positive blood culture episodes in the current study, 655 (41.5%) were judged to represent contamination and another 84 (5.3%) were of indeterminate significance. Thus, only about half of all positive blood cultures represented true bloodstream infection. These findings contrast markedly with the observations in our earlier study, in which approximately one-third of all positive blood cultures represented contamination [10].

There are several possible explanations for these findings. One is the increasing use of central, long-term intravascular catheters (e.g., Hickman and Broviac) and the utilization of these access devices for the purpose of obtaining blood for culture. Access ports from intravascular devices may be more difficult to sterilize than skin at venipuncture sites, thereby resulting in increased contamination rates; at least one study has documented increased contamination rates when blood culture specimens are obtained from central lines [34].

Although physicians may believe they are benefiting their patients by obtaining blood culture specimens from catheters (i.e., saving patients from needlesticks), they actually may be doing a disservice, since culture contaminants (false-positives

Table 14. Comparison of univariate and multivariate analysis of factors affecting risk of death in patients with bacteremia and fungemia.

Variable	Univariate high risk	Univariate RR	Multivariate RR
Age	>70 y	1.88	1.80*
Place of acquisition	Hospital	1.39	1.12
Microorganisms	Fungi and Enterobacteriaceae other than *E. coli*	5.13	2.27†
Type of episode	Polymicrobial	2.16	1.55
Source of infection	Respiratory tract, bowel, peritoneum, or unknown	2.56	2.86†
Predisposing factor	Malignancy, AIDS, or renal failure	1.92	1.98†
Blood pressure	Hypotension	2.85	2.29†
Leukocyte count	<4,000/μL or >20,000/μL	1.67	1.24
Absolute neutrophil count	<1,000/μL	1.58	0.65
Body temperature	Absence of fever (<37.9°C)	2.06	2.04†
Antibiotic therapy	Inappropriate at ≥2 time points	2.32	2.72†

* $P < .05$.
† $P < .01$.

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cultures) have been shown to result in longer hospitalizations and increased costs to patients and institutions [35].

A second possible reason for the increased incidence of contaminants is blood culture technique. Although several recent studies have indicated that the current single-needle technique for obtaining blood and inoculating cultures is not associated with increased rates of contamination [14, 36, 37], Spitalnic et al. [38], in a meta-analysis, have suggested otherwise. Alternatively, it may be that in institutions such as ours, in which house officers and medical students obtain the majority of blood culture specimens, failure to apply antiseptic solutions (usually iodophors and alcohol) properly and to let them exert their antimicrobial effect over 1–2 minutes as recommended results in increased contamination.

Possible remedies include use of blood culture teams from the laboratory's phlebotomy service, which seems unlikely in the managed care era, or the development and use of potentially more effective antiseptic skin preparation materials (e.g., 2% iodine tincture) before blood sampling. A final possible explanation for increased rates of contamination of blood cultures could be that newer blood culture systems and media are more sensitive and capable of detecting the few viable skin bacteria that might remain after appropriate antiseptic preparation.

Of the 843 septicemias, a source was confirmed by culture in 294 (34.9%) and by clinical evidence in 282 (33.4%). Of the remaining 267 episodes, at least two blood cultures were positive for the same microorganism in 181 (67.8%; 21.5% of total septicemias). Thus, there was objective evidence of true infection in 757 of the 843 episodes (89.8%), an observation that is remarkably similar to that in our earlier study [10]. This finding is important clinically, since it suggests that, despite increased rates of contamination of blood cultures, in the great majority of instances physicians should be able to determine with some confidence whether a positive blood culture represents significant infection.

Nevertheless, positive blood cultures yielding coagulase-negative staphylococci may present great interpretative difficulties, even when more than one culture set is positive. For example, Zaidi et al. [39] have found that coagulase-negative staphylococci with identical species designations, serotypes, and antibiograms recovered from the blood of infants sometimes represented different strains when the isolates were analyzed by molecular typing techniques. Similarly, even when both of two blood cultures yielded *S. epidermidis* of the same biotype in the current study, we were frequently not certain of the isolates' clinical significance (table 2).

Patterns of positive blood cultures. In our earlier study [10], we noted different patterns of blood culture positivity in patients with endocarditis, those with true septicemia that was not due to endocarditis, and those with contaminant isolates. Similar observations were made in this study. Thus, in patients with endocarditis, a disease characterized by continuous seeding of blood from the infected heart valve, all blood cultures obtained in a series were positive.

By contrast, for patients with septicemia not due to endocarditis, most but not all blood cultures obtained in a series were positive, a finding consistent with the understanding that bloodstream infection in such patients may be short-lived or intermittent (abscesses). For patients whose blood cultures were contaminated, an initial positive culture in a series virtually always was followed by negative cultures. When a subsequent culture was positive, it usually was positive with a different microorganism (e.g., *S. epidermidis* followed by a diphtheroid).

The proportion of patients with polymicrobial septicemia in this study (79 of 843; 9.4%) is consistent with findings in earlier studies, in which frequencies of polymicrobial bacteremia ranged from 6% to 18% [10, 17, 40–43].

Epidemiological Observations

Place of acquisition of septicemia. At our institutions the proportions of episodes that were of community-acquired septicemia and hospital-acquired septicemia were nearly equal (48% vs. 52%). This observation contrasts with the results of our earlier study at the University of Colorado hospitals, in which nearly two-thirds of episodes were nosocomial [10]. The difference may relate not only to patient-population variability [44, 45] but also to changes in health care, particularly shorter lengths of stay in the 1990s than those of 2 decades ago, as well as outpatient surgery and chemotherapy.

In contrast to the relative equivalence of community- and hospital-acquired septicemic episodes overall, there were important differences with regard to individual microorganisms. For example, 91% of pneumococcal bacteremias and all mycobacteremias and cryptococcemias were community-acquired. These observations are consistent with prior reports (on pneumococci) and with our understanding of the epidemiology of infections due to these microorganisms [10, 44, 46]. However, nosocomial pneumococcal bacteremia can occur and may be relatively common in institutions with longer patient stays [47, 48].

Fungemia, enterococcal bacteremia, and coagulase-negative staphylococcal bacteremia disproportionately were nosocomial in origin (table 3). The observations for fungi and enterococci were virtually identical to those in our earlier studies of bacteremia [10] and probably relate to the fact that infection with these microorganisms tend to occur in more debilitated patients. The predominance of hospital-acquired coagulase-negative staphylococcal bacteremia is explained by the current use of long-term indwelling central and peripheral catheters as well as other prosthetic devices, the ubiquity of these bacteria as normal skin flora, and the ability of these relatively avirulent microorganisms to adhere to the surfaces of biomaterials.

P. aeruginosa bacteremia usually occurs as a nosocomial infection. In the current study, *P. aeruginosa* bacteremia was community-acquired in 39.6% of episodes, compared with 17% in our earlier study. The explanation for this difference in the epidemiology of *P. aeruginosa* bacteremia may be related in

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part to the prevalence of HIV infection. In bacteremic patients known to be infected with HIV, *P. aeruginosa* was the third most frequently isolated pathogen, and in seven of 11 episodes in these patients, bacteremia was community-acquired. Several recent reports have documented similar findings in patients with HIV infections [49–51].

Hospital service. The overwhelming majority of bloodstream infections in this series occurred in patients hospitalized on either the medical services (73.6%) or nontransplantation surgical services (21.3%), an observation similar to that in our previous report [10] in which 54.6% of episodes occurred in medical patients and 27.2% of episodes occurred in surgical patients.

The current study also confirmed the rarity of *P. aeruginosa* bacteremia in medical patients (4.4% of episodes), the absence of enterococcal bacteremias in obstetrical and gynecologic patients, the high proportion of fungemias in transplantation patients (23.1% of episodes), and the proportionately increased frequency of anaerobic bacteremia in patients hospitalized on the surgical and gynecologic services (6.6% and 11.1% of episodes, respectively).

Sources of septicemia. Onc of the striking findings in the currcnt scries in comparison with our earlier work [10] was the ascendancy of intravascular catheters as an important source of bloodstream infections. Whereas only 3% of episodes were catheter-related in the previous study, iv catheters were the source of 19% of the episodes in the current series. The increasing importance of intravascular catheters also was noted by Mylotte et al. [47], who examined nosocomial bacteremia between 1979 and 1987; in that study, the proportion of episodes associated with intravascular devices increased from 6% (1979) to 19% (1987). During a similar time period, the proportion of bloodstream infections due to intravascular devices at a university hospital in Berlin was consistently ~16% [19].

The inability to determine the focus of bacteremia and fungemia remains a vexing problem. Despite substantial advances in diagnostic imaging over the past 2 decades, 26% of the septicemic episodes in this series, compared with 31% in our earlier study [10], had no discernible focus. Leibovici and colleagues [20] noted similar results; 23% of episodes during 1988 and 1989 at their university hospital in Israel were of unknown origin.

Since episodes with unknown foci are associated with increased mortality ([11, 20] and present study), improved methods for determining the primary site of infection in septicemic patients clearly are needed. Microorganisms from unknown foci commonly are assumed to have a gut mucosal source. The organisms associated highly with an unknown source in this study (e.g., *E. cloacae, K. pneumoniae, Candida* species, *T. glabrata,* viridans streptococci, and *M. avium* complex) support this hypothesis.

When we examined the sources of septicemia according to each microorganism or microorganism group (table 5), there were several noteworthy observations. For example, in the years since our previous study, the proportion of *S. aureus* bacteremias associated with intravascular catheters has nearly doubled, from 20% to 35%. Respiratory and skin sources remained important primary foci for staphylococcal bacteremia. The recent report by Roberts and colleagues [18] confirmed the importance of intravascular and pulmonary foci for staphylococcal bacteremia. In addition, in the current study and in the report by Roberts et al. [18], respiratory foci for klebsiella bacteremia were considerably less prominent than we observed previously [10]; intraabdominal and genitourinary sources now predominate. In contrast to the findings of Roberts et al., who found enterococcal bacteremia most commonly to have wound sources [18], our patients most often had genitourinary tract foci.

Epidemiology of septicemia in neutropenic patients. The differences in the microbiology of bacteremia and fungemia in neutropenic patients compared with nonneutropenic patients (table 6) stand in contrast with the observations in our earlier report [10]. In the present series bacteremia due to *S. aureus* was significantly less common and fungemia significantly more common in neutropenic than nonneutropenic patients, whereas there were no such differences noted in the previous study. However, in both series, polymicrobial episodes were more frequent in granulocytopenic patients.

A study of bacteremia and fungemia in granulocytopenic patients during 1985 and 1986 at the University of Colorado Health Sciences Center [52], which was the site of our earlier study, showed both similarities to and differences from the distributions of microorganisms in the 1975–1977 review [10] and the current one. For example, in the study by Ehni et al. [52], fungemias were proportionately less common (2%, vs. 11% [10] and 12% [current study]) and *P. aeruginosa* bacteremias were more common (27%, vs. 9% [10] and 7% [current study]). However, the proportionate frequency of bacteremias due to Enterobacteriaceae was similar in all three studies.

In the study by Ehni and colleagues [52] and the present report, bacteremia due to *S. aureus* accounted for ~5% of episodes in neutropenic patients, whereas in the 1975–1977 review [10], 13% of episodes in neutropenic patients were caused by *S. aureus.* Finally, the increasing importance of bacteremia due to coagulase-negative staphylococci in neutropenic patients was evident in the study of Ehni et al. [52] and in the current one (14% and 8% of episodes in neutropenic patients, respectively). In our earlier review, coagulase-negative staphylococcal bacteremia was sufficiently uncommon in granulocytopenic patients that it did not merit mention [10].

A possible explanation for the higher rates of fungemia currently includes the extensive use of more effective antipseudomonal β-lactam drugs such as piperacillin, ceftazidime, and imipenem. Although their early and empirical use may decrease mortality owing to *P. aeruginosa* infection, their prolonged pressure on normal gut flora is associated with overgrowth of yeasts and increased risk of subsequent fungemia [53]. The relative importance of coagulase-negative staphylococci presently probably relates to the common and prolonged use of

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central iv catheters and the resistance of this group of organisms to commonly used antimicrobial agents.

Epidemiology of septicemia in hypotensive patients. Septic shock most frequently has been associated with gram-negative bacteremia. Indeed, in our earlier review [10], aerobic or facultative gram-negative rods accounted for 53% of the isolates from hypotensive patients. In the current series, however, whereas we observed that aerobic or facultative gram-negative rods continued to be common etiologic agents of septic shock, they were isolated less frequently than in the past (43% of isolates). *S. aureus* was detected twice as frequently in hypotensive patients in the current series (16%, vs. 7% in the earlier series), and anaerobic bacteria were detected substantially less often in hypotensive patients (4%, vs. 11% in the earlier series). In both series, hypotensive patients were twice as likely as normotensive patients to have polymicrobial bacteremia ([10] and table 7).

Clinical and Prognostic Observations

Our observations suggest that the mortality associated with bacteremia and fungemia appears to have decreased during the past 2 decades. However, this conclusion may not be applicable widely and should be interpreted with caution. Indeed, the differences in patient population as well as the prospective nature of the current study vs. our retrospective earlier review [11] limited the ability to make direct comparisons with the previous work. Nonetheless, mortality attributable to septicemia in this study was markedly less than in the 1975–1977 study (17.5% vs. 31%, respectively). Moreover, Geerdes et al. [19] recently reported that between 1979 and 1989, mortality from septicemia at a university hospital in Berlin decreased from 34% to 21%.

Crude mortality has varied substantially in recent reports of bacteremic patients, ranging from 16% at a Swedish university hospital from 1973 to 1980 [54] to >40% among patients with nosocomial bacteremia from 1981 to 1983 at a university hospital in the United States [55] and with gram-negative bacteremia at a Turkish university hospital from 1983–1989 [21]. By comparison, crude mortality among septicemic patients at the University of Colorado during 1975–1977 was 42% [11], vs. 22.5% in this study (patients were followed for a maximum of 30 days after detection of bacteremia). Most comparable to our data are the observations of Roberts and colleagues, who recently reported a 30-day mortality of 27% among bacteremic patients studied during 1984–1987 in western Canada [18].

Age and sex. Numerous reports have emphasized the importance of advanced age as an unfavorable prognostic factor in septicemic patients [11, 15, 18, 21, 54, 55]. In contrast to our earlier data, which showed a statistically significant increase in mortality due to septicemia after age 40 years [11], in this series significantly increased mortality occurred after age 70 years. No differences in mortality according to sex were evident in this study or in a recent report from a Swedish university hospital [54].

Place of acquisition of bacteremia and fungemia. Nosocomial septicemias historically have been associated with substantially higher mortality than community-acquired septicemias [9, 11, 44]. In the current series and in another recent report [21], however, the evidence suggests that the increase in mortality associated with hospital-acquired bacteremia and fungemia may be less dramatic than reported in the past. Uzun et al. [21] noted crude mortality of 46% in episodes of nosocomial bacteremia vs. 37% in those of community-acquired bacteremia. In this series, associated mortality due to nosocomial septicemia was 20.3%, vs. 14.6% due to community-acquired septicemia.

Microorganisms. Many studies have looked at the mortality rates with bloodstream infections due to individual microorganisms; some have focused only on certain patient populations. Unfortunately, definitions of mortality in the various reports have not been uniform: some have evaluated total (or crude) mortality, others have evaluated only septic deaths (those judged to be directly related to septicemia), and still others have addressed mortality judged directly or indirectly attributable to septicemia. Furthermore, not all studies have indicated clearly whether mortality rates have been calculated on the basis of unimicrobial episodes, thereby excluding the confounding variable of concomitant bacteremia with other microorganisms. These differences make direct comparisons of mortality in other reports problematic, and the comments that follow should be interpreted accordingly.

The lower mortality overall from bacteremia in this series compared with that noted in our earlier work [11] was reflected in the mortality rates associated with individual microorganisms or groups thereof (table 8). Several comparisons and contrasts with regard to etiologic microorganisms deserve emphasis.

Fungemia, which was associated with more than a sixfold increased risk of death in the earlier series [11], also carried a sixfold increased relative risk of death in the present study (table 8). Overall mortality associated with fungemia, however, was lower in the current series than in our earlier report [11], and the associated mortality in this series was somewhat less (36%) than that due to candida and torulopsis fungemias (44%) in Detroit in the mid-1980s [56].

Among episodes of polymicrobial septicemia, for which the directly related mortality was 35% in the earlier series [11], the associated mortality in this series was 34% and the risk of death was significantly increased compared with that in unimicrobial episodes. The mortality associated with polymicrobial bacteremia in the recent report by Cooper et al. [17] was remarkably similar to the observations in our earlier and current series.

In our earlier review, the mortality directly related to pneumococcal bacteremia was 15% (crude mortality, 22%), vs. 17.6% associated mortality in this series. Data from other recent reports are consistent with these findings [57, 58]. These data

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provide impressive evidence that there has been little change in the outcome of *Streptococcus pneumoniae* bacteremia since the classic studies of Austrian and Gold >3 decades ago [59].

By contrast, the dramatically increased risk of death from bacteremia due to *P. aeruginosa* in our earlier report (RR, 6.84) was modcrated in this study (RR, 3.04). The mortality associated with pseudomonas bacteremia was 16.7%, compared with 36% for deaths directly due to bacteremia in the earlier review [11]. Two studies examining pseudomonas bacteremia during the early 1980s revealed case fatality rates attributable to sepsis of 41% and 48% [60, 61]. Thus, our data suggest the possibility that the outcome of bacteremia due to *P. aeruginosa* may have improved over the past decade.

Mortality from bacteremia due to gram-positive organisms also was lower in the current study than in the prior review [11]. In the case of *S. aureus,* septicemia-associated mortality in the current series was 11.9%, compared with crude mortality of 33% and directly related mortality of 9% in the earlier series. By comparison, in the recent report from Lautenschlager et al. [62] encompassing the years 1980–1986 in Basel, Switzerland, total mortality was 34% and directly related mortality was 20%.

Coagulase-negative staphylococcal bacteremia had the lowest attributable mortality of all microorganism groups in the current study (5.5%); case-fatality rates were somewhat higher during the mid-1980s: 13.6% at the University of Iowa Hospital [63] and 18% at a large hospital in Spain [64]. The mortality associated with enterococcal bacteremia was 13% in this series, considerably lower than the crude or directly related mortality (45% and 27%, respectively) in our earlier series [11], despite the presence of vancomycin-resistant enterococci at both RWJUH and DUMC during the current study period. By comparison, reports based on data from the 1980s have described case fatality rates associated with enterococcal bacteremia varying from 12% to 51% [65–67].

Several studies have recently provided data on the outcome of bacteremia due to members of the family Enterobacteriaceae. Mortality due to *E. coli* bacteremia appears to be lower now than 2 decades ago. In our earlier report [11], 41% of patients died of causes directly related to bacteremia, compared with an associated mortality of 10.3% in this study.

Grandsen et al. [68] prospectively evaluated *E. coli* bacteremia in London from 1969 through 1987 and noted a case-fatality rate of 20.7%; approximately half the deaths were judged to be directly related to sepsis. Similarly, the recent review by Roberts and colleagues [18] noted that the 30-day mortality due to *E. coli* bacteremia was 21.5%. Mortality associated with *K. pneumoniae* bacteremia has ranged from 14.6% in the current study to 37% (crude mortality) in another recent report [69]. Korvick et al. [70] reported 19% mortality at 14 days in a recent multicenter study of 230 patients with klebsiella bacteremia.

Mortality associated with serratia bacteremia was 30% among our patients; by contrast, Saito and colleagues [71] reported a mortality rate of 23% in cancer patients between 1982 and 1987. In the present series, associated mortality among 12 patients with *E. cloacae* bacteremia was 8.3%, compared with crude mortality of 24% in a recent multicenter study of 129 patients with enterobacter (all species) bacteremia [72]. The attributable mortality between 1980 and 1992 among patients with *Proteus mirabilis* bacteremia was 25.6% in a recent report [73], remarkably similar to the bacteremia-associated mortality of 23.1% in this series.

Source of infection. As in our earlier study [11], the mortality associated with bacteremia was increased when the primary focus of infection was either unknown or at a site that was difficult to treat, such as the respiratory tract or the bowel and peritoneum. Similarly, when the primary focus of infection could be removed or drained easily (e.g., the genitourinary tract), the mortality was reduced (table 9). The higher mortality in septicemia with an unknown primary focus of infection also has been noted by others [19–21].

Body temperature. The current study confirmed the observations made in our earlier report [11], namely, that the inability of a patient to mount a febrile response to septicemia is a poor prognostic sign (figure 2). This relationship has been noted by others [9, 74, 75] but could not be confirmed in a study designed to examine independent predictors of mortality associated with bloodstream infections [55]. Kluger [76] and Roberts [77] have each recently presented information to support the premise that the presence of physiologically elevated body temperature is beneficial.

Blood pressure. The well-known association between hypotension as a marker for septic shock and poor outcome was again confirmed during this study. This association was noted not only in prior studies [9, 11, 74] but also in more recent reports [18–21]. Compared with data in our earlier review [11], the incremental risk of death when hypotension was present was greater in the current series than was noted previously (RR, 2.8 vs. 2.0).

Total leukocyte count and absolute neutrophil count. Infection-associated mortality and relative risk of death from bacteremia were increased among patients with leukopenia and absolute granulocytopenia, as in our earlier study [11]. In addition, in this study mortality was increased also among patients with total leukocyte counts $\geq 20{,}000/\mu L$. Recent studies in varied patient groups have provided similar observations [17, 60].

Predisposing factors. For consistency and to enable accurate comparisons of risk associated with various underlying conditions that may affect mortality among patients with bacteremia and fungemia, we used the same criteria and definitions as in our earlier review [11] and included HIV infection and AIDS, neither of which were known at the time the earlier study was undertaken. Moreover, the risk associated with each factor was judged when that condition was the only one present (table 12).

As in the earlier study [11], increased risk of death in bacteremia was associated with the presence of malignancies and

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biopsy-proven hepatic cirrhosis. In contrast with our earlier observations, the presence of moderate renal failure (serum creatinine level, 2.0–5.0 mg/dL) but not severe renal failure (serum creatinine level, >5 mg/dL) was associated with increased mortality among bacteremic patients.

Although this observation may seem paradoxical, we interpret the results to suggest that patients with chronic renal failure probably were undergoing dialysis and therefore had stable albeit poor renal function, whereas those with moderate renal failure were more likely to have acute deterioration of function and greater metabolic instability which, in turn, was associated with a greater likelihood of a poor outcome. Finally, the presence of AIDS was associated with an increased risk of death associated with bacteremia or fungemia.

Antibiotic and other therapy. Intuitively, one would expect that administration of antimicrobial agents active in vitro against the infecting microorganism(s) would be associated with improved prognosis. Our prior study and others [11, 78, 79] have supported this assumption, and the current study again confirmed the principle (table 13). By assessing therapy at several different time points, we hoped to determine that degree to which appropriate treatment affected outcome at each stage.

One might have expected, for example, that appropriate therapy given early (empirical therapy time point) would be associated with lower attributable mortality than would appropriate therapy delayed until after susceptibility test results were available to the physician. Indeed, this was the case. As is evident in table 13, the lowest attributable mortality occurred among those patients who received appropriate therapy throughout the course of their septicemic episodes (10.4%). Prompt initiation of appropriate therapy by physicians after notification of a positive blood culture also was associated with low mortality (13.3%). If appropriate therapy was not initiated until after susceptibility test results were available, mortality was 25.8%.

Why 60 (7.6%) of 791 septicemic patients received inappropriate therapy even after the identification and antibiotic susceptibilities of infecting microorganisms were reported is uncertain (table 13). Antibiotic misuse has been studied by others. In one report [80], the most common form of misuse in bacteremic patients was the administration of superfluous agents, a finding that corroborates our observations. In another study [81], multivariate analysis showed that four clinical variables (i.e., nosocomial bacteremia, recent prior antibiotic therapy, nursing home residence, and central iv catheters) and four microorganisms (i.e., *Candida, Acinetobacter, Enterococcus,* and *Pseudomonas* species) were independently associated with inappropriate antimicrobial therapy. Our data also showed that the use of inappropriate therapy was more likely to occur on the surgical services.

A fundamental principle in the management of bloodstream infections has always been that eradication of the primary source of infection is a necessary component of the therapeutic regimen. Thus, removal, drainage, or excision of an infected focus, when possible, should result in an improved prognosis. Both the current study and our prior report [11] provide support for this principle. Indeed, in the current study, infection-associated mortality among patients who had a primary focus that was excised, drained, or removed was less than one-third that among patients who did not have these interventions (6.2% vs. 22.0%, respectively).

Multivariate Analysis of Factors Influencing Prognosis

As in the earlier review by our group [11], we subjected each of the variables that were associated with an increased risk of death in univariate analyses to multivariate analysis (table 14). In the earlier report, seven variables were independently associated with an increased risk of death; all but one were confirmed in the current study. These included advanced age, microorganism, source of infection, predisposing factors, hypotension, and absence of fever. Nosocomial acquisition of bacteremia was not an independent predictor of death in the current study, in contrast to the observations in the earlier report.

In our earlier report we were unable to include antimicrobial therapy in the multivariate analysis. Inclusion of therapy was possible in this study and confirmed the importance of administering appropriate antimicrobial agents.

Although advanced age again was an independent predictor of poor prognosis, the increased risk statistically was greatest after age 70 years in the current study, compared with age >40 years in the earlier series. Septicemia caused by a high-risk microorganism also was again an independent risk factor in multivariate analysis, but there were some changes in the individual microorganisms associated with a high risk of death. In the earlier report there was increased risk with gram-negative rods generally, whereas in the current study increased risk was observed only with Enterobacteriaceae other than *E. coli.*

The reasons for this difference are not readily apparent. Speculation might focus on greater resistance to antimicrobial agents among these strains than among *E. coli.* In contrast to the results of the earlier series, enterococcal bacteremia was not associated with increased risk in the current study. However, fungemia was confirmed to be associated with poor prognosis, in concordance with our earlier observations.

Primary foci of infection in the respiratory tract, bowel, or peritoneum and septicemia from an unknown source again were shown to be independent predictors of poor prognosis. However, primary foci in abscesses, skin, and surgical wounds, each of which was associated with an increased risk of death in the earlier series, were not associated independently with increased risk in the present study.

As in the earlier study, the presence of underlying diseases associated with high risk in univariate analysis was an independent predictor of increased mortality in the multivariate analysis. The underlying diseases associated with high risk were somewhat different from those in the earlier report and included AIDS, a syndrome that was unknown at the time of the earlier

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review; renal failure, which was not a high-risk factor in the prior study; and malignancies, which were high-risk factors in the earlier study.

Comparative Features of Bacteremia and Fungemia in the 1970s and 1990s

During the past 20 years, numerous changes have occurred in medicine and health care. Nevertheless, several fundamental aspects of bloodstream infections have remained constant. Major examples include the continued frequency with which *S. aureus* and *E. coli* are causative agents of bacteremia; the importance of the respiratory tract, genitourinary tract, and bowel as primary foci; the association between gram-negative or polymicrobial bacteremia and septic shock; and the importance of advanced age, difficult-to-eradicate or unknown sources, malignancies and renal failure, hypotension, and absence of fever as independent predictors of a poor outcome (table 15).

The differences noted in the 1990s provide cause for concern but perhaps also for optimism (table 15). The increased proportion of blood isolates representing contamination is of concern, especially in an environment that mandates cost-effective care. The frequency of coagulase-negative staphylococcal isolation particularly is problematic, since it often is difficult for clinicians to determine the clinical significance of these bacteria. The decrease in anaerobic bacteremia and proportionate increase in fungemia have prompted some authorities to recommend changes in routine blood culture techniques [82].

Table 15. Major similarities and differences in positive blood cultures, 1975–1977 [10, 11] and 1992–1993.

Similarities	• *Staphylococcus aureus* and *Escherichia coli* most frequent etiologic agents
	• Importance of respiratory tract, genitourinary tract, and bowel as primary foci
	• Association of gram-negative and polymicrobial bacteremia with septic shock
	• Importance of age, source of infection, predisposing factors, hypotension, and absence of fever as independent predictors of poor outcome
Differences	• Increased importance of iv catheters as source of septicemia
	• Increased proportion of isolates representing contamination
	• Increased isolation of coagulase-negative staphylococci, both as contaminants and as pathogens
	• Increased frequency of *Pseudomonas aeruginosa* as a community-acquired pathogen
	• Emergence of *M. avium* complex as cause of bloodstream infection in HIV-infected patients
	• Proportionate increase in fungemia and decrease in anaerobic bacteremia
	• Decreased mortality

The most frequent source of bloodstream infections has become the intravenous catheter, and it may be expected that prosthetic materials and devices will continue to be important sources of infection. HIV infection and AIDS have allowed *M. avium* complex to become a bloodstream pathogen, and the increased frequency of community-acquired *P. aeruginosa* bacteremia also seems to be associated with HIV-infected patients [49–51].

The most optimistic finding with regard to bacteremia and fungemia in the 1990s is that mortality associated with these serious infections has decreased. The reasons for this improved outcome are not fully explained but could be related to earlier detection with use of modern blood culture systems; more sophisticated imaging methods that better elucidate primary foci of infection; the frequency of infections emanating from easily removed (iv catheters) or drained (genitourinary tract) foci; and improved antimicrobial agents and use thereof by clinicians.

Although we have shown that mortality is lower than it was 2 decades ago, bacteremia and fungemia remain serious syndromes with substantial risk. Moreover, the combination of an aging population, improved survival among immunocompromised patients and those with organ transplants, and the emergence of β-lactam-drug-resistant gram-positive and gram-negative bacteria as well as vancomycin-resistant enterococci (and possibly staphylococci in the future) [83], will continue to challenge all who care for patients with bloodstream infections.

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Doing It Right the First Time: Quality Improvement and the Contaminant Blood Culture

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The aim of the project was to determine whether the rate of contaminant blood cultures could be reduced by using a team of dedicated phlebotomists. Comparisons were made between adult patients requiring blood cultures for suspected bacteremia on medical and surgical units before and after the introduction and withdrawal of a dedicated blood culture team. The results showed that a significant reduction in the contaminant blood culture rate was achieved by the blood culture team ($P < 0.001$; χ^2 test). Therefore, in our experience, the rate of contaminant blood cultures can be reduced in a teaching hospital by using a team of dedicated phlebotomists. Calculations made with our data and those published by others suggest that cost savings from reducing false-positive blood cultures are greater than the cost of the blood culture team.

The costs of correcting a defective product often exceed the costs of designing a system to avoid producing a defect (5). For hospitals, these costs are not only monetary but also carry a burden of human suffering. The contaminant blood culture can be regarded as a "defective product." The cost of correcting this defect far exceeds the cost of repeating the blood culture itself (2, 6). Contaminant blood cultures are common events in teaching hospitals (1, 2, 10). They are associated with increased length of stay, inappropriate administration of antibiotics, and use of further testing (2, 6), resulting in more than 50% greater total hospital charges (2).

Standards published by the American Society of Microbiology indicate that the rate of blood culture contamination should not exceed 3% (8). Nevertheless in many teaching hospitals the contamination rate exceeds 6% (2, 10). A recent publication suggested that this could be reduced to less than 4% by using a different method of skin preparation (10). In our institution the contamination rate reported to our quality assessment and improvement committee was 4.7%, and this was identified as an opportunity for improvement.

When quality concerns occur, there is a natural tendency to blame the line worker (3). For many teaching hospitals, the line worker who collects blood for culture is usually an intern or resident. Our initial effort was to educate the house staff on proper performance and provide guidelines for appropriate test use. Despite this effort, the contamination rate remained the same. To achieve a quality improvement breakthrough, we questioned the system rather than blaming the line worker. We hypothesized that our house staff had numerous clinical responsibilities and could not possibly dedicate the time and energy required to perform the process of collecting blood for culture without the result being a contamination rate that is unacceptable. We instituted a trial of a blood culture team (BCT) consisting of dedicated phlebotomists. We hypothesized that this would lead to a significant reduction in the rate of contaminant blood cultures. Published data (2) indicated that saving the true costs of contaminant blood cultures would make this initiative economically advantageous. The subsequent quality improvement would pay for the cost of the program, confirming the contention of industry consultants that for some goals quality is free (4). We report a significant reduction in the rate of blood culture contamination achieved by a team of dedicated phlebotomists ($P < 0.001$; χ^2 test).

MATERIALS AND METHODS

Patient population. The New York Hospital Medical Center of Queens is an acute-care community hospital with 487 beds. There are independent medical and surgical residency programs. The patient units chosen for this study were adult general medical and surgical care units. All patients on these units requiring a blood culture for suspected bacteremia during the study periods were included. No consents were obtained, and patients were not informed of this study. Institutional review board approval was not deemed necessary.

Study design. A BCT consisting of three full-time phlebotomists was established. Blood samples for culture were collected by the BCT after orders were written by house staff or attending physicians by a standardized protocol based on methods published previously (9). Briefly, a commercially available skin preparation kit (prep kit) with isopropanol and tincture of iodine (Cepti-seal blood culture prep kit II; Mediflex Hospital Systems, Overland Park, Kans.) was used according to the manufacturer's specifications, and two sets of blood samples for culture were collected from separate sites of each patient. Each was inoculated into one anaerobic and one aerobic culture bottle (BACTEC NR 7A and 6A, respectively; Becton-Dickinson Diagnostic Systems, Sparks, Md.). Blood samples were collected by house staff when the BCT was not available to the patient care unit.

The house staff were educated in proper technique by conventional methods (alcohol and povidone-iodine swabs), but no attempt was made to verify their use. Commercial prep kits were not available to the house staff initially. These were made available on one patient unit after the BCT was withdrawn and the house staff was educated regarding their use. This was done to evaluate the effect of the commercial prep kit.

Blood cultures were evaluated by using BACTEC NR-660 (Becton-Dickinson Diagnostic Systems). Blood cultures were considered contaminated if microorganisms derived from common skin flora were cultured: *Corynebacterium* spp., *Bacillus* spp., *Propionibacterium* spp. (e.g., *Propionibacterium acnes*), and coagulase-negative staphylococci.

The presence of coagulase-negative staphylococci was closely monitored since it may represent true infection. Culture sets in which only one of four bottles or two of four bottles (one set) were positive were analyzed. Coagulase-negative staphylococci present in three of four and four of four bottles were not considered contaminants for the purposes of this study to avoid including true positives.

The following criteria were used in combination to confirm contamination for cultures positive for coagulase-negative staphylococci: (i) subsequent (and often prior) cultures were negative and (ii) physician review of the medical record indicated that contamination was present.

Two patient care units (designated units A and B) were selected for sequential

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TABLE 1. Comparison of blood culture collection techniques by house staff and phlebotomy team (BCT)

Blood culture collection technique	Unit A			Unit B		
	Duration of study (mo)	No. of contaminated cultures/total no. of cultures (%)[a]	*P* value	Duration of study (mo)	No. of contaminated cultures/total no. of cultures (%)	*P* value
A. House staff without prep kits	3	24/287 (8.4)	<0.001[b]	2	15/312 (4.8)	<0.001[b]
B. BCT with prep kits	6	11/956 (1.2)	<0.001[c]	3	8/799 (1.0)	
C. House staff with prep kits	3	10/208 (4.8)				

[a] For comparison of techniques A and C, $P = 0.173$.
[b] Comparison of techniques A and B.
[c] Comparison of techniques B and C.

introduction of the BCT. Unit A was a large, busy general medical floor and was heavily weighted toward emergency admissions. This area had been noted in the past to have a high rate of blood culture contamination. Unit B consisted of a smaller general medical floor and a general surgical floor. Historically, the rate of blood culture contamination on unit B was similar to that for the institution as a whole. Blood culture data were collected for 3 months prior to the introduction of the BCT on unit A and for 2 months prior to the introduction of the BCT on unit B. Data were collected for a subsequent 6 months for unit A and 3 months for unit B after the introduction of the BCT. The BCT was then withdrawn from unit A and the commercial prep kits made available to the house staff, who were instructed to use them according to specifications. Data were then collected for 3 subsequent months for unit A.

Statistical methods. The Mantel-Haenszel chi-square test was performed with True Epistat software (Epistat Services, Richardson, Tex.) on an International Business Machines Corporation-compatible desktop computer. Two-tailed *P* values were used.

RESULTS

Effects of BCT and commercial skin prep. The results of studies examining the effects of the BCT and the commercially available skin prep are presented in Table 1 and are displayed graphically in Fig. 1. Unit A had a high baseline rate of blood culture contamination (8.4%), a rate that exceeded that seen in the hospital as a whole (4.7%; unpublished data). This high rate was thought to be due to the character of the unit, a busy, high-turnover, general medical floor heavily weighted toward emergency admissions, and the effect that this had on the house staff workload. Unit B had a lower baseline rate of contamination of blood cultures (4.8%), and this result was similar to that for the whole institution. After the introduction of a BCT, the rate of contamination decreased significantly for unit A to 1.2% ($P < 0.001$; χ^2 test) and decreased significantly for unit B to 1% ($P < 0.001$; χ^2 test). When the BCT was withdrawn from unit A, commercial blood culture kits with isopropanol and tincture of iodine were supplied and the house staff were educated in their use. Despite the use of the prep kits, there was a significant increase in the contamination rate to 4.8% compared to that observed with the BCT, 1.2% ($P < 0.001$; χ^2 test). The performance of the house staff on unit A did exhibit a trend toward improvement with the use of the commercial prep kits compared to that at the baseline (4.8 versus 8.4%), but this was not statistically significant ($P = 0.173$; χ^2 test). Others have found significant improvements with improved methods of skin preparation (9, 10).

Calculations of economic benefits. Data establishing the true consequences of false-positive blood cultures have been published by Bates et al. (2). The median hospital charges for patients with false-positive blood cultures were reported to be more than 50% greater than those for similar patients with true-negative blood cultures. This was accounted for by increased length of stay and increases in pharmacy and laboratory charges, with an increase in total median charges of more $4,000 per patient. In our hospital, costs account for greater than 98% of charges. If we assume a 50% increase in actual hospital costs and average diagnosis-related group charges of approximately $5,000, then each contaminant blood culture costs our institution $2,500. If we accept this conservative estimate, then the following calculation can be made. For unit A, over 6 months, 11 of 956 cultures of blood collected by the BCT with a commercial skin prep kit were contaminated. Without blood collection by the BCT and with the use of the commercial skin prep kit, 4.8%, or 45 contaminant blood cultures, would have been expected. This represents elimination of 34 contaminant cultures or a calculated savings of $85,000. The cost of the BCT, with three full-time equivalent salaries and benefits, for 6 months was $45,000. The savings resulting from this improvement, $40,000, does not include further cost reductions that the BCT achieved simultaneously on unit B, which were also substantial, as well as other productive work that the team performed (collection of blood at appropriate intervals for determination of antibiotic levels for patients on aminoglycosides). More than 14,000 blood culture sets were collected in our institution for the year 1994. We would predict that at least 650 sets would have been contaminated on the basis of an institutional contamination rate of 4.7%. A reduction of the contamination rate to 1.2% would eliminate more than 480 contaminant cultures, with potential savings of $1,200,000.

DISCUSSION

Our data have indicated that a significant reduction in the rate of contaminant blood cultures was achieved in two patient care units by a BCT using commercial prep kits ($P < 0.001$) compared to the results obtained by house staff. Improved

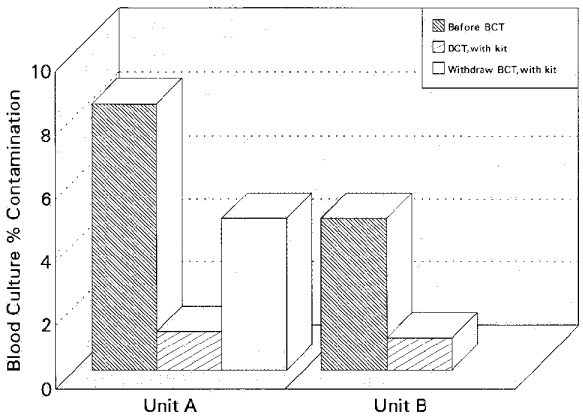


FIG. 1. Effect of BCT and commercial prep kits on rate of blood culture contamination.

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results occurred when house staff used a commercial prep kit, although the difference from the baseline data was not statistically significant ($P = 0.173$; χ^2 test). Others have shown that significant benefits result from improved methods of skin preparation (9, 10). The trend that we observed would corroborate those reports. Conservative estimates of the cost savings achieved by reductions in contaminant blood cultures indicated that the BCT was economically advantageous.

Quality can be defined for some products as conformance to specifications measured by the number of defects divided by the number of opportunities to produce a defect (7). The contaminant blood culture is an easily measured example of a defect produced by a process within a hospital. Unfortunately, the implications of producing this defect are not merely economic. Human suffering results from the increased use of diagnostic testing and additional hospital days with treatment with unnecessary antibiotics. Improving quality in hospital settings is a valid goal, regardless of cost. Nevertheless, pressures to reduce costs from consumers and government exist independently of consideration of quality. In other industries, when the cost of error is calculated, it is clear that improving quality by designing systems to reduce the production of defects results in substantial savings (7). Calculations made by using our results and those reported by others (2) indicate that this is the case for contaminant blood cultures.

Quality improvement can reduce costs in medicine as well as in other industries. Incentives to do so are already present. Organizations that harness the tools of quality improvement theory should be well equipped to meet this challenge. An appropriate goal for hospitals is to control costs by improving quality. To do otherwise risks the substantial achievements of generations of physicians and scientists.

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(57) [Summary] (Modified)
[Problem] To provide a cheaper and simpler phlebotomy needle that facilitates visualization of flashbacks.
A central portion (106) of the needle (100) includes a hole or opening (110) that communicates with the flow path defined by the needle (100), and a transparent housing (112) covers the opening (110). Positioned around to facilitate visualization of blood flow through needle 100 .
A material that allows passage of air and provides an indication of blood flow through needle

100 is positioned over opening 110 . The material is in the form of plugs or alternatively in th e form of patches or collars. The phlebotomy needle includes a needle 100, a housing 112 hav ing a passive vent, and an observation area for visualizing blood flow in the housing 112. FIG. [Selection drawing] Fig. 2-1

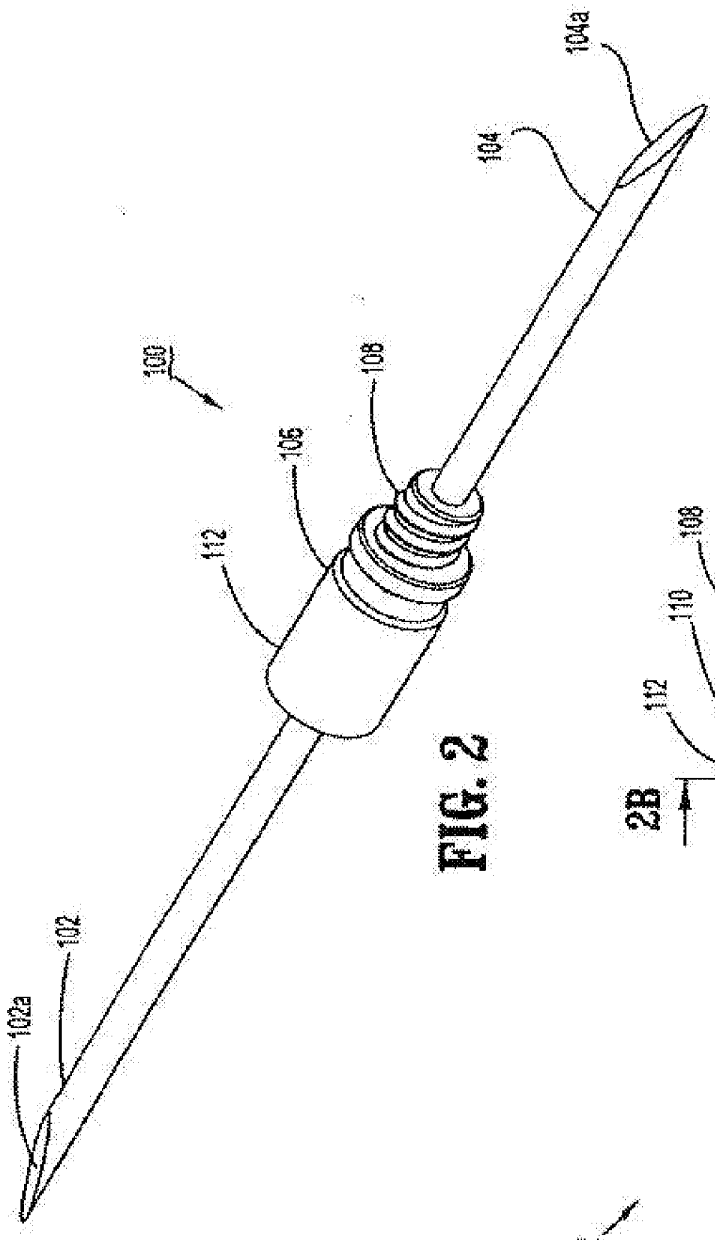


FIG. 2

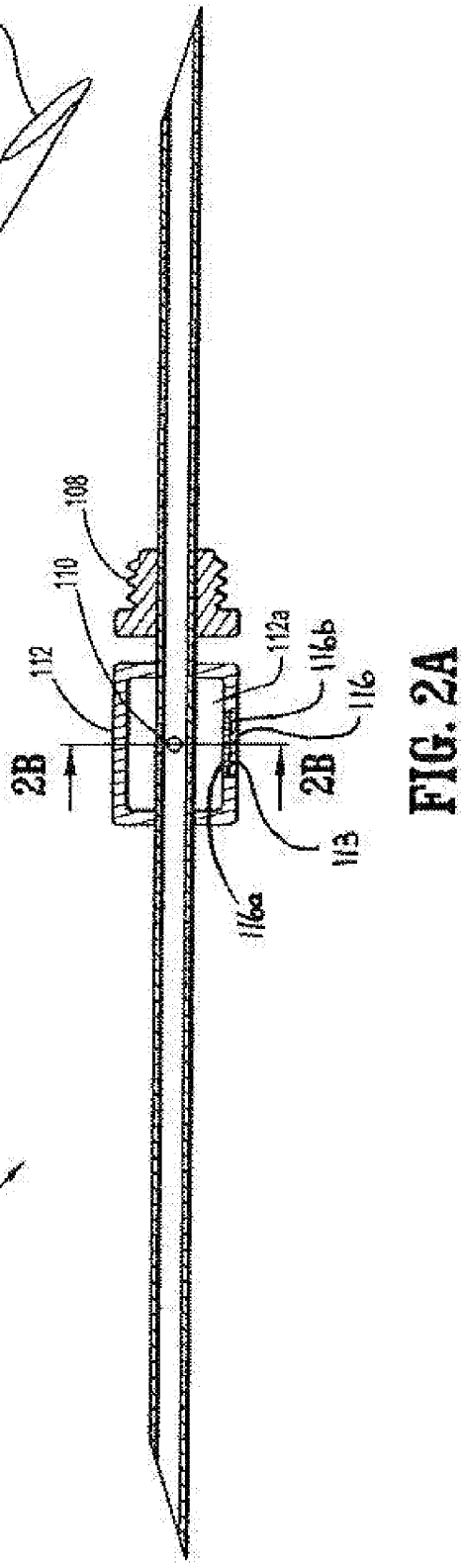


FIG. 2A

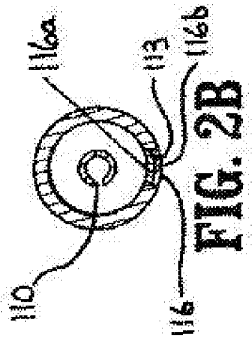


FIG. 2B

The scope of the claims open ----

Claims:

1. A
_phlebotomy needle: a distal needle portion
_having a sharpened distal end configured to pierce tissue; and a distal needle portion configured to pierce a stopper of a blood collection tube. a proximal needle portion having a sharpened proximal end, the distal needle portion and the proximal needle portion defining a fluid channel; a housing supported over the needle
_; a housing, comprising a passive vent, the housing defining a viewing area for viewing blood in the housing; and an elastomeric shield positioned about the proximal needle portion
_, A phlebotomy needle comprising an elastomeric shield and an elastomeric shield wherein the proximal needle portion defines a fluid flow path into the housing.

2. The phlebotomy needle of claim 1
, further comprising a fluted member positioned within said housing, said fluted member defining a plurality of fluid channels.

3.
The phlebotomy needle of claim 2, wherein said fluted member extends distally beyond said elastomeric shield.

4.
The phlebotomy needle of claim 2, wherein the fluid channel of the fluted member is configured to allow the passage of blood.

5.
The phlebotomy needle of claim 2, further comprising a hydrophilic material supported within said housing. 6. The phlebotomy of claim 5, wherein said flow path directs blood from the proximal end of said needle into the fluid channel of said fluted member and into contact with said hydrophilic material
.
needle.

[Claim 7]

6. The phlebotomy needle of claim 5, wherein a portion of said fluted member is surrounded by said hydrophilic material.

8. The method of claim
5, wherein a proximal end of said fluted member is surrounded by said elastomeric shield and a distal end of said fluted member is surrounded by said hydrophilic material. Phlebotomy needle.

9.
The phlebotomy needle of claim 5, wherein the proximal portion of the housing includes an inwardly extending annular rib.
10.
The elastomeric shield has an open distal end including an annular flange, and an annular rib of the housing engages the flange to extend the distal end of the elastomeric shield into the housing. 10. The phlebotomy needle of claim 9, held in the
11.
The phlebotomy needle of claim 10, wherein the elastomeric shield flange is positioned adjacent to the hydrophilic material.
12.
The phlebotomy needle of claim 1, wherein the distal end of said elastomeric shield is received in said housing and the proximal end of said elastomeric shield extends proximally from said housing.

detailed description open ----

Description: BACKGROUND 1.
Technical Field The present disclosure relates to medical needles having structures that facilitate visualization of flashback. More particularly, the present disclosure provides vented phlebotomy needles that include structures that facilitate visualization of flashback.

Regarding. 2. Background of Related Art
Medical devices for drawing blood from a patient are well known. These devices include standard needle-syringes, butterfly needle sets, and phlebotomy needles. A butterfly needle set typically includes a hollow needle having a sharpened distal end and a proximal end secured to a needle hub. A proximal portion of the needle hub is connected to flexible tubing. The needle hub defines a fluid conduit in communication with the tubing and includes a pair of flexible, radially extending wings that facilitate grasping of the butterfly needle set by a medical practitioner. Generally, the flexible tubing is formed of a transparent material that allows medical personnel to visualize blood flow, or flashback, through the tubing proximate to the needle hub. Flashback visualization allows medical personnel to confirm that the needle has been correctly inserted into the patient. [0003] Some clinicians utilize a hypodermic needle-syringe with a clear needle hub to take blood samples. During insertion, these clinicians usually observe flashb

acks in the needle hub. Phlebotomy needles generally do not include structures for visualizin g flashback. The lack of a flashback visualization feature on the phlebotomy needle is not a m ajor drawback for more experienced HCWs, but for HCWs with little experience of drawing blo od with a phlebotomy needle, the needle may be a problem. Not having any means of confirm ing proper positioning in the patient can increase the time required to draw blood and can incr ease patient discomfort. [0005]

In an attempt to overcome the above disadvantages, US Pat. No. 6,200,300 to Norris et al. discloses a phlebotomy needle, which is attachable to a blood collection tube, comprises an ou ter needle, an inner needle, and a valve (bulb). The valve is transparent, allowing medical pe rsonnel to visualize the blood when the outer needle is correctly positioned within the patien t's vein. The valve also includes a button that can be depressed by a medical practitioner to v ent air from within the needle. Air in the needle prevents blood from flowing through the need le and must be vented.
[0006]
[
0006] US Pat.
No. 5,450,856 . SUMMARY OF THE INVENTION [0007] The Norris phlebotomy needle is a H owever, a cheaper and simpler phlebotomy needle that facilitates flashback visualization is de sired. SUMMARY OF THE INVENTION The present disclosure relates to a phlebotomy needle having a sharpened distal end configured to penetrate tissue.

a proximal needle portion having a sharpened proximal end configured to penetrate a blood c ollection tube stopper; and a central needle portion defining an opening. The distal needle por tion, the proximal needle portion and the central needle portion define a fluid channel in com munication with the opening. A material is positioned adjacent to the opening. The material is

of a type that allows air to exit the fluid channel through the openings while preventing the pa ssage of blood. In one embodiment, the material provides a visual indication of blood flow, or flashback, adjacent the opening.

[0009]

In one embodiment, the material comprises a hydrophobic material. In alternative embodim ents, the material comprises a hydrophilic capillary action material. In yet another embodime nt, the material includes hydrophobic plugs. Alternatively, the material may define a collar pos itioned around the opening.

[0010]

In one embodiment, the opening is circular. Alternatively, the openings are envisioned to be of various configurations, such as rectangular or slot-shaped.

[0011]

In one embodiment, a transparent housing is positioned around the opening to facilitate visu alization of the flashback. A housing may also be positioned to contain the material and may i nclude a vent for venting air from the needle.

[0012]

In one embodiment, the phlebotomy needle includes engagement structure configured to en gage the needle holder.

In one

embodiment, a check valve is provided to prevent air from entering the fluid channel throug h the opening. In yet another embodiment, the phlebotomy needle includes a needle holder. For example, the present invention provides the following items.

(Item 1)

A phlebotomy needle,

a distal needle portion having a sharpened distal end configured to penetrate tissue and a sh arpened

proximal end configured to pierce a stopper of a blood collection tube. and a central needle p ortion

defining an opening, wherein the distal needle portion, the proximal needle portion and the c entral needle portion are in fluid communication with the opening a central needle portion defi ning a channel;

A material positioned adjacent to the opening of a type that allows air to exit the fluid chann el through the opening while preventing the passage of blood to reduce blood flow.

A phlebotomy needle comprising a material that further enables visual indication .

(Item 2)

The phlebotomy needle of item 1, wherein the material comprises a hydrophobic material.

3.

The phlebotomy needle of claim 1, wherein said material comprises a hydrophilic capillary ac tion material.

4.

The phlebotomy needle of claim 1, wherein said material comprises an inner layer of hydrophilic material facing towards said opening and an outer layer of hydrophobic material.

(Item 5)

The phlebotomy needle according to item 1, wherein the opening is circular.

6.

The phlebotomy needle of claim 1, wherein the opening defines an elongated slot.

7.

The phlebotomy needle of claim 1, further comprising a transparent housing positioned around the opening. Clause 8.

The phlebotomy needle of clause 1, further comprising an engagement structure supported by the phlebotomy needle, the

engagement structure configured to engage a needle holder.

9.

The phlebotomy needle of claim 1, wherein the material defines a collar covering the opening and positioned about the needle.

10.

The phlebotomy needle of claim 9, further comprising a transparent housing positioned around the collar material.

11.

The phlebotomy needle of claim 1, further comprising a check valve for preventing air from entering the fluid channel through the opening.

12.

The phlebotomy needle of claim 1, further comprising a needle holder.

13.

The phlebotomy needle of claim 1, wherein the material provides a visual indication of blood flow through the opening.

(Item 14)

A phlebotomy needle, a

distal needle portion having a sharpened distal end configured to penetrate tissue and a

sharpened proximal end configured to pierce a stopper of a blood collection tube. and a central needle portion

defining an opening, wherein the distal needle portion, the proximal needle portion and the central needle portion are in fluid communication with the opening A central needle portion defining a channel and

a hydrophobic material positioned adjacent the opening to permit air to exit the fluid channel through the opening while allowing blood to exit the fluid channel. A hydrophobic material of a type that prevents passage and further permits visual indication of blood flow, a

transparent housing positioned around the opening, and

an engagement supported by the phlebotomy needle. A

phlebotomy needle comprising: a structure, and an engagement structure configured to eng age the needle holder .

(Item 15)

The phlebotomy needle of item 14, further comprising the needle holder.

(Item 16)

A phlebotomy needle,

a distal needle portion having a sharp distal tip configured to penetrate tissue;

a proximal needle portion having a sharpened proximal end configured to penetrate a blood collection tube stopper; and a central needle portion

defining an opening, the distal needle portion, the proximal The needle portion and the centr al needle portion define a fluid channel in communication with the opening, a hydrophilic

capillary action material positioned adjacent the central needle portion and the opening, whe rein air flows into the a hydrophilic capillary active material of a type that allows exiting the fl uid channel through the opening while preventing the passage of blood, further permitting a v isual indication of blood flow; and the opening

. and an engagement structure supported by the phlebotomy needle

, the engagement structure configured to engage a needle holder

.

(Item 17)

The phlebotomy needle of item 16, further comprising the needle holder.

(Item 18)

A phlebotomy needle, the phlebotomy needle

penetrating a distal needle portion having a sharpened distal end configured to penetrate tis sue and a stopper of a blood collection tube. a proximal needle portion having a pointed proxi mal end configured to define a fluid channel

; a housing that includes a passive vent and

defines an observation area for visualizing blood in the housing

.

(Item 19)

19, further comprising an elastomeric shield positioned about the proximal needle portion, th e elastomeric shield and the proximal needle portion defining a fluid flow path into the housin g; Phlebotomy needle as described.

(Item 20)

20. The phlebotomy needle of any one of items 18 and 19, further comprising a fluted memb er positioned within the housing, the fluted member defining a plurality of fluid channels.

(Item 21)

The phlebotomy needle according to any one of items 18 to 20, further including a hydrophili c material supported within the housing.

22.

The phlebotomy needle of any one of items 18-21, wherein the needle has a central portion defining an opening into the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

An embodiment of the presently disclosed vented phlebotomy needle with a flashback chamber is disclosed herein with reference to the drawings.

1 is a perspective view, with parts separated, of a "prior art" phlebotomy needle with a needle holder, a protective needle cover and a blood collection tube shown in phantom; FIG.

1A is a side cross-sectional view of an assembled "prior art" phlebotomy needle, needle holder, and blood collection tube shown in phantom, with the distal portion of the phlebotomy needle positioned within a vein; It is

2-1 is a side perspective view of one embodiment of the presently disclosed phlebotomy needle; FIG . 2A is a cross-sectional view of the phlebotomy needle shown in FIG. 2; FIG . 2B is a cross-sectional view along section line 2B-2B of FIG. 2A.

2-2C is a side cross-sectional view of another embodiment of a phlebotomy needle of the present disclosure; FIG.

3 is a side cross-sectional view of an alternate embodiment of the phlebotomy needle of the present disclosure; FIG . FIG. 3A is a cross-sectional view taken along section line 3A--3A of FIG.

FIG. 4 is a side perspective cutaway view of another embodiment of the phlebotomy needle of the present disclosure; FIG . FIG. 4A is a cross-sectional view along section line 4A--4A of FIG.

FIG. 5 is a side perspective cutaway view of another embodiment of the phlebotomy needle of the present disclosure; FIG.

6 is a side cross-sectional view of another embodiment of the phlebotomy needle of the present disclosure; FIG.

7 is a cross-sectional view along section line 7-7 of FIG. 6; FIG. DETAILED DESCRIPTION OF EMBODIMENTS

Embodiments of vented phlebotomy needles of the present disclosure with flashback chambers will now be described in detail with reference to the drawings

, In the drawings, like reference numbers indicate identical or corresponding elements in each of the several drawings. FIG . 1 shows a known phlebotomy needle 10, needle holder 12, and needle covers 14 and 16. As shown in FIG. A blood collection tube 17 is shown in phantom. Phlebotomy needle 10 includes a distal needle portion 20 , a proximal needle portion 22 and an intermediate needle hub 23 with an engaging portion 24 . Engaging portion 24 is provided to facilitate connecting phlebotomy needle 10 to needle holder 12 . In one embodiment, the engaging portion includes a male fitting 24 a configured to engage a female fitting or engaging member 26 , which engages the distal end of needle holder 12 . provided to Alternatively, oth

er engagement structures may be used, including screws, snap-type connectors, and the like. An elastomeric shield 28 is positioned over the proximal needle portion 22 to seal the proxima l needle portion 22, as described in further detail below . [0017]

Needle holder 12 includes a substantially cylindrical body 30 having a distal end including en gagement member 26 and a proximal end including a pair of flange members 32 . Flange me mber 32 facilitates grasping and insertion of blood collection tube 17 by medical personnel. Cy lindrical body 30 defines cavity 34 (FIG. 1A) for receiving blood collection tube 17 . Blood coll ection tube, usually
17 is sealed by a penetrable stopper 17a to define a low pressure cavity 17b (FIG. 1A). The di stal end of holder 12 defines an opening 36 through engagement member 26 , opening 36 siz ed to receive proximal needle portion 22 . In use, needle 10 is secured to the distal end of n eedle holder 12 via engagement portion 24 and engagement member 26, as shown in FIG. 1A .
When needle 10 is secured to needle holder 12 , proximal needle portion 22 is positioned with in cavity 34 of body 30 of needle holder 12 and elastomeric shield 28 is positioned over proxi mal needle portion 22 . be. A blood collection tube 17 (shown in phantom) containing a penet rable stopper 17a is then positioned within cavity 34 . When blood collection tube 17 is inserte d into cavity 34 , proximal needle portion 22 engages stopper 17 a and penetrates shield 28 . Shield 28 is compressed downward (FIG. 1A) so that proximal needle portion 22 penetrates st opper 40 and enters cavity 17b of blood collection tube 17 . Once the distal needle portion 20 is properly positioned in the patient's vein 38 and the blood collection tube 17 is positioned wi thin the cavity 34, blood is typically flowed through the needle 10 and into the blood collection tube 17. The blood collection tube 17 is maintained under vacuum. When the blood collection tube 17 is removed from the needle holder 12 , the resilient elastomeric shield 28 returns to it s original configuration, covering and sealing the proximal needle portion 22 .
[0019]
FIGS. 2 and 2A illustrate one embodiment of the phlebotomy needle of the present disclosur e with a flashback chamber, generally indicated as 100. FIG. Needle 100 includes distal end 1 02 , proximal end 104 and central portion 106 . Distal end 102 has a pointed end 102a config ured to penetrate patient tissue, and proximal end 104 is configured to pierce stopper 17a of blood collection tube 17 (see FIG. 1A). It has a sharp edge 104a. Central portion 106 includes an engagement member 108, as discussed above, which is configured to engage a needle hol der (FIG. 1). Central portion 106 also includes an opening or hole 110 and a translucent or tra

nsparent housing 112 positioned around central portion 106 of the portion defining opening 1 10 . Although opening 110 is shown as circular, other configurations are envisioned, such as r ectangular, square, oval, elongated slot 39 (FIG. 5), and the like. A transparent housing 112 d efines a blood reservoir 112a. Vent openings 113 are preferably formed in transparent housin g 112 . Vent opening 113 facilitates venting needle 100 and allows blood flow through needle 100 . As discussed below, the vent opening 113 of the housing 112 may be covered with a ma terial that allows passage of air but not liquid, such as blood, for example. Referring to FIGS. 2A and 2B, vent opening 113 may be covered with filter 116

.

Filter 116 preferably includes an inner layer 116a of hydrophilic material and an outer layer 1 16b of hydrophobic material. Preferably, at least one of layers 116a and 116b has a pore size of less than 0.45 microns. Such a pore size allows air to pass through but prevents bacteria fr om entering the housing 112 .

[0021]

Referring to FIG. 2C, in an alternative embodiment, filter 116 may be replaced by a hydroph obic check valve, such as flap valve 150, for example. As shown, flap valve 150 is configured t o flex outward from housing 112 to expose vent opening 113 and vent housing 112 when bloo d begins to flow into housing 112 . be.

A hydrophobic sheet 152 is positioned over opening 113 to prevent blood from exiting vent op ening 113 when the check valve is open . Prior to blood beginning to flow into housing 112 , fl ap valve 150 seals opening 113 to prevent material from entering housing 112 . Alternatively, flap valve 150 may be formed from a hydrophilic material if the pore size of the hydrophilic m aterial is sized to block the passage of blood components. When the distal end 102 of needle 100 is properly positioned within the patient's vein, ie,

blood

The transparent housing 112 allows the medical practitioner to visualize blood flow through th e needle 100 as air flows through the needle 100 and air is vented and blood enters the reser voir 112a through the opening 110. make it possible. This allows the medical practitioner to c onfirm that the distal end 102 of the needle 100 has been properly positioned within the patie nt's vein for drawing blood. This provides a significant benefit to medical practitioners attempt ing to draw blood from patients, especially those who have limited experience with drawing bl ood from patients with phlebotomy needles.

[0023]

FIG. 3 illustrates an alternative embodiment of the vented phlebotomy needle of the present disclosure with a flashback chamber generally indicated as 200. As shown in FIG. Needle 200 i s substantially similar to needle 100, except as described below. Needle 200 includes distal en d 202 , proximal end 204 and central portion 206 . Distal end 202 has a sharpened end 202a configured to pierce patient tissue, and proximal end 204 has a sharpened end 202a configure

d to pierce a stopper of a blood collection tube (see FIG. 1A). It has a tapered end 204a. Cent ral portion 206 includes an opening or hole 210 and an engagement member 212a. Material 2 14 is positioned over hole 210 . Material 214 may be a hydrophilic material that wicks blood in to the material so that blood flow through needle 200 can be readily discerned by medical per sonnel. To facilitate venting of needle 200, material 214 may be a hydrophilic material that is permeable to air but impermeable to liquids, such as blood. In one embodiment, the hydrophil ic material can be of the type that changes color when in contact with blood. The material ma y be in the form of collar 250 (Fig. 3) or plug 252 (Fig. 4). Additionally, the material may be p ositioned within a transparent housing or hub 212, or alternatively positioned adjacent openin g 210 without any housing. In an alternative embodiment, the material is a hydrophobic mate rial that is air permeable but blood impermeable. It is noted that ventilation openings 226 ma y be provided in housing 212 to facilitate ventilation of the housing. A vent can be in the form of an opening in housing 212 that allows air to flow out of housing 212 as blood enters.

[0024]

In an alternative embodiment, further illustrated in FIGS. 3 and 3A, material 214 may be for med of an expandable material that allows air to pass through vent openings 226 before cont acting the expandable material with blood. enable Material 214 may expand upon contact with blood, closing vent opening 226 . Although only hydrophilic and hydrophobic materials have been disclosed herein, other materials that facilitate the passage of air while preventing the p assage of blood and provide an indication of blood flow are disclosed in the present disclosure .

phlebotomy needles. The material may have other configurations not disclosed herein. For exa mple, the material may define a pad that covers the opening.

FIGS.

6 and 7 illustrate another embodiment of the phlebotomy needle of the present disclosure wi th a flashback chamber, generally indicated as device 398. FIG. Phlebotomy needle 398 includ es needle 400 and stepped housing 408 . Needle 400 includes distal end 402 , proximal end 4 04 and central portion 406 . Distal end 402 has a pointed end 402a configured to penetrate ti ssue of a patient, and proximal end 404 is adapted to pierce a stopper (not shown) of a blood collection tube (not shown). It has a configured pointed end 404a.

The

stepped housing 408 has a distal portion 408a and a larger diameter proximal portion 408b. A stepped housing 408 is supported at the central portion 406 . Distal portion 408a defines a t hroughbore 412 sized to receive central portion 406 of the needle. Distal portion 408a is seale d and secured to needle 400 using adhesive 410, for example. Alternatively, other known tech niques such as crimping, clamping, screws, welding, etc. may be used to secure needle 400 to housing 408 . Proximal portion 408b is a transparent or translucent material.

formed to facilitate visualization within proximal portion 408 b of housing 408 . Proximal porti on 408 b also defines a through hole 414 that communicates with through hole 412 but has a

larger diameter than through hole 412 . Proximal portion 408 b defines an annular recess 416 between portion 408 b and proximal end 404 of needle 400 . Recess 416 is sized to receive hy drophilic material 418 and inner fluted member 420 . An inner fluted member 420 is positione d around proximal end 404 of needle 400 and defines a plurality of channels 422 in communic ation with hydrophilic material 418 . A ventilation opening 409 is provided through housing 40 8 .

[0028]

An elastomeric shield 428 is positioned over the proximal end 404 of the needle 400 . As dis cussed above, elastomeric shield 428 may be resilient, sealing proximal end 404 of needle 40 0 when proximal end 404 of needle 400 is not connected to a blood collection tube (not show n). function to Elastomeric shield 428 includes a closed proximal end 428a and an open distal end 428b. Open distal end 428 b includes an annular flange 430 positioned adjacent material 418 within recess 416 of housing 408 . A proximal portion 408b of the housing 408 includes a n inwardly extending annular rib 432 that engages a flange 430 of an elastomeric shield 428 a nd a distal end 428b of the shield 428. within recess 416 of housing 408 . A channel 436 is de fined between elastomeric shield 428 and proximal end 404 of needle 400 , as indicated by ar row 434 . Channel 436 directs blood from proximal end 404 of needle 400 into fluted channel 422 of fluted member 420 and into contact with hydrophilic material 418 . In use, when blood contacts material 418 , material 418 provides a visual indication of blood flow that is visible th rough proximal portion 408 b of housing 408 .

[0029]

defined with filter 116 (FIGS. 2A-2B), defined with filter 252 (FIGS. 4-4A), or defined with fil ter 39 (FIG. 5), or defined with check valve 150 (FIG. 5). FIG. 2C) Vent opening 113, as well as openings 226 (FIGS. 3-3A) and opening 409 (FIG. 6) can all be described as passive vent o penings, which are positioned within the needle cannula. Allows gases with pressures greater than atmospheric pressure to automatically leak into the atmosphere. These passive ventilatio n openings do not require any action by the user of the device according to the invention.

[0030]

It is understood that various modifications may be made to the embodiments disclosed herei n. Therefore, the above should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the sc ope and spirit of the claims appended hereto.

drawing open —

[Fig. 1-1]

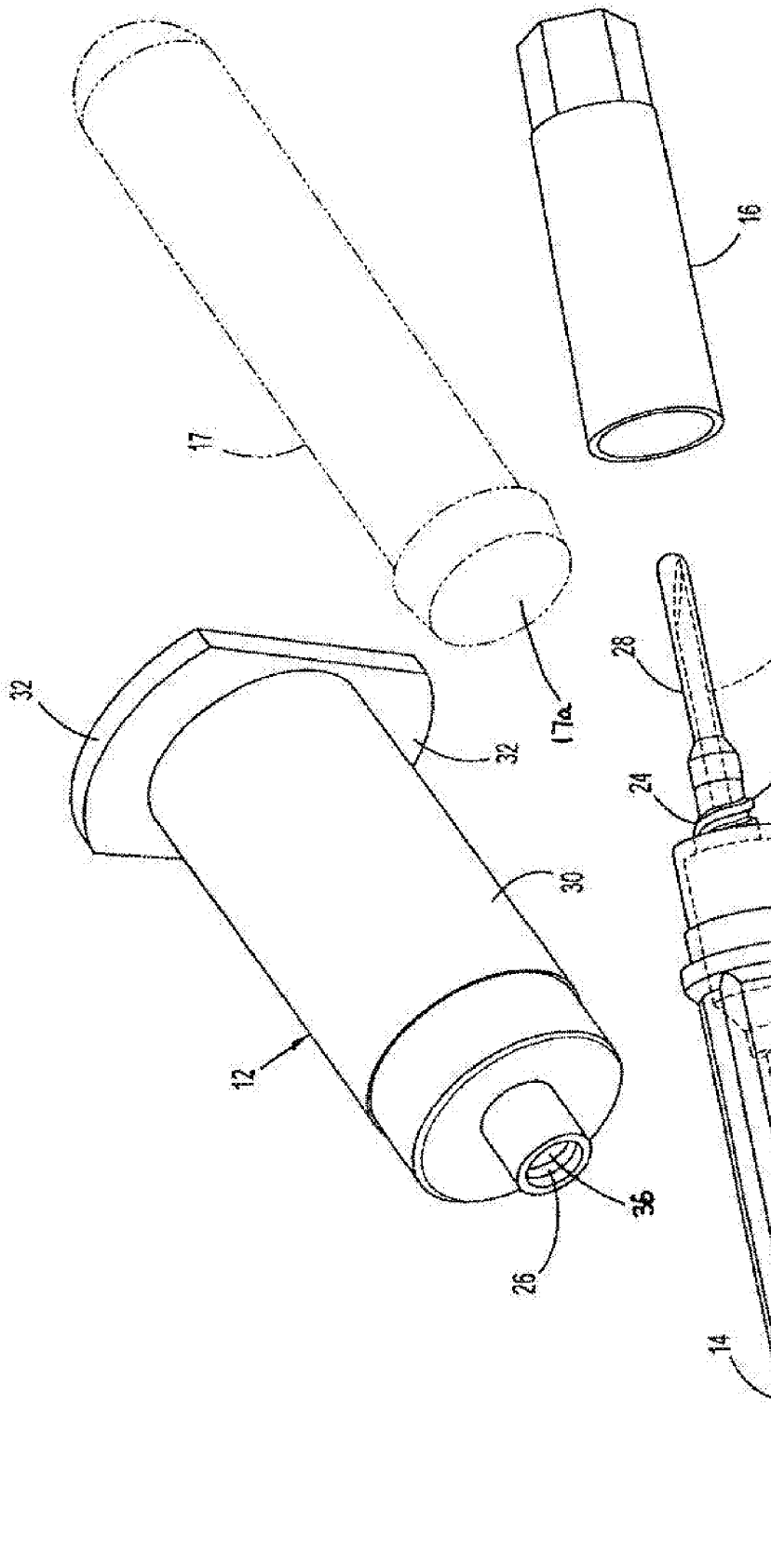


FIG. 1

[Figure 1-2]

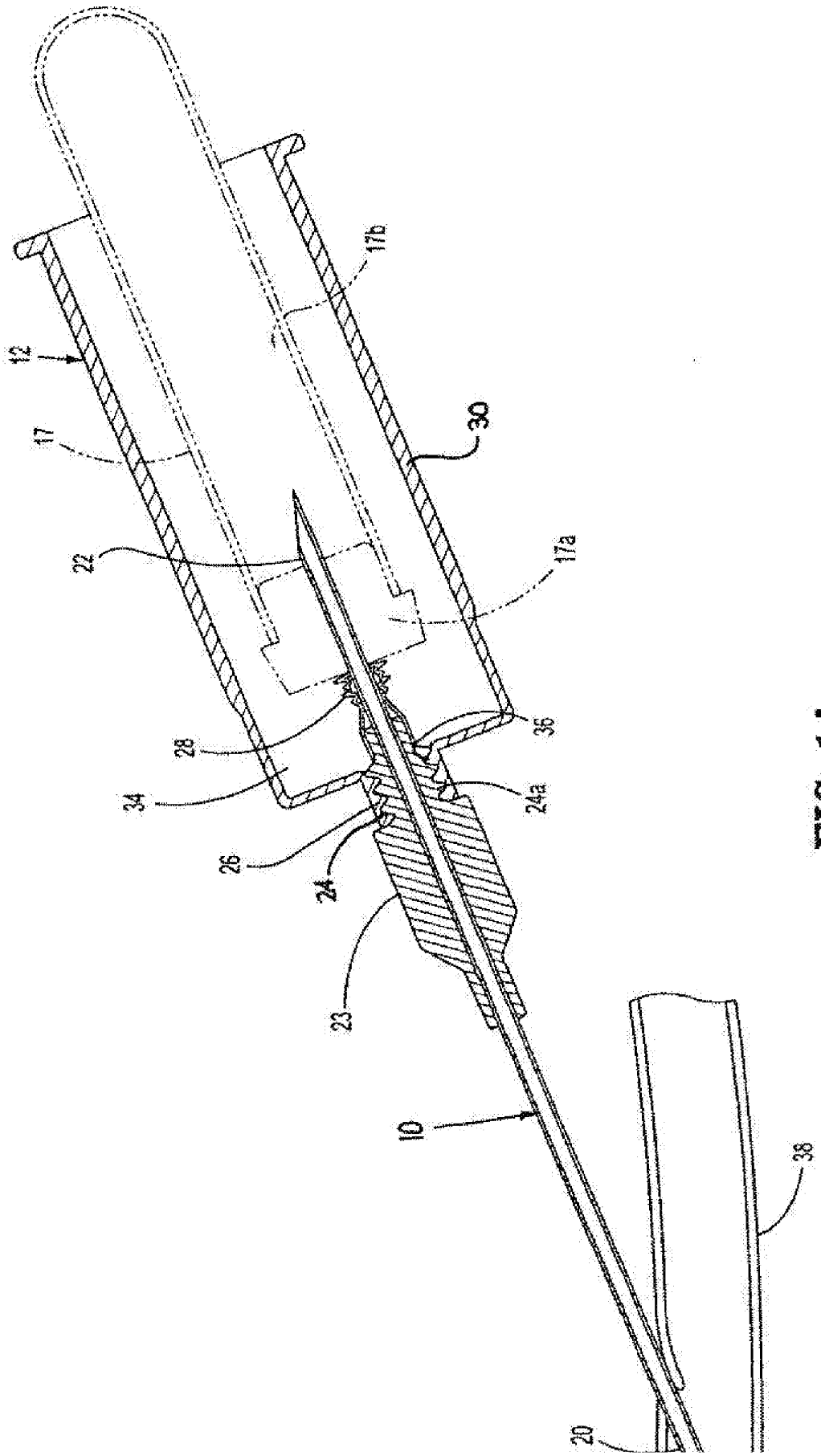
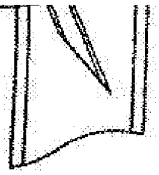


FIG. 1A

[Figure 2-1]



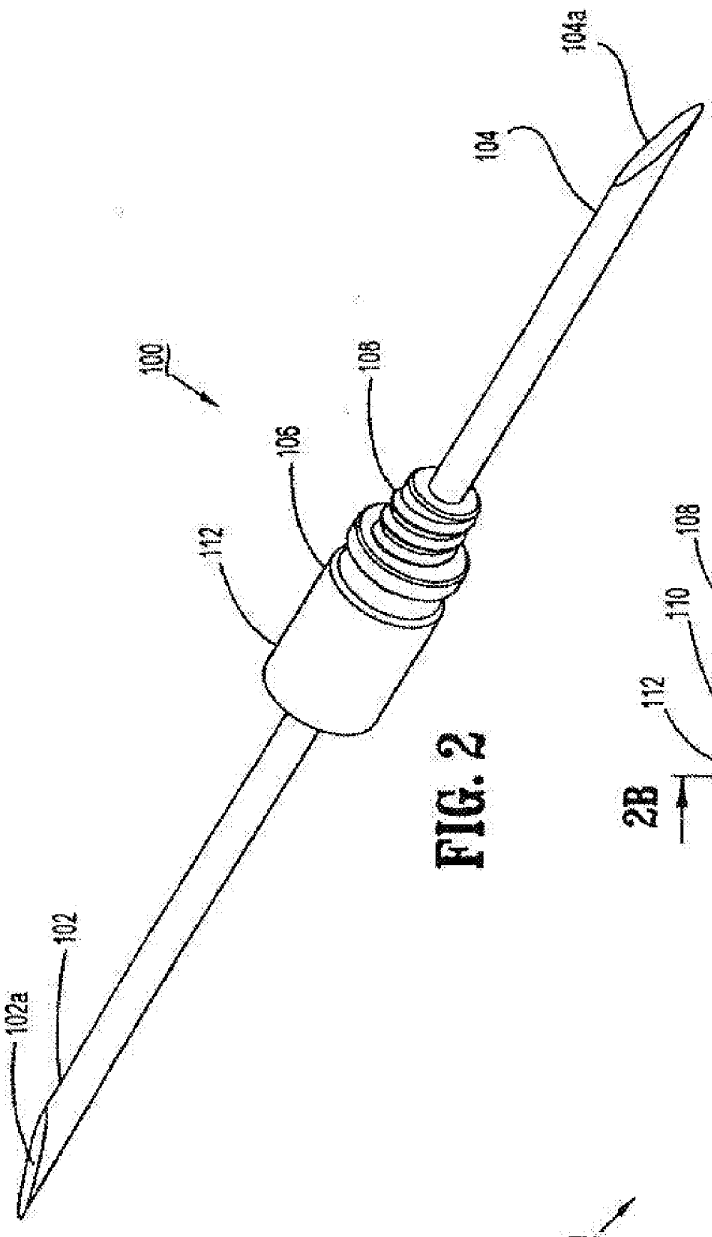


FIG. 2

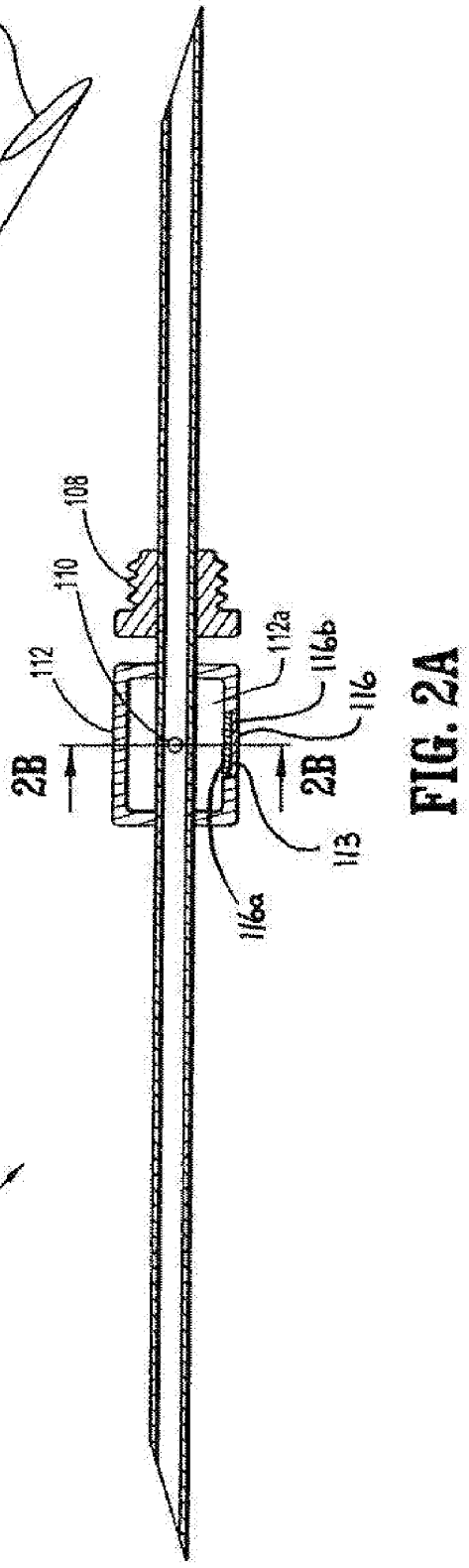


FIG. 2A

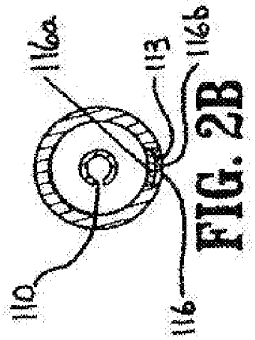


FIG. 2B

[Figure 2-2]

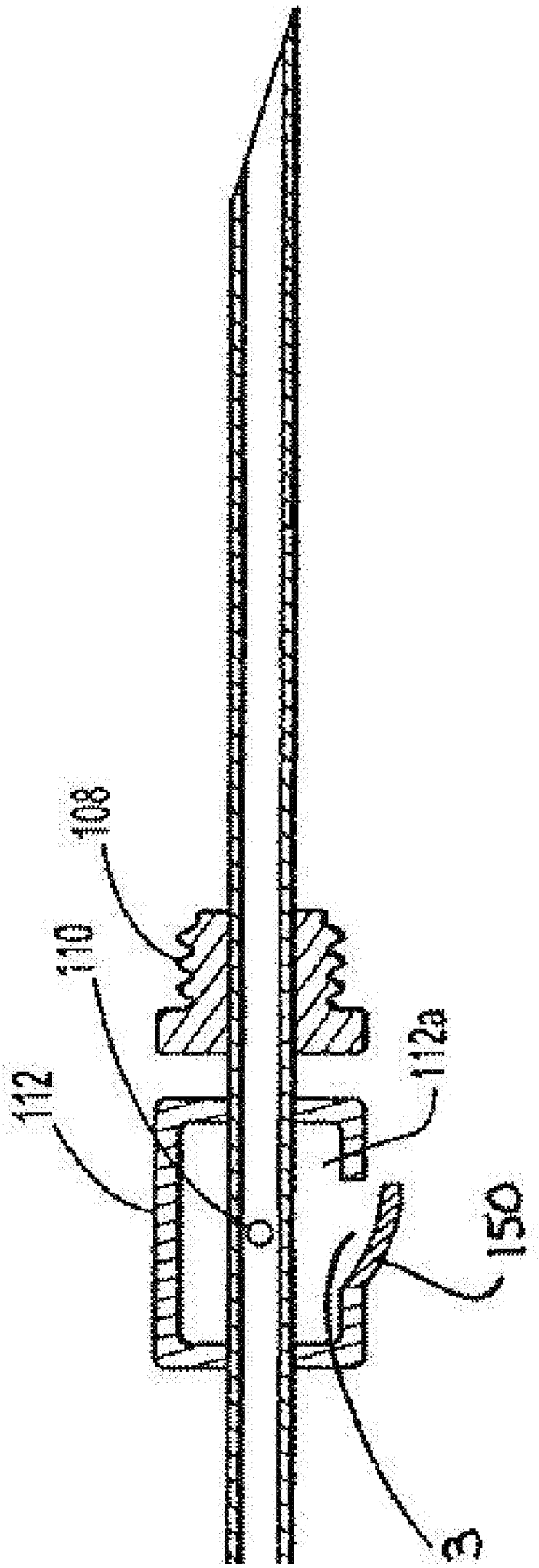
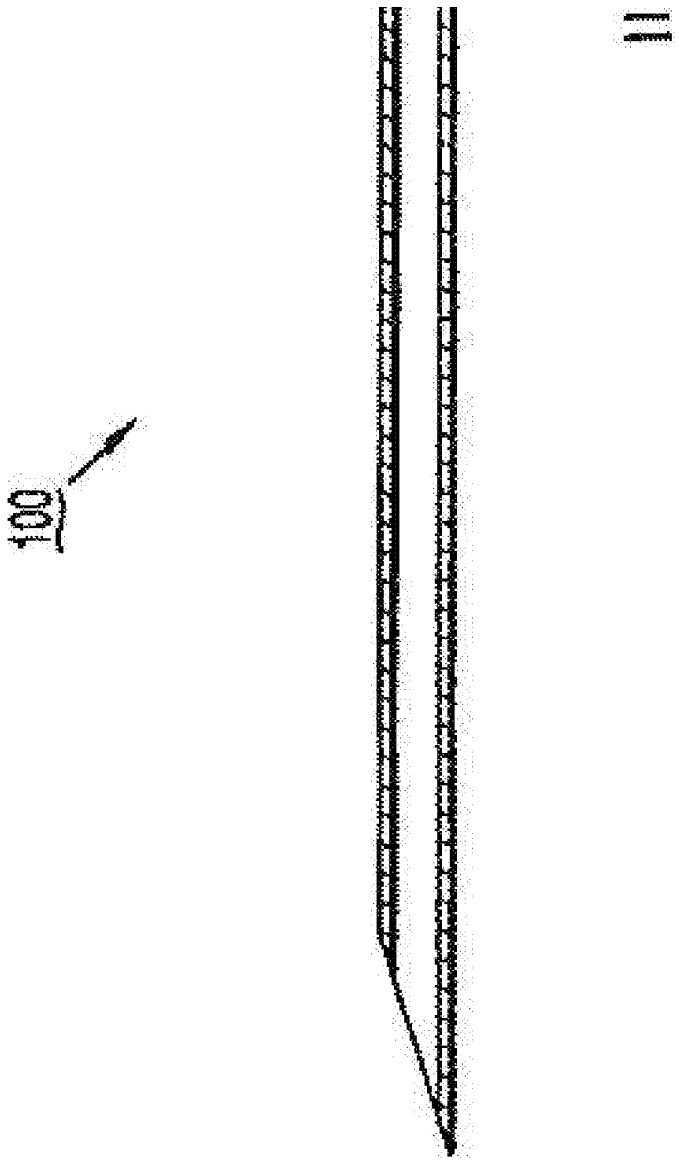


FIG. 2C

[Figure 3]



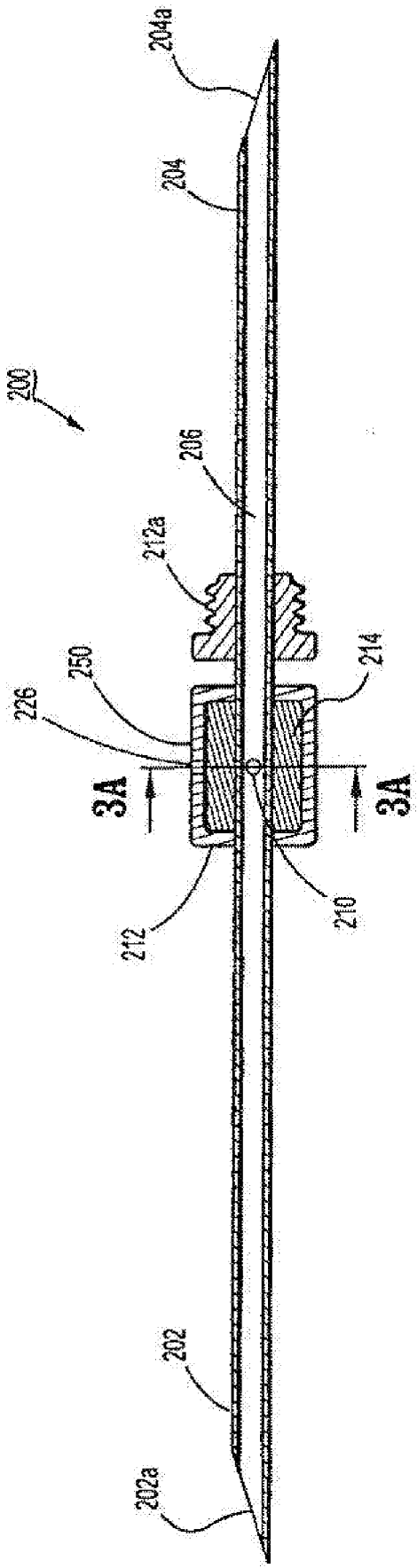

204a
204
200
206
212a
214
250
226
3A
3A
212
210
202
202a

FIG. 3

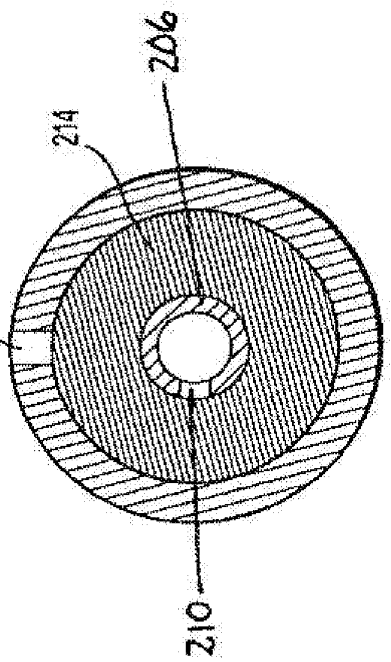

206
214
226
210

FIG. 3A

[Figure 4]

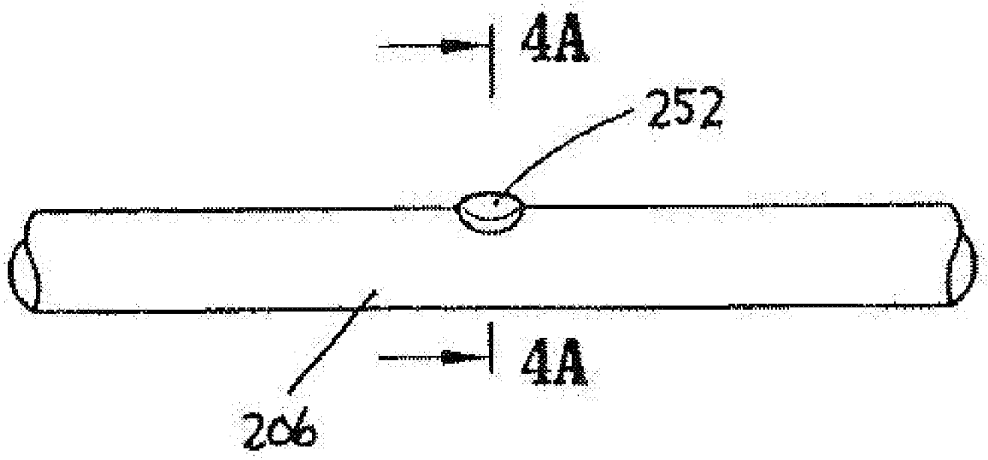


FIG. 4

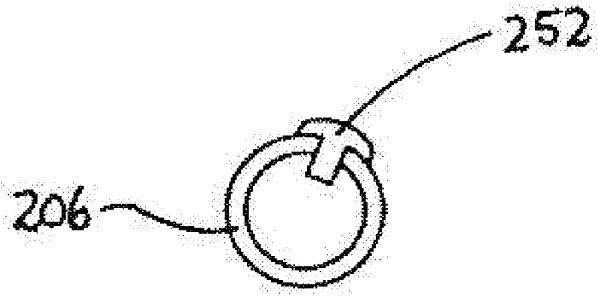


FIG. 4A

[Figure 5]

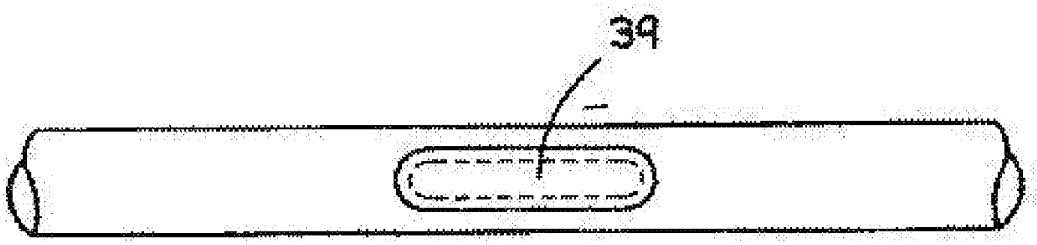


FIG. 5

[Fig. 6]

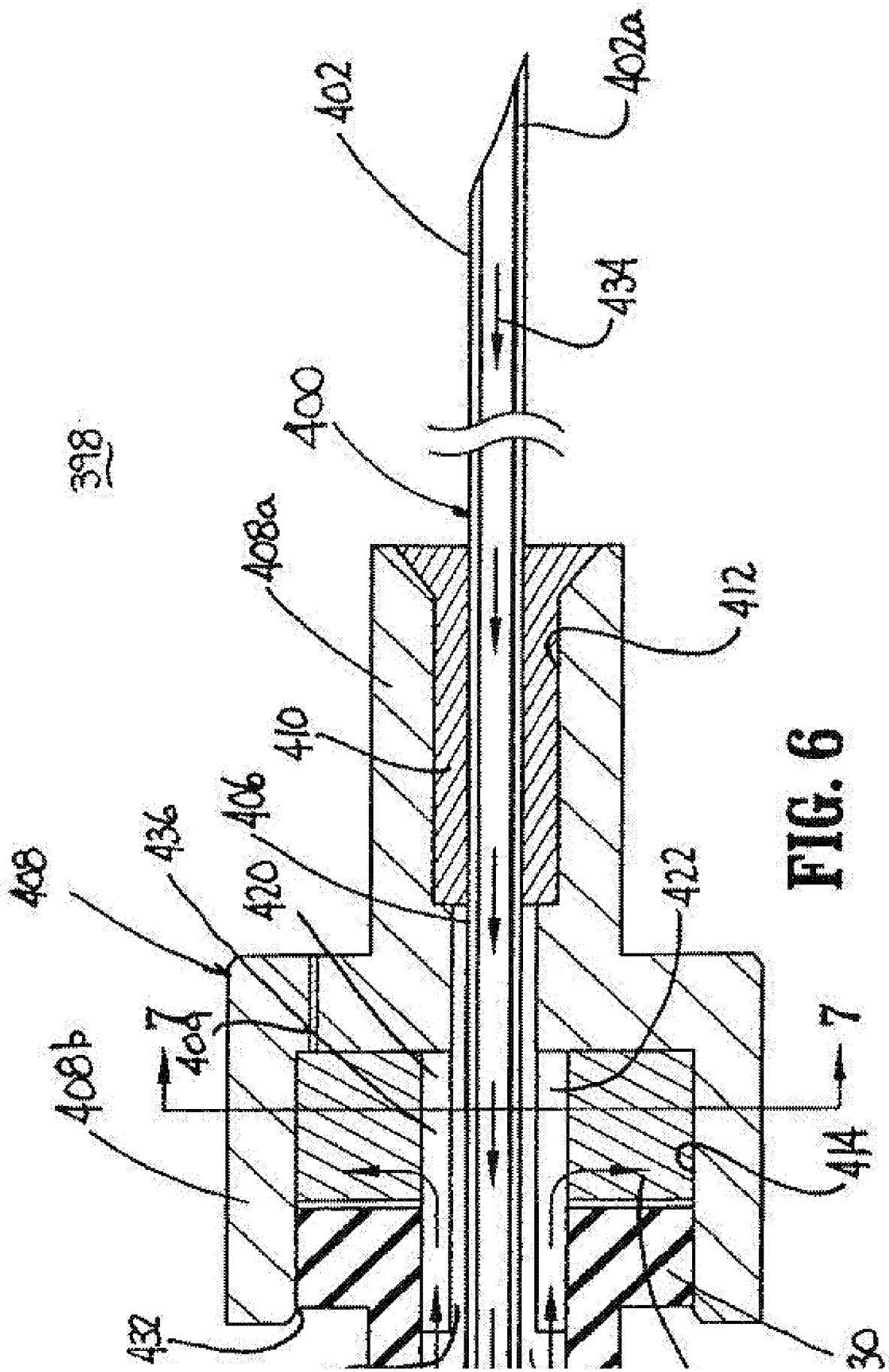

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402a
434
400
398
408a
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408
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422
7
404
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408b
414
432
30

FIG. 6

[Fig. 7]

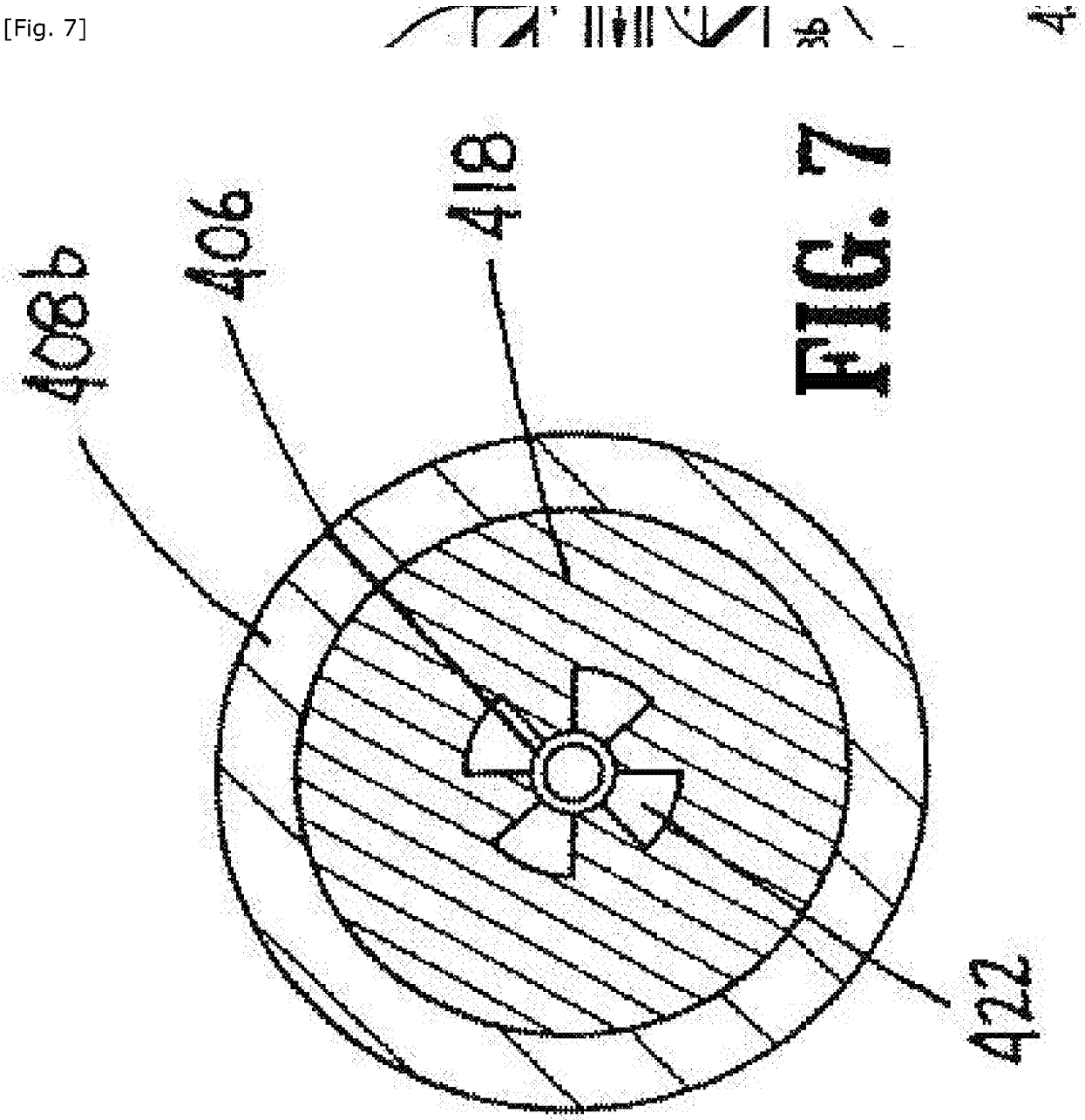


FIG. 7

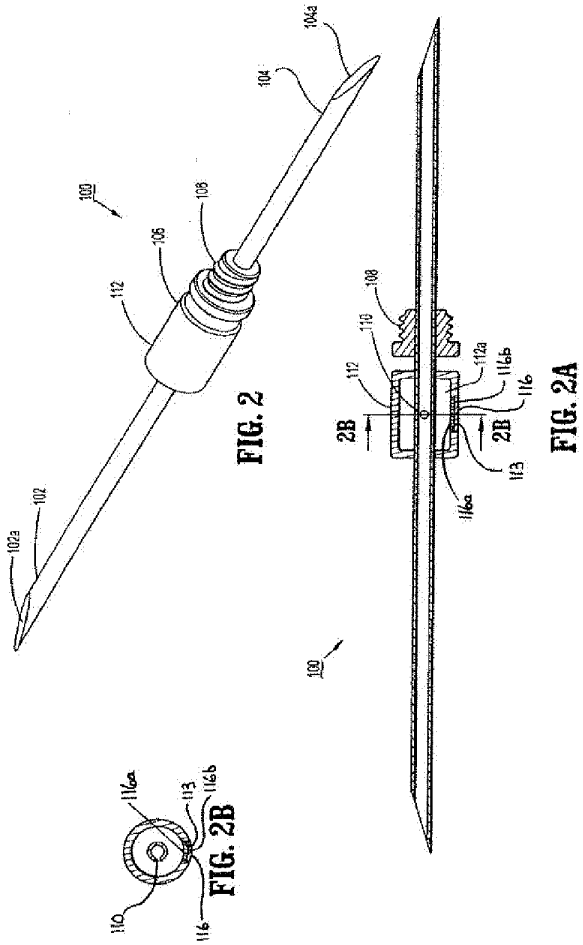
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drawing open

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Representative drawing

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Bibliographic data: JP2013240628 (A) — 2013-12-05

VENTED PHLEBOTOMY NEEDLE WITH FLASHBACK CHAMBER

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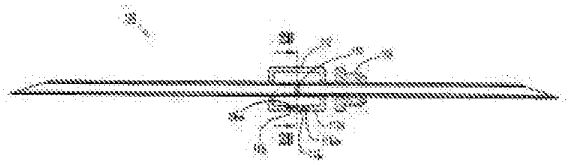
Classification: **- international:** ***A61B5/153; A61B5/154***
- cooperative: **A61B5/15003 (EP, US); A61B5/150213 (EP, US); A61B5/150389 (EP, US); A61B5/150473 (EP, US); A61B5/150572 (EP, US); A61B5/150732 (EP, US); A61B5/1545 (EP, US)**

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Abstract of JP2013240628 (A)



PROBLEM TO BE SOLVED: To provide a less expensive, less complex phlebotomy needle which facilitates visualization of flashback.SOLUTION: A central portion 106 of a needle 100 includes a hole or opening 110 which communicates with a flow channel defined by the needle 100 and a transparent housing 112 is positioned about the opening 110 to facilitate visualization of blood flow through the needle 100. A material which allows passage of air and provides an indication of blood flow through the needle 100 is positioned over the opening 110. The material is in the form of a plug or, alternately, in the form of a patch or collar. The phlebotomy needle includes the needle 100 and the housing 112 having a passive vent and a viewing region for visualizing blood flow in the housing 112.

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A61B	5/153	(2006.01)	A61B	5/14	300F	

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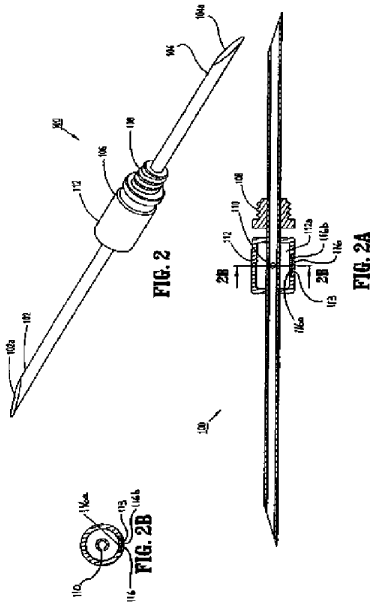
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最終頁に続く

(54)【発明の名称】フラッシュバックチャンバを備えた通気型瀉血針

(57)【要約】　（修正有）
【課題】フラッシュバックの可視化を容易にするより安価な、より簡単な瀉血針の提供。
【解決手段】針１００の中央部分１０６は穴または開口部１１０を含み、該穴または開口部１１０は、針１００によって画定された流路と連通し、透明の筐体１１２が、開口部１１０の周りに位置決めされ、針１００を通る血流の可視化を容易にする。空気の通過を可能にし、針１００を通る血流の表示を提供する材料が、開口部１１０を覆い位置決めされる。材料は、プラグの形であるか、または代替として、パッチまたはカラーの形である。瀉血針は、針１００と、受動通気孔を有する筐体１１２と、筐体１１２の血流を可視化するための観察領域とを含む。
【選択図】図２－１



【特許請求の範囲】
【請求項１】
瀉血針であって：
組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分とを有し、該遠位の針部分と該近位の針部分が流体チャンネルを画定する、針；
該針上に支持される筐体であって、受動通気孔を含み、該筐体が該筐体中に血液を観察するための観察領域を画定する、筐体；および
該近位の針部分の周りに位置決めされるエラストマーのシールドであって、該エラストマーのシールドおよび該近位の針部分が該筐体中への流体の流路を画定する、エラストマーのシールド、を備える、瀉血針。
【請求項２】
前記筐体内に位置決めされる縦溝のある部材をさらに含み、該縦溝のある部材が複数の流体チャンネルを画定する、請求項１に記載の瀉血針。
【請求項３】
前記縦溝のある部材が、前記エラストマーのシールドを超えて遠位方向に延びる、請求項２に記載の瀉血針。
【請求項４】
前記縦溝のある部材の流体チャンネルが血液の通過を可能にするように構成されている、請求項２に記載の瀉血針。
【請求項５】
前記筐体内に支持される親水性材料をさらに含む、請求項２に記載の瀉血針。
【請求項６】
前記流路が、血液を、前記針の近位端から前記縦溝のある部材の流体チャンネル中に、および前記親水性材料との接触に向ける、請求項５に記載の瀉血針。
【請求項７】
前記縦溝のある部材の一部分が、前記親水性材料によって取り囲まれる、請求項５に記載の瀉血針。
【請求項８】
前記縦溝のある部材の近位端が前記エラストマーのシールドによって取り囲まれ、そして該縦溝のある部材の遠位端が前記親水性材料によって取り囲まれる、請求項５に記載の瀉血針。
【請求項９】
前記筐体の近位部分が、内方に延びる環状のリブを含む、請求項５に記載の瀉血針。
【請求項１０】
前記エラストマーのシールドが環状のフランジを含む開いた遠位端を有し、前記筐体の環状のリブが該フランジを係合し、該エラストマーのシールドの遠位端を該筐体内に保持する、請求項９に記載の瀉血針。
【請求項１１】
前記エラストマーのシールドのフランジが、前記親水性材料に隣接して位置決めされる、請求項１０に記載の瀉血針。
【請求項１２】
前記エラストマーシールドの遠位端が前記筐体中に受容され、そして該エラストマーシールドの近位端が該筐体から近位方向に延びる、請求項１に記載の瀉血針。
【発明の詳細な説明】
【技術分野】
【０００１】
（１．技術分野）
本開示は、フラッシュバックの可視化を容易にする構造を有する医療用針に関する。より詳細には、本開示は、フラッシュバックの可視化を容易にする構造を含む通気型瀉血針

に関する。
【背景技術】
【０００２】
（２．関連技術の背景）
患者から血液を抜き取る医療用デバイスは周知である。これらのデバイスは、標準的な針－注射器、蝶型針セット、および瀉血針を含む。通常、蝶型針セットは、尖った遠位端および針ハブに固定された近位端を有する中空の針を含む。針ハブの近位部分は、可撓性の配管に接続されている。針ハブは、配管と連通する流体導管を画定し、一対の可撓性の、半径方向に延びるウィングを含み、該ウィングは、医療従事者による蝶型針セットの把持を容易にする。一般に、可撓性の配管は、医療従事者が、針ハブに直近の配管を通る血流、すなわちフラッシュバックを可視化することを可能にする透明の材料で形成される。フラッシュバックの可視化は、針が患者の中に正しく挿入されたことを、医療従事者が確認することを可能にする。
【０００３】
一部の臨床医は、血液サンプルを採取するために、透明の針ハブを備えた皮下針－注射器を利用する。挿入の間、これらの臨床医たちは通常、針ハブの中のフラッシュバックを観察する。
【０００４】
一般に、瀉血針は、フラッシュバックを可視化するための構造を含んでいない。瀉血針にフラッシュバックを可視化するための構造がないことは、より経験のある医療従事者にとっては大きな欠点ではないが、瀉血針によって血液を抜き取る経験をほとんど有しない医療従事者にとっては、針が正しく患者の中に位置決めされたことを確認するいかなる手段もないことは、血液を抜き取るために必要な時間を増加させ得、患者の不快を増加させ得る。
【０００５】
上記の不利を克服する試みとして、Ｎｏｒｒｉｓらへの特許文献１は、瀉血針を開示し、該瀉血針は、採血管に取り付け可能であり、外側針、内側針、およびそれらの間にバルブ（ｂｕｌｂ）を含む。バルブは、透明であり、外側針が正しく患者の静脈内に位置決めされたとき、医療従事者が血液を可視化することを可能にする。バルブは、針内から空気を通気するために医療従事者によって押し下げられ得るボタンも含む。針内の空気は、血液が針を通って流れることを妨げ、通気されなければならない。
【先行技術文献】
【特許文献】
【０００６】
【特許文献１】米国特許第５，４５０，８５６号明細書
【発明の概要】
【発明が解決しようとする課題】
【０００７】
Ｎｏｒｒｉｓの瀉血針は、フラッシュバックの可視化を容易にするが、フラッシュバックの可視化を容易にするより安価な、より簡単な瀉血針が望まれる。
【課題を解決するための手段】
【０００８】
本開示は瀉血針に関し、該瀉血針は、組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分と、および開口部を画定する中央の針部分とを含む。遠位の針部分、近位の針部分および中央の針部分は、開口部と連通する流体チャンネルを画定する。材料が、開口部に隣接して位置決めされる。材料は、空気が開口部を通って流体チャンネルを出ることを可能にし、一方、血液の通過を防止するタイプのものである。一実施形態において、材料は、開口部に隣接する血流、すなわちフラッシュバックの可視表示を提供する。
【０００９】

一実施形態において、材料は疎水性材料を含む。代替の実施形態において、材料は親水性毛管作用材料を含む。さらに別の実施形態において、材料は疎水性のプラグを含む。あるいは、材料は開口部の周りに位置決めされたカラー部を画定し得る。

【００１０】

一実施形態において、開口部は円形である。あるいは、開口部は様々な構成、例えば長方形またはスロット形状であることが想定されている。

【００１１】

一実施形態において、透明の筐体が開口部の周りに位置決めされ、フラッシュバックの可視化を容易にする。筐体はまた、材料を包含するように位置決めされ得、針から空気を通気するための通気孔を含み得る。

【００１２】

一実施形態において、瀉血針は、針ホルダーと係合するように構成された係合構造を含む。

【００１３】

一実施形態において、空気が開口部を通って流体チャンネルの中に入ることを阻止するために、逆止弁が提供される。さらに別の実施形態において、瀉血針は、針ホルダーを含む。

例えば、本発明は以下の項目を提供する。

（項目１）

瀉血針であって、

組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、

採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分と、

開口部を画定する中央の針部分であって、該遠位の針部分、該近位の針部分および該中央の針部分は、該開口部と連通する流体チャンネルを画定する、中央の針部分と、

該開口部に隣接して位置決めされた材料であって、空気が該開口部を通って該流体チャンネルを出ることを可能にし、一方、血液の通過を防止するタイプのものであり、血流の可視表示をさらに可能にする、材料と

を備えている、瀉血針。

（項目２）

上記材料は疎水性材料を含む、項目１に記載の瀉血針。

（項目３）

上記材料は親水性毛管作用材料を含む、項目１に記載の瀉血針。

（項目４）

上記材料は、上記開口部の方に向かう親水性材料の内側層と、疎水性材料の外側層とを含む、項目１に記載の瀉血針。

（項目５）

上記開口部は円形である、項目１に記載の瀉血針。

（項目６）

上記開口部は細長いスロットを画定する、項目１に記載の瀉血針。

（項目７）

上記開口部の周りに位置決めされた透明の筐体をさらに含む、項目１に記載の瀉血針。

（項目８）

上記瀉血針で支持された係合構造であって、針ホルダーと係合するように構成された、係合構造をさらに含む、項目１に記載の瀉血針。

（項目９）

上記材料は、上記開口部を覆い上記針の周りに位置決めされたカラー部を画定する、項目１に記載の瀉血針。

（項目１０）

上記カラー部の材料の周りに位置決めされた透明の筐体をさらに含む、項目９に記載の瀉血針。

（項目１１）
空気が、上記開口部を通って上記流体チャンネルの中に入ることを阻止するための逆止弁をさらに含む、項目１に記載の瀉血針。
（項目１２）
針ホルダーをさらに含む、項目１に記載の瀉血針。
（項目１３）
上記材料は、上記開口部を通る血流の可視表示を提供する、項目１に記載の瀉血針。
（項目１４）
瀉血針であって、
組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、
採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分と、
開口部を画定する中央の針部分であって、該遠位の針部分、該近位の針部分および該中央の針部分は、該開口部と連通する流体チャンネルを画定する、中央の針部分と、
該開口部に隣接して位置決めされた疎水性材料であって、空気が該開口部を通って該流体チャンネルを出ることを可能にし、一方、血液の通過を防止するタイプのものであり、血流の可視表示をさらに可能にする、疎水性材料と、
該開口部の周りに位置決めされた透明の筐体と、
該瀉血針で支持された係合構造であって、針ホルダーと係合するように構成された、係合構造と
を備えている、瀉血針。
（項目１５）
上記針ホルダーをさらに含む、項目１４に記載の瀉血針。
（項目１６）
瀉血針であって、
組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、
採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分と、
開口部を画定する中央の針部分であって、該遠位の針部分、該近位の針部分および該中央の針部分は、該開口部と連通する流体チャンネルを画定する、中央の針部分と、
該開口部に隣接して位置決めされた親水性毛管作用材料であって、空気が該開口部を通って該流体チャンネルを出ることを可能にし、一方、血液の通過を防止するタイプのものであり、血流の可視表示をさらに可能にする、親水性毛管作用材料と、
該開口部の周りに位置決めされた透明の筐体と、
該瀉血針で支持された係合構造であって、針ホルダーと係合するように構成された、係合構造と
を備えている、瀉血針。
（項目１７）
上記針ホルダーをさらに含む、項目１６に記載の瀉血針。
（項目１８）
瀉血針であって、該瀉血針は、
針であって、組織を貫通するように構成された尖った遠位端を有する遠位の針部分と、採血管のストッパを貫通するように構成された尖った近位端を有する近位の針部分とを含み、該遠位の針部分および該近位の針部分は、流体チャンネルを画定する、針と、
該針で支持された筐体であって、受動通気孔を含み、該筐体の血液を可視化するための観察領域を画定する、筐体と
を備えている、瀉血針。
（項目１９）
上記近位の針部分の周りに位置決めされたエラストマーのシールドをさらに含み、該エラストマーのシールドおよび該近位の針部分が、上記筐体の中への流体の流路を画定する、項目１８に記載の瀉血針。
（項目２０）

上記筐体内に位置決めされた縦溝のある部材をさらに含み、該縦溝のある部材は、複数の流体チャンネルを画定する、項目１８および項目１９のうちのいずれか一項に記載の瀉血針。

（項目２１）

上記筐体内に支持された親水性材料をさらに含む、項目１８～項目２０のうちのいずれか一項に記載の瀉血針。

（項目２２）

上記針は、上記筐体の中への開口部を画定する中央部分を有する、項目１８～項目２１のうちのいずれか一項に記載の瀉血針。

【図面の簡単な説明】

【００１４】

フラッシュバックチャンバを備えた本開示の通気型瀉血針の実施形態が、図面を参照して本明細書に開示される。

【図１－１】図１は、針ホルダー、保護針カバーおよび幻影で示された採血管を備えた「従来技術」の瀉血針の斜視図であり、部品は分離されている。

【図１－２】図１Ａは、組み立てられた「従来技術」の瀉血針、針ホルダー、および幻影で示された採血管の側面断面図であり、瀉血針の遠位部分は静脈内に位置決めされている。

【図２－１】図２は、本開示の瀉血針の一実施形態の側面斜視図である。図２Ａは、図２で示された瀉血針の断面図である。図２Ｂは、図２Ａの切断線２Ｂ－２Ｂに沿った断面図である。

【図２－２】図２Ｃは、本開示の瀉血針の別の実施形態の側面断面図である。

【図３】図３は、本開示の瀉血針の代替の実施形態の側面断面図である。図３Ａは、図３の切断線３Ａ－３Ａに沿った断面図である。

【図４】図４は、本開示の瀉血針の別の実施形態の側面斜視切取り図である。図４Ａは、図４の切断線４Ａ－４Ａに沿った断面図である。

【図５】図５は、本開示の瀉血針の別の実施形態の側面斜視切取り図である。

【図６】図６は、本開示の瀉血針の別の実施形態の側面断面図である。

【図７】図７は、図６の切断線７－７に沿った断面図である。

【発明を実施するための形態】

【００１５】

（実施形態の詳細な記述）

フラッシュバックチャンバを備えた本開示の通気型瀉血針の実施形態がここで、図面を参照して詳細に記述され、該図面においては、同様の参照番号は、幾つかの図面の各々において同一のまたは対応する要素を示す。

【００１６】

図１は、公知の瀉血針１０、針ホルダー１２、ならびに針カバー１４および１６を示す。採血管１７が幻影で示されている。瀉血針１０は、遠位の針部分２０と、近位の針部分２２と、係合部分２４を備えた中間の針ハブ２３とを含む。係合部分２４は、瀉血針１０を針ホルダー１２に接続することを容易にするように提供される。一実施形態において、係合部分は、雄継手２４ａを含み、雄継手２４ａは、雌継手または係合部材２６と係合するように構成され、係合部材２６は、針ホルダー１２の遠位端に提供される。あるいは、ねじ、スナップ型コネクタ、その他を含む他の係合構造が使用され得る。下にさらに詳細に記述されるように、エラストマーのシールド２８が近位の針部分２２を覆い位置決めされ、近位の針部分２２をシールする。

【００１７】

針ホルダー１２は、実質的に円筒状の本体３０を含み、実質的に円筒状の本体３０は、係合部材２６を含む遠位端および一対のフランジ部材３２を含む近位端を有する。フランジ部材３２は、医療従事者による採血管１７の把持および挿入を容易にする。円筒状の本体３０は、採血管１７を受け入れるための空洞３４（図１Ａ）を画定する。通常、採血管

１７は、貫通可能ストッパ１７ａによってシールされ、低圧の空洞１７ｂ（図１Ａ）を画定する。ホルダー１２の遠位端は、係合部材２６を通る開口部３６を画定し、開口部３６は、近位の針部分２２を受け入れる大きさとされる。

【００１８】

図１Ａに示されるように、使用に際して、針１０は、係合部分２４および係合部材２６を介して針ホルダー１２の遠位端に固定される。針１０が針ホルダー１２に固定されると、近位の針部分２２は、針ホルダー１２の本体３０の空洞３４内に位置決めされ、エラストマーのシールド２８は、近位の針部分２２を覆い位置決めされる。次に、貫通可能ストッパ１７ａを含む採血管１７（幻影で示される）が、空洞３４内に位置決めされる。採血管１７が空洞３４の中に挿入されると、近位の針部分２２が、ストッパ１７ａと係合し、シールド２８を貫通する。近位の針部分２２が、ストッパ４０を貫通し、採血管１７の空洞１７ｂに入るように、シールド２８は下向きに圧縮（図１Ａ）される。遠位の針部分２０が患者の静脈３８に正しく位置決めされ、採血管１７が空洞３４内に位置決めされると、血液が、針１０を通って採血管１７の中に流入するように、通常、採血管１７は、真空に維持される。採血管１７が針ホルダー１２から取り外されると、弾力的なエラストマーのシールド２８は、その元の構成に戻り、近位の針部分２２を被覆し、近位の針部分２２をシールする。

【００１９】

図２および図２Ａは、概して１００として示されるフラッシュバックチャンバを備えた本開示の瀉血針の一実施形態を示す。針１００は、遠位端１０２と、近位端１０４と、中央部分１０６とを含む。遠位端１０２は、患者の組織を貫通するように構成された尖った端１０２ａを有し、近位端１０４は、採血管１７（図１Ａを参照）のストッパ１７ａを貫通するように構成された尖った端１０４ａを有する。中央部分１０６は、上に論議されたように、係合部材１０８を含み、係合部材１０８は針ホルダー（図１）と係合するように構成される。中央部分１０６はまた、開口部または穴１１０と、開口部１１０を画定する部分の中央部分１０６の周りに位置決めされた半透明または透明の筐体１１２とを含む。開口部１１０は円形として示されているが、他の構成、例えば長方形、正方形、楕円形、細長いスロット３９（図５）、その他が想定されている。透明の筐体１１２は、血液レザバ１１２ａを画定する。通気開口部１１３は好ましくは、透明の筐体１１２に形成される。通気開口部１１３が針１００の通気を容易にし、針１００を通る血流を可能にする。下に論議されるように、筐体１１２の通気開口部１１３は、空気の通過は許すが、例えば血液のような液体の通過は許さない材料によって被覆され得る。

【００２０】

図２Ａおよび図２Ｂを参照して、通気開口部１１３は、フィルタ１１６で被覆され得る。フィルタ１１６は好ましくは、親水性材料の内側層１１６ａと、疎水性材料の外側層１１６ｂとを含む。好ましくは、層１１６ａおよび層１１６ｂのうちの少なくとも１つは、０．４５ミクロンを下回る孔サイズを有する。かかる孔サイズは、空気の通過は可能にするが、バクテリアが筐体１１２の中に入ることを防止する。

【００２１】

図２Ｃを参照して、代替の実施形態において、フィルタ１１６は、例えばフラップ弁１５０のような疎水性逆止弁によって置き換えられ得る。図示のように、フラップ弁１５０は、筐体１１２の中に血液が流入し始めると、筐体１１２から外向きに曲がり、通気開口部１１３を露出させ、筐体１１２を通気するように構成される。逆止弁が開いたとき、血液が通気開口部１１３から出ることを防止するために、疎水性シート１５２が開口部１１３を覆い位置決めされる。血液が筐体１１２の中に流入し始めるのに先立って、フラップ弁１５０は開口部１１３をシールし、物質が筐体１１２の中に入ることを防止する。あるいは、フラップ弁１５０は、親水性材料の孔サイズが血液成分の通過を遮るサイズである場合は、該親水性材料から形成され得る。

【００２２】

針１００の遠位端１０２が患者の静脈内に正しく位置決めされたとき、すなわち、血液

が針１００を通って流れ、空気が通気されて、血液が開口部１１０を通ってレザバ１１２ａの中に入るとき、透明の筐体１１２は、医療実施者が針１００を通る血流を可視化することを可能にする。これによって、医療実施者は、針１００の遠位端１０２が、血液を抜き取るために患者の静脈内に正しく位置決めされたことを確認することができる。これは、患者から血液を抜き取ろうと試みる医療実施者に対して、特に瀉血針によって患者から血液を抜き取ることについて限られた経験しか有しないような実施者に対して大きな利益を提供する。

【００２３】

図３は、概して２００として示されるフラッシュバックチャンバを備えた本開示の通気型瀉血針の代替の実施形態を示す。針２００は、下に記述されるとおりを除いて、針１００と実質的に同様である。針２００は、遠位端２０２と、近位端２０４と、中央部分２０６とを含む。遠位端２０２は、患者の組織を貫通するように構成された尖った端２０２ａを有し、近位端２０４は、採血管（図１Ａを参照）のストッパを貫通するように構成された尖った端２０４ａを有する。中央部分２０６は、開口部または穴２１０と係合部材２１２ａとを含む。材料２１４は、穴２１０を覆い位置決めされている。医療従事者が針２００を通る血流を容易に識別し得るように、材料２１４は、材料の中に血液を毛管作用で吸い込む親水性の材料であり得る。針２００の通気を容易にするために、材料２１４は、空気に対しては透過性があるが、例えば血液のように液体に対しては透過性がない親水性材料であり得る。一実施形態において、親水性材料は、血液と接触したとき、色が変わるタイプのものであり得る。材料は、カラー２５０（図３）またはプラグ２５２（図４）の形であり得る。さらに、材料は、透明の筐体もしくはハブ２１２内に位置決めされ得るか、または代替的に、いかなる筐体もなく開口部２１０に隣接して位置決めされ得る。代替の実施形態において、材料は、空気は通すが血液は通さない疎水性の材料である。通気開口部２２６は筐体２１２に提供され得、筐体の通気を容易にし得ることに留意される。通気孔は、筐体２１２における開口部の形であり得、該開口部は、血液が入ると筐体２１２から空気が流れ出ることを可能にする。

【００２４】

図３および図３Ａでさらに示される代替の実施形態において、材料２１４は、膨張可能な材料で形成され得、該膨張可能な材料が血液と接触する前に、空気が通気開口部２２６を通ることを可能にする。材料２１４は、血液と接触すると膨張し得、通気開口部２２６を閉じ得る。

【００２５】

本明細書において、親水性材料および疎水性材料のみが開示されたが、血液の通過を防止しながら空気の通過を容易にし、血流の表示を提供する他の材料が、本開示の瀉血針に対して使用され得る。材料は、本明細書に開示されていない他の構成を有し得る。例えば、材料は、開口部を被覆するパッドを画定し得る。

【００２６】

図６および図７は、概してデバイス３９８として示されるフラッシュバックチャンバを備えた本開示の瀉血針の別の実施形態を示す。瀉血針３９８は、針４００と段付き筐体４０８とを含む。針４００は、遠位端４０２と、近位端４０４と、中央部分４０６とを含む。遠位端４０２は、患者の組織を貫通するように構成された尖った端４０２ａを有し、近位端４０４は、採血管（図示されず）のストッパ（図示されず）を貫通するように構成された尖った端４０４ａを有する。

【００２７】

段付き筐体４０８は、遠位部分４０８ａおよびより大きな直径の近位部分４０８ｂを有する。段付き筐体４０８は、中央部分４０６で支持されている。遠位部分４０８ａは、針の中央部分４０６を受け入れる大きさとされた通し穴４１２を画定する。遠位部分４０８ａは、例えば接着剤４１０を使用して、針４００にシールされ、固定される。あるいは、他の公知の技術、例えばクリンプ加工、クランプ、ねじ、溶接その他が使用され得、針４００を筐体４０８に固定し得る。近位部分４０８ｂは、透明の材料または半透明の材料で

形成され、筐体４０８の近位部分４０８ｂ内の可視化を容易にする。近位部分４０８ｂはまた、通し穴４１４を画定し、通し穴４１４は通し穴４１２と連通するが、通し穴４１２よりも直径が大きい。近位部分４０８ｂは、部分４０８ｂと針４００の近位端４０４との間に環状のリセス４１６を画定する。リセス４１６は、親水性材料４１８および内側の縦溝のある部材４２０を受け入れるような大きさとされる。内側の縦溝のある部材４２０が、針４００の近位端４０４の周りに位置決めされ、親水性材料４１８と連通する複数のチャンネル４２２を画定する。通気開口部４０９は、筐体４０８を通して提供される。

【００２８】

エラストマーのシールド４２８は、針４００の近位端４０４を覆い位置決めされる。上に論議されたように、エラストマーのシールド４２８は弾力的であり得、針４００の近位端４０４が採血管（図示されず）に接続されていないとき、針４００の近位端４０４をシールするように機能する。エラストマーのシールド４２８は、閉じた近位端４２８ａと開いた遠位端４２８ｂとを含む。開いた遠位端４２８ｂは環状のフランジ４３０を含み、環状のフランジ４３０は、筐体４０８のリセス４１６内で材料４１８に隣接して位置決めされる。筐体４０８の近位部分４０８ｂは、内向きに延びる環状のリブ４３２を含み、内向きに延びる環状のリブ４３２は、エラストマーのシールド４２８のフランジ４３０と係合し、シールド４２８の遠位端４２８ｂを筐体４０８のリセス４１６内に保持するように位置決めされる。矢印４３４によって示されるように、流路４３６は、エラストマーのシールド４２８と針４００の近位端４０４との間に画定される。流路４３６は、針４００の近位端４０４から縦溝のある部材４２０の縦溝のあるチャンネル４２２の中に血液を導き、親水性材料４１８と接触させる。使用に際して、血液が材料４１８と接触すると、材料４１８は、筐体４０８の近位部分４０８ｂを通して目視可能となる血流の可視表示を提供する。

【００２９】

フィルタ１１６と共に画定された（図２Ａ～図２Ｂ）、フィルタ２５２と共に画定された（図４～図４Ａ）、もしくはフィルタ３９と共に画定された（図５）、または逆止弁１５０と共に画定された（図２Ｃ）通気開口部１１３、ならびに開口部２２６（図３～図３Ａ）および開口部４０９（図６）はすべて、受動通気開口部として記述され得、該受動通気開口部は、針カニューレ内において大気圧よりも大きな圧力の気体が大気中に自動的に漏れることを可能にする。これらの受動通気開口部は、本発明によるデバイスのユーザによるいかなる行動も必要としない。

【００３０】

本明細書に開示された実施形態には、様々な変更がなされ得ることは理解される。したがって、上述は、限定するものとして解釈されるべきではなく、好ましい実施形態の単なる例示として解釈されるべきである。当業者は、本明細書に添付された請求項の範囲および精神内で他の変更に想到する。

【図１－１】

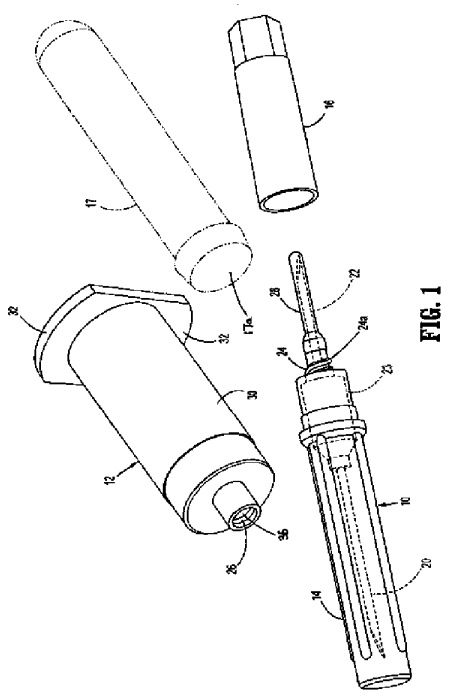


FIG. 1

【図１－２】

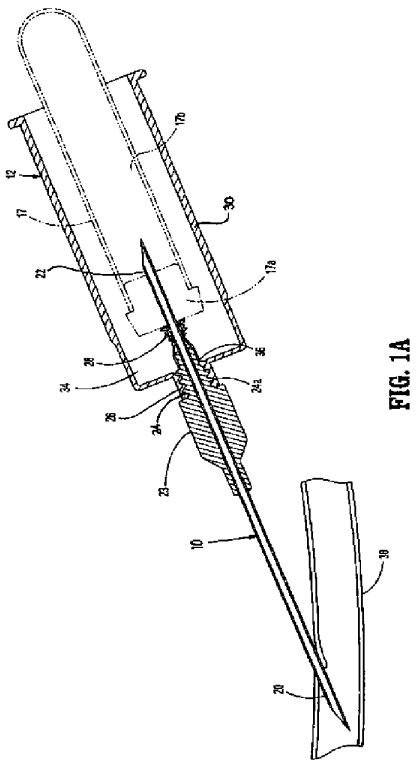


FIG. 1A

【図２－１】

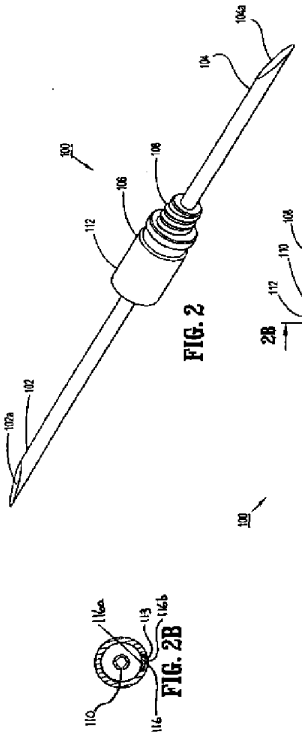


FIG. 2

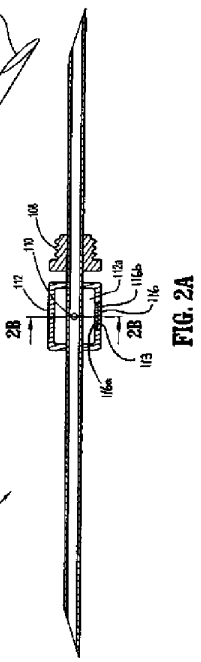


FIG. 2A

FIG. 2B

【図２－２】

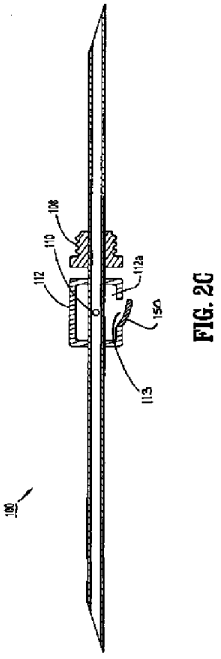


FIG. 2C

【図３】

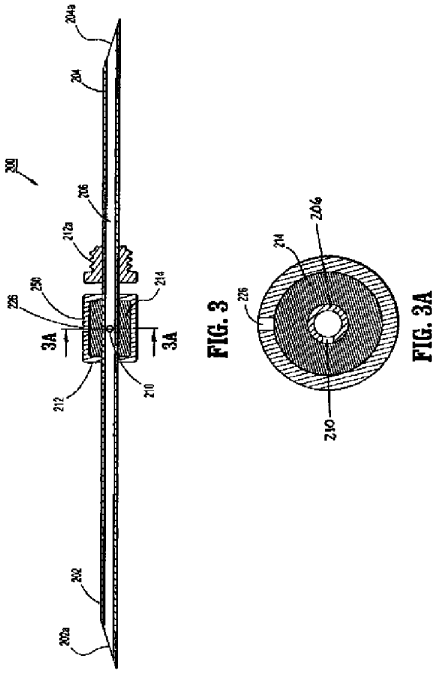


FIG. 3

FIG. 3A

【図４】

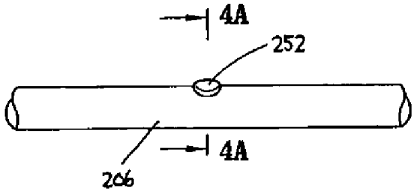


FIG. 4

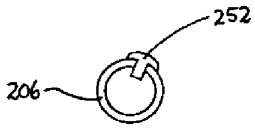


FIG. 4A

【図５】

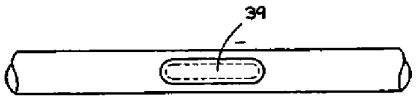


FIG. 5

【図６】

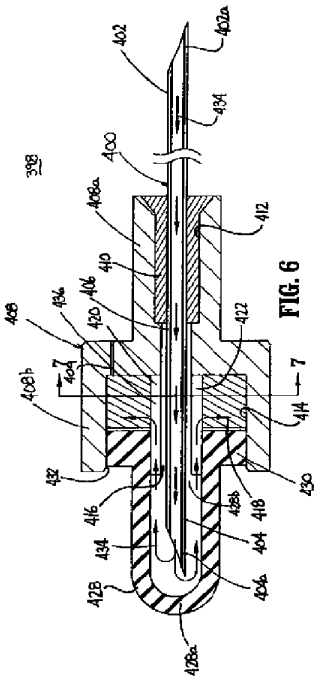


FIG. 6

【図７】

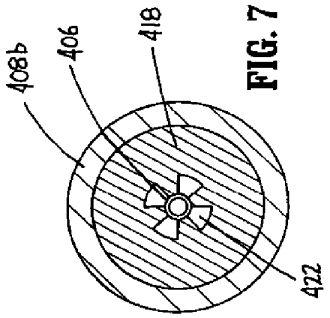


FIG. 7

フロントページの続き

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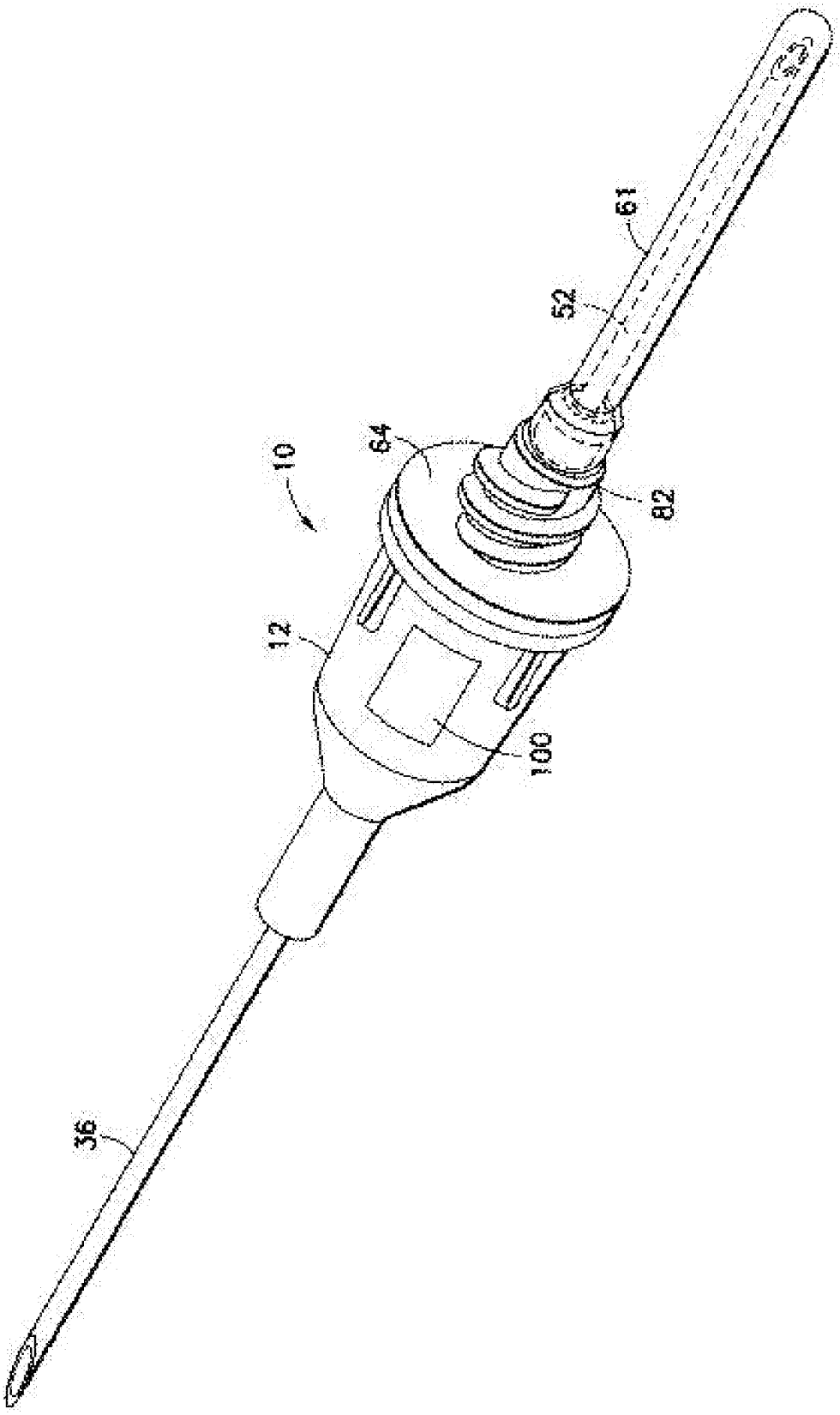
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wrap up close

(57) [Summary] (Modified)
[Problem] To easily confirm that puncturing has been performed reliably when collecting bloo d, and to prevent outflow of fluid such as blood.
A self-venting blood collection needle assembly for extracting at least one fluid sample into a vacuum container for clinical testing, the blood collection needle assembly allowing a flow of b lood to allow a user to successfully perform a venipuncture. To provide a transparent or semi-transparent flashback chamber in which cracking can be visually confirmed. The self-venting mechanism is designed to allow the release of air and prevent the escape of fluids, such as bl ood, during use. Thus, air under venous pressure can be expelled from the blood collection ne edle assembly by the time the blood reaches the venting mechanism.
[Selection drawing] Fig. 1


61
52
64
10
82
12
100
36

The scope of the claims

open —

1. A hub having an inlet end, an
outlet end and a chamber formed therebetween; an
inlet cannula, a distal end external to said hub; an inlet cannula extending through the cann ula and having a lumen attached to the hub in communication with the chamber; an outlet ca nnula having a proximal end outside the hub
; an exit cannula extending through and attached to the hub so as to communicate with the chamber; and multiple specimens mounted over
portions of the exit cannula outside the hub. a multiple sample sleeve, wherein the lumen of the inlet cannula, the chamber, the lumen of the outlet cannula, and an inner surface of the m ultiple sample sleeve form a fluid passage; the fluid passage and the external atmosphere
; a venting mechanism in communication with the needle assembly for permitting the outflo w of air from the needle assembly through the venting mechanism to an external atmosphere and substantially inhibiting the outflow of liquid from the needle assembly through the venting mechanism to the external atmosphere; and a venting mechanism,
wherein said inlet and outlet cannulas are separate or a single cannula having an opening co mmunicating with said chamber.
2.
The needle assembly as recited in claim 1, wherein said venting mechanism extends through said hub.
3.
The needle assembly as recited in claim 2, wherein said venting mechanism comprises a ven ting medium.
[Claim 4]
3. The needle assembly of claim 2, wherein said venting mechanism includes at least one op ening through said hub, said opening including a vent plug.
5. The
needle assembly as recited in claim 4, wherein said venting mechanism further comprises a check valve.
6.
The vent mechanism includes at least one opening through the hub and a vent ring surround ing the inlet cannula, the vent ring being positioned through the hub in the chamber proximat e to the opening. 2. The needle assembly of claim 1, wherein the needle assembly comprises:
7.
The needle assembly of claim 1, wherein said venting mechanism is disposed in said passag

e beyond the proximal end of said exit cannula.

8.

The needle assembly as recited in claim 7, wherein said venting mechanism comprises a ven ting medium.

9.

The needle assembly of claim 1, wherein said hub further comprises a non-patient locking pr ojection, said vent mechanism extending through said non-patient locking projection. .

10.

The needle assembly as recited in claim 9, wherein said venting mechanism comprises a ven ting medium.

11.

The needle assembly of claim 9, wherein said venting mechanism comprises a passageway t hrough said non-patient stop projection and a vent plug disposed in said passageway.

[Claim 12]

10. The needle assembly of claim 9, wherein said venting mechanism comprises a notch ext ending through said non-patient locking projection and a venting disc.

13. The method of claim

9, wherein said venting mechanism comprises at least one opening extending through said n on-patient side locking projection and a vent plug arranged in said opening. needle assembly.

14.

The needle assembly of claim 1, wherein said hub further comprises a non-patient locking pr ojection, at least a portion of said non-patient locking projection comprising said venting mec hanism. .

15. The

needle assembly as recited in claim 14, wherein said venting mechanism comprises a ventin g medium.

16.

At least part of said non-patient side locking projection is made of a porous hydrophobic mat erial, or at least part of said non-patient side locking projection is made of a porous material h aving a hydrophobic surface. 15. The needle assembly of claim 14, wherein the needle assem bly is made of material.

17.

A needle assembly as in claim 14, wherein said venting mechanism comprises a porous mat erial impregnated with a hydrophilic material.

18.

The hub further comprises a non-patient side locking projection to which the multiple sample sleeves are securely attached, and wherein the venting mechanism is disposed between the n on-patient side locking projection and the multiple sample sleeves. 2. The needle assembly of claim 1, wherein the needle assembly is .

19. The

needle assembly as recited in claim 18, wherein said venting mechanism comprises a ventin g sleeve.

[Claim 20]

20. The needle assembly of claim 19, wherein said vent sleeve comprises a porous hydropho bic material or said vent sleeve comprises a porous material with a hydrophobic surface.

21.

The needle assembly of claim 18, wherein said venting mechanism comprises a ventable ven t cord.

22.

The needle assembly of claim 18, wherein said venting mechanism comprises a textile surfac e.

23.

The needle assembly of claim 1, wherein said multiple sample sleeve includes said venting m echanism.

24. The

needle assembly as recited in claim 23, wherein said venting mechanism comprises a ventin g medium.

25. Said

multiple sample sleeve is formed of a porous hydrophobic material or said multiple sample sl eeve comprises a porous material having a hydrophobic surface. A needle assembly as describ ed in .

26.

The needle assembly of claim 1, wherein at least a portion of said hub is formed by a ventin g medium such that said hub constitutes said venting mechanism.

27.

At least a portion of said hub is made of a porous material such that said hub constitutes sai d ventilation mechanism.

2. The needle assembly of claim 1, wherein the needle assembly is formed by:

28.

The needle assembly of claim 1, wherein said hub further comprises a non-patient thread as sembly and a hub insert assembled together to form a reservoir.

29.

The venting mechanism includes a first passage through the non-patient thread assembly to the reservoir, a second passage from the reservoir to the outside atmosphere, and a vent loca ted in the reservoir. 29. The needle assembly of Claim 28, comprising:

30.

Further comprising a non-patient thread assembly, at least a portion of said non-patient thre ad assembly being defined by a vent medium such that said non-patient thread assembly con

stitutes said vent assembly. 2. The needle assembly of claim 1, wherein the needle assembly comprises:

31.

Further comprising a non-patient thread assembly, at least a portion of the non-patient thre ad assembly formed of a porous material such that the non-patient thread assembly constitut es the vent assembly. 2. The needle assembly of claim 1, wherein the needle assembly is .

32.

The needle assembly of claim 1, wherein said venting mechanism comprises a venting mediu m.

33.

The needle assembly of claim 1, further comprising a shield selectively covering said first ca nnula.

34.

a hub having an inlet end, an outlet end and a chamber formed therebetween;

a cannula having a distal end mounted to the hub so as to be external to the hub, a proxima l end and a lumen extending therebetween; and a proximal end of the cannula external to the hub

. Multiple sample sleeves mounted over a portion, wherein the lumen, the inner surface of th e multiple sample sleeve and the chamber form a fluid passageway, and the fluid passageway communicates with an external atmosphere

. a venting mechanism that allows air to escape from the needle assembly through the venti ng mechanism to the external atmosphere and substantially prevents fluid from exiting the ne edle assembly through the venting mechanism to the external atmosphere. A needle assembl y,

comprising: a venting mechanism.

35.

The needle assembly as recited in claim 34, wherein said venting mechanism is disposed in s aid passageway beyond said proximal end of said exit cannula.

36.

The needle assembly of claim 35, wherein said venting mechanism comprises a venting medi um.

37.

The needle assembly of claim 34, wherein the hub further comprises a non-patient locking p rojection, and wherein the vent mechanism extends through the non-patient locking projectio n. .

38. The

needle assembly as recited in claim 37, wherein said venting mechanism comprises a ventin g medium.

39. The needle assembly of claim 37,

wherein said venting mechanism comprises a passageway through said non-patient stop pro jection and a vent plug disposed in said passageway.

[Claim 40]

The vent mechanism includes a notch extending through the non-patient side locking project ion and a vent disc.

38. The needle assembly of claim 37, characterized by:

41. The needle of claim 37,

wherein said venting mechanism comprises at least one opening extending through said non -patient stop projection and a vent plug disposed in said opening. assembly.

42.

The needle assembly of claim 34, further comprising a non-patient locking projection, at leas t a portion of said non-patient locking projection comprising said venting mechanism.

43. The

needle assembly as recited in claim 42, wherein said venting mechanism comprises a ventin g medium.

44.

At least part of said non-patient side locking projection is formed of a porous hydrophobic m aterial, or at least part of said non-patient side locking projection is made of porous material having a hydrophobic surface. 43. The needle assembly according to Claim 42, comprising a material.

45. A

needle assembly as in claim 32, wherein said venting mechanism comprises a porous materi al impregnated with a hydrophilic material.

detailed description open —

Description: BACKGROUND OF THE INVENTION 1.

Field of the Invention The present invention relates to a device for performing a vascular pun cture on a patient to obtain a blood sample. More particularly, the present invention is useful f or collecting multiple blood samples when collecting blood samples from a patient into a vacu um blood collection tube, where the self-venting feature allows the phlebotomist to know if th e vessel has been punctured. of the needle assembly. BACKGROUND OF THE INVENTION Vas cular puncture is the primary method used to obtain blood samples for clinical examination . P erforming a vascular puncture requires the phlebotomist to perform multiple steps simultaneo usly. This step includes evaluating the patient's overall physical and psychological condition to appropriately select the vascular puncture site and technique. The phlebotomist also needs to

select the proper instrumentation, perform techniques to control bleeding, and properly collec t and identify fluid samples for clinical examination. All of these concurrent factors must be id entified by the phlebotomist, as these factors adversely affect vessel dilatation and the length of the vascular puncture procedure. [0003] Various vascular puncture devices have been dev eloped to address the aforementioned problems. These devices include a needle assembly hav ing a hub defining a chamber therein with a single pointed cannula secured to the hub. The va scular end of the cannula is configured to be inserted into a patient's blood vessel and the non -patient end of the cannula has a sealable sleeve and pierces a pierceable stopper disposed wi thin the reduced pressure vessel. is configured as DISCLOSURE OF THE INVENTION [Problem to be Solved by the Invention]

When the vessel end of the cannula is inserted into the vessel, blood flows through the cann ula into the sealable sleeve and into the hub's chamber, which is transparent or translucent fo r visualization ("flashback"). When air is evacuated from the hub chamber, the blood therein is pressurized each time the sealable sleeve is pushed toward the hub chamber by the action of the vacuum reservoir. Due to the time lag between vessel insertion and flashback, the phleb otomist did not obtain a satisfactory vessel puncture because the transparent chamber did not immediately indicate that a vessel puncture had occurred

.

You may mistakenly believe that you were not. The phlebotomist then uses the vacuum cham ber and/or

Unnecessarily repeated vascular punctures requiring replacement of the needle assembly itsel f. Repetition of such procedures prolongs the physical and emotional discomfort experienced b y the patient.

[0006]

If no flashback occurs, the air in the injection cannula and flashback chamber is compressed there, so that the air in the needle hub is pressurized to venous pressure. This pressurized air needs to be expelled somewhere, so when the needle is withdrawn from the patient after the blood draw is complete, this pressurized air pushes the blood towards the tip of the needle. p ush out to

[0007]

Accordingly, to provide a rapid, accurate and cost-effective solution to conventional blood sa mpling methods in which phlebotomists consistently rely on flashback to achieve satisfactory venous punctures. is desired. In addition, a blood collection needle assembly is provided that allows blood to flow directly into the flashback chamber through a relatively short needle and to expel pressurized air from the interior of the needle assembly, thereby providing a vein. It would be particularly desirable to have a direct indication of successful puncture of the assem bly and no leakage of blood from the assembly. As used herein, ventilation media refers to ele ments that actually allow air to pass, such as plugs, coatings, surface treatments, and the lik e. Means

for Solving the Problems

SUMMARY OF THE INVENTION The present invention is a self-venting blood collection needle assembly for extracting at least one fluid sample into a vacuum vessel for clinical testing, the blood collection needle assembly providing visual confirmation of a successful venipuncture by the user. Provide a transparent or translucent flashback chamber for viewing by This self-venti ng mechanism allows the release of air during use, but prevents the escape of liquids such as blood. Venting mechanism, as used herein, refers to one or more devices or elements that all ow air to escape but prevent the passage of liquids. Thus, air under venous pressure can be e xpelled from the blood collection needle assembly by the time it reaches the venting mechanis m. The venting mechanism then blocks or prevents the flow of blood around or through it, all owing blood to be collected into a vacuum collection tube or other suitable blood collection co ntainer. The present invention provides good instant visualization within the flashback chambe r without adversely affecting the blood collection process. There are a variety of suitable vent mechanisms, vent media or vent locations, as described below.

[0009]

A self-venting blood collection needle assembly is provided for drawing at least one fluid sam ple from a patient and subsequently expelling it into at least one vacuum vessel. The self vent ed blood collection needle assembly of the present invention includes a hub having a fluid inle t defined by a cylindrical outer wall. The wall defines a flashback chamber for retaining the blo od sample within the hub and at least a portion of the wall being transparent or translucent so that the jet is visible from the outside. The hub further has a fluid outlet end communicating with the fluid inlet end. A first inlet cannula in fluid communication with the blood inlet end ex tends outwardly therefrom. The first cannula has an inner proximal end located at the proxim al end of the chamber and an opposite outer distal end adapted to puncture a patient's vein. Similarly, a second non-patient exit cannula is disposed in fluid communication with the fluid e xit end and extends outwardly therefrom. The second non-patient cannula has an inner distal end positioned proximal to the first inner end and further includes an outer proximal end oppo site the second inner end. The second non-patient outer proximal end is configured to pass th

rough a pierceable stopper of a vacuum vessel. The second patient cannula further includes a sealable multiple sample sleeve. However, a single cannula containing a notch could be used i nstead of two cannulas. Another alternative cannula configuration is to use a single cannula wi thout a notch to pass through the proximal end of the non-patient cannula, around multiple s ample sleeves and through a vent before flashback occurs. there is The outer portion of the h ub near the proximal end is formed with a single external thread, or other mounting structur e, for receiving blood.

A collection needle assembly can be attached to a collection tube holder or other medical devi ce. Alternatively, the holder can be pre-attached to the needle assembly.

[0010]

In one embodiment, the venting mechanism is located in the flashback chamber of the hub. The use of the double cannula type construction or the notched single cannula is suitable for t his configuration. The vent mechanism thereby communicates the fluid passageway with the o utside atmosphere via the hub.

In another embodiment, a venting mechanism is placed over the proximal end of the non-pati ent cannula which

allows air to pass through the proximal end of the non-patient cannula from which blood is a spirated and then through the vent. means to pass. A single cannula without a notch is suitabl e in this case, but any cannula construction can be used. Specifically, air flows through the sp ace between the outside of the needle and the multiple sample sleeve and exits the fluid pass ageway out the proximal end of the non-patient cannula. The air is then directed to the non-p atient locking lug, non-patient hub threads, non-patient hub body, multiple specimen sleeves, or other location beyond the proximal end of the non-patient cannula. or through vents in any combination of these locations. A collection tube attached to the proximal end of the non-pati ent cannula draws blood only from the fluid passageway and not from the vented space. This embodiment thus allows blood to flow through the entire collection passageway. This also pre vents contact of the blood sample with the vent, which could potentially lead to platelet activa tion or contamination or other undesirable consequences. This also prevents air from being dr awn back into the fluid passageway when a vacuum tube is installed. It should also be noted t hat this embodiment requires a smaller ejection chamber than the previous embodiment in w hich the vent is located in the hub.

[0012]

Another embodiment of the invention has a venting mechanism comprising an integral hub a t least partially formed of a porous material such as sintered plastic, ceramic or metal. This po rous material either before air enters the non-patient cannula or after air exits the proximal e nd and flows through the non-patient cannula into the space between the cannula and the mu ltiple sample sleeve. can be arranged so that the evacuation takes place at the same time. Th e porous material allows air to pass through but prevents blood from leaking. In typical embo diments, this porous material is hydrophobic. Porous materials further include materials that s

well when wet. Other venting methods are possible. The walls of the internal passageway may be coated with a sealant to prevent contamination of the blood sample with porous material. This embodiment allows blood to flow over the entire collection path. If desired, the hub can b e permanently joined to the tube holder to eliminate the need and inconvenience of a threade d connection. Bonding to this holder can be accomplished by solvent, welding, heat, pressure or other suitable means, or a combination thereof. A device integrated in this way can be man ufactured efficiently, and the holder can be discarded together with the needle, thereby increa sing the safety of medical procedures.

[0013]

In yet another embodiment, the vent mechanism vents air out through a side opening locate d in the hub, the opening being shaped to be mechanically retained in or against the opening. covered by a breathable material having This venting material is preferably hydrophobic and t he surface tension is also such that it prevents leakage. The vent media material of this embo diment preferably has a resilient nature and shape so that the energy of the spring holds the vent material against the device. For example, a C-shaped vent medium can be used where t wisting of the shape requires the vent medium to extend over the receiving structure on the h ub. When the vent media is placed on the support structure, it releases and uses its own elast icity to hold it in place without any bonding material such as epoxy that could be absorbed by the vent media and adversely affect it. be done. The venting mechanism of this embodiment may first compress the venting material, place the material in the opening, and then release t he venting material to expand within the opening. BEST

MODE FOR CARRYING OUT THE INVENTION

SUMMARY OF THE INVENTION The present invention is a self-venting blood collection needle assembly with a self-venting mechanism that prevents the escape of fluids such as blood and aids in the release of air, which draws blood or other fluids from a patient through one or mor e vacuum tubes. An assembly is provided that provides a visual indication of vascular insertio n ("flashback") as it is drawn into a blood collection tube. The aeration medium may be a se parate physical element, such as a plug or insert, or an integral part of the device, treated, su ch as by laser drilling, or made wholly or partially of a porous material, or impregnated, for ex ample

.

Note that it may be a film, layer, etc., formed by depositing the material on the device by, coa ting, spraying, or the like.

A blood collection needle assembly according to

one embodiment of the present invention is shown in FIG. The needle assembly 10 includes a hub 12 that carries a fluid entry needle (first cannula) 36 on one side and a fluid exit needle (second cannula) 52 on the opposite side. Fluid withdrawn from the first cannula passes throu gh the hub 12 and is immediately visible in the flashback chamber through the translucent wi

ndow 100, and with the aid of the venting mechanism, at the appropriate time that a proper v essel puncture has occurred. give proper instructions.

[0017]

Figures 2-28 illustrate various embodiments of the present invention including various config urations of venting mechanisms in blood collection needle assemblies. In particular, Figures 2, 3, 4A, 4B and 4C show embodiments in which the venting mechanism is located on the hub p ortion. Figures 5-12 show embodiments in which the venting mechanism is located beyond th e proximal end 60 of the non-patient cannula. Figures 13 and 14 show an embodiment in whic h a portion of the hub of the needle acts as the vent medium. FIG. 15 shows an embodiment i n which the venting mechanism is a unified hub 132 . Figures 16-26 show embodiments in wh ich the ventilation mechanism is a breathable cord. Figures 27A and 27B show an embodimen t in which the vent mechanism is a check valve. Figure 28 shows an embodiment with a single notched cannula. Note that in each of the two cannula embodiments below, a single notched c annula can be used as well.

FIGS.

2, 3, 4A, 4B and 4C illustrate a venting mechanism in which a venting ring 300 is placed aro und the proximal end 301 of first cannula 36. FIG. This vent ring forms an interference fit with the inner wall of flashback chamber 302 . Therefore, air can escape from the ventilation openi ngs 303 to the outside atmosphere through this ventilation ring. These openings can be locate d anywhere on the distal end of the hub. 2 and 3, these openings are located at the distal end of hub 304. FIG. 4A, 4B and 4C show another embodiment in which the vent openings are lon gitudinal vent windows 305 that abut the distal side of the vent ring 300. FIG.

[0019]

Some embodiments include a venting mechanism located beyond the proximal end 60 of the non-patient cannula. This venting mechanism uses a smaller flashback chamber 22a and redu ces the amount of air exhausted from the hub assembly 12 compared to the previous embodi ments such as FIGS. 2, 3, 4A, 4B, 4C. It is advantageous for The next embodiment uses a lar ger annular flange 68a to create a smaller flashback chamber 22a, although other designs are possible. Examples of these designs are a window of translucent/transparent material near th e surface of the hub and/or part of the flashback chamber for better visibility of the flash. Not e that a flashback chamber or window can be placed in the air/blood passageway, especially f or embodiments using a single cannula without a notch. In the embodiment of FIG. 5, air flo ws from the fluid passageway 306 to the proximal end 60 of the non-patient cannula and thro ugh the space 307 between the outside 308 of the needle and the inside of the multiple sampl e sleeve 61 to the non-patient cannula

.

It reaches the position of a vent hole 309 consisting of a locking projection 310 on the patient side and a vent plug 311 that allows air to escape but prevents blood or other fluids from esca ping to the outside atmosphere.

6, 7, 8A, 8B, 9A, 9B, 10A and 10B illustrate embodiments in which the venting mechanism is located beyond the proximal end 60 of the non-patient cannula . is shown. The embodiment o f Figures 6 and 7 shows a vent plug 312 that also functions as at least part of the non-patient side locking projection. As shown in these figures, in both embodiments, at least a portion of t he vent is close to the exterior through which air is exhausted. 8A and 8B show an embodime nt in which the notch 313 in the non-patient locking projection 314 is configured to allow air t o escape to the vent disc 315. FIG. 9A and 9B show another embodiment in which the notch 3 16 in the non-patient locking projection 314 contains a vent plug 317. FIG. 10A and 10B show a non-patient locking projection 318 configuration in which the ventilation sleeve 319 is modifi ed to allow air to escape. In each embodiment, the venting mechanism (and similar elements described herein) allows air to escape, but prevents blood or other fluids from escaping to the outside atmosphere.

FIG.

11 shows another embodiment of a venting mechanism located beyond the proximal end 60 of the non-patient cannula. According to this embodiment, air is vented through the material of the multiple sample sleeve 320 itself which prevents fluid from exiting the non-patient cann ula 52 . The multiple sample sleeve 320 maintains its normal function of being pierced by the sharpened proximal end 60 of the non-patient cannula 52 in response to the force created by the vacuum tube stopper. A multiple sample sleeve 320 can be made that also functions as a vent by forming the sleeve from a porous, hydrophobic material such as those previously desc ribed.

[0023]

12 shows that air passes through narrow passage 353 between the outside of non-patient ne edle 52 and non-patient locking projection 354 and then between base 64 and annular flange 68 to contain vent medium 357. Another embodiment is shown in which it enters the reservoi r 355 of the hub 356 and is discharged to the outside atmosphere via a passageway 358 at th e interface 80 between the hub 356 and the base 64 of the non-patient hub. A hub insert 359 forms a reservoir 355 .

FIGS.

13 and 14 illustrate a venting mechanism in which hub 321 or non-patient threaded assembl y 322 is made of a porous material and thus acts as a venting medium. FIG. 13 shows hub 32 1 as a venting medium for venting air through ramp 28 of hub 321 and out of annular groove 26 into the surrounding atmosphere. FIG. 14 shows a non-patient threaded assembly 322 as a venting medium. This embodiment allows air to pass through the wall of the flashback cham ber 22a and then out through the non-patient side locking projection 324 .

FIG .

15 is made of a porous material venting medium that allows air to escape through the wall o f the annular groove 26 and the flashback chamber 22a and through the fluid passageway 30

6 and out the proximal end 60 of the non-patient cannula. The venting mechanism is shown t o be an integral one-piece hub 325 with the air further passing through the space 307 betwee n the outside of the needle 308 and the inside of the multiple specimen sleeve 61 and then th rough the non-patient locking projections 326 . through and into the surrounding atmosphere. Due to the integral nature of the hub 325, this holder is not threaded and can be pre-attached to the hub 325 by bonding. However, threads may be provided if desired, as shown. Solvents, welding, heat, pressure, other conventional means or combinations thereof are used to bond t he tube holder to the integral non-patient hub 325 .

FIG.

16 illustrates the venting mechanism of a breathable ventable cord 326 located between the inside of the sealing surface of multiple sample sleeve 61 and the non-patient locking projecti on 327 . Due to the cord being placed on the sealing surface, air is evacuated from the space 307 between the outside of the needle 308 and the outside of the multiple sample sleeve 61, but only through the nature of the material of the cord and/or the passageway formed by the cord. The very small dimensions of the prevent fluid leakage

. Venting using this mechanism is accomplished by positioning a venting medium (eg, placem ent, coating, treatment, etc.) between any one or more of the sealing surfaces along the fluid path 306 . Figures 17-26 show cross-sections of cords with suitable breathability. Other shape s and combinations of these shapes are also available. The cord is made by extruding, spinnin g or the like and is advantageously coated with a hydrophobic coating such as wax.

[0027]

In other embodiments, the venting mechanism uses a check valve located anywhere along t he fluid passageway. This valve allows air to pass through but closes when a vacuum is applie d, so when a vacuum collection tube is attached to the tip of the needle, this tube will draw bl ood from the fluid passageway, but not air. Figures 27A and 27B show an example of a check valve. The venting mechanism may be located at any point or points along fluid passageway 3 06 , but is preferably located at hub 328 . The valve 349 itself may be a thin flap such as a pl astic film 350 covering the vent, a seal such as a deformable rubber, or a plastic duckbill type valve, a deformable wrap over the vent, or any other means. or a combination thereof. This v alve 349 is located either proximally or distally to the vent. In the embodiment shown in FIG. 27B, a thin plastic film valve 349 is attached to hub 328 along one sealed edge of film 351 an d is pulled out of fluid passageway 306 by venous pressure during an initial venipuncture. Air i s pushed through the porous vent plug 352 and out under the free edge of the plastic film 34 9 . However, when a vacuum is applied to the fluid passageway 306 (via the blood collection t ube attachment), the thin plastic film 349 sucks tightly against the porous vent plug 352, seal ing the vent to keep air out. Prevents re-entry into the fluid passageway. Thus, this embodime nt serves the primary or backup function of preventing air from re-entering the system after e vacuation has taken place.

[0028]

FIG. 28 shows a blood collection needle assembly with a single cannula 360 and a vent plug 361 that serves as a non-patient locking projection. This cannula 360 is positioned in bore 34 such that bore 365 of cannula 360 is provided at the location of annular groove 26 and remai ns in fluid communication therewith. When cannula 360 is properly positioned, it frictionally e ngages hole 34 or is secured thereto, such as by adhesive. During venipuncture, air flows fro m fluid passageway 306, exits proximal end 362 of cannula, and flows into space 307 betwee n the outside of needle 363 and the inside of multiple sample sleeve 61 to vent plug 361. .
As will be appreciated by those skilled in the art, it

is possible to combine more than one vent mechanism in one device, and to attach the same vent mechanism to one location in one device. Additionally, any of a variety of venting media may be used in the venting mechanism of the present invention. Moreover, the venting mecha nisms described herein are applicable to various devices other than blood collection needle as semblies. Venting media, as used herein, include, for example : a generally hydrophobic sub strate or carrier coated, impregnated, or containing a hydrophilic material that swells on conta ct with water-soluble or water-containing substances
; A porous plug formed of a material whose swellable properties provide a sealing function to the vent when in contact with blood; Matte finish, micro-sized passages, laser drilled holes, to rtuous passages ; vent holes provided by a porous material or holes, gaps or passages large e nough to allow air to pass but small enough to prevent blood leakage, e.g. provided between sealing surfaces in the cord;

A porous plug that closes when in contact with blood, using biological phenomena such as coa gulation and/or cell agglutination to block the vent, or a super plug that seals the vent by swe lling on contact with aqueous fluids
. Absorbent material; or
Check valves: thin flaps such as plastic films covering vents, deformable seals such as rubber or duckbill type valves, or deformable wraps covering vents.
or combinations thereof. Preferably, the porous plug is coated with, impregnated with, or con taining a hydrophilic material such as carboxymethylcellulose (CMC) or polyacrylate, or a hydr ophobic material such as high density polyethylene (HDPE)
.
formed by Alternative hydrophobic materials include, but are not limited to, polytetrafluoroeth ylene (PTFE), ultra high molecular weight polyethylene (UHMPE), nylon 6, polypropylene (PP), polyvinylidene fluoride, or polyethersulfone. (PES). As will be described in further detail belo w, the venting media of the present invention are suitable for venting mechanisms and device s, including one or more micro-dimensioned matte-finished passages, laser-drilled holes, vent able Cords, superabsorbent check valves, or other means, or any combination thereof, may al

ternatively be used. Thus, although any particular venting medium, such as, for example, a pl ug, is referred to herein, it is intended to be non-limiting and to include other suitable membe rs of venting media.

[0032]

One embodiment of the venting media consists of micro-sized holes formed in the outer wal l. These holes are large enough to allow air to pass, but small enough to prevent blood leakag e. The vent can be any number, including one, but multiple holes are preferred for reliable fun ction. These holes are laser drilled, ie they are burned through the wall using one or more las er beams. The substrate can be any common material, but a thin plastic film is preferred. The venting mechanism can include a check valve as previously described. This venting mechanis m may be located at any convenient space along the fluid passageway within the syringe or p atient cannula, hub, or additional component, but to produce a flush along the entire length of the tube, , is preferably provided at the proximal end.

[0033]

Porous plugs that are sealed by biological phenomena when in contact with blood use porous materials such as sintered plastics, ceramics, or metals, or use breathable cords, or have sma ll pores between parts. or by placing a biological agent in the space. The vent may be of any c onventional shape. Venting may occur at any location(s) in the fluid passageway, but preferab ly at the proximal end, such as the hub, close to the collection device. The vent is made of an d includes a stimulant that interacts with blood to promote clotting and/or cell clumping such t hat clotted and/or congealed cells inhibit flow through the vent. , preferably adjacent to or co operating with. Examples of clotting stimulants are silica, crushed glass, or glass fibers. One e xample of a glue is a lectin. Examples of platelet activators are collagen or thrombin. Neutraliz ing agents for anticoagulants such as protomin sulfate may be included. The biological stimula nt can be applied as a powder, solution, suspension, slurry, or other form using any convenien t process. It may be dried or vacuum freeze dried. Various other changes and modifications can be made by those skilled in the art without departing from the scope or spirit of this inven tion, all of which are intended to be within the scope of the invention

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is intended as

BRIEF DESCRIPTION OF THE DRAWINGS

[0035]

FIG. 1 is a perspective view of a blood collection needle assembly;

2 is a cross-sectional view of another embodiment of the blood collection needle assembly of t he present invention; FIG.

3 is a side sectional view similar to FIG. 2, but showing another embodiment of the invention; FIG.

4A is a side cross-sectional view similar to FIG. 2, but showing another embodiment of the pr esent invention; FIG.

4B is a side view of FIG. 4B; FIG.

4C is a front view of FIG. 4BA looking in the direction of RR; FIG.

5 is a cross-sectional view of one embodiment of a blood collection needle assembly; FIG.

FIG. 6 is a cross-sectional view similar to FIG. 5, but showing another embodiment of the inve ntion;

FIG. 7 is a cross-sectional view similar to FIG. 5, but showing another embodiment of the inve ntion;

8A is a cross-sectional view similar to FIG. 5, but showing another embodiment of the inventi on; FIG.

8B is a front view of FIG. 8A looking in the direction XX; FIG.

9A is a cross-sectional view similar to FIG. 5, but showing another embodiment of the inventi on; FIG.

9B is a front view of FIG. 9A looking in the direction YY; FIG.

10A is a cross-sectional view similar to FIG. 5, but showing another embodiment of the invent ion; FIG.

10B is an enlarged view of FIG. 10A viewed from area Z; FIG.

FIG. 11 is a cross-sectional view of one embodiment of a blood collection needle assembly;

FIG. 12 is a cross-sectional view of one embodiment of a blood collection needle assembly;

FIG. 13 is a cross-sectional view of one embodiment of a blood collection needle assembly;

FIG. 14 is a cross-sectional view of one embodiment of a blood collection needle assembly;

15 is a cross-sectional view of one embodiment of a blood collection needle assembly; FIG.

FIG. 16 is a cross-sectional view of one embodiment of a blood collection needle assembly;

FIG. 17 is a cross-sectional view of one embodiment of a ventable cord;

FIG. 18 is a cross-sectional view similar to FIG. 17 but showing another embodiment of the in vention;

Figure 19 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

Figure 20 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

Figure 21 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

Figure 22 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

Figure 23 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

FIG. 24 is a cross-sectional view similar to FIG. 17 but showing another embodiment of the in vention;

Figure 25 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

Figure 26 is a cross-sectional view similar to Figure 17 but showing another embodiment of th e invention;

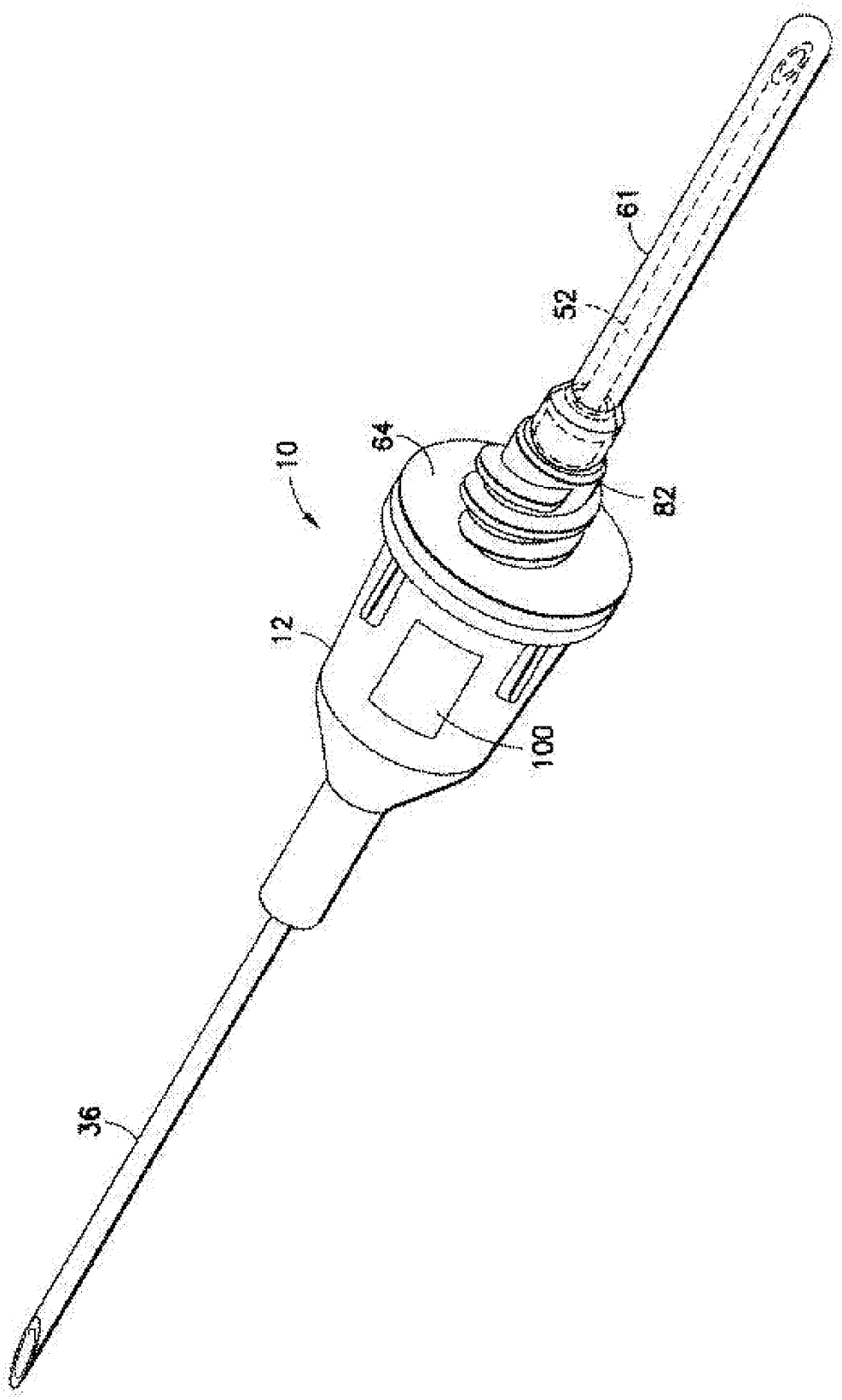
Figure 27A is a cross-sectional view of one embodiment of a blood collection needle assembly;

27B is an enlarged view of FIG. 27A viewed from region R; FIG.

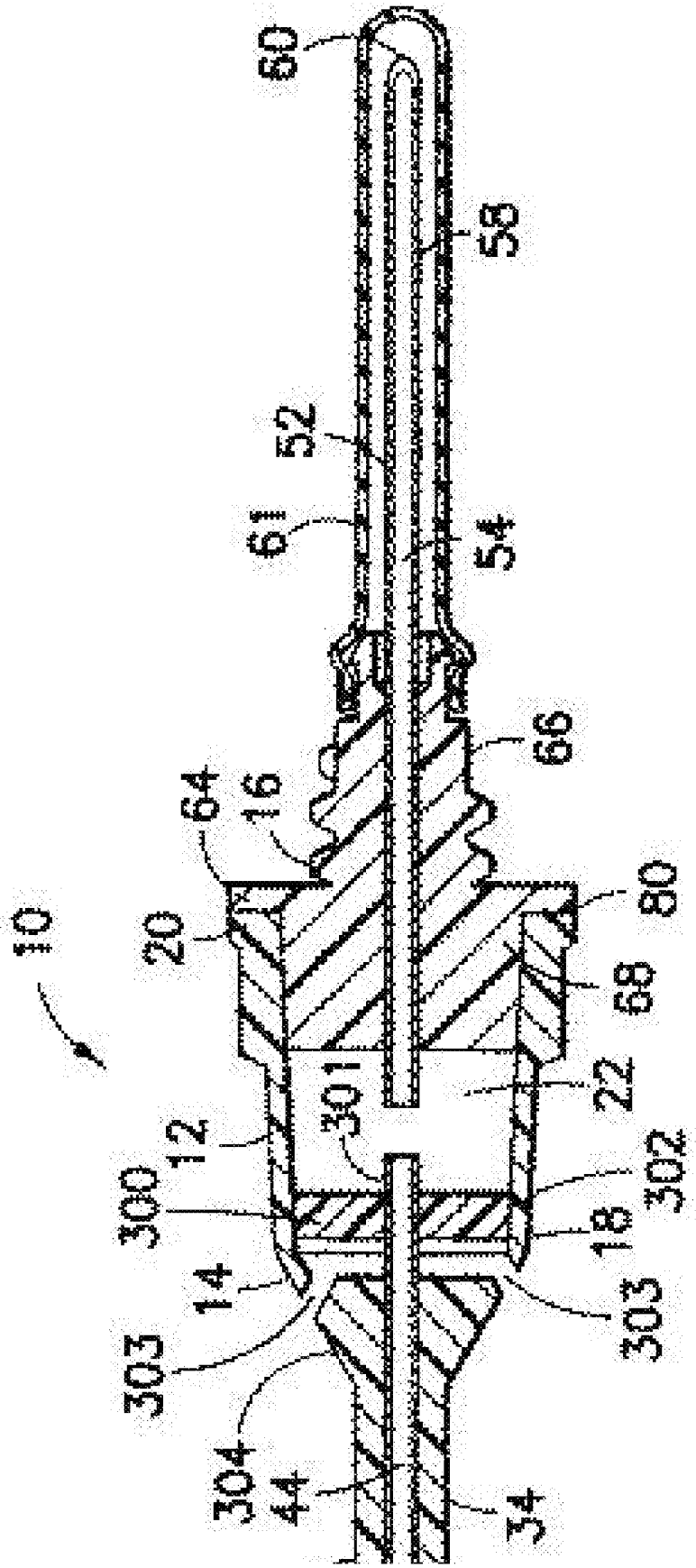
Figure 28 is a cross-sectional view of one embodiment of a blood collection needle assembly;

drawing	open ----

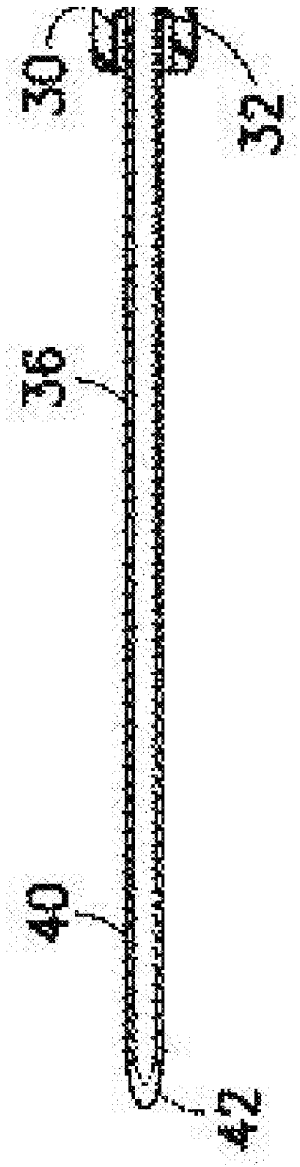
[Fig. 1]

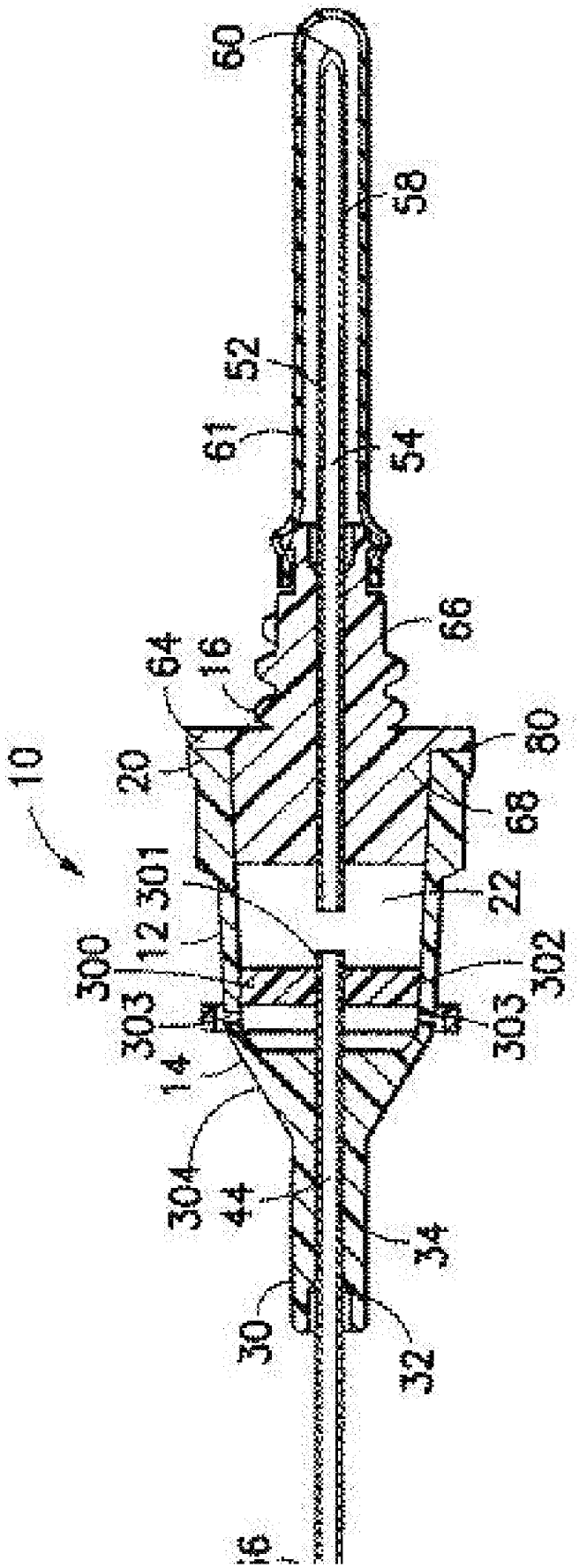


[Figure 2]

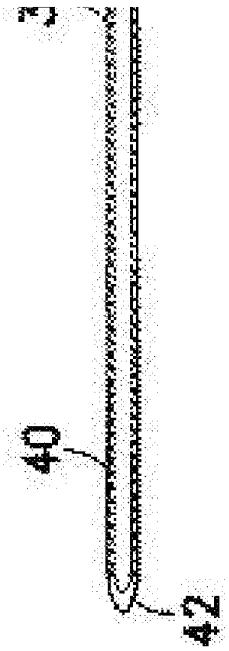

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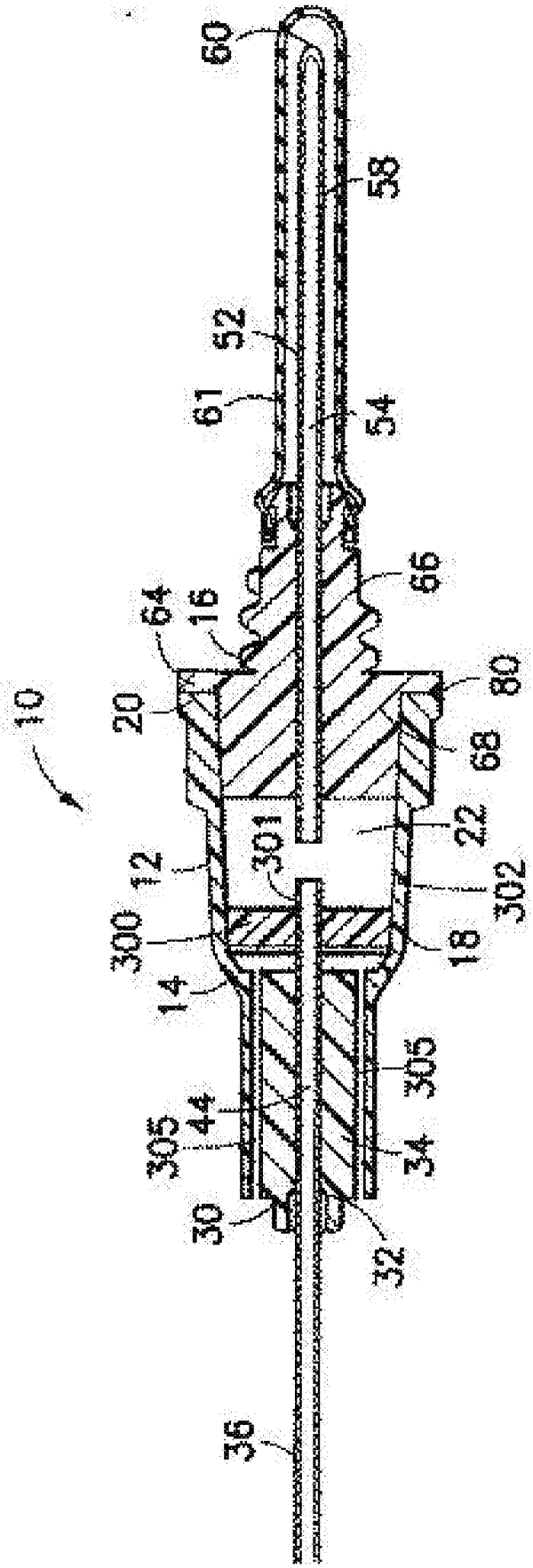
[Figure 3]



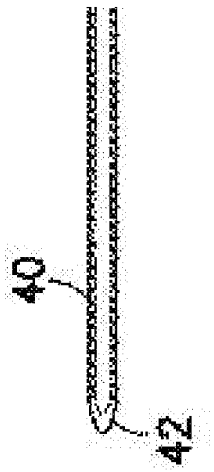

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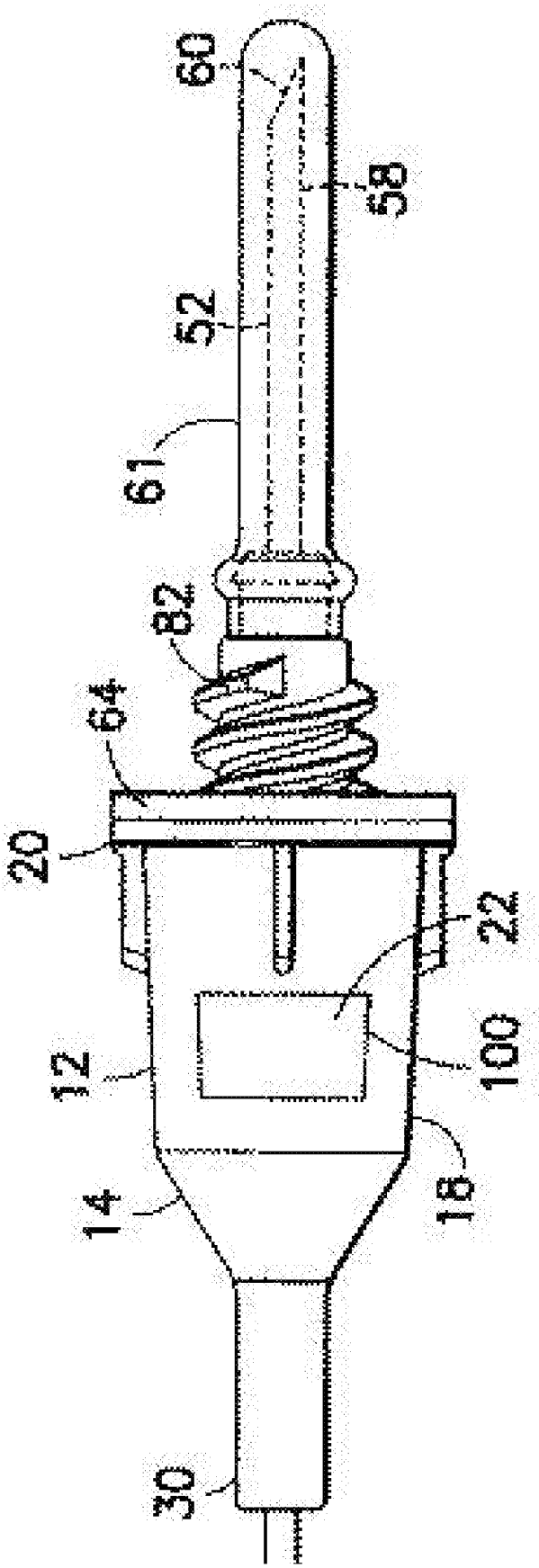
[Fig. 4A]



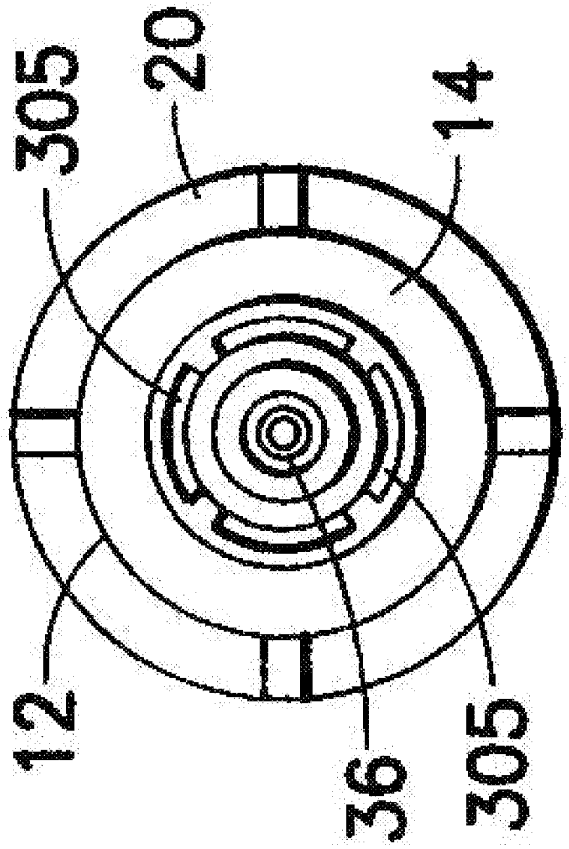

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[Fig. 4B]

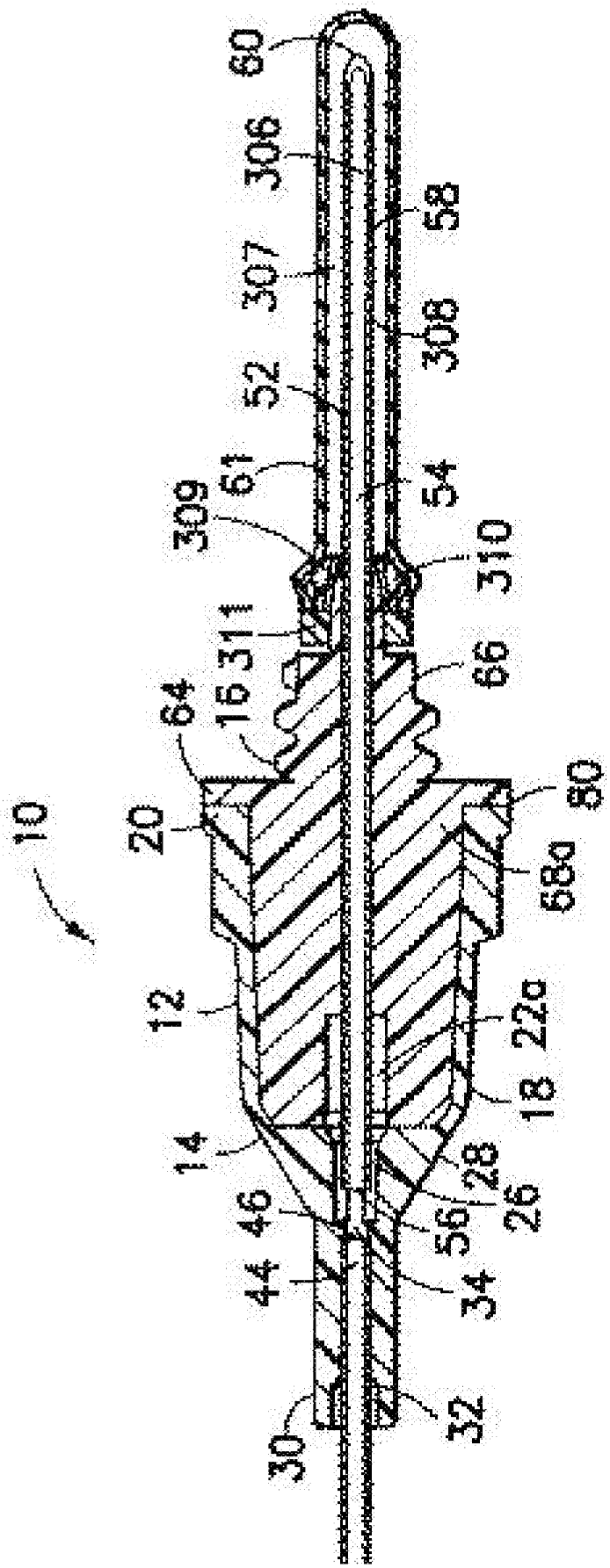



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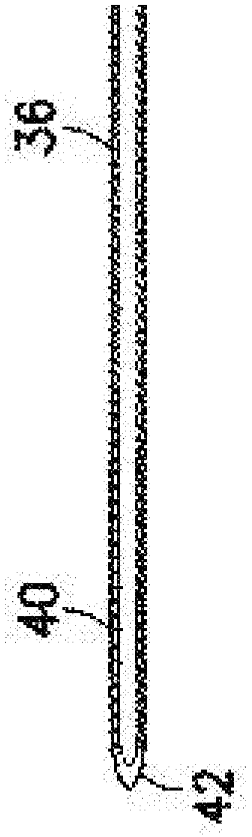
[Fig. 4C]

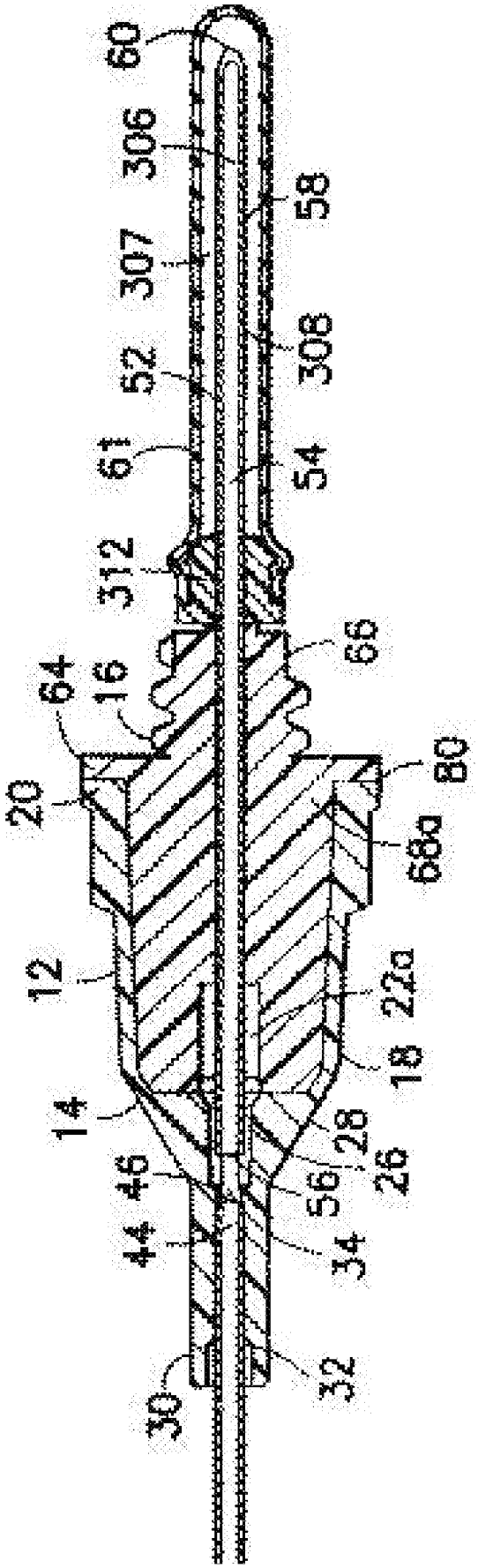


[Figure 5]

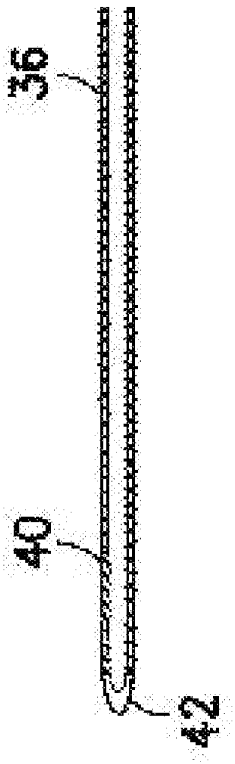

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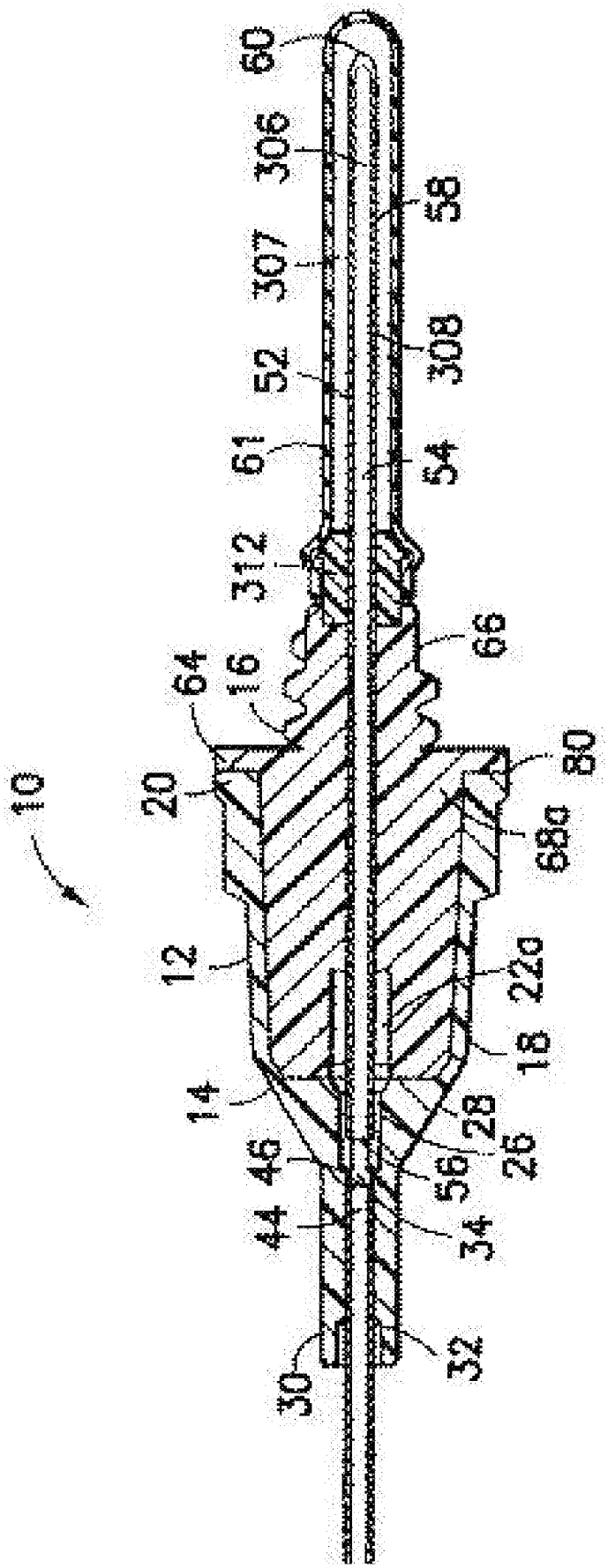
[Fig. 6]



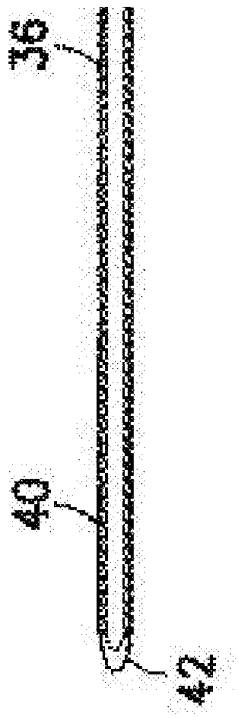

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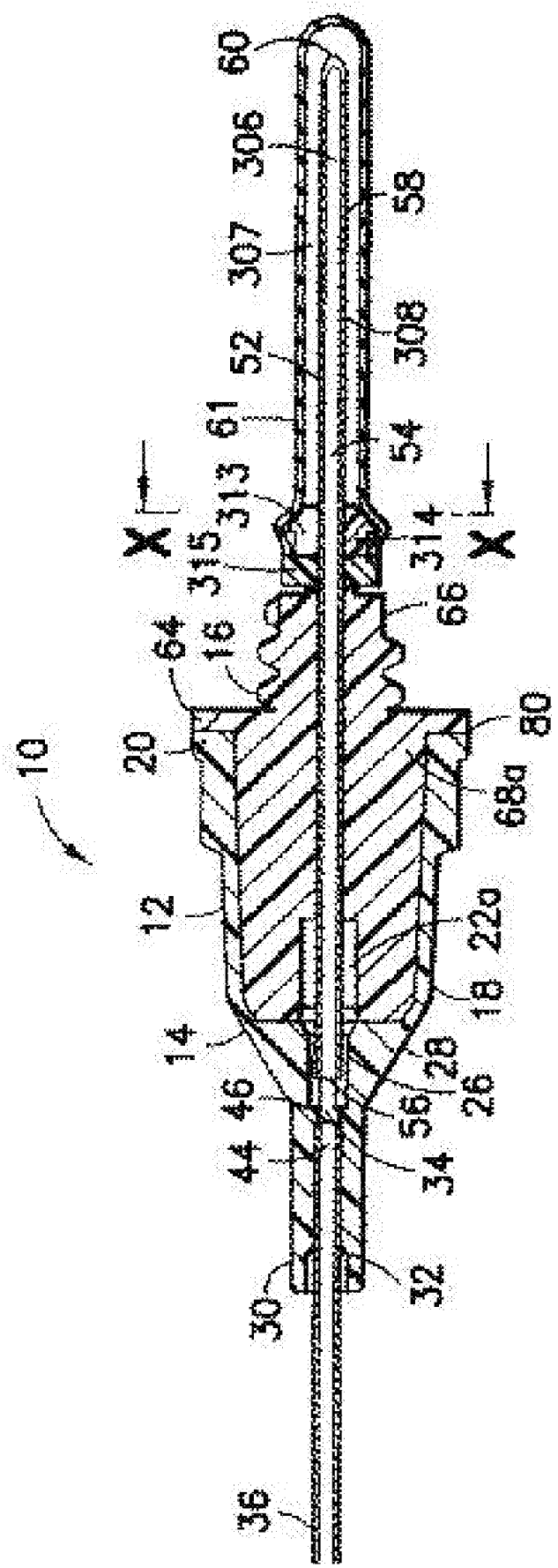
[Fig. 7]



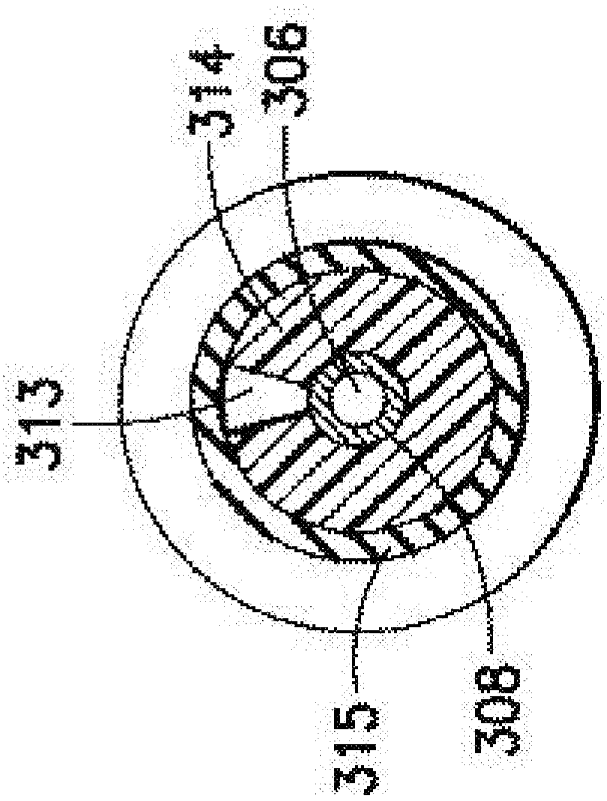

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[Fig. 8A]

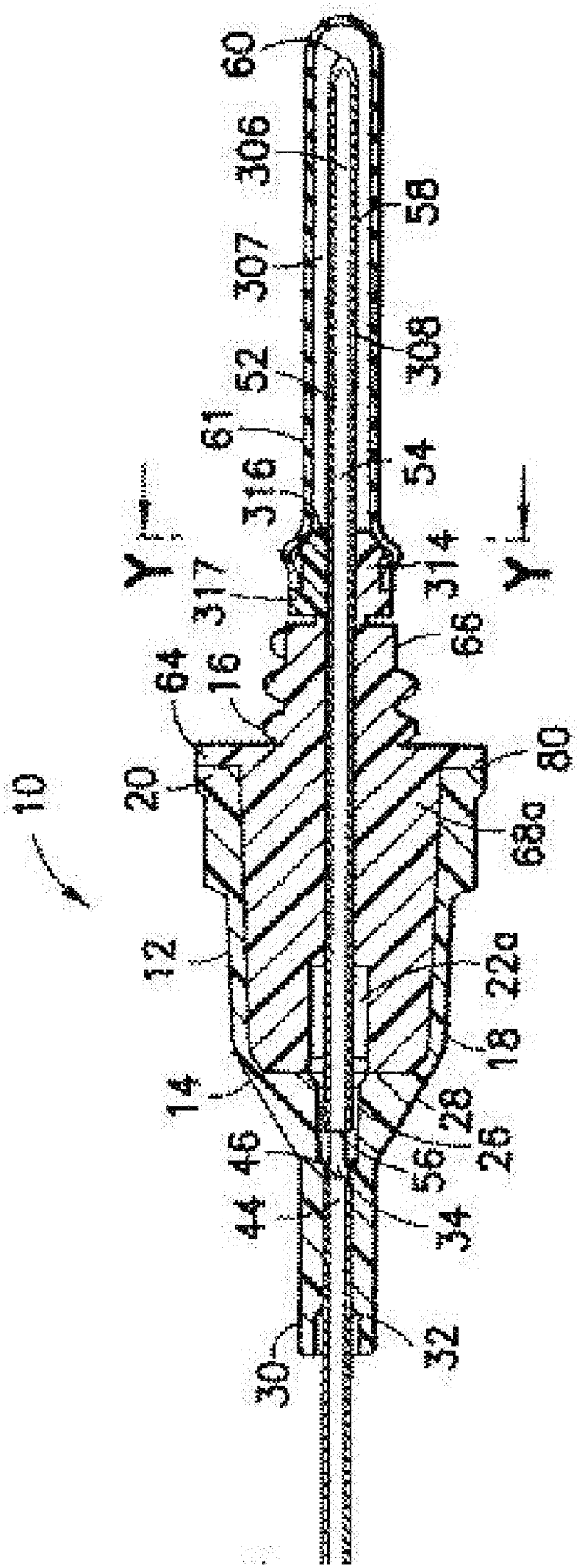



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[Fig. 8B]

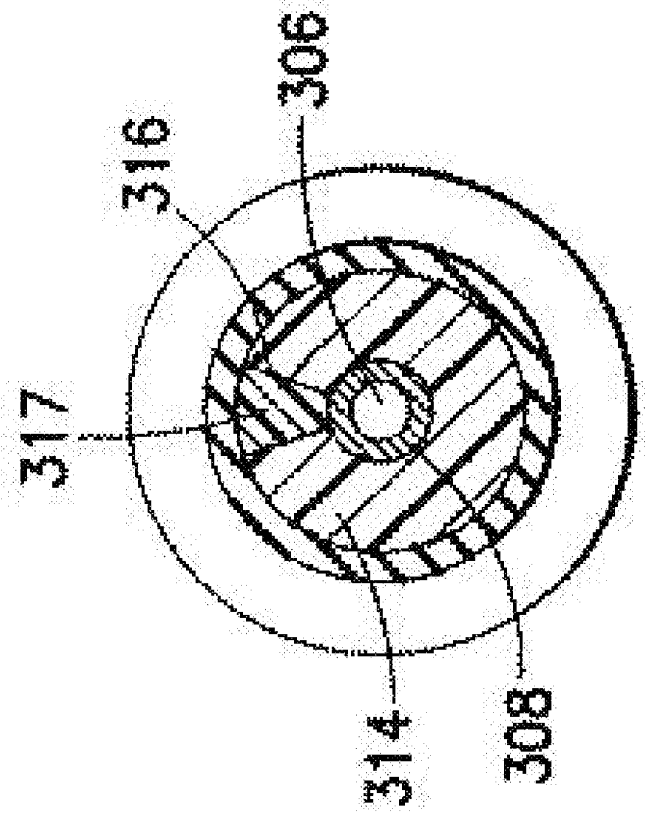


[Fig. 9A]

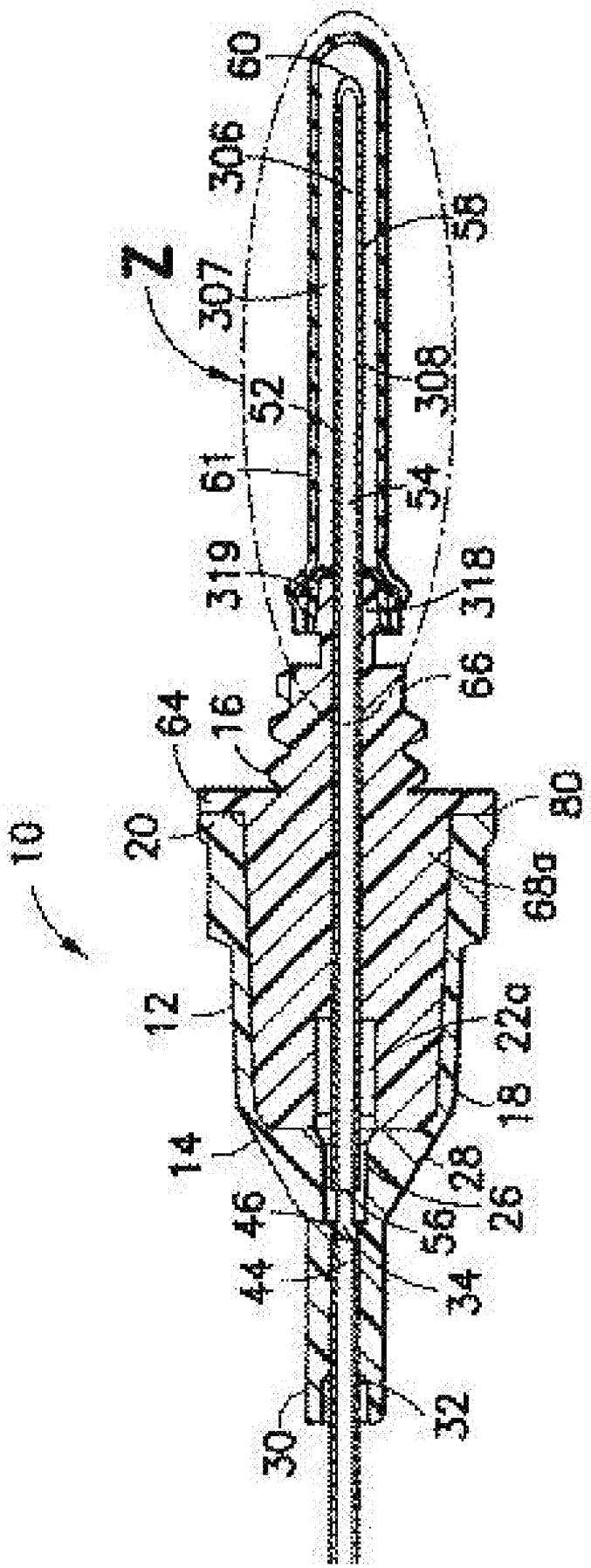

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[Fig. 9B]

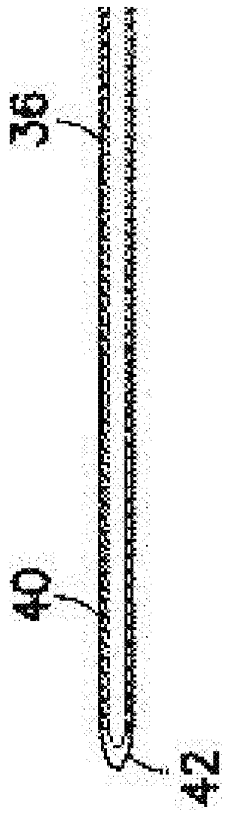


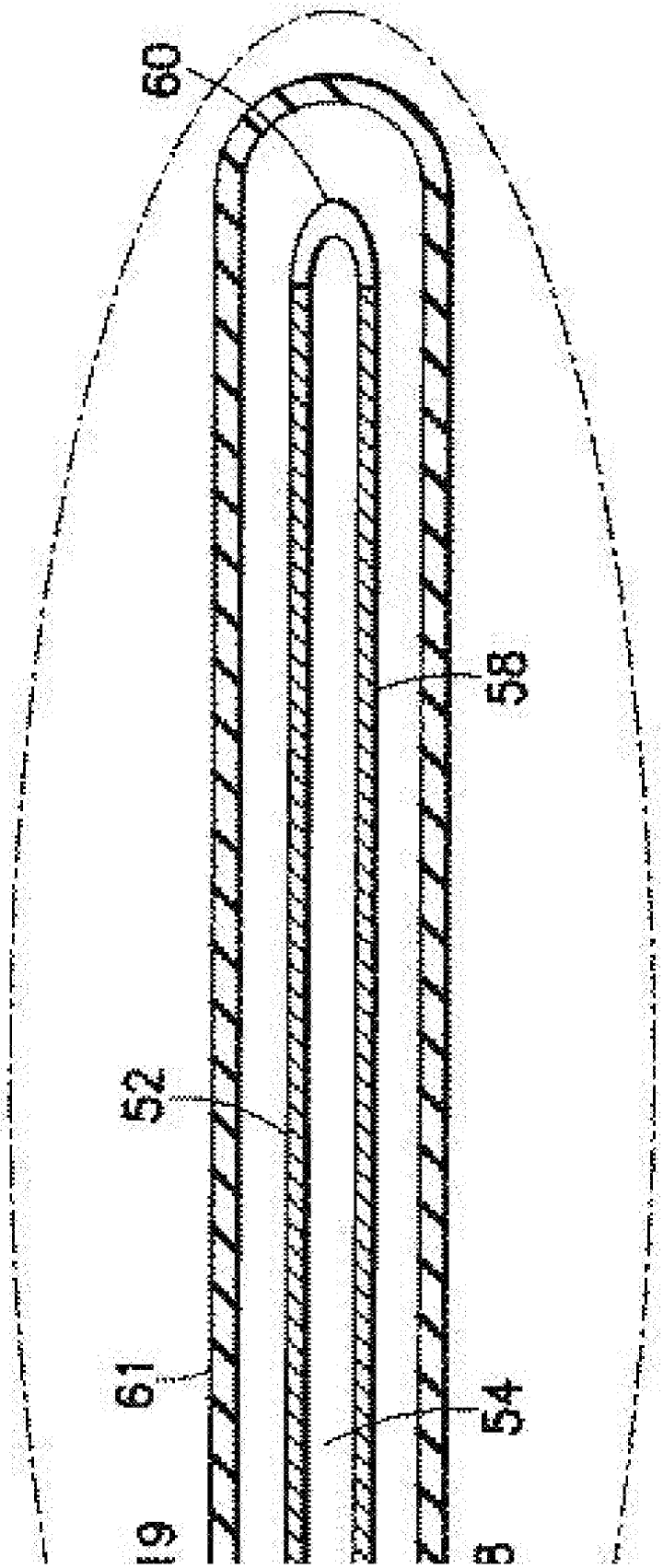


[Fig. 10A]

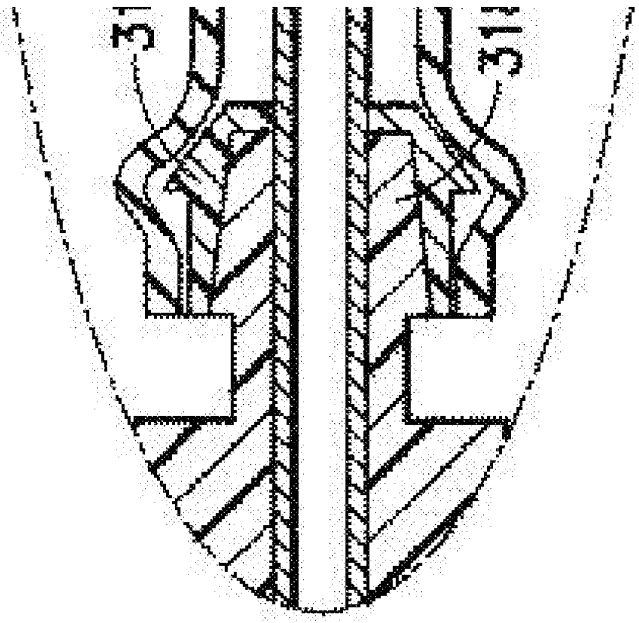

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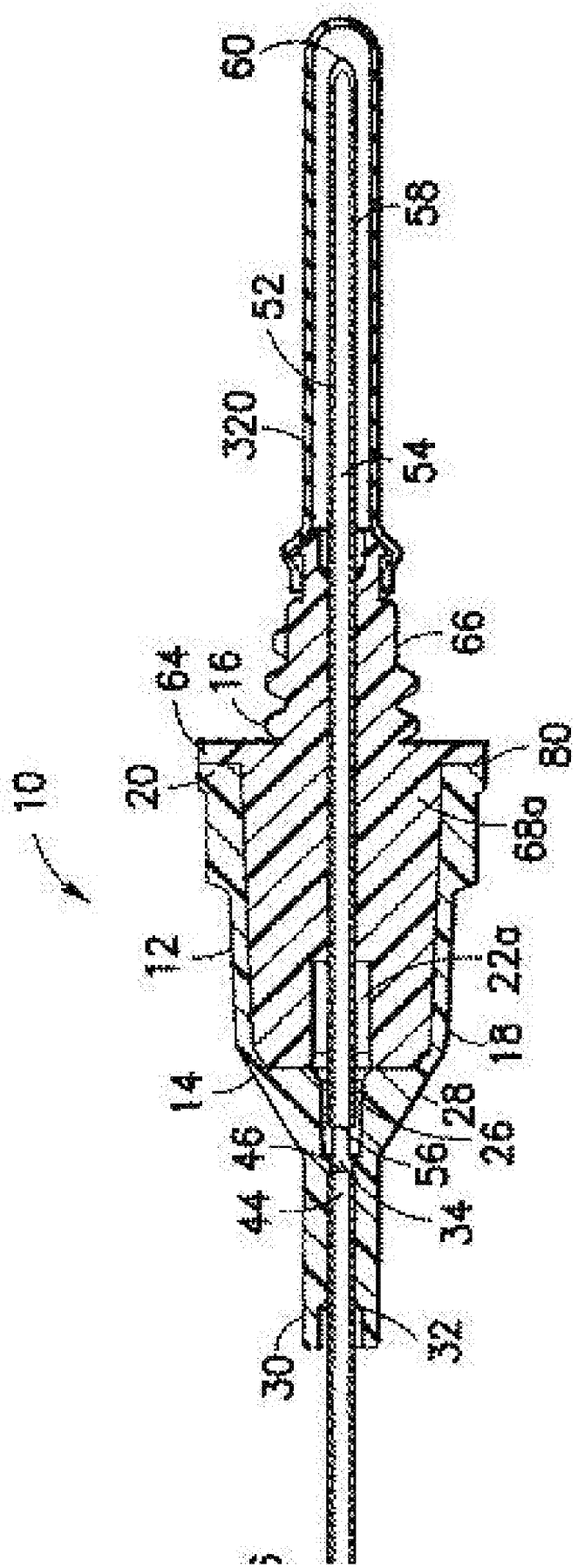
[Fig. 10B]



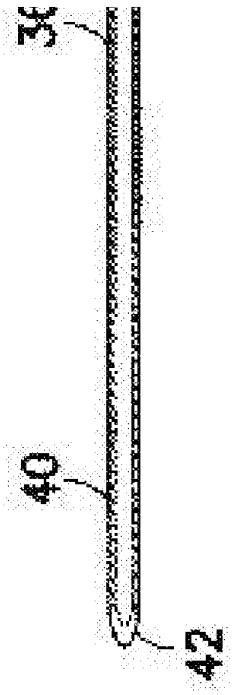

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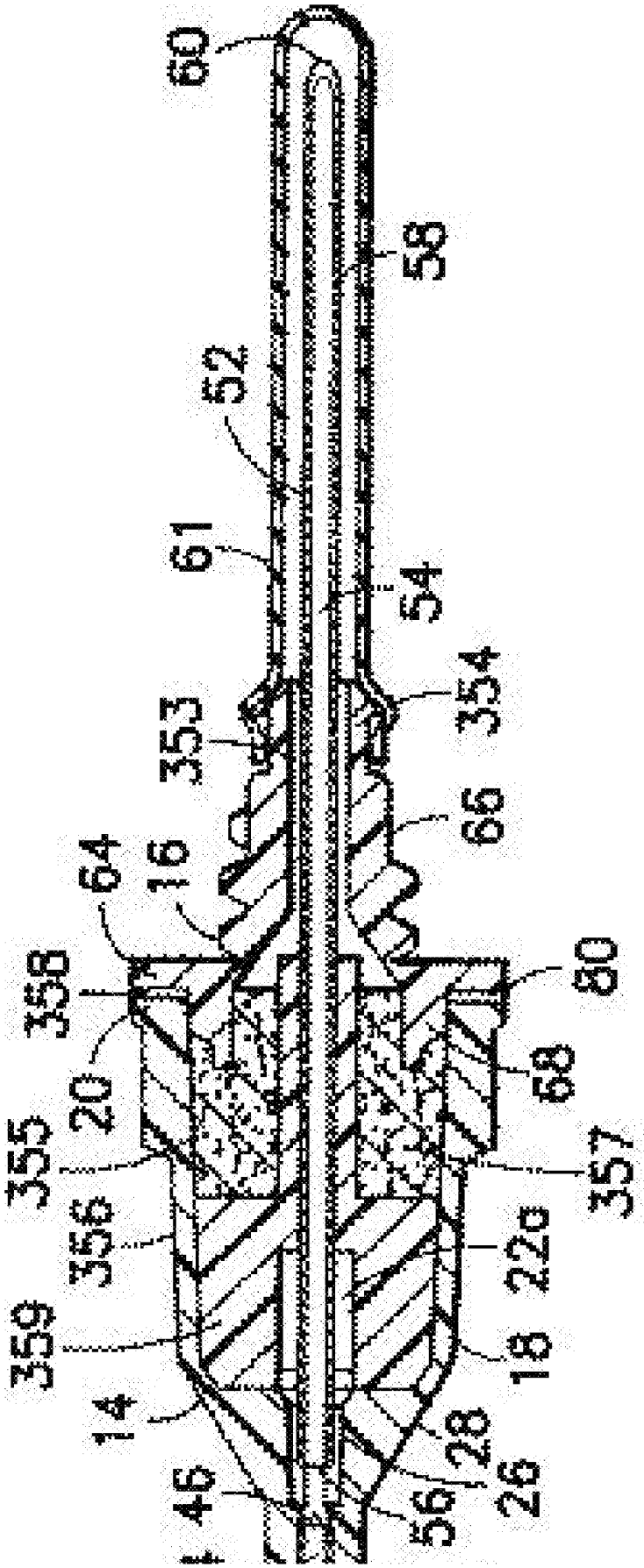
[Fig. 11]



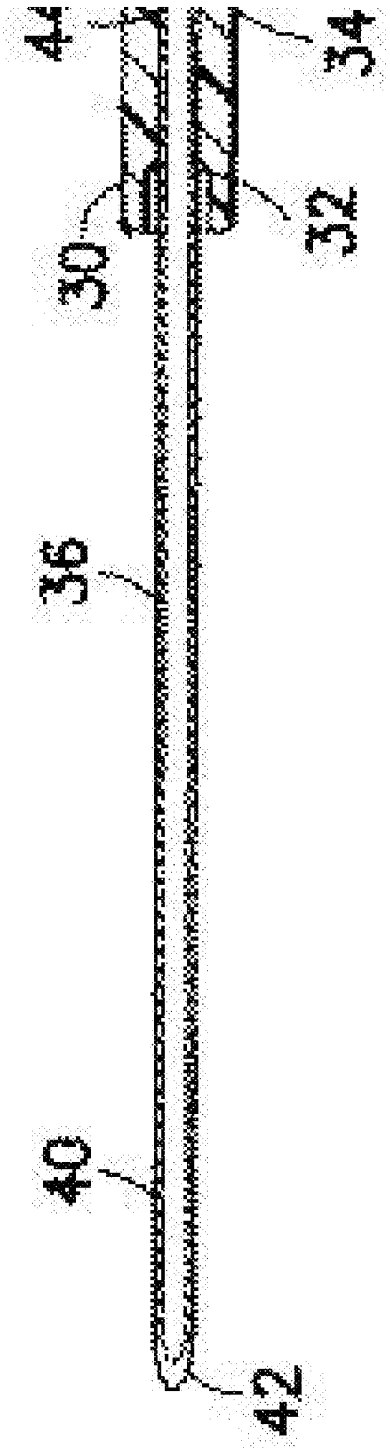

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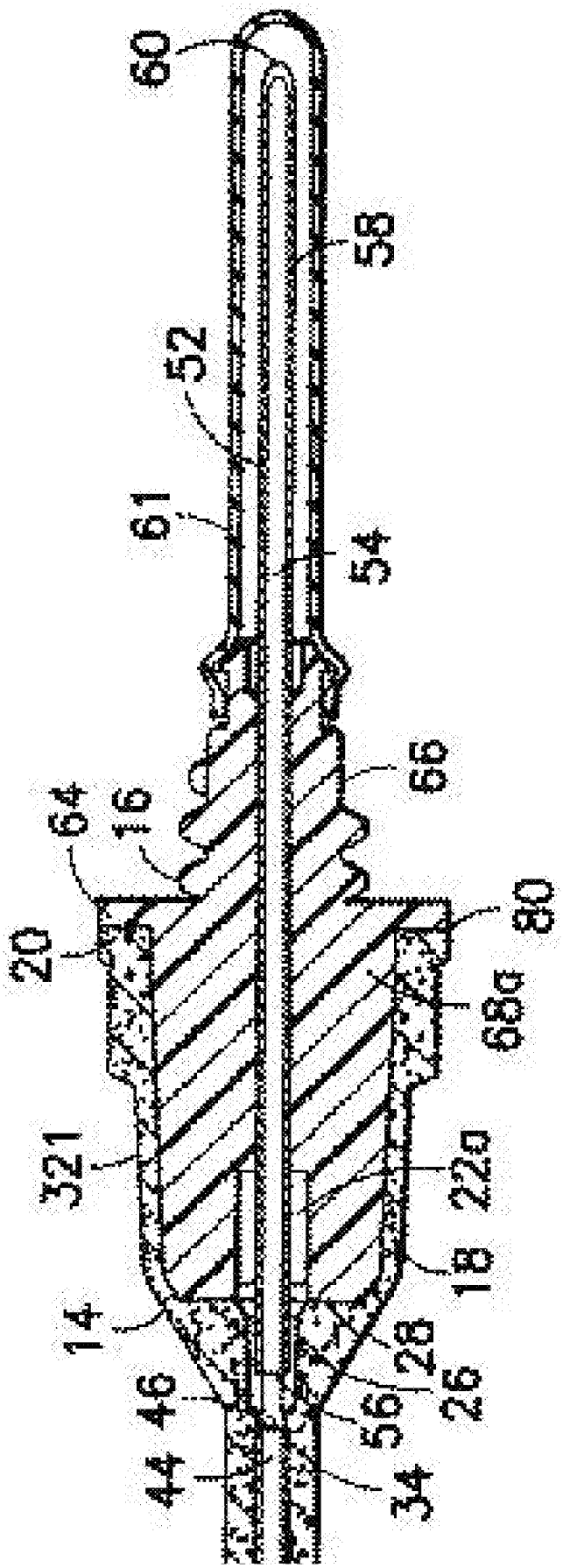
[Fig. 12]



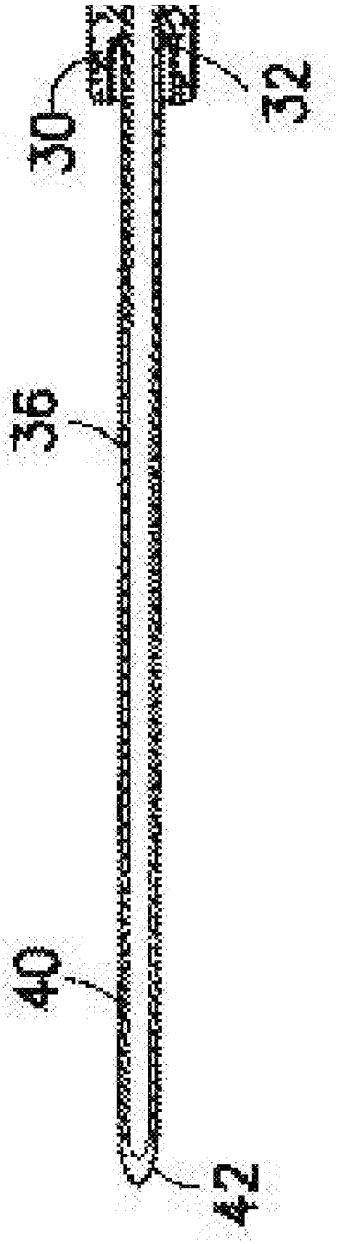

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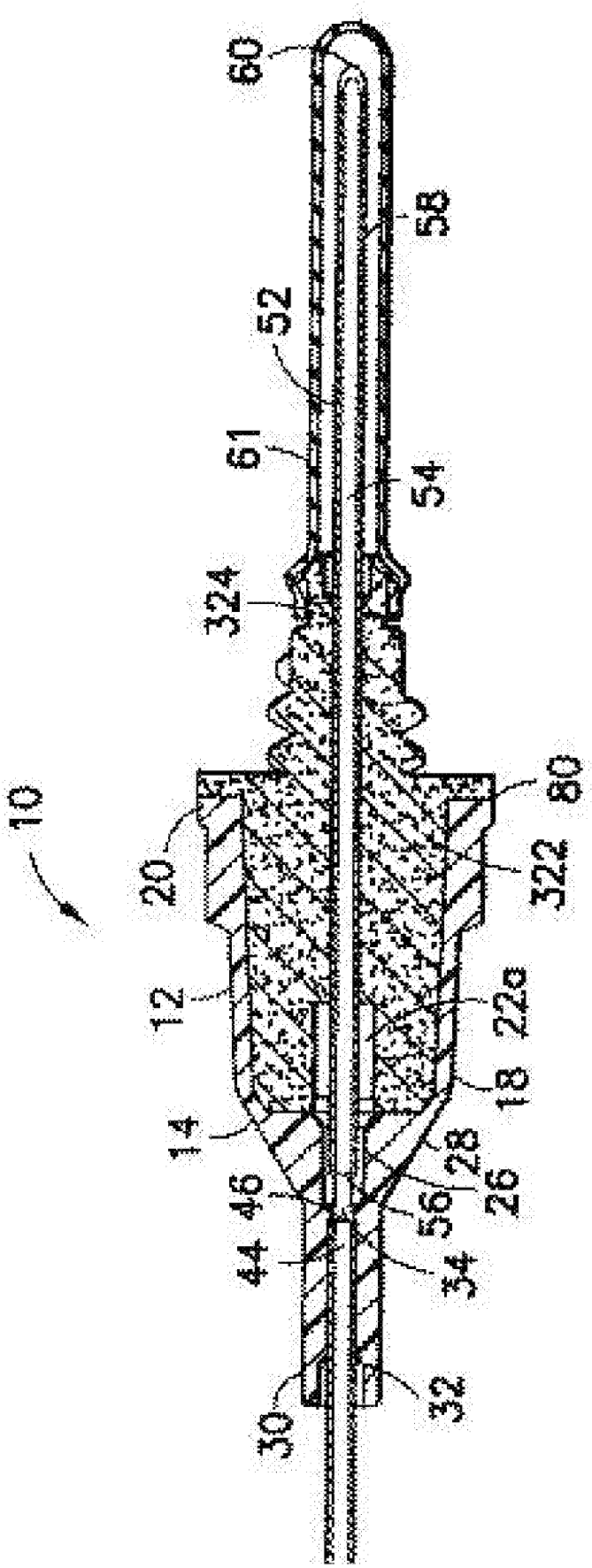
[Fig. 13]



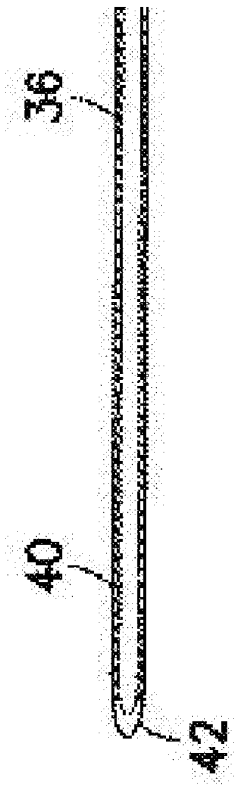

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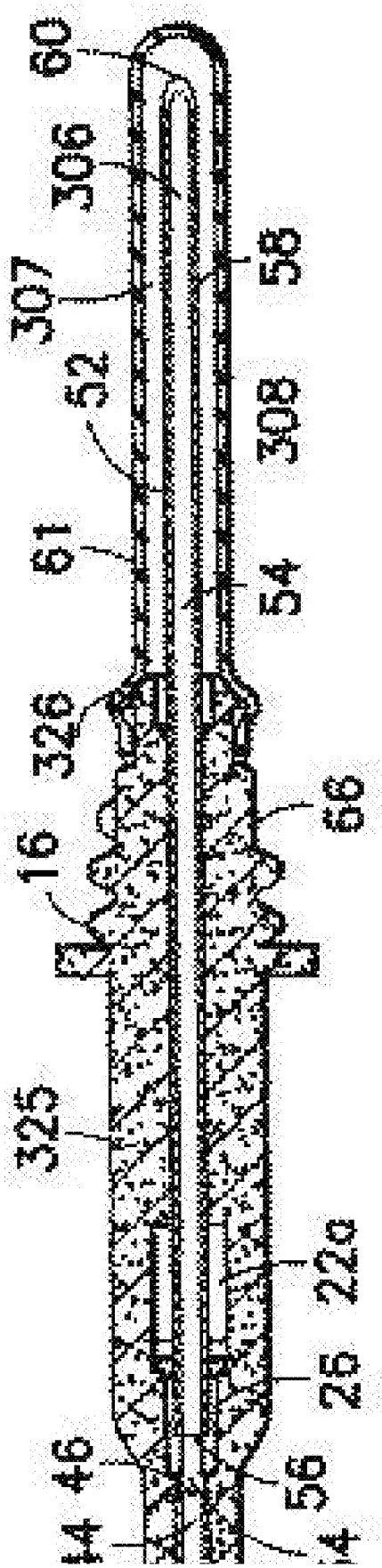
[Fig. 14]



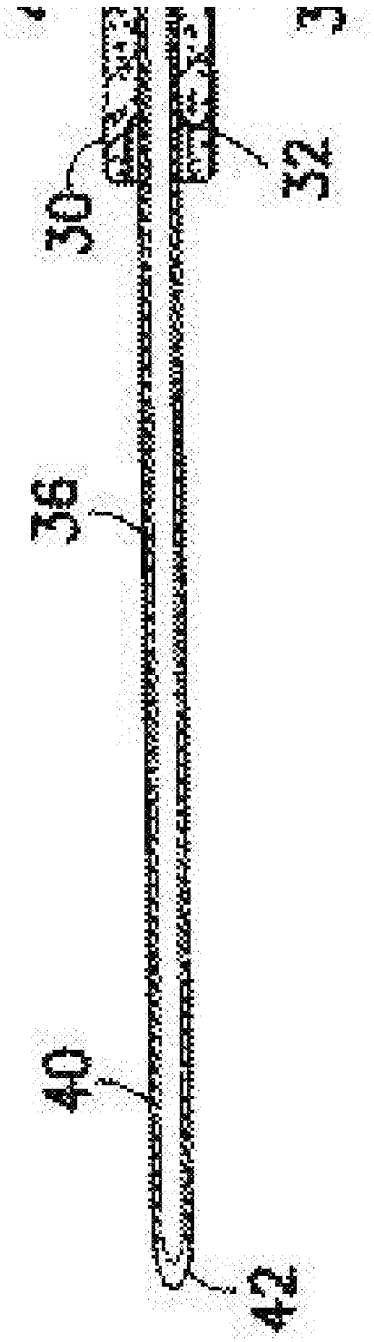

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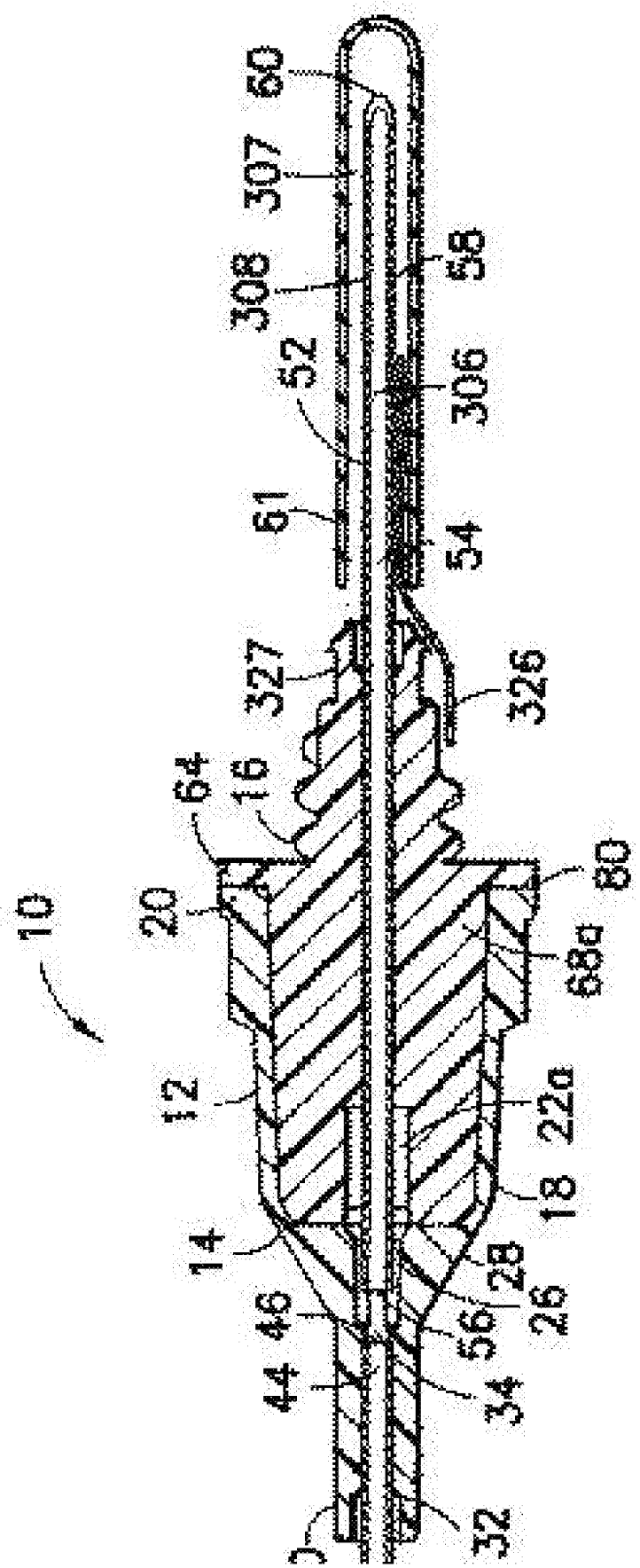
[Fig. 15]



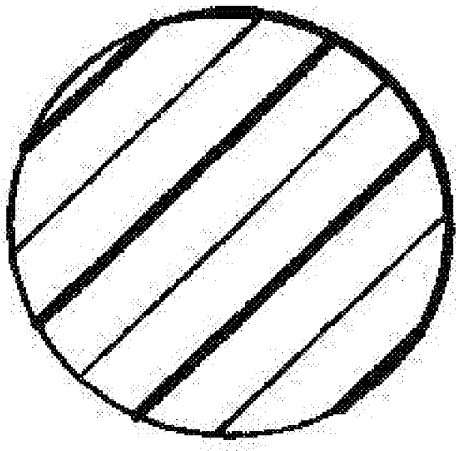

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[Fig. 16]



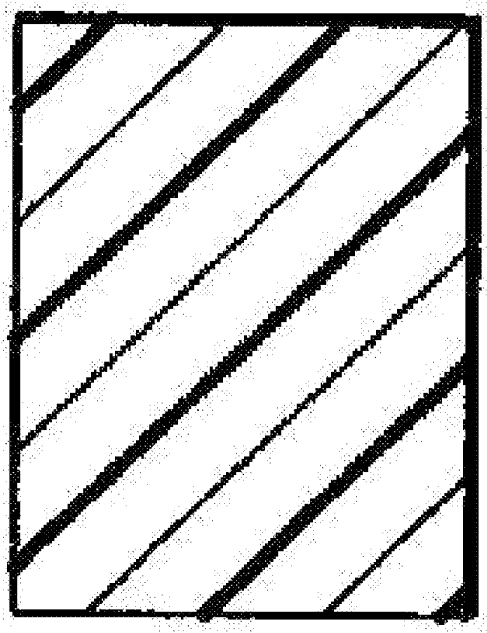

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[Fig. 17]

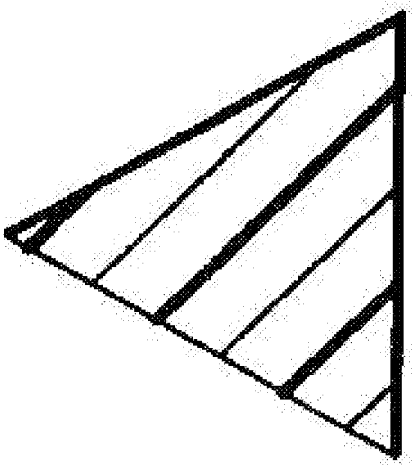


[Fig. 18]

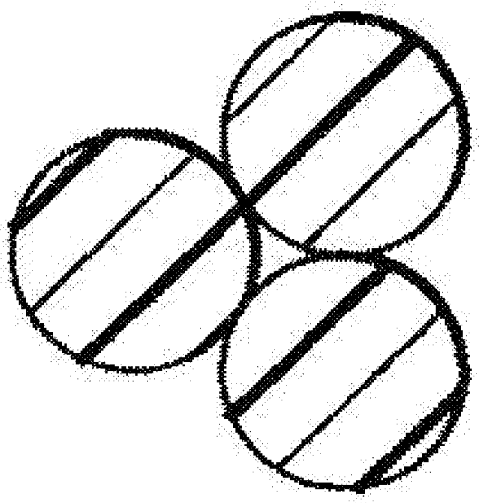




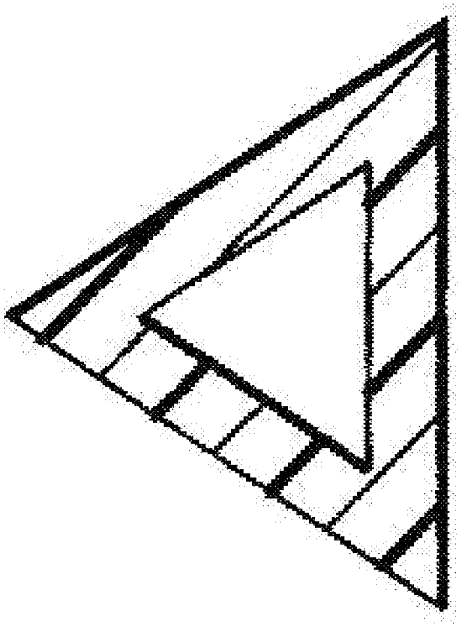
[Fig. 19]



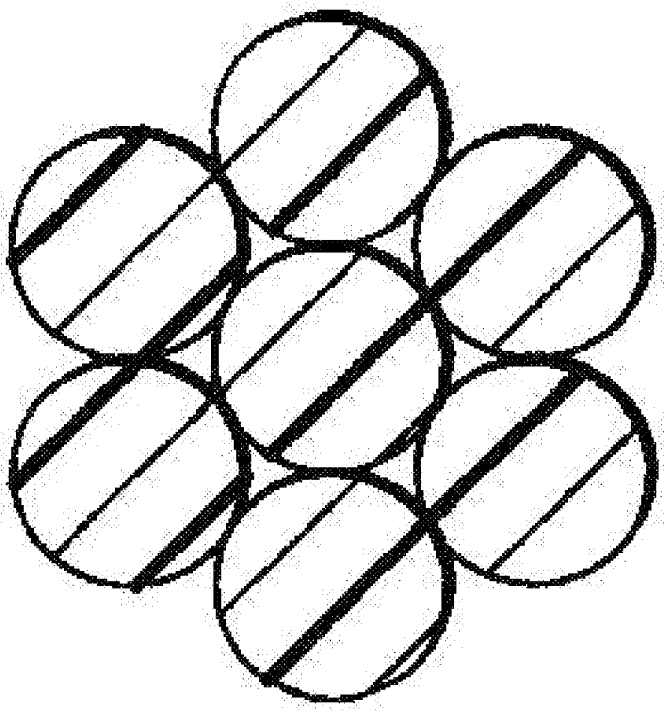
[Fig. 20]



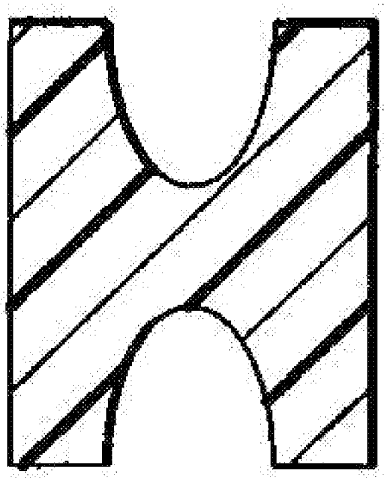
[Fig. 21]



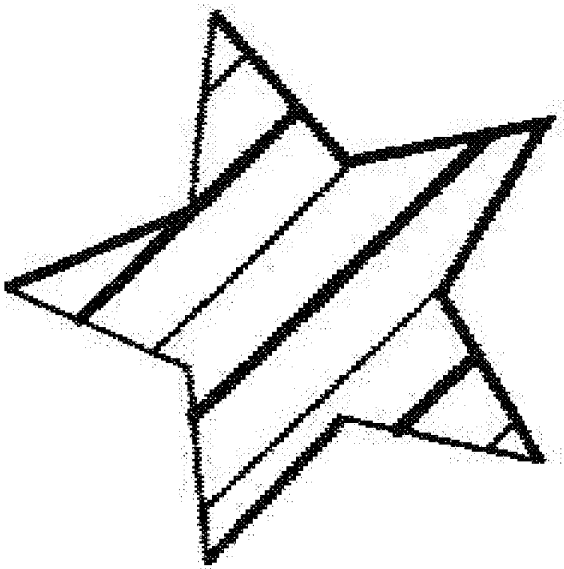
[Fig. 22]



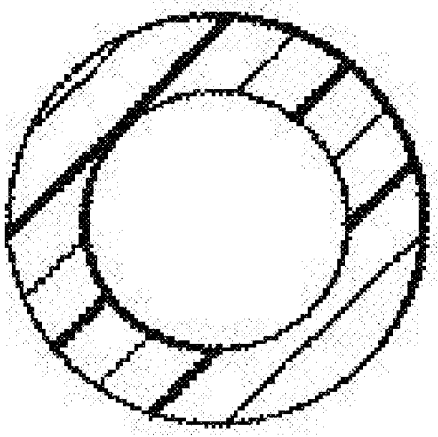
[Fig.23]



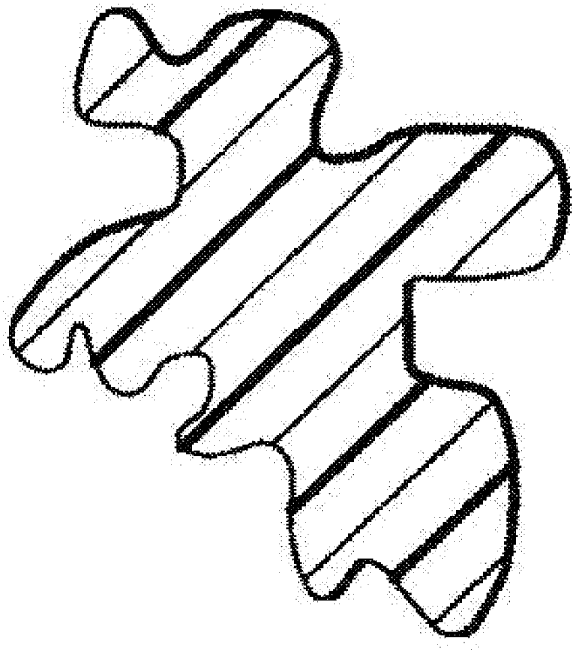
[Fig.24]



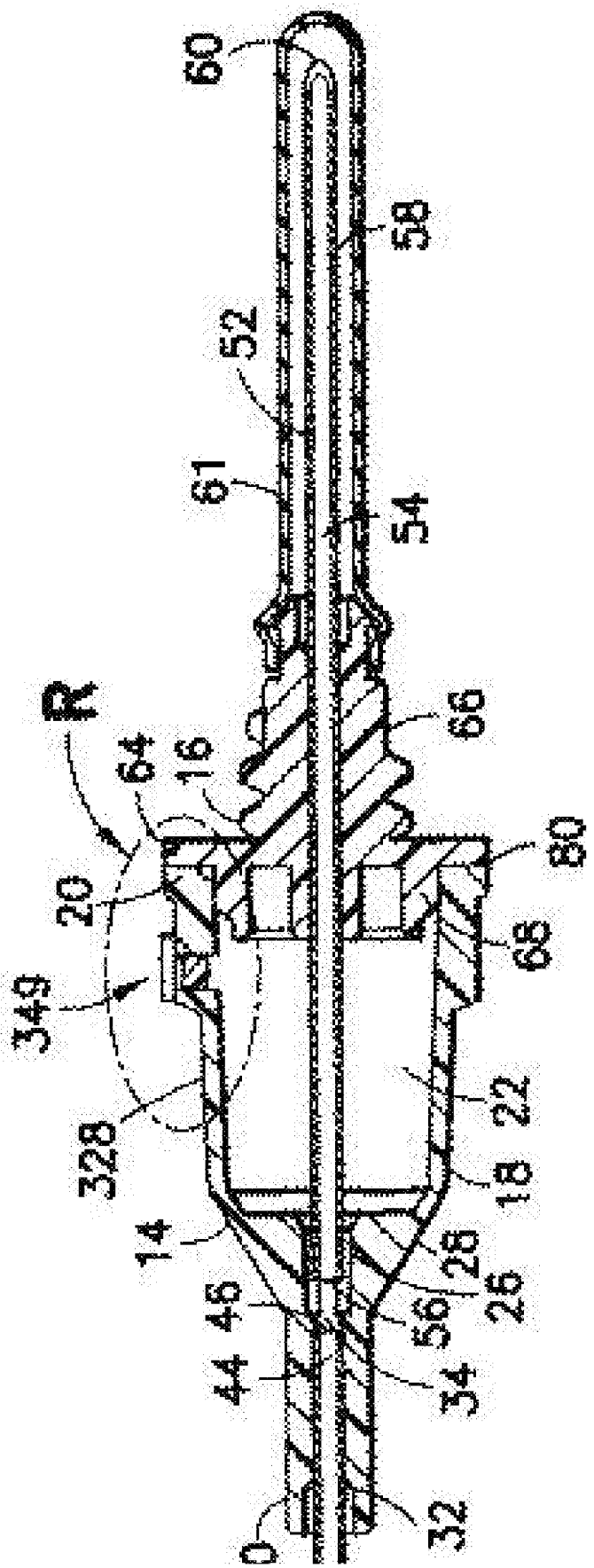
[Fig.25]



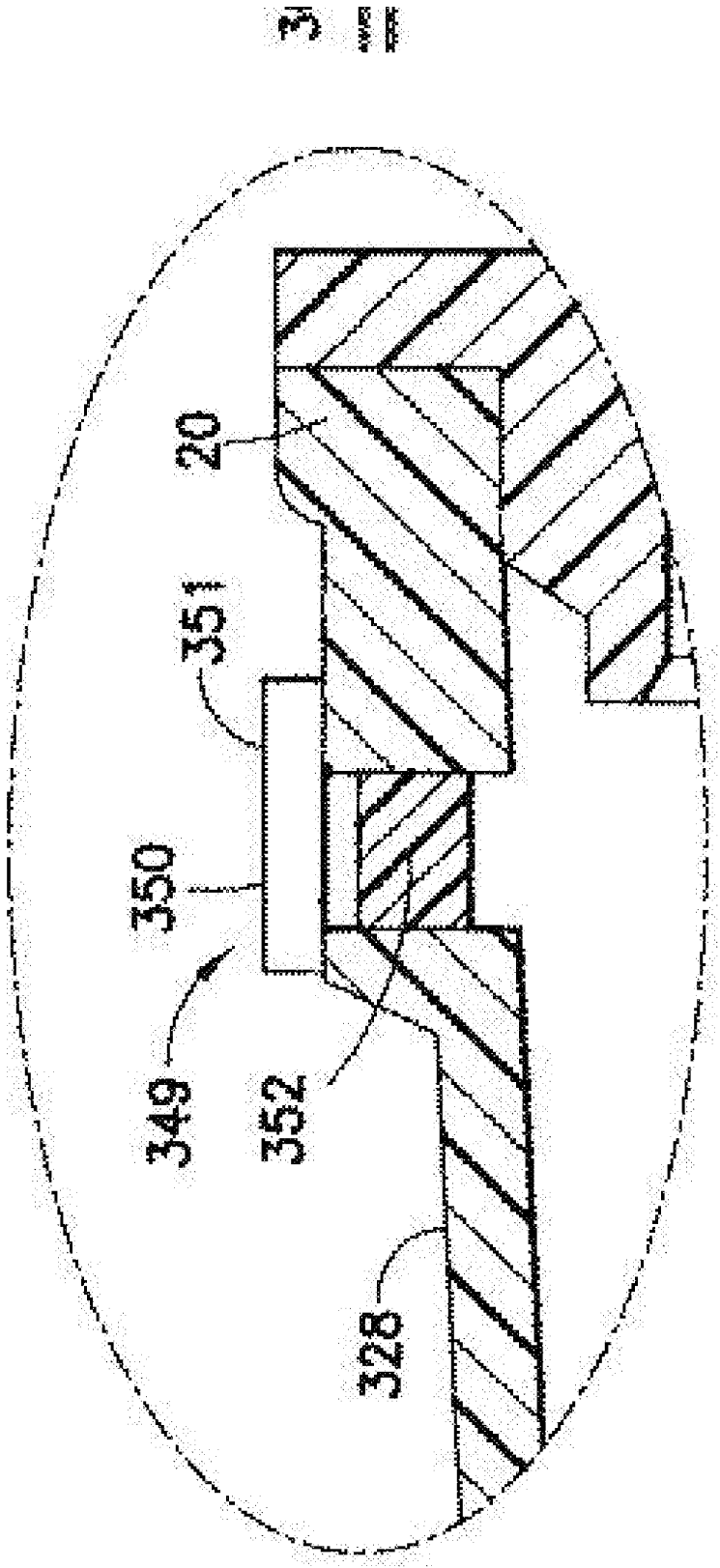
[Fig.26]



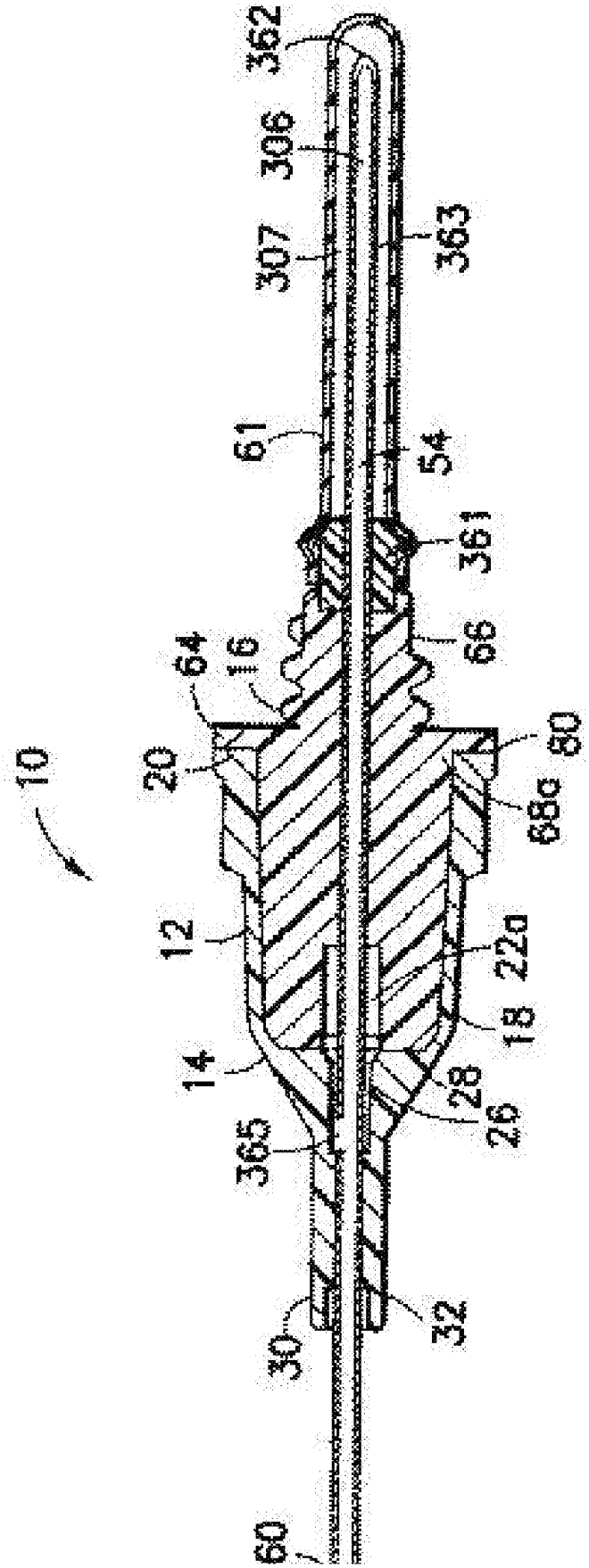
[Fig. 27A]


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[Fig. 27B]



[Fig.28]


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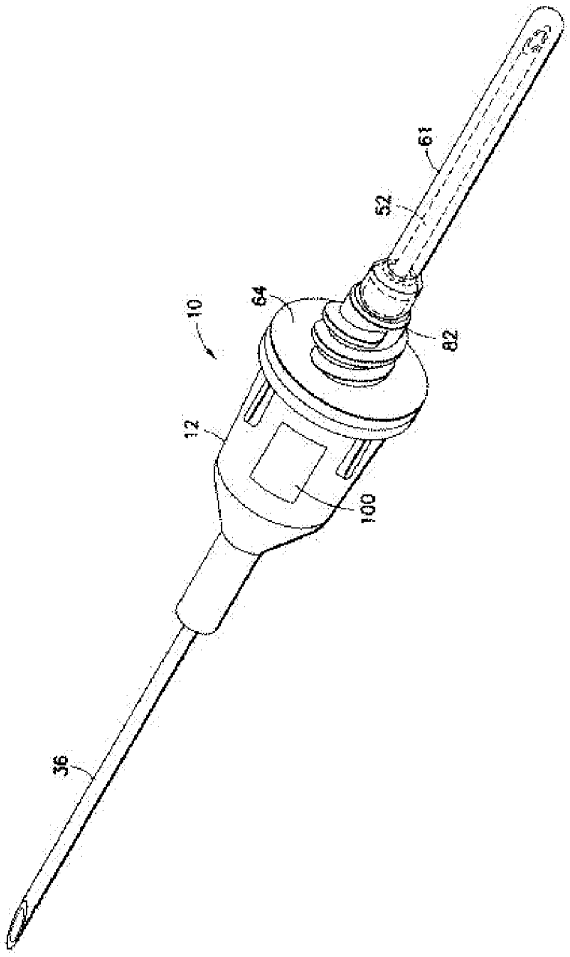
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FLASHBACK BLOOD COLLECTION NEEDLE

Inventor(s): NAIR HAREESH; SWENSON KIRK D; CONWAY HUGH T; NEWBY C MARK; BLOCH CURTIS; LEVY RICHARD; WILKINSON BRADLEY; SCHNEIDER JAMES C; TOWNS BRYAN; ISKRA MICHAEL; ELLIS ROBERT; BENNETT MICHAEL; MARSDEN STEWART ± (NAIR HAREESH, ; SWENSON KIRK D, ; CONWAY HUGH T, ; NEWBY C MARK, ; BLOCH CURTIS, ; LEVY RICHARD, ; WILKINSON BRADLEY, ; SCHNEIDER JAMES C, ; TOWNS BRYAN, ; ISKRA MICHAEL, ; ELLIS ROBERT, ; BENNETT MICHAEL, ; MARSDEN STEWART)

Applicant(s): BECTON DICKINSON CO ± (BECTON DICKINSON & CO)

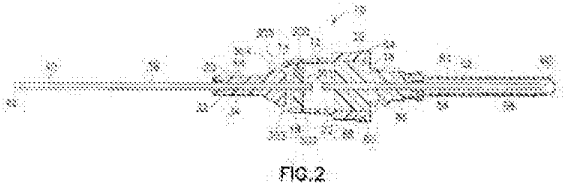
Classification: **- international:** ***A61B5/00; A61B5/15; A61M5/158; A61M5/32;*** (IPC1-7): A61B5/15; A61M5/158; A61M5/32
- cooperative: **A61B5/15003 (EP, US); A61B5/150213 (EP, US); A61B5/150389 (EP, US); A61B5/150488 (EP, US); A61B5/150496 (EP, US); A61B5/150572 (EP, US); A61B5/150732 (EP, US); A61B5/1545 (EP, US)**

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Abstract of JP2005349196 (A)


FIG.2

PROBLEM TO BE SOLVED: To easily confirm that puncture is surely performed at the time of blood collection and to prevent an outflow of fluid such as blood. ;SOLUTION: The application refers to a self-venting blood collection needle assembly for the extraction of at least one fluid sample into an evacuated container for laboratory testing. This blood collection needle assembly provides a clear or translucent flashback chamber for the blood to flow into, for visualization by a user to confirm successful vein puncture. The self-venting mechanism permits escape of air during use, and which, typically, also prevents an outflow of fluid, such as blood. Thus, air under venous pressure will be allowed to escape from the blood collection needle assembly until the blood reaches the venting mechanism. ;COPYRIGHT: (C)2006,JPO&NCIPI

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A61M	5/158	A61M	5/32		4C066
A61M	5/32	A61M	5/14	369F	
		A61M	5/14	369H	

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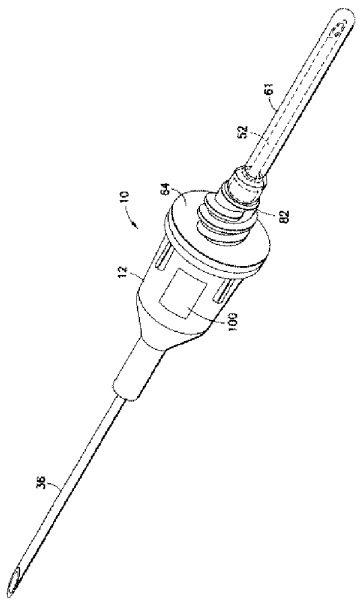
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(54)【発明の名称】フラッシュバック式血液採取針

(57)【要約】　（修正有）
【課題】血液採取時に穿刺が確実に行なわれていることを容易に確認でき、且つ血液などの流体の流出を防止する。
【解決手段】臨床検査のために減圧容器に少なくとも１つの流体試料を抽出する自己通気型血液採取針アセンブリであり、この血液採取針アセンブリは、血液を流入させて使用者が静脈穿刺がうまく行われたことを目視によって確認できる透明または半透明のフラッシュバックチャンバを提供する。この自己通気機構は使用の際に空気の放出を可能にし、且つ血液などの流体の流出を防止するように構成されている。こうして、静脈圧力下の空気は、血液が通気機構に到達するまでにこの血液採取針アセンブリから放出することができる。
【選択図】図１



【特許請求の範囲】
【請求項1】
入口端と、出口端と、これら両端の間に形成されたチャンバを有するハブと、
入口カニューレであって、前記ハブの外側にある末端と、この入口カニューレを貫通して延在し、前記チャンバと連通するように前記ハブに装着される内腔とを有する入口カニューレと、
出口カニューレであって、前記ハブの外側にある基端と、この出口カニューレを貫通して延在し、前記チャンバに連通するように前記ハブに装着される内腔とを有する出口カニューレと、
前記ハブの外側に位置する前記出口カニューレの部分を覆って装着されるマルチプル試料スリーブであって、前記入口カニューレの内腔と、前記チャンバと、前記出口カニューレの内腔と、このマルチプル試料スリーブの内面とが流体通路を形成するマルチプル試料スリーブと、
前記流体通路と外部雰囲気とを連通させる通気機構であって、針アセンブリからこの通気機構を介して外部雰囲気への空気の流出を可能にすると共に前記針アセンブリから前記通気機構を介して前記外部雰囲気への液体の流出を実質的に阻止する通気機構と、
を具え、前記入口および出口カニューレが別個のものであるか、または前記チャンバに連通する開口を持った１本のカニューレであることを特徴とする針アセンブリ。
【請求項2】
前記通気機構が前記ハブを介して延在していることを特徴とする請求項１に記載の針アセンブリ。
【請求項3】
前記通気機構が通気媒体を具えていることを特徴とする請求項２に記載の針アセンブリ。
【請求項4】
前記通気機構が前記ハブを貫通する少なくとも１つの開口を具え、該開口は通気栓を具えていることを特徴とする請求項２に記載の針アセンブリ。
【請求項5】
前記通気機構が逆止め弁をさらに具えていることを特徴とする請求項４に記載の針アセンブリ。
【請求項6】
前記通気機構が前記ハブを貫通する少なくとも１つの開口と、前記入口カニューレを取り囲む通気リングとを具え、該通気リングは前記チャンバ内の前記ハブを介して前記開口の近傍に位置していることを特徴とする請求項１に記載の針アセンブリ。
【請求項7】
前記通気機構が前記出口カニューレの基端を越えて前記通路に配されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項8】
前記通気機構が通気媒体を具えていることを特徴とする請求項７に記載の針アセンブリ。
【請求項9】
前記ハブが非患者側係止突起をさらに具え、前記通気機構がこの非患者側係止突起を介して延在していることを特徴とする請求項１に記載の針アセンブリ。
【請求項10】
前記通気機構が通気媒体を具えていることを特徴とする請求項９に記載の針アセンブリ。
【請求項11】
前記通気機構が前記非患者側係止突起を貫通する通路と、この通路に配された通気栓とを具えていることを特徴とする請求項９に記載の針アセンブリ。

【請求項12】
前記通気機構が前記非患者側係止突起を貫通する切欠きと、通気円板とを具えていることを特徴とする請求項９に記載の針アセンブリ。
【請求項13】
前記通気機構が、前記非患者側係止突起を貫通する少なくとも１つの開口と、この開口に配された通気栓とを具えていることを特徴とする請求項９に記載の針アセンブリ。
【請求項14】
前記ハブが非患者側係止突起をさらに具え、この非患者側係止突起の少なくとも一部が前記通気機構を具えていることを特徴とする請求項１に記載の針アセンブリ。
【請求項15】
前記通気機構が通気媒体を具えていることを特徴とする請求項１４に記載の針アセンブリ。
【請求項16】
前記非患者側係止突起の少なくとも一部が多孔質疎水性材料で形成されているか、または前記非患者側係止突起の少なくとも一部が疎水性の表面を持った多孔質材料で形成されていることを特徴とする請求項１４に記載の針アセンブリ。
【請求項17】
前記通気機構が親水性材料を含浸させた多孔質材料を具えていることを特徴とする請求項１４に記載の針アセンブリ。
【請求項18】
前記ハブは、前記マルチプル試料スリーブがしっかりと装着される非患者側係止突起をさらに具え、前記通気機構が前記非患者側係止突起と前記マルチプル試料スリーブとの間に配されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項19】
前記通気機構が通気スリーブを具えていることを特徴とする請求項１８に記載の針アセンブリ。
【請求項20】
前記通気スリーブが多孔質の疎水性材料を具えるか、または前記通気スリーブが疎水性表面を持った多孔質材料を具えていることを特徴とする請求項１９に記載の針アセンブリ。
【請求項21】
前記通気機構が通気可能な通気コードを具えていることを特徴とする請求項１８に記載の針アセンブリ。
【請求項22】
前記通気機構が織物面を具えていることを特徴とする請求項１８に記載の針アセンブリ。
【請求項23】
前記マルチプル試料スリーブが前記通気機構を具えていることを特徴とする請求項１に記載の針アセンブリ。
【請求項24】
前記通気機構が通気媒体を具えていることを特徴とする請求項２３に記載の針アセンブリ。
【請求項25】
前記マルチプル試料スリーブが多孔質の疎水性材料にて形成されるか、または前記マルチプル試料スリーブが疎水性表面を持った多孔質材料を具えていることを特徴とする請求項２３に記載の針アセンブリ。
【請求項26】
前記ハブが前記通気機構を構成するように、前記ハブの少なくとも一部が通気媒体によって形成されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項27】

前記ハブが前記通気機構を構成するように、前記ハブの少なくとも一部が多孔質材料によって形成されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項28】
前記ハブが非患者側ねじ山アセンブリとハブインサートとをさらに具え、これらを組み立ててリザーバを形成することを特徴とする請求項１に記載の針アセンブリ。
【請求項29】
前記通気機構が、前記非患者側ねじ山アセンブリを通って前記リザーバに達する第１通路と、前記リザーバから外部雰囲気に至る第２通路と、前記リザーバに配された通気栓とを具えていることを特徴とする請求項２８に記載の針アセンブリ。
【請求項30】
非患者側ねじ山アセンブリをさらに具え、この非患者側ねじ山アセンブリの少なくとも一部は、当該非患者側ねじ山アセンブリが前記通気アセンブリを構成するように、通気媒体によって形成されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項31】
非患者側ねじ山アセンブリをさらに具え、この非患者側ねじ山アセンブリの少なくとも一部は、当該非患者側ねじ山アセンブリが前記通気アセンブリを構成するように、多孔質材料によって形成されていることを特徴とする請求項１に記載の針アセンブリ。
【請求項32】
前記通気機構が通気媒体を具えていることを特徴とする請求項１に記載の針アセンブリ。
【請求項33】
前記第１カニューレを選択的に被覆するシールドをさらに具えていることを特徴とする請求項１に記載の針アセンブリ。
【請求項34】
入口端と、出口端と、これら両端の間に形成されたチャンバとを有するハブと、
このハブの外側にあるように前記ハブに装着される末端と、基端と、これら両端の間に延在する内腔とを有するカニューレと、
前記ハブの外側に位置する前記カニューレの基端の部分を覆って装着されるマルチプル試料スリーブであって、前記内腔と、このマルチプル試料スリーブの内面と、前記チャンバとで流体通路を形成するマルチプル試料スリーブと、
前記流体通路と外部雰囲気とを連通する通気機構であって、針アセンブリからこの通気機構を通って外部雰囲気への空気の流出を可能にすると共に針アセンブリから当該通気機構を介して外部雰囲気への液体の流出を実質的に阻止する通気機構と
を具えたことを特徴とする針アセンブリ。
【請求項35】
前記通気機構が前記出口カニューレの前記基端を越えて前記通路に配されていることを特徴とする請求項３４に記載の針アセンブリ。
【請求項36】
前記通気機構が通気媒体を具えていることを特徴とする請求項３５に記載の針アセンブリ。
【請求項37】
前記ハブが非患者側係止突起をさらに具え、前記通気機構がこの非患者側係止突起を通って延在していることを特徴とする請求項３４に記載の針アセンブリ。
【請求項38】
前記通気機構が通気媒体を具えていることを特徴とする請求項３７に記載の針アセンブリ。
【請求項39】
前記通気機構が前記非患者側係止突起を貫通する通路と、この通路に配された通気栓とを具えていることを特徴とする請求項３７に記載の針アセンブリ。
【請求項40】

前記通気機構が前記非患者側係止突起を貫通する切欠きと、通気円板とを具えていることを特徴とする請求項３７に記載の針アセンブリ。
【請求項41】
前記通気機構が前記非患者側係止突起を貫通する少なくとも１つの開口と、この開口に配された通気栓とを具えていることを特徴とする請求項３７に記載の針アセンブリ。
【請求項42】
非患者側係止突起をさらに具え、この非患者側係止突起の少なくとも一部が前記通気機構を具えていることを特徴とする請求項３４に記載の針アセンブリ。
【請求項43】
前記通気機構が通気媒体を具えていることを特徴とする請求項４２に記載の針アセンブリ。
【請求項44】
前記非患者側係止突起の少なくとも一部が多孔質の疎水性材料にて形成されるか、または前記非患者側係止突起の少なくとも一部が疎水性表面を持った多孔質材料を具えていることを特徴とする請求項４２に記載の針アセンブリ。
【請求項45】
前記通気機構が親水性材料を含浸した多孔質材料を具えていることを特徴とする請求項３２に記載の針アセンブリ。
【発明の詳細な説明】
【技術分野】
【0001】
本発明は、患者に血管穿刺を行って血液試料を採取する装置に関する。さらに詳しくは、本発明は、患者から血液試料を減圧血液採取管に採取する場合、自己通気特性によって瀉血士が血管への穿刺ができたか否かを知ることができるマルチプル血液試料を採取するための針アセンブリに関する。
【背景技術】
【0002】
血管穿刺は臨床検査用の血液試料を得るのに用いられる主たる方法である。血管穿刺を行う場合、瀉血士は複数のステップを同時に行う必要がある。このステップとしては、患者の全体的な身体的および心理的状態を評価して、血管穿刺箇所と技術を適正に選択することを含む。瀉血士は、適正な対応器具を選び、出血を制御する技術を実行し、そして臨床検査用の流体試料を適正に採取し且つ特定することも必要である。これらの要因は血管の膨張と血管穿刺処置の長さに悪影響を与えるので、瀉血士はこれらの同時に起こる要因のすべてを確認しなければならない。
【0003】
前述の問題に対応するため、種々の血管穿刺装置が開発されている。これらの装置は、内部にチャンバを画成したハブを有する針アセンブリを含んでおり、両端が尖った１本のカニューレがこのハブに固定されている。このカニューレの血管側の端は患者の血管に挿入されるように構成され、このカニューレの非患者側の端は密閉可能なスリーブを有し、減圧容器内に配された突き刺し可能なストッパを突き刺すように構成されている。
【発明の開示】
【発明が解決しようとする課題】
【0004】
カニューレの血管側の端を血管に挿入すると、血液はカニューレを通って密閉可能なスリーブと、可視化（「フラッシュバック」）のために透明または半透明であるハブのチャンバとに流入する。ハブのチャンバから空気が排出されると、その中の血液は減圧容器の作用によって密閉可能なスリーブがハブのチャンバの方に押される度に加圧される。
【0005】
血管挿入とフラッシュバックとの間の時間差に起因して、血管穿刺が行われたことが即時に透明チャンバに示されなかったことによって、瀉血士は満足すべき血管への穿刺が得られなかったと誤って信じるかもしれない。そして、瀉血士は、減圧容器および／または

針アセンブリ自体の交換を必要とする血管穿刺を不必要に繰り返しことになる。このような処置の繰り返しは患者の受ける身体的、情緒的不快感を長引かせる。

【0006】

フラッシュバックが生じなかった場合、注射カニューレおよびフラッシュバックチャンバの空気がそこで圧縮されるので、針のハブ内の空気は静脈圧力まで加圧される。この加圧された空気は、何れかに排出されることが必要であり、そこで、血液採取が終了した後に注射針が患者から引き抜かれる時、この加圧空気は血液を注射針の先端の方に押し出す。

【0007】

従って、瀉血士が一貫してフラッシュバックを頼りにしている従来の血液採取方法に対し、迅速、正確且つコスト効果の高い解決策を提供し、満足すべき静脈への穿刺を行うことが望まれている。さらに、血液を比較的短い針を介してフラッシュバックチャンバに直接流すことができ、そして針アセンブリの内部から加圧された空気を排出することができる血液採取針アセンブリを提供し、それによって静脈への穿刺が成功し、このアセンブリからの血液の漏洩が無いことを直接的に示すことが、特に望まれている。ここで用いられるように、通気媒体は空気を実際に通す要素、例えば栓，被覆，表面処理などを示している。

【課題を解決するための手段】

【0008】

本発明は、少なくとも１つの流体試料を臨床検査用に減圧容器に抽出する自己通気型の血液採取針アセンブリであり、この血液採取針アセンブリは、静脈穿刺がうまく行われたことを使用者が目視によって確認するための、透明または半透明のフラッシュバックチャンバを提供する。この自己通気型機構は、使用の際に空気の放出を可能にするが、血液などの液体の流出は阻止する。ここで使用されている通気機構とは、空気を排出させるが、液体の通過を阻止する１つ以上の装置または要素のことを称する。従って、静脈圧力下の空気を、通気機構に到達するまでに血液採取針アセンブリから排出することができる。そしてこの通気機構は、これを迂回または通って血液が流れることを遮断または防止し、血液が減圧採取管その他の適宜な血液採取容器に採取されることを可能にする。本発明は、血液採取プロセスに悪影響を与えることなく、フラッシュバックチャンバ内における良好な瞬時可視化を提供する。以下に述べるように、好適な種々の通気機構，通気媒体または通気位置が存在する。

【0009】

少なくとも１つの流体試料を患者から採取して少なくとも１つの減圧容器内に引き続いて排出するため、自己通気型血液採取針アセンブリが提供される。本発明の自己通気型血液採取針アセンブリは、円筒状外壁によって画成された流体入口を有するハブを具えている。この壁は、ハブ内に血液試料を保持するためのフラッシュバックチャンバと、外から噴出が目視できるように透明または半透明の壁の少なくとも一部とを画成している。このハブは、流体入口端に連通する流体出口端をさらに具えている。この血液入口端に流体連通する第１の入口側カニューレがそこから外向きに延在している。この第の１カニューレはチャンバの基端に位置する内側基端と、これと反対側で患者の静脈を穿刺するように構成された外側末端とを有する。同様に、流体出口端に流体連通する第２の非患者側出口カニューレが配され、そこから外向きに延在している。この第２の非患者側カニューレは、前記第１の内側端の基端側に位置決めされた内側末端を有し、前記第２の内側端の反対側の外側基端をさらに具えている。この第２の非患者側外側基端は、減圧容器の突き刺し可能なストッパを貫通するように構成されている。第２の患者側カニューレは、さらに密閉可能なマルチプル試料スリーブを具えている。しかしながら、２本のカニューレの代わりに切欠きを含む１本のカニューレを使用することもできる。他の別なカニューレの構成は、非患者側カニューレの基端を通り、マルチプル試料スリーブを巡って通気孔を通った後、フラッシュバックが起こるように、切欠きの無い１本のカニューレを用いている。基端近傍のハブの外側部分は、一条の外側ねじ山、またはその他の装着構造で形成され、血液

採取針アセンブリを採取管ホルダその他の医療装置に装着することができる。あるいは、このホルダを針アセンブリに予め取り付けておくことができる。

【0010】

一実施形態において、通気機構はハブのフラッシュバックチャンバに配されている。前記２本カニューレ型構造または切欠き付き１本カニューレの使用は、この構成に適している。これによって、通気機構は、ハブを介して流体通路と外部雰囲気とを連通させる。

【0011】

他の実施形態において、通気機構が非患者側カニューレの基端を越えて配され、これは空気が、血液が吸引される非患者側カニューレの基端を通過し、次いで通気孔を通過することを意味する。この場合、切欠きを持たない１本カニューレが適しているが、あらゆるカニューレ構造が使用可能である。詳しくは、空気は針の外側とマルチプル試料スリーブとの間の空間を流れ、流体通路から非患者側カニューレの基端の外に排出される。次に、空気は、非患者側係止突起か、非患者側ハブのねじ山か、非患者側のハブ本体か、マルチプル試料スリーブか、またはその他の非患者側カニューレの基端を越えた位置やこれらの位置を組合せた位置にある通気機構を介して流れる。非患者側カニューレの基端に装着される採取管は、流体通路のみから血液を吸引し、通気空間からは吸引しない。従って、この実施形態は、採取通路全体を通して血液を流すことができる。これは、潜在的に血小板の活性化か、汚染またはその他の望ましくない結果をもたらす血液試料の通気孔への接触も防ぐ。これは、減圧管が装着された場合、空気が流体通路に逆に吸い込まれることも防止する。この実施形態は、通気孔がハブに配された前述の実施形態に比べて、小さな噴出チャンバしか必要でないことにも注目すべきである。

【0012】

本発明の別の実施形態は、少なくとも一部が焼結プラスチック，セラミックまたは金属などの多孔質材料で形成された一体化されたハブからなる通気機構を有している。この多孔質材料は、空気が非患者側カニューレに入る前か、または空気が基端を出てカニューレとマルチプル試料スリーブとの間の空間へと非患者側カニューレを通って流れた後の何れかに、排気が行われるように配置することができる。多孔質材料は空気の通気は行うが、血液の漏洩は阻止する。典型的な実施形態において、この多孔質材料は疎水性である。多孔質材料は、濡れると膨潤する材料をさらに含んでいる。他の通気方法も可能である。内部通路の壁面は、多孔質材料による血液試料の汚染を防ぐシーラントによってコーティングされてもよい。この実施形態は、全採取経路に亙って血液を流すことができる。ねじ山による接続の必要性や不便さを排除するため、必要に応じてハブは恒久的に管ホルダに接合することができる。このホルダへの接合は、溶剤，溶着，加熱，加圧または他の適当な手段、あるいはこれらの組み合せによって行うことができる。このようにして一体化された装置は効率よく製造され、ホルダが針と一緒に廃棄されることによって、医療行為の安全性を高めることができる。

【0013】

さらに別の実施形態において、通気機構はハブに配された側面開口を介して空気を外に排出するが、この開口は、当該開口内にまたは開口に接して機械的に保持されるような形状を有する通気材料によって覆われている。この通気材料は疎水性であることが好ましく、表面張力もまた漏洩を防止するようになっている。この実施形態の通気媒体材料は、ばねのエネルギーが通気材料をこの装置に対して保持するように、弾性的な性質および形状を有していることが好ましい。例えば、形状が捻じれるには通気媒体がハブ上の受け入れ構造の全体に亙って伸びることが必要なＣ字型形状の通気媒体を使用することができる。通気媒体が支持構造体に設置されると、通気媒体に吸収されて悪影響を与えることのあるエポキシなどの接合材料が無くても、それは解放されてそれ自体の弾性を用いて所定の位置に保持される。この実施形態の通気機構は、最初に通気用材料を圧縮し、この材料を開口に置き、そして通気用材料を解放して開口内で拡張させるようにしてもよい。

【発明を実施するための最良の形態】

【0014】

本発明は、血液などの流体の流出を防止すると共に空気の放出を助ける自己通気機構を具えた自己通気型血液採取用針アセンブリであって、患者から血液やその他の流体を１本以上の減圧血液採取管に採取する際、血管への挿入の可視的指示（「フラッシュバック」）を与えるアセンブリを提供するものである。

【0015】

通気媒体は、例えば栓やインサートなどの別の物理的要素か、レーザー穿孔などによって処理されたり全体的または部分的に多孔質材料にて形成される装置の一体部品か、あるいは例えば含浸，被覆，スプレーなどにより装置に対して材料を配することによって形成される膜や層などであってよいことに留意されたい。

【0016】

本発明の一実施形態にかかる血液採取針アセンブリを図１に示す。針アセンブリ１０は、一方の側に流体入口針（第１カニューレ）３６を、反対側に非患者側の流体出口針（第２カニューレ）５２を支えるハブ１２を具えている。第１カニューレから採取された流体はハブ１２を通り、半透明の窓１００を介してフラッシュバックチャンバ内で直ちにに見ることができ、通気機構の助けによる適正な血管穿刺が行われたことの適時な指示を与える。

【0017】

図２～図２８は、血液採取針アセンブリにおける通気機構の種々の構成を含む本発明の種々の実施形態を示す。特に、図２，図３，図４Ａ，図４Ｂおよび図４Ｃは、通気機構がハブの部分に配された実施形態を示している。図５～図１２は、通気機構が非患者側カニューレの基端６０を越えた所に配された実施形態を示している。図１３および図１４は、針のハブの一部が通気媒体として作動する実施形態を示している。図１５は、通気機構が単一化されたハブ１３２である実施形態を示している。図１６～図２６は、通気機構が通気性を有するコードである実施形態を示している。図２７Ａおよび図２７Ｂは、通気機構が逆止め弁である実施形態を示している。図２８は、１つの切欠き付きカニューレを具えた実施形態を示している。２本のカニューレがある以下の各実施形態において、１本の切欠き付きカニューレが同様に使用可能であることに留意されたい。

【0018】

図２，図３，図４Ａ，図４Ｂおよび図４Ｃは、第１カニューレ３６の基端３０１の周囲に通気リング３００を配した通気機構を示している。この通気リングは、フラッシュバックチャンバ３０２の内壁と締まり嵌めを形成する。従って、空気はこの通気リングを介して通気開口３０３から外部雰囲気へ放出できる。これらの開口をハブの末端のどこにでも配することができる。図２および図３において、これらの開口はハブ３０４の末端に配されている。図４Ａ，図４Ｂおよび図４Ｃには、通気開口が通気リング３００の末端側に当接する長手方向の通気窓３０５である別の実施形態が示されている。

【0019】

幾つかの実施形態は、非患者側カニューレの基端６０を越えた所に配した通気機構を具えている。この通気機構は、より小さなフラッシュバックチャンバ２２ａを用い、図２，図３，図４Ａ，図４Ｂ，図４Ｃなどの前述の実施形態に比べて、ハブアセンブリ１２から排気される空気の量を減らすのに有利である。次の実施形態は、より大きな環状フランジ６８ａを用い、より小さなフラッシュバックチャンバ２２ａを作っているが、別な設計でもよい。これらの設計の例は、フラッシュを見やすくするためのハブの表面に近い半透明／透明材料の窓および／またはフラッシュバックチャンバの一部である。特に切欠きの無い１本のカニューレを使用する実施形態の場合、フラッシュバックチャンバまたは窓を空気／血液通路に配することができることに留意されたい。

【0020】

図５の実施形態において、空気は流体通路３０６から非患者側カニューレの基端６０まで流れ、さらに針の外側３０８とマルチプル試料スリーブ６１の内側との間の空間３０７を通って、非患者側の係止突起３１０と空気の流出は許すが血液その他の流体は外部雰囲気へ流出させない通気栓３１１とで構成されている通気孔３０９の位置まで達する。

【0021】
図６，図７，図８Ａ，図８Ｂ，図９Ａ，図９Ｂ，図１０Ａおよび図１０Ｂは、通気機構が非患者側カニューレの基端６０の越えた所に設けられている実施形態を示している。図６および図７の実施形態は、非患者側の係止突起の少なくとも一部としても機能する通気栓３１２を示す。これらの図に示されているように、両方の実施形態では、通気孔の少なくとも一部が外部に接近しており、これを介して空気を排気する。図８Ａおよび図８Ｂは、非患者側の係止突起３１４における切欠き３１３が空気を通気用円板３１５に逃がすように構成された実施形態を示している。図９Ａおよび図９Ｂは、非患者側の係止突起３１４における切欠き３１６が通気栓３１７を含んでいる別の実施形態を示している。図１０Ａおよび図１０Ｂは、通気スリーブ３１９が空気を逃がすように改変された非患者側の係止突起３１８の構成を示している。各実施形態においては、通気機構（およびここに述べられた類似のエレメント）が空気を流出させるが、血液その他の流体が外部雰囲気に流出することは防止している。
【0022】
図１１は、非患者側のカニューレの基端６０を越えた所に設けられた通気機構の別の実施形態を示す。この実施形態によれば、空気は、非患者側のカニューレ５２からの流体の流出を防ぐマルチプル試料スリーブ３２０自体の材料を通って排気される。このマルチプル試料スリーブ３２０は、減圧採取管のストッパによって生じる力に応じて、非患者側カニューレ５２の尖った基端６０によって突き破られるその正常な機能を維持している。スリーブを前述のような多孔質の疎水性材料で形成することにより、通気孔としても機能するマルチプル試料スリーブ３２０を作ることができる。
【0023】
図１２は、空気が非患者側針５２の外側と非患者側係止突起３５４との間の狭い通路３５３を通り、次にベース６４と環状フランジ６８との間を通って通気媒体３５７を収容するハブ３５６のリザーバ３５５内に入り、ハブ３５６と非患者側ハブのベース６４との間の境界８０に設けた通路３５８を介して外部雰囲気に排出される別の実施形態を示している。ハブのインサート３５９がリザーバ３５５を形成している。
【0024】
図１３および図１４は、ハブ３２１または非患者側のねじ山付きアセンブリ３２２が多孔質材料で作られ、従って通気媒体として作用する通気機構を示している。図１３は、空気をハブ３２１の傾斜部２８を通って環状溝２６から周囲の大気中に排出する通気媒体としてのハブ３２１を示している。図１４は、通気媒体としての非患者側のねじ山付きアセンブリ３２２を示している。この実施形態は、空気をフラッシュバックチャンバ２２ａの壁に通し、次に非患者側の係止突起３２４を通して放出させることができる。
【0025】
図１５は、環状溝２６とフラッシュバックチャンバ２２ａの壁を通じ、且つ流体通路３０６を介して空気を逃し、非患者側のカニューレの基端６０から排出する多孔質材料の通気媒体で作られた一体化されたワンピース型のハブ３２５である通気機構を示し、空気はさらに針３０８の外側とマルチプル試料スリーブ６１の内側との間の空間３０７を通り、次いで非患者側係止突起３２６を通って周囲の大気中に流出する。一体化されたハブ３２５の性質によって、このホルダはねじ山を設けず、接合によって予めハブ３２５に装着可能である。しかし、図示のように必要に応じてねじ山を設けてもよい。管ホルダをこの一体型の非患者側のハブ３２５に接合するには、溶剤，溶着，加熱，圧力その他、従来からある手段やそれらの組合せが用いられる。
【0026】
図１６は、マルチプル試料スリーブ６１の密閉表面の内側と非患者側の係止突起３２７との間に設けられた通気性を有する通気可能なコード３２６の通気機構を示している。密閉表面にコードが設けられているので、空気は針３０８の外側とマルチプル試料スリーブ６１の外側との間の空間３０７から排出されるが、コードの材料の性質および／またはコードによって形成される通路の寸法が非常に小さいことによって流体の漏洩が防止される

。この機構を使用した通気は、通気媒体（例えば設置，被覆，処理などの）を流体通路３０６に沿って任意の１つまたは複数の密閉表面の間に位置させることにより行われる。図１７～図２６は、好適な通気性を有するコードの断面を示す。その他の形状やこれらの形状の組み合せも利用可能である。コードは押し出しや紡織などで作られ、そしてワックスなどの疎水性のコーティングを施すことが有利である。

【0027】

他の実施形態において、通気機構は流体通路に沿った何れかに配される逆止め弁を使用している。この弁は、空気を通過させるが真空がもたらされると閉じ、従って減圧採取管が針の先端に取り付けられると、この管は流体通路から血液を吸引するが、空気を吸い込まない。図２７Ａおよび図２７Ｂは、逆止め弁の一例を示す。この通気機構を流体通路３０６に沿った任意の箇所（単数または複数）に設けることができるが、好ましくはハブ３２８に設けられる。この弁３４９自体は、通気孔を被覆するプラスチックフィルム３５０などの薄いフラップ，変形可能なゴムなどのシール，またはプラスチック製ダックビル型の弁，通気孔を覆う変形可能なラップ，他の任意の手段，またはこれらの組み合せであってよい。この弁３４９は、通気孔に対して基端側または末端側に位置している。図２７Ｂに示した実施形態では、薄いプラスチックフィルムの弁３４９が、フィルム３５１の一方の密閉された縁に沿ってハブ３２８に取り付けられ、最初の静脈穿刺の際に、静脈圧力によって流体通路３０６から多孔質通気栓３５２を介して空気が押し出され、プラスチックフィルム３４９の固定されていない縁の下から出て行く。しかし、流体通路３０６に（血液採取管の取り付け部を介して）真空がもたらされると、薄いプラスチックフィルム３４９が多孔質通気栓３５２に対してぴったりと吸い付けられ、通気孔を密閉して空気が流体通路に再び入ることを防止する。こうして、この実施形態は、排気が行われた後でシステム内に空気が再侵入することを防ぐ、主たるまたはバックアップの機能を発揮する。

【0028】

図２８は、１本のカニューレ３６０と非患者側の係止突起として機能する通気栓３６１とを具えた血液採取針アセンブリを示している。このカニューレ３６０は、カニューレ３６０の孔３６５が環状溝２６の位置に設けられ、これとの流体連通を保つように、孔３４に位置している。カニューレ３６０が適正に位置決めされると、カニューレは孔３４と摩擦係合し、または接着剤などによってこれに固定される。静脈穿刺の際には、空気は流体通路３０６から流れ、カニューレの基端３６２から排出され、さらに針３６３の外側とマルチプル試料スリーブ６１の内側との間の空間３０７に流れ、通気栓３６１に達する。

【0029】

当業者ならば理解できるように、１つの装置に１つ以上の通気機構を組み合わせたり、同じ通気機構を１つの装置の１つの箇所に取り付けることが可能である。さらに、本発明の通気機構に種々の通気媒体の任意のものを使用することも可能である。さらに、ここに述べられた通気機構は、血液採取針アセンブリ以外の種々の装置にも適用可能である。

【0030】

ここで使用される通気媒体は、例えば

・水溶性または水を含む物質に接触すると膨潤する親水性材料がコーティングされ，含浸され，またはこれを含む一般的に疎水性の基材またはキャリア材料にて形成され、この膨潤可能な性質によって、血液に接触すると通気孔に密閉機能が与えられる多孔質栓か、

・艶消し仕上げ，微小寸法の通路，レーザー穿設孔，曲りくねった通路、多孔質材料によって設けられるか、または穴，間隙または通路が空気を通すには充分に大きいが、血液の漏洩を防ぐためには充分に小さい、例えばコードにおけるシール面の間に設けられる通気孔か、

・例えば通気孔を塞ぐ凝固および／または細胞の膠着による生物学的現象を利用し、血液と接触すると塞がる多孔質栓か、

・水性流体と接触して膨潤することにより、通気孔を密閉する超吸収性材料か、または

・逆止め弁：例えば通気孔を覆うプラスチックフィルムなどの薄いフラップ，ゴムまたはダックビル型弁の如き変形可能なシール，または通気孔を覆う変形可能なラップ

の何れかまたはこれらの組み合せを含むことができる。

【0031】

好ましくは、多孔質栓は、カルボキシメチルセルロース（ＣＭＣ）またはポリアクリレートなどの親水性材料によって被覆されるか、含浸させられるか、またはこれを含む高密度ポリエチレン（ＨＤＰＥ）などの疎水性材料にて形成される。代わりの疎水性材料として、これに限定されるものではないが、ポリテトラフルオロエチレン（ＰＴＦＥ），超高分子量ポリエチレン（ＵＨＭＰＥ），ナイロン６，ポリプロピレン（ＰＰ），ポリビニリデンフルオライド，またはポリエーテルスルホン（ＰＥＳ）が挙げられる。次にさらに詳細に説明されるように、本発明の通気媒体は、通気機構および装置に好適なものとして、艶消し仕上げされた１つ以上の微小寸法の通路，レーザー穿設孔，通気可能なコード，超吸収性逆止め弁，または他の手段、あるいはこれらの任意の組み合せを代わりに用いることができる。このように、例えば栓などの任意の特定な通気媒体についてここで述べているが、これらに限定するものではなく、他の通気媒体の適当な部材も含むことを意図している。

【0032】

通気媒体の一実施形態は、外壁に形成された微小寸法の孔からなる。これらの孔は空気を通すには充分に大きいが、血液の漏洩を阻止するには充分に小さい。この通気孔は、１つの孔を含む任意の数でよいが、信頼性のある機能のためには複数の孔が好ましい。これらの孔は、レーザーにて穿孔され、即ちこれらは１本以上のレーザービームを用いて壁を焼き切って貫通形成される。基板は普通の材料でよいが、薄いプラスチックフィルムが好ましい。通気機構は前述のように逆止め弁を含むことができる。この通気機構は注射器側または患者側カニューレ，ハブ，または付加された構成部品内の流体通路に沿った都合のよい任意の空間に設けられるが、管の全長に亙ってフラッシュを発生させるには、基端に設けられるのが好ましい。

【0033】

血液と接触すると生物学的現象によって密閉される多孔質栓は、例えば焼結プラスチック，セラミック，または金属の如き多孔質材料を用いるか、あるいは通気可能なコードを用いるか、または部品間の小さな孔や空間に生物学的薬剤を配置することによって用いることができる。この通気孔は従来からある任意の形状であってよい。通気は流体通路の任意の位置（単数および複数）で行われるが、採取装置に近いハブなどの基端が好ましい。通気孔は、凝固しおよび／または固まった細胞が通気孔を通過する流れを阻止するように、血液と相互作用して凝血および／または細胞の膠着を促進する刺激剤で作られ、これを含み、これと隣接し、またはこれと協同することが好ましい。凝血刺激剤の一例は、シリカ，破砕ガラス，またはガラス繊維である。膠着剤の一例はレクチンである。血小板賦活剤の一例はコラーゲンまたはトロンビンである。プロトミンスルフェートなどの抗凝固剤のための中和剤が含まれていてもよい。生物学的刺激剤は、粉末，溶液，懸濁液，スラリー，または他の形状として、都合の良い任意のプロセスを用いて付与することができる。これは乾燥、または真空凍結乾燥したものであってよい。

【0034】

当業者であれば本発明の範囲や精神から逸脱することなく、種々の他の変更や修正を行うことが可能であり、これらの変更や修正は、すべて本発明の範囲に入るものとして意図されるものである。

【図面の簡単な説明】

【0035】

【図1】血液採取針アセンブリの斜視図である。

【図2】本発明の血液採取針アセンブリの別の実施形態の断面図である。

【図3】図２と同様な側断面図であるが、本発明の別の実施形態を示している。

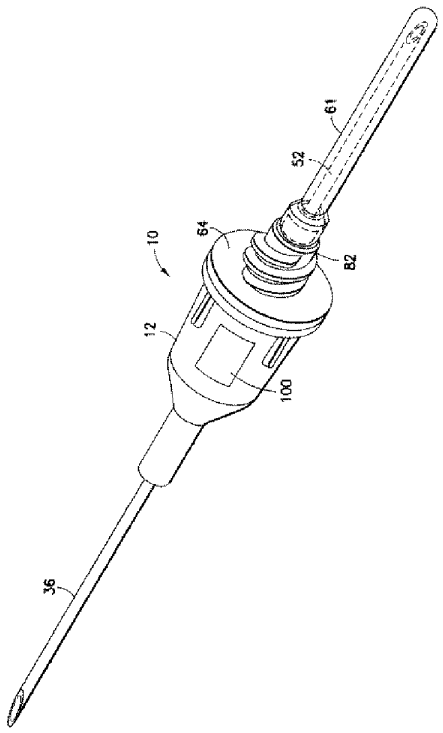
【図4A】図２と同様な側断面図であるが、本発明の別の実施形態を示している。

【図4B】図４Ｂの側面図である。

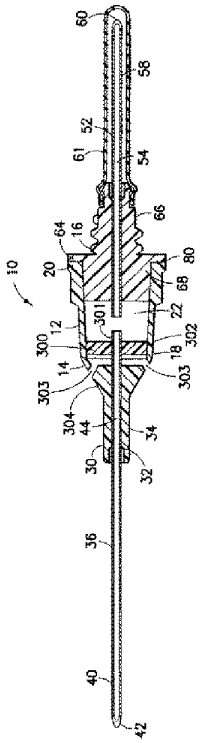
【図4C】Ｒ－Ｒの方向から見た図４ＢＡの正面図である。

【図5】血液採取針アセンブリの一実施形態の断面図である。
【図6】図５と同様な断面図であるが、本発明の別の実施形態を示している。
【図7】図５と同様な断面図であるが、本発明の別の実施形態を示している。
【図8A】図５と同様な断面図であるが、本発明の別の実施形態を示している。
【図8B】Ｘ－Ｘの方向から見た図８Ａの正面図である。
【図9A】図５と同様な断面図であるが、本発明の別の実施形態を示している。
【図9B】Ｙ－Ｙの方向から見た図９Ａの正面図である。
【図10A】図５と同様な断面図であるが、本発明の別の実施形態を示している。
【図10B】領域Ｚから見た図１０Ａの拡大図である。
【図11】血液採取針アセンブリの一実施形態の断面図である。
【図12】血液採取針アセンブリの一実施形態の断面図である。
【図13】血液採取針アセンブリの一実施形態の断面図である。
【図14】血液採取針アセンブリの一実施形態の断面図である。
【図15】血液採取針アセンブリの一実施形態の断面図である。
【図16】血液採取針アセンブリの一実施形態の断面図である。
【図17】通気可能なコードの一実施形態の断面図である。
【図18】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図19】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図20】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図21】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図22】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図23】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図24】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図25】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図26】図１７と同様な断面図であるが、本発明の別の実施形態を示している。
【図27A】血液採取針アセンブリの一実施形態の断面図である。
【図27B】領域Ｒから見た図２７Ａの拡大図である。
【図28】血液採取針アセンブリの一実施形態の断面図である。

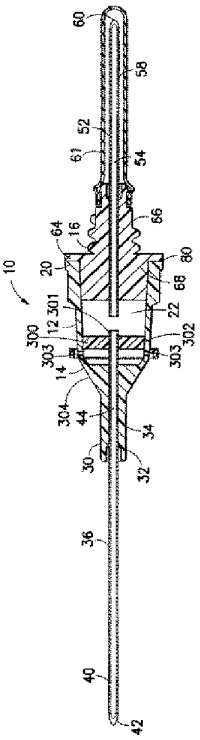
【図1】


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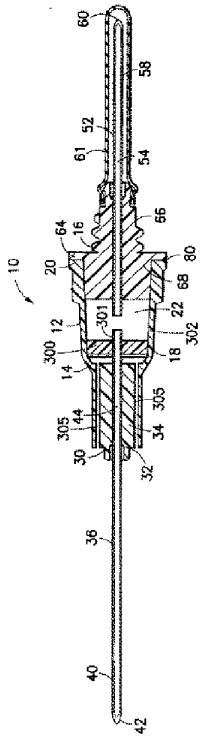
【図2】


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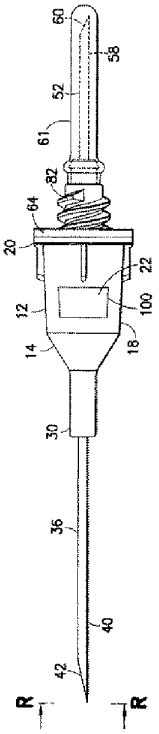
【図3】


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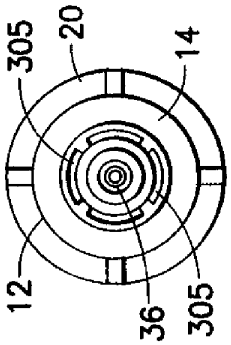
【図4A】


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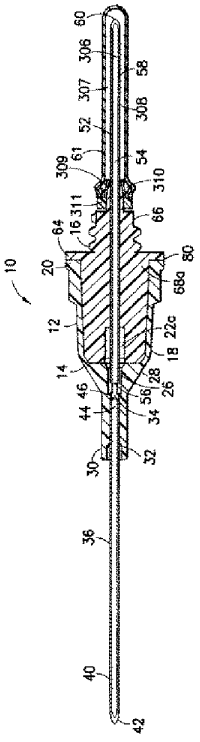
【図4B】


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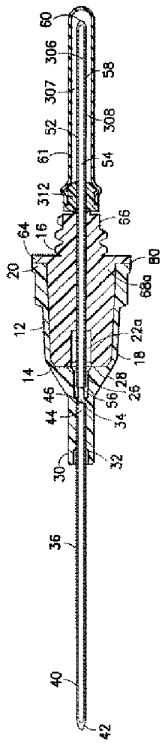
【図4C】


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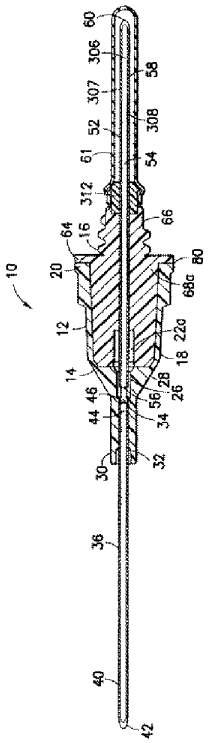
【図5】


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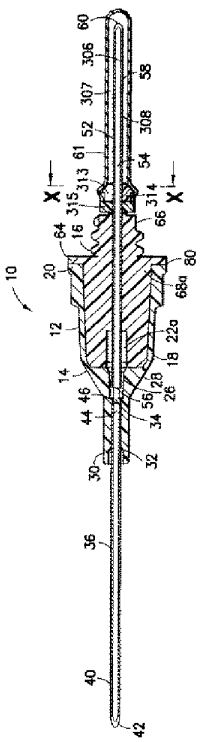
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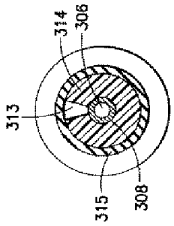
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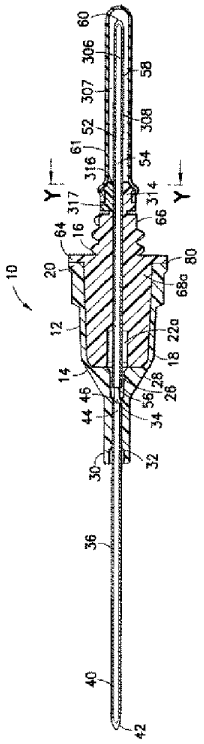
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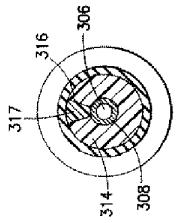
【図8B】



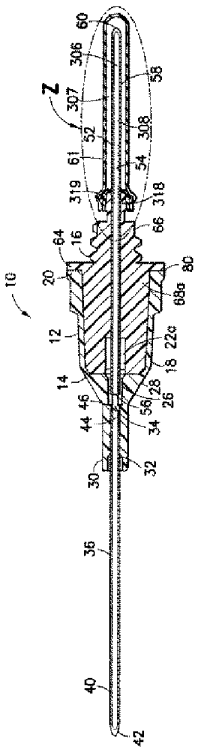
【図9A】



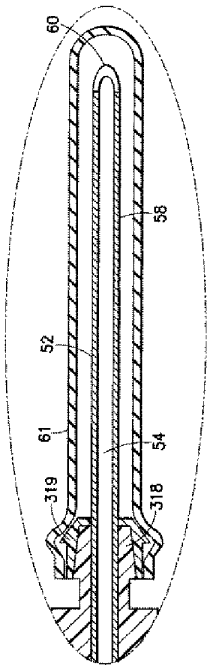
【図9B】



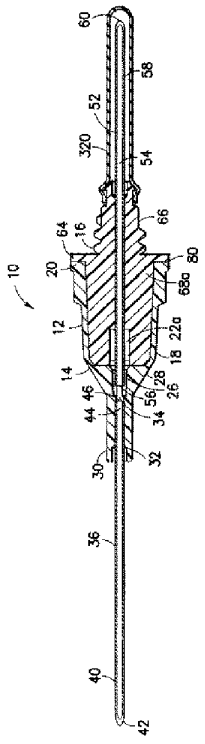
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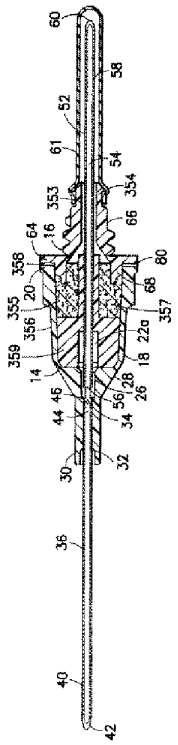
【図10B】



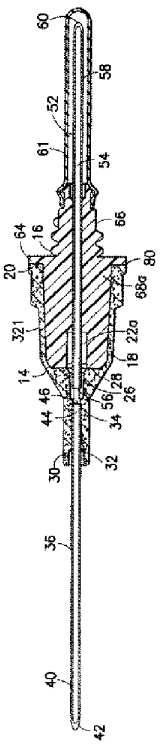
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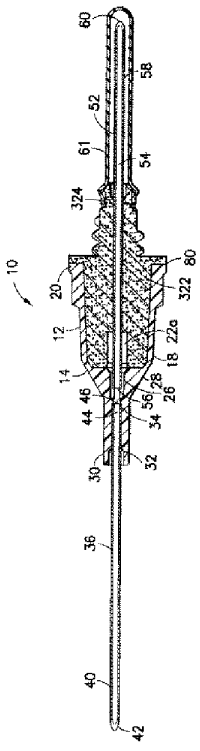
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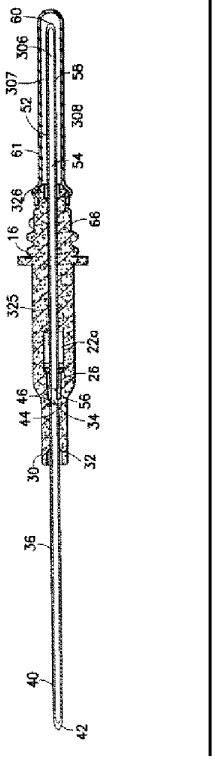
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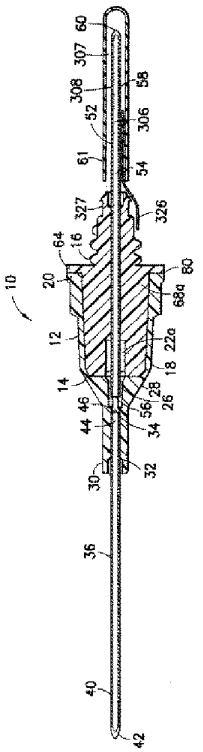
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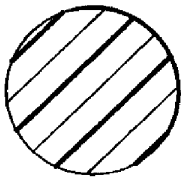
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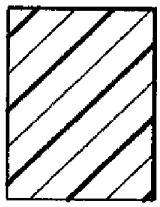
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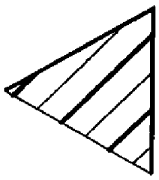
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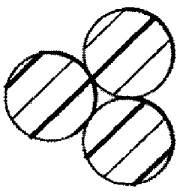
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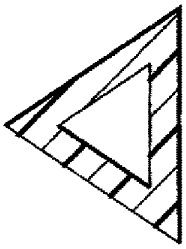
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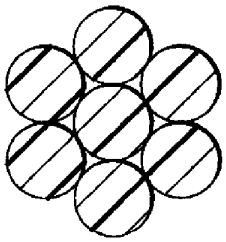
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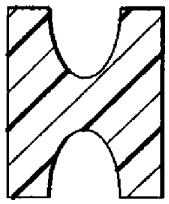
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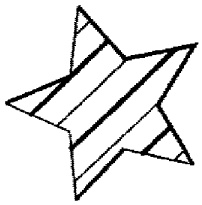
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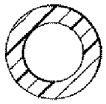
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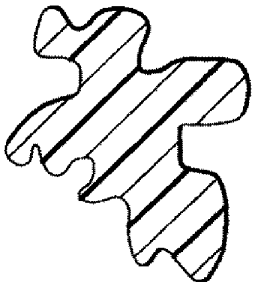
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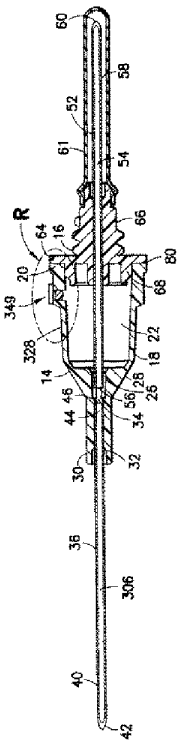
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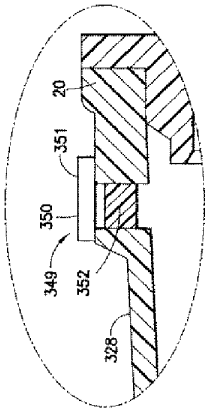
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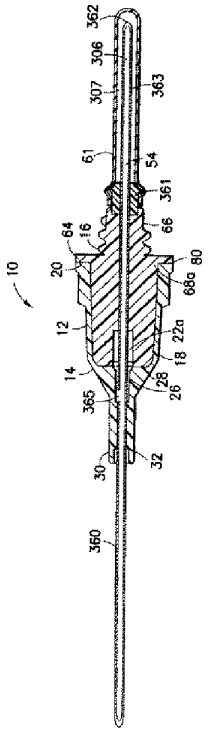
【図27A】



【図27B】



【図28】


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(72)発明者　ジェイムズ　シー．シュナイダー
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Ｆターム(参考)　4C038 TA06　UJ02
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【外国語明細書】
2005349196000001.pdf

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Nursing disinfection bottle

Inventor(s):	ZHU WENFENG XIA WENBO LI YAN
Applicant(s):	QINGDAO CITY HUANGDAO DISTR TCM HOSPITAL
Classification:	- international: A61M35/00 - cooperative:
Application number:	CN201520978112U 20151130
Priority number(s):	CN201520978112U 20151130
Also published as:	CN205127111 (U)

Abstract of CN205127111 (U)

The utility model discloses a nursing disinfection bottle, including bottle, bottle lid and cotton balls, wherein, the bottleneck of bottle sets up the one deck diaphragm, the bottleneck and the bottle lid of bottle are connected, the roof of bottle lid is the shell fragment, and the shell fragment in the bottle lid inclines and sets up the pjncture needle of directional bottleneck, the cotton balls sets up the shell fragment side outside the bottle lid, the shell fragment fretwork, contain the antiseptic solution in the bottle. During the use, press the shell fragment, the shell fragment promotes the diaphragm that the bottle bottleneck was punctureed to the pjncture needle, with the pjncture needle pull -up when shell fragment is bounce, then inverts this nursing disinfection bottle, and the antiseptic solution soaks the cotton balls through the diaphragm the punctureed shell fragment through the fretwork to disinfect to the patient. Because the direction of pjncture needle and cotton balls opposite direction, so the danger that the pjncture needle punctured the disinfection position can not take place.

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(12)实用新型专利

(10)授权公告号 CN 205127111 U
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(21)申请号 201520978112.4

(22)申请日 2015.11.30

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(51)Int.Cl.
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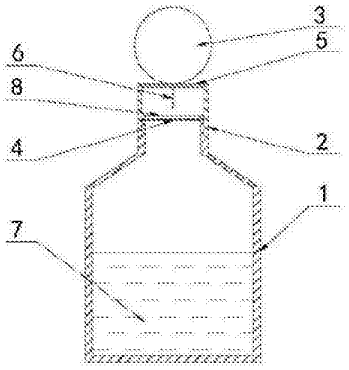
权利要求书1页 说明书2页 附图1页

(54)实用新型名称

一种护理消毒瓶

(57)摘要

本实用新型公开了一种护理消毒瓶，包括瓶体、瓶盖和棉球，其中，所述瓶体的瓶口设置一层隔膜，所述瓶体的瓶口与瓶盖连接，所述瓶盖的顶壁为弹片，在瓶盖内的弹片侧设置指向瓶口的穿刺针，所述棉球设置在瓶盖外的弹片侧，所述弹片镂空，所述瓶体内盛有消毒液。使用时，按压弹片，弹片推动穿刺针刺破瓶体瓶口的隔膜，弹片弹起时将穿刺针拉起，然后将该护理消毒瓶倒置，消毒液经刺破的隔膜通过镂空的弹片将棉球浸湿，从而对病患者进行消毒。由于穿刺针的方向与棉球方向相反，所以不会发生穿刺针扎破消毒部位的危险。



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1.一种护理消毒瓶，其特征是，包括瓶体、瓶盖和棉球，其中，所述瓶体的瓶口设置一层隔膜，所述瓶体的瓶口与瓶盖连接，所述瓶盖的顶壁为弹片，在瓶盖内的弹片侧设置指向瓶口的穿刺针，所述棉球设置在瓶盖外的弹片侧，所述弹片镂空，所述瓶体盛设有消毒液。

2.如权利要求1所述的一种护理消毒瓶，其特征是，所述隔膜为铝箔膜。

3.如权利要求1所述的一种护理消毒瓶，其特征是，所述穿刺针为空心结构。

4.如权利要求1所述的一种护理消毒瓶，其特征是，所述瓶口与瓶盖螺旋连接。

5.如权利要求4所述的一种护理消毒瓶，其特征是，所述瓶盖的螺纹上方侧壁上设置环形凸缘。

一种护理消毒瓶

技术领域

[0001] 本实用新型涉及医疗用具技术领域，具体涉及一种护理消毒瓶。

背景技术

[0002] 用于医学上的透析大致分为两类：血液透析和腹膜透析。血液透析简称血透，通俗的说法也称之为人工肾、洗肾，是血液净化技术的一种。

[0003] 临床上，在进行血液透析时需要对病患者的局部皮肤进行消毒，通常，医护人员主要是用镊子夹持消毒棉球，然后反复蘸取消毒液来擦拭患者的皮肤以进行消毒，其操作繁琐，费时费力，增加了医护人员的工作负担。

[0004] 中国专利(申请号为2011205473003)公开了一种护理消毒器，该消毒器在筒体前端设置有消毒棉球，后端设有活塞杆，筒体内设有消毒液隔膜，消毒液隔膜与活塞杆所围成的空间存储消毒液，活塞杆的活塞上设有穿刺针，使用时，推动活塞杆使穿刺针扎破消毒液隔膜，让消毒液浸湿棉球，从而用棉球对消毒部位进行消毒。但是，该装置具有穿刺针，若直接用该装置消毒，会有穿刺针扎破消毒部位的危险，若将棉球取下，则解决不了操作繁琐的问题。

实用新型内容

[0005] 为解决上述问题，本实用新型公开了一种护理消毒瓶，不会发生穿刺针扎破消毒部位的危险，同时解决了操作繁琐、费时费力的问题。

[0006] 为实现上述目的，本实用新型的技术方案为：

[0007] 一种护理消毒瓶，包括瓶体、瓶盖和棉球，其中，所述瓶体的瓶口设置一层隔膜，所述瓶体的瓶口与瓶盖连接，所述瓶盖的顶壁为弹片，在瓶盖内的弹片侧设置指向瓶口的穿刺针，所述棉球设置在瓶盖外的弹片侧，所述弹片镂空，所述瓶体内盛有消毒液。使用时，按压弹片，弹片推动穿刺针刺破瓶体瓶口的隔膜，弹片弹起时将穿刺针拉起，然后将该护理消毒瓶倒置，消毒液经刺破的隔膜通过镂空的弹片将棉球浸湿，从而对病患者进行消毒。由于穿刺针的方向与棉球方向相反，所以不会发生穿刺针扎破消毒部位的危险。

[0008] 优选的，所述隔膜为铝箔膜。保证穿刺针只能将隔膜穿破成孔，防止将隔膜完全穿破，使消毒液流入棉球的量过大，造成浪费。

[0009] 优选的，所述穿刺针为空心结构。防止弹片不能弹起，导致消毒液不能流入棉球中。

[0010] 优选的，所述瓶口与瓶盖螺旋连接。

[0011] 进一步优选的，所述瓶盖的螺纹上方侧壁上设置环形凸缘。防止瓶盖旋过，使穿刺针刺破隔膜。

[0012] 本实用新型的有益效果是：本实用新型结构简单、操作简便、安全、可靠，消毒液内置，避免消毒液被外界污染，并且穿刺针的方向与棉球方向相反，不会发生穿刺针扎破消毒部位的危险。

附图说明

[0013] 图1为本实用新型的结构示意图；

[0014] 其中，1.瓶体，2.瓶盖，3.棉球，4.隔膜，5.弹片，6.穿刺针，7.消毒液，8.环形凸缘。

具体实施方式

[0015] 下面将参考附图并结合实施例来详细说明本实用新型。

[0016] 如图1所示，一种护理消毒瓶，包括瓶体1、瓶盖2和棉球3，其中，瓶体1的瓶口设置一层隔膜4，瓶体1的瓶口与瓶盖2螺旋连接，瓶盖2的顶壁为弹片5，在瓶盖2内的弹片5侧设置指向瓶口的穿刺针6，棉球3设置在瓶盖2外的弹片5侧，弹片5镂空，瓶体1内盛有消毒液7。

[0017] 隔膜4为铝箔膜。保证穿刺针只能将隔膜4穿破成孔，防止将隔膜4完全穿破，使消毒液流入棉球的量过大，造成浪费。

[0018] 穿刺针6为空心结构。防止弹片5不能弹起，导致消毒液7不能流入棉球3中。

[0019] 瓶盖2的螺纹上方侧壁上设置环形凸缘8。防止瓶盖2旋过，使穿刺针6刺破隔膜4。

[0020] 使用时，按压弹片5，弹片5推动穿刺针6刺破瓶体1瓶口的隔膜4，弹片5弹起时将穿刺针6拉起，然后将该护理消毒瓶倒置，消毒液7经刺破的隔膜4通过镂空的弹片5将棉球浸湿，若弹片5不能弹起，消毒液7则顺着穿刺针的空心结构浸湿棉球3，从而对病患者进行消毒。由于穿刺针6的方向与棉球方向相反，所以不会发生穿刺针扎破消毒部位的危险。

[0021] 上述虽然结合附图对本实用新型的具体实施方式进行了描述，但并非对实用新型保护范围的限制，所属领域技术人员应该明白，在本实用新型的技术方案的基础上，本领域技术人员不需要付出创造性劳动即可做出的各种修改或变形仍在本实用新型的保护范围内。

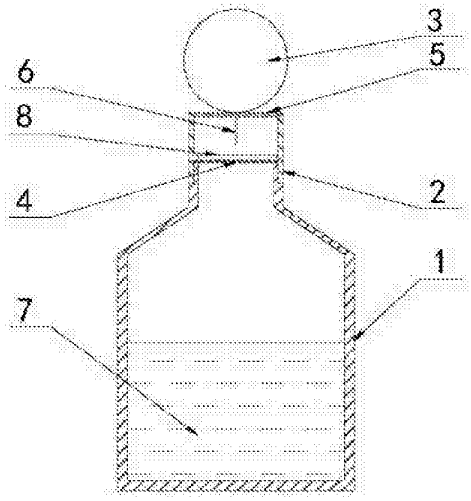


图1

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Safe reverse-resistant vacuum blood sampling guide-showing device and method of use thereof

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Abstract of CN101352346 (A)

The invention provides a safety reverse resistance vacuum blood collecting indicator and a usage method thereof, comprising a vein piercing needle pipe, a test tube piercing needle pipe, a checking valve mechanism, an indicator body, a deformation film, a sealing bottom cover and a rubber sealing sleeve; the indicator body is provided with two holes which are respectively communicated with each other by a soft pipe or which are directly provided with the vein piercing needle pipe and the test tube piercing needle pipe; a communicated pipeline structure is designed between the vein piercing needle pipe and the test tube piercing needle pipe; the communicated pipeline structure is internally provided with a checking valve mechanism which only leads the blood to flow from the vein piercing needle pipe towards the test tube piercing needle pipe, and stops the blood from flowing from the test tube piercing needle pipe towards the vein piercing needle pipe; during the operation process of the vacuum blood collecting, according to different pattern shape displays corresponding to different operation stages, the operators are guided to carry out the operation according to the indicating meaning presented by the pattern shape displayed by the indicator, thus realizing the safety, reliability and exact consistency of the blood collection.

[19] 中华人民共和国国家知识产权局

[51] Int. Cl.
A61B 5/153 (2006.01)

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[11] 公开号 CN 101352346A

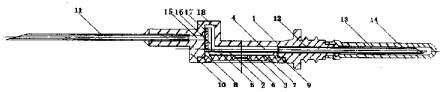
[22] 申请日 2008.4.28
[21] 申请号 200810104931.0
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权利要求书 2 页 说明书 6 页 附图 2 页

[54] 发明名称

安全阻逆真空采血示导器及其使用方法

[57] 摘要

一种安全阻逆真空采血示导器及其使用方法，包括静脉穿刺针管、试管穿刺针管、单向阀机构、示导体、变形薄膜、密封底盖和橡胶密封套，所述的示导体上有 2 个孔，所述的 2 个孔分别以软管连通或直接安装静脉穿刺针管和试管穿刺针管，在静脉穿刺针管和试管穿刺针管之间设计成连通的管道结构，在所述的连通管道结构内设计有单向阀机构，该单向阀机构只许可血液从静脉穿刺针管流向试管穿刺针管，阻止血液从试管穿刺针管流向静脉穿刺针管；在真空采血的操作过程中，通过不同操作阶段所对应的不同图案形态显示指导采血操作人员按照示导器所显示的图案形态所表示的指示含义实施操作，实现采血的安全可靠和精确一致。



1．一种安全阻逆真空采血示导器，包括静脉穿刺针管、试管穿刺针管、单向阀机构、示导体、底盖和橡胶密封套，所述的示导体上有 2 个孔,所述的 2 个孔分别安装或连通静脉穿刺针管和试管穿刺针管，在静脉穿刺针管和试管穿刺针管之间设计成连通的管道结构,在所述的连通管道结构内设计有单向阀机构,该单向阀机构只许可血液从静脉穿刺针管流向试管穿刺针管，阻止血液从试管穿刺针管流向静脉穿刺针管。

2．如权利要求 1 所述的安全阻逆真空采血示导器，其特征在于，示导体为透明材料制造，底盖为非透明材料制造，示导体下面有凹槽，凹槽两端分别与所述的 2 个孔连通,凹槽上覆盖有变形薄膜，示导体与底盖夹合变形薄膜的边缘密封扣合,变形薄膜覆盖在带有凹槽的示导体下面并形成边缘密封开口在凹槽的闭合性腔隙结构。

3．如权利要求 1 所述的安全阻逆真空采血示导器，其特征在于，静脉穿刺针管与单向阀机构之间是整体固定的硬性连通或通过软性导管连通。

4．如权利要求 1 所述的安全阻逆真空采血示导器，其特征在于，单向阀机构内的开闭结构是由折叠形状或管环形状的弹性薄膜构成，该弹性薄膜厚度为 0.01 毫米至 2 毫米，单向阀正向许可液体通过的压力是 0 至 20 厘米水柱、反向阻止液体通过的标准是 100 厘米水柱压力条件下在 1 秒钟内反流液体量是 0 至 100 微升。

5．如权利要求 1 所述的安全阻逆真空采血示导器，其特征在于，在静脉穿刺针管和试管穿刺针管之间的连通管道上安装有人工控制的开关。

6．一种安全阻逆真空采血示导器使用方法，在真空采血的操作过程中，对应每个操作阶段,示导器显示各阶段所特有的图案形态用以指导采血操作人按照图案形态的指示实施操作，该使用方法包括以下 3 个使用步骤：

步骤 1：静脉穿刺的成功显示,当静脉穿刺针管刺入静脉时,血液从静脉穿刺针管尾部流出进入示导体或进入透明软连接管内显示出“回血”含义的图案形态，则判断为静脉穿刺成功，此时可以连接真空试管；

步骤 2：插接试管的真空显示,当真空试管与示导器上的试管穿刺针管接插

时，示导体显示出“负压”含义的图案形态时，则判断为试管内有负压存在并处于抽血状态，此时不可以拔出试管或/和抽出静脉穿刺针管；

步骤 3：抽血停止的完成显示，当示导体显示出“平衡”含义的图案形态时，则判断为试管内负压消失和采血完成，此时可以更换其它真空试管或拔出真空试管和撤出静脉穿刺针管结束全部操作。

7. 如权利要求 6 所述的安全阻逆真空采血示导器的使用方法，其特征在于，所述的“回血”图案形态是指血液从静脉穿刺针管进入示导体的凹槽内并向侧边的闭合性腔隙充盈扩散所形成的图案形态或血液从静脉穿刺针管进入透明软连管所形成的图案形态。

8. 如权利要求 6 所述的安全阻逆真空采血示导器的使用方法，其特征在于，所述的“负压”含义的图案形态是指变形薄膜被吸附紧贴于示导体下面的凹槽上以及示导体下面的凹槽在血液流经时显示凹槽所形成的充满血液的静止的线条图案形态。

9. 如权利要求 6 所述的安全阻逆真空采血示导器的使用方法，其特征在于，所述的“平衡”含义的图案形态是指由权利要求 8 所述的“负压”含义的图案形态转变而成的血液从示导体下面的凹槽内向周围的闭合性腔隙扩散充盈所形成的图案形态。

10. 如权利要求 6 所述的安全阻逆真空采血示导器的使用方法，其特征在于，所述的使用方法的 3 个步骤的每个步骤分别与所述的示导体下面的凹槽内的压力变化所形成的 3 个阶段相对应，所述的 3 各阶段分别是指从静脉穿刺时血液进入管路或示导体凹槽所形成的正压状态的第 1 阶段过度到连接真空试管时所形成的负压状态的第 2 阶段再过度到抽血完成时所再次达到的与连通静脉平衡了的正压状态的第 3 阶段，而在每个阶段内血液在管路中或闭合性腔隙内产生的图案形态各不相同。

安全阻逆真空采血示导器及其使用方法

技术领域

本发明涉及一种安全阻逆真空采血示导器及其使用方法。特别是涉及一种安全的在任何失误性操作情况下可以实现阻止血液逆流进入血管作用的采血器械，同时还具有采用可变形的腔隙结构实现在采血过程中对每个主要阶段实现可视性的特定视觉形态对应特定功能状态的具体的显示指导功能。

技术背景

目前，所有使用的采血针是采用直接连接静脉穿刺针管管与真空试管模式，其间的整个通路上没有起单向阀门作用的安全保障机构，所以具不具备防止血液逆流再进入血管的安全性功能， 在某些操作失误时，将使得试管内的带有试剂的血液再次反流进入血管，将可能导致促使人体内血液凝集或大量堵塞毛细血管或引起抗凝作用导致出血倾向发生，后果及其严重。

另外，用于真空试管静脉采血的针具分为2种，一是没有任何提示作用的盲穿型采血针，不具备任何对采血过程的状态有提示性作用，完全凭人的操作经验和熟练程度判断，因此对操作人的要求很高，不适合广大范围的和更年轻的人员快速容易地掌握；二是带有可视回血的采血针，仅仅显示针尖进入血管后产生可以看见的回血表现，只提示了针尖的位置，对后续的操作环节没有进一步的再提示。由于真空试管内的真空有无一般没有简单的判断的方法，以往的操作只能在操作时进行被动的试探，遇到血管或针尖因素而不能采集到血液时会错误判断为试管内没有真空；或试管内没有真空而却错误判断是针尖或血管的原因，总之由于可能的前后两方面的影响因素不能明确分开，会导致操作时判断不准确；另外在真空试管抽吸血液完成时一般只表现在试管内的针尖不再出血，但由于试管头部一般都在套桶里，而套桶又在手里握持，不方便于查看或看不清楚，会导致撤管过早或延迟，影响采血量的准确而造成检验失真或耽误操作时间。

发明内容

为了解决上述现有技术所存在的缺陷，本发明提供一种安全阻逆真空采血示导器及其使用方法，首先通过在针具与真空试管的管路中设置一个安全的单向阀机构实现血液单向流动的目的，其指标是：正向血液通过压力处于0至20厘米水柱；反向逆流液体量在0至100微升/秒。从而保障在可能发生的失误性操作

时不出现污染试剂的血液反流进入人体血管的问题。

其次再通过采用可闭合或充盈的可变形腔隙结构实现在采血过程中对每个主要阶段实现对应特定功能状态的可视性的特定视觉形态，从而提示给操作人员作为准确判断的依据。

本发明所提出的一种安全阻逆真空采血示导器，包括静脉穿刺针管、试管穿刺针管、单向阀机构、示导体、变形薄膜、密封底盖和橡胶密封套，所述的示导体上有 2 个孔,所述的 2 个孔分别以软管连通或直接安装静脉穿刺针管和试管穿刺针管，在静脉穿刺针管和试管穿刺针管之间设计成连通的管道结构,在所述的连通管道结构内设计有单向阀机构,该单向阀机构只许可血液从静脉穿刺针管流向试管穿刺针管，阻止血液从试管穿刺针管流向静脉穿刺针管。

所述的示导体为透明材料制造，所述的密封底盖为非透明材料制造，所述的示导体上方为观察面，所述的示导体下面设计有凹槽，凹槽两端分别与所述的 2 个孔连通；所述的变形薄膜覆盖在示导体下面的凹槽上，所述的示导体下方与密封底盖夹合所述的变形薄膜边缘密封扣合；所述的变形薄膜覆盖在带有凹槽的示导体下面并形成边缘密封开口在凹槽的闭合性腔隙结构，变形薄膜在受到来自于与静脉穿刺针管管腔相通的凹槽内的正压力时可以向外膨胀、受到来自于与真空试管连通的试管穿刺针管的凹槽内的真空力时可以与示导体下面及凹槽口紧密贴合，从而显示不同状态下的相应的针尖位置或试管内真空状态或两者之间压力平衡状态的信息提示。

本发明所提出的一种安全阻逆真空采血示导器的使用方法，在真空采血的操作过程中，通过不同操作阶段所对应的不同图案形态显示指导采血操作人员按照示导器所显示的图案形态所表示的指示含义实施操作，该使用方法包括以下 3 个使用步骤：

（1）静脉穿刺成功显示：当静脉穿刺针管刺入静脉时,血液从静脉穿刺针管尾部流出进入示导体或进入软连接管显示出“回血”含义的形态时，则判断为静脉穿刺成功，此时可以连接真空试管；

（2）真空试管采血显示：当真空试管与示导器上的试管穿刺针管接插时，由于真空试管内真空的抽吸作用将采血针内的血液包括管路中的和扩散进入变形薄膜内面与示导体下面之间的腔隙中的血液吸出，使得原来扩散呈片状分布的血液形态消失,只显示凹槽内血液通路的形态，从示导体的观察面看时仅仅呈线条状，同时变形薄膜呈现为紧密贴合于示导体下面和凹槽口部，示导体显示出“负压”含义的形态时，则判断为试管内有真空存在并处于抽血状态，此时不可以拔出试管或/和抽出静脉穿刺针管；

（3）采血完成显示：当接通的真空试管吸入血液后，真空试管内真空逐渐

降低直至完全消失并逐渐再次达到所连通的静脉内的正压力，此时，变形薄膜则从原来紧密贴合于示导体下面和凹槽口部的状态逐渐松弛并再次向外膨胀，血液也再次从变形薄膜内面与示导体下面之间的腔隙向周围逐渐扩散，从示导体的观察面看时在原有真空状态所呈现的凹槽血液通路的线条状图案的同时又逐渐增加显现出血液扩散所形成的片状分布图案，当示导体显示出“平衡”含义的形态时，提示静脉血压与真空试管内压处于压力平衡的状态，则判断为试管内真空消失和采血完成，此时可以拔出真空试管更换其它真空试管或可以拔出真空试管和撤出静脉穿刺针管结束全部操作。

在本发明所述的结构和使用方法中，静脉穿刺针管与单向阀机构之间是直接的硬性连接或通过软性导管连接；所述的单向阀机构内所用的阀门开闭结构是折叠形状或管环形状的弹性薄膜，所述的弹性薄膜厚度为 0.01 毫米至 2 毫米，所述的单向阀正向许可液体通过的压力是 0 至 20 厘米水柱，所述的单向阀反向阻止液体通过的标准是 100 厘米水柱压力条件下在 1 秒钟内反流液体量是 0 至 4 滴或 0 至 100 微升。所述的“回血”含义的形态是指血液从静脉穿刺针管进入示导体内并扩散所形成的图案形态或血液从静脉穿刺针管进入软连管所形成的形态或形成所规定的其它形态。所述的“负压”含义的形态是指变形薄膜被吸贴于示导体下面的凹槽上或/和示导体下面的凹槽在血液流经时显示凹槽所形成的充满血液的线条形态或规定的区别于“回血”含义的形态的其它静止或活动形态。所述的“平衡”含义的形态是指由权利要求 8 所述的“负压”含义的形态转变而成的血液从示导体下面的凹槽向周围扩散所形成的形态或规定的区别于“回血”含义的形态和“负压”含义的形态的其它形态。所述的使用方法的 3 个步骤的每个步骤分别与所述的示导体下面的凹槽内的压力变化所形成的 3 个阶段的特定图案形态相对应，所述的 3 各阶段分别是指从静脉穿刺时血液进入凹槽所形成的凹槽内的正压状态的第 1 阶段过度到连接真空试管时所形成的真空状态的第 2 阶段再过度到抽血完成时所再次达到的与连通静脉平衡了的正压状态的第 3 阶段，而在每个阶段内血液在权利要求 5 中所述的闭合性腔隙结构中产生的图案形态各不相同。

本发明的积极效果是：确保在任何人员因为任何原因发生操作失误时可以保障带有污染试剂的血液不会反流进入人体的血管内引发其它的严重问题，同时操作人员从采血针的针尖穿刺进入静脉开始直到真空试管完成采血为止的全部过程均可以在采血针的观察面上看到不同阶段时的血液扩散或收缩所形成的视觉形态性的图案，并在相关的图案提示下作出各个操作阶段上的明确而简单的准确判断，监测采血操作的全过程并简单提示可能出现的问题的原因以便于作出快速决定，最终实现高效正确的真空采血操作。

附图说明

下面结合附图及实施例对本发明作进一步说明，附图中：

图 1 是本发明所提出的安全阻逆真空采血示导器结构示意图；

图 2 是本发明所提出的安全阻逆真空采血示导器的软连接管路实施例结构示意图；

图 3 是本发明所提出的安全阻逆真空采血示导器的使用方法流程步骤。

具体实施方式

如图 1 所示，为本发明所提出的安全阻逆真空采血示导器，包括静脉穿刺针管 11、试管穿刺针管 13、单向阀机构 16、示导体 1、变形薄膜 2、密封底盖 3 和橡胶密封套 14。示导体 1 的边缘有 2 个侧孔分别是静脉穿刺针管侧孔 10 和试管穿刺针管侧孔 12，静脉穿刺针管 11 插入静脉穿刺针管侧孔 10 内并粘接密封，试管穿刺针管 13 插入试管穿刺针管侧孔 12 内并粘接密封。示导体 1 的下面设计有凹槽 4，凹槽 4 的两端分别与静脉穿刺针管侧孔 10 和试管穿刺针管侧孔 12 对应连通，同时也分别与静脉穿刺针管 11 和试管穿刺针管 13 的管腔沟通。在单向阀机构 16 的内部安装有可以开关的弹性膜 17，该弹性膜 17 平贴在静脉穿刺针管侧孔 10 后部的流入孔 15 的口部外壁上，该弹性膜 17 的后边有凹槽 4 的延伸弯折部分形成为单向阀的流出槽 18，呈 L 形；所述的变形薄膜 2 覆盖但不固定在示导体 1 的下面及凹槽 4 的口部，边缘由密封底盖 3 的外侧边 8 和示导体 1 的内侧边 9 夹合密封，最终形成一个边缘密封开口在凹槽 4 的可以闭合或充盈膨胀的变形性腔隙结构。变形薄膜 2 在受到来自于凹槽 4 内的正压力作用时可以向外膨胀，表现为腔隙充盈；当变形薄膜 2 受到来自于凹槽 4 内的真空力作用时可以与示导体 1 的下面及凹槽 4 的口部紧密贴合，表现为腔隙闭合，从而可以根据腔隙的闭合或充盈显示不同压力状态下的相应操作程序时的静脉穿刺针管 11 的尖部相对与血管的位置或与试管穿刺针管 13 插接连通的试管内真空状态或两者之间压力平衡状态等 3 个阶段的视觉形态所表达的提示性信息。

在密封底盖 3 上有通孔 6，密封底盖 3 的内面设计有凹陷的平面，该平面上有与通孔 6 连接的放射形棱 7，该平面与变形薄膜 2 之间有距离并合围形成了膨胀腔 5，该膨胀腔 5 通过通孔 6 连通外界。在试管穿刺针管 13 的外部套装一个橡胶密封套 14 用于密封试管穿刺针管。

如图 2 所示，为本发明所提出的安全阻逆真空采血示导器一个另外形式的实施例，在该实施例中的静脉穿刺针管 11 与示导体 1 的静脉穿刺针管侧孔 10 通过一个透明的软连管 19 相连接，其中静脉穿刺针管侧孔 10 与软连管 19 经过套管 22 密封固定连通；静脉穿刺针管 11 与软连管 19 经过带有侧翼 20 的套管 21 密

封粘接连通，在透明的软连管 19 上安装有开关 23，便于关闭管路。其它结构等同于图 1 所示。该结构在使用中，软连管可以实现任意弯转，方便操作。

如图 3 所示，为本发明所提出的安全阻逆真空采血示导器的使用方法，正常操作情况下包括以下流程步骤：

第一步骤是实现“回血”含义的形态显示：常规静脉穿刺，判断静脉穿刺针管 11 的尖端是否进入血管内腔，实现正压性的针尖定位判读。具体是当静脉穿刺针管 11 的针尖穿刺进入静脉时，处于正压的血液进入示导体 1 中的凹槽 4 内并挤压凹槽 4 口部的变形薄膜 2 向外膨胀并从该膜的中部内面与示导体 1 下面之间的腔隙由中心向周围扩散，变形薄膜 2 向外侧的膨胀腔 5 膨胀时将其外侧的空气通过密封底盖 3 上的通孔 6 排出到外界，从而可以使得血液进入和充盈变形薄膜 2 的内面与示导体 1 下面之间的腔隙，从示导体 1 的外侧观察面看时进入凹槽 4 的血液显示为线条状图案；同时，扩散进入变形薄膜 2 的内面与示导体 1 下面之间的腔隙的血液显示为片状扩散分布图案，两个图案同时存在；对于软连管结构的实施例，血液只进入静脉穿刺针管 11 后部的软连管 19 的官腔中，此时判断为静脉穿刺针管 11 的针尖部已经进入血管的管腔中，静脉穿刺成功，实现了第一步骤，流程 301。

第二步骤是实现“负压”含义的形态显示：将试管穿刺针管 13 接插进入真空试管的内部，判断真空试管内部是否存在真空。具体是当试管穿刺针管 13 接通真空试管时,由于真空试管内真空的抽吸作用将采血针内的血液包括凹槽 4 中的和扩散进入变形薄膜 2 的内面与示导体 1 下面之间的腔隙中的血液吸出，使得原来充盈扩散呈片状分布的血液形态消失，只显示凹槽 4 内的血液通路的形态，从示导体 1 的外侧观察面看时仅仅呈线条形态，同时变形薄膜 2 则呈现为紧密贴合于示导体 1 的下面和凹槽 4 的口部；在软连管的实施例中则直接显示示导体 1 观察面呈线条形态和变形薄膜 2 则呈现为紧密贴合于示导体 1 的下面和凹槽 4 的口部，此时判断为真空试管内存在真空并开始抽吸血液进入真空试管，实现了第二步骤，流程 302。

在操作过程中如果接通真空试管后，原来扩散呈片状分布的血液形态不消失或变形薄膜 2 未呈现为紧密贴合于示导体 1 的下面和凹槽 4 的口部，则提示真空试管内无负压存在，不能抽血。

第三步骤是实现“平衡”含义的形态显示：待真空试管抽吸血液完成后，显示血管内腔的血压与真空试管内的压力处于平衡状态，判断为采血完毕。具体是当接通的真空试管吸入血液后,试管内的真空度逐渐减小直至完全消失并逐步再升高达到血管中的正压力，在此阶段，变形薄膜 2 则由原来紧密贴合于示导体 1 下面和凹槽 4 口部的状态逐渐松弛并再次向外膨胀，血液也再次从变形薄膜 2

的内面与示导体1的下面之间的腔隙由中心向周围逐渐膨胀扩散，从示导体1 的外侧观察面看时原有真空状态所呈现的线条状图案逐渐再次显现呈片状扩散分布图案并与原有的凹槽4的线条图案并存，此时判断为真空试管内的真空消失，采血完成，实现了第三步骤，流程303。

本发明实现了在任何失误操作时均可以保障带有污染试剂的试管内血液不可以反流进入人体血管的安全性目标，克服了现有产品的严重缺陷。

本发明实现了还不同阶段的示导器内部的压力对应特定血液扩散或收缩的视觉形态，给予操作人员明确的各采血阶段的状态提示和可能出现的问题的简单提示及原因判断，更快速可靠统一性地指导操作，提高采血效率，最重要的是建立了以器械为提示和判断依据的统一的操作模式，提高了试剂与血液配比的精确性和检测的准确性。

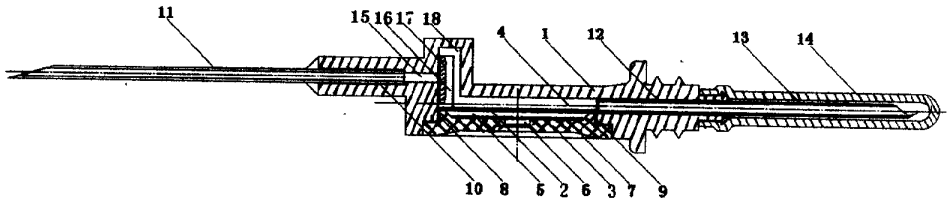

11
15 16 17 18
4
1
12
13
14
10 8 5 2 6 3 7 9

图 1

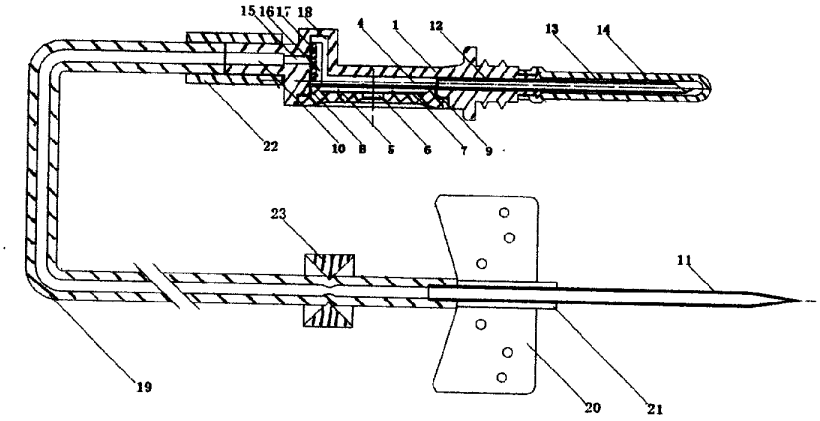

15 16 17 18
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21

图 2

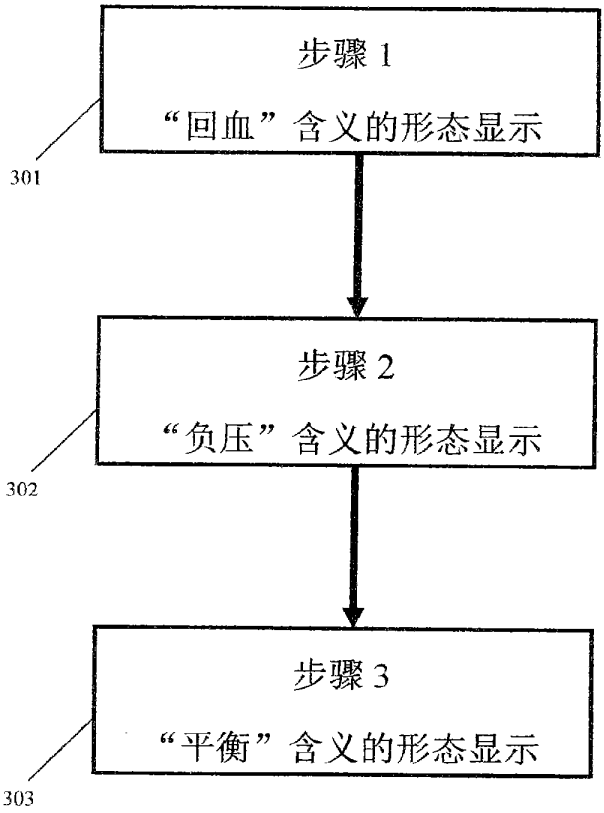


图 3

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Closed Blood Conservation Device for Reducing Catheter-Related Infections in Children After Cardiac Surgery

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Abstract

Background Arterial catheters are potential sources of nosocomial infection.

Objective To investigate use of a closed blood conservation device in preventing catheter-related bloodstream infections in children after cardiac surgery.

Methods Children with an indwelling arterial catheter after cardiac surgery were randomly assigned to 2 groups: a control group with a conventional 3-way stopcock in the catheter system and an interventional group with the conservation device in the catheter system. Catheter tips, catheter intraluminal fluid, and blood samples obtained from the catheter and peripherally were cultured for microbiological analysis. RESULTS Intraluminal fluid contamination was significantly lower (P = .03) in the interventional group (3 of 147 catheters) than in the control group (10 of 137 catheters). The 2 groups did not differ significantly in the rate of tip colonization (9 of 147 vs 12 of 137, P = .40) or in the number of catheter-related bloodstream infections (0 of 147 vs 2 of 137, P = .21).

Conclusion Use of a closed blood conservation device could decrease the incidence of catheter-related contamination of intraluminal fluid.

This article has been designated for CNE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. Describe closed blood conservations devices
2. Identify the key findings of the study and implications on preventing catheter-related bloodstream infections in pediatric patients
3. Discuss the indications for use in the pediatric intensive care unit

Arterial catheters are routinely used in critically ill patients for continuous monitoring of arterial blood pressure and for obtaining blood samples for arterial blood gas analysis. Catheter-related bloodstream infections (BSIs) are a common and serious complication of intravascular catheters and are associated with increased morbidity, mortality, length of hospital stay, and medical costs.[1–5] Although previous studies[6–8] indicated a low risk for infections associated with use of arterial catheters, recent studies[9–11] showed that the risk for arterial catheter–related infection was high, comparable to the risk associated with short-term use of central venous catheters. Compared with adult patients, children are more susceptible to nosocomial infection, and catheter-related BSI is considered the most common nosocomial infection in pediatric intensive care units (PICUs).[12] Prevention of catheter-related BSI in PICU patients with multiple intravascular catheters has become a top priority.

Catheter-related BSI is the most common nosocomial infection in PICUs.

Unlike central venous catheters, arterial catheters have an open-loop design that allows backflow of blood into the pressure tubing. This backflow and frequent blood sampling are now considered the 2 major causes of catheter-related BSI.[13–15] Keeping the arterial catheter system closed could be an effective method to decrease the risk of catheter-related BSI. Several investigators have reported that the risk for blood contamination could be minimized for both central venous[14,16–18] and arterial[13,19] catheters in adult patients when closed-loop systems were used.

The venous arterial blood management protection (VAMP) device (Edwards Lifesciences Corporation) is a needleless closed-loop blood sampling system. The device has been introduced into clinical practice to eliminate discarding of blood during blood sampling.[20] Besides reducing blood loss, use of a VAMP device may also reduce the risk for catheter-related BSI by keeping the arterial catheter system closed. Oto et al[21] reported that the risk for contamination of intraluminal fluid in adult patients could be decreased by adding a VAMP device to the arterial catheter system. However, the potential benefit of using this type of device to prevent catheter-related BSI in children is still not well recognized. The objective of our study was to investigate the effect of a VAMP device in reducing the occurrence of catheter-related BSI in children after cardiac surgery.

Materials and Methods

Setting and Sample

The study was approved by the appropriate ethical committee, and informed written consent was obtained from patients' parents. The study sample consisted of children who had undergone open heart surgery and were admitted to the PICU. Patients were included if they were less than 12 years old, were expected to stay more than 48 hours in the PICU, and had an arterial catheter inserted. Patients were excluded if they were expected to stay less than 48 hours or die during the study period, had an apparent infection before admission to the PICU, had the arterial catheter removed within 48 hours of surgery, or had confirmed diagnosis of non–catheter-related infection (eg, pulmonary or surgical site infection). All arterial catheters were inserted in the operating room or reinserted in the PICU. Aseptic technique was used for all insertions, and all patients received prophylactic antibiotics for 48 hours after surgery.

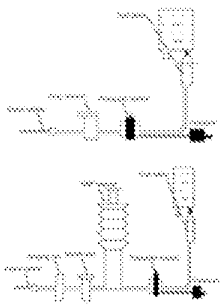
Samples and Randomization

A 2-sided test for randomized control trials indicated that for 80% power and $\alpha = .05$, a sample size of at least 130 patients in each group was needed. During the study period, each patient was randomly allocated to 1 of 2 groups by using a sealed-envelope method. The control group had a conventional 3-way stopcock system in the catheter, and the interventional group had a VAMP Plus device in the catheter. Both groups were followed up until removal of the arterial catheter, discharge from the PICU, or death.

The Figure shows the components of the blood sampling systems in the 2 groups. In the control group, the heparin cap of the 3-way stopcock was removed and a sterile syringe was inserted into the stopcock port after the port was cleaned with iodine swabs. After about 5 mL of blood was obtained, the first syringe was removed and another sterile syringe was inserted into the stopcock port for obtaining the required amount of blood. Then, the 5 mL of blood in the first syringe was injected back into the patient through the arterial catheter, and the stopcock port was cleaned again with iodine swabs. Finally, a new sterile heparin cap was reconnected to the 3-way stopcock, and the mixture of heparin and physiological saline in the flush device was infused into the arterial catheter system. Throughout the entire process, the heparin cap was off, leaving the 3-way stopcock port open to the outside. Also, 2 sterile syringes were needed, and blood obtained with the first syringe was injected back into the patient.

Figure

Schematic diagrams of the conventional 3-way stopcock arterial catheter system (top, control group) and the venous arterial blood management protection (VAMP, Edwards Life-Sciences) system (bottom, VAMP group). In



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the conventional 3-way stopcock system, key components are an arterial catheter, a 3-way stopcock capped with a sterile heparin cap, a pressurized reservoir, a transducer, and a continuous flush device containing a solution of heparin (6.25 IU/mL) in physiological saline. In the VAMP system, the 3-way stopcock is replaced by a VAMP device, a needleless closed-loop blood-sampling system, including a sampling port, a shutoff valve, and a closed-loop blood reservoir.

In the VAMP group, the inner cylinder of the blood reservoir was pulled back until blood passed the sample port and filled half of the blood reservoir, and then the shutoff valve was closed. The sampling port was disinfected twice with iodine swabs, an arterial blood collection syringe (Becton, Dickinson and Company) with an attached blood collection cap (VMP400, Edwards Life-sciences Corporation) was inserted into the sampling port, and the required blood sample was obtained. After collection of the blood sample, the syringe was removed and the sample port was disinfected with iodine swabs. Finally, the shutoff valve was opened, and the blood in the reservoir and the mixture of heparin and physiological saline in the flush device were reinjected into the patient. Throughout the entire process, no parts of the arterial catheter system were removed and the system was completely closed.

During the study period, each patient had an arterial catheter device in place for at least 48 hours. The heparin-saline solution in the flush device was replaced every 24 hours. Other components of the systems (including transducer, continuous flush device, and the tubing) were replaced at 96-hour intervals.[22] All medical personnel were strictly trained in the blood-sampling procedure and routine care of the arterial catheter system. The arterial catheter was removed if it was no longer necessary, the patient had signs of catheter-related BSI, or complications related to use of the catheter occurred.

Keeping the arterial catheter system closed is an effective method of decreasing the risk of catheter-related BSI.

Microbiological Analysis

The differential time to positivity between cultures of blood from the catheter and cultures of peripheral blood is a simple and reliable tool for diagnosis of catheter-related BSI.[23] Samples of blood from the arterial catheter and samples of peripheral blood were cultured simultaneously when a patient's temperature was greater than 38.5°C (101.3°F) and were monitored continually. A diagnosis of catheter-related BSI was made when cultures of the catheter blood became positive for microbial growth 2 hours earlier than did cultures of peripheral blood and cultures of both samples had the same microorganisms.

Arterial catheter tips were cultured after removal of the catheters. A 5-cm segment of the catheter (or the entire short catheter) was placed into a sterile tube and cultured by using a roll plate technique.[24] Colonization of a tip was defined as a growth of 15 or more colony-forming units in a semiquantitative culture.

Intraluminal fluid from both arterial catheter systems was also cultured. After aseptic removal of the arterial catheter, sampling port, and transducer, a sterile syringe containing 10 mL of sterile physiological saline was inserted at the proximal connection of the transducer, and the saline was injected into the arterial catheter. In the catheters with the VAMP device, the 10 mL of saline was also used to flush the VAMP reservoir. Finally a 10-mL aliquot of the mixture of saline and intraluminal fluid was drained into a sterile culture bottle and cultured in trypticase soy broth for 7 days at 37°C (98.6°F). The cultures were examined daily; if the broth was cloudy, standard laboratory subculturing was performed.

Data Collection

Patient demographic data included age, sex, and score on the Acute Physiology and Chronic Health Evaluation II at PICU admission. Data on the arterial catheters included the location of the catheter, date of insertion, site of any reinsertion, and final date of removal. Data on cultures of catheter tips, intraluminal fluid from the catheter, and samples of blood obtained simultaneously from the catheter and peripherally also were noted.

Statistical Analysis

Statistical analysis was performed by using SPSS, version 16.0 (IBM SPSS). Quantitative variables were expressed as means and standard deviations unless stated otherwise and were compared by using a *t* test or the Mann-Whitney test. Categorical data were compared between groups by using χ^2 analysis or the Fisher exact test. Logistic regression analysis was used to evaluate the direct relationship between arterial catheter–related infection and patients' demographic or catheter characteristics. A bidirectional hypothesis was applied, and a *P* less than .05 was considered significant.

Results

Characteristics of the Patients and the Arterial Catheters

From March 2010 to December 2012, 260 children were enrolled in the study. A total of 12 patients were excluded because of death (3 patients), confirmed pulmonary infection (7 patients), or removal of the arterial catheter within 48 hours after surgery (2 patients). The final sample consisted of 248 children and 284 placements of an arterial catheter. The VAMP group included 128 patients with 147 arterial catheters inserted. The control group consisted of 120 patients with 137 arterial catheters inserted. The median duration of insertion for both groups was 7 days. The 2 groups did not differ significantly in age, sex, score on the Acute Physiology and Chronic Health Evaluation II, insertion site of the arterial catheter, and length of time the catheter was in place (Table 1).

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Table 1

Basic characteristics of patients in the venous arterial blood management protection (VAMP) and control groups

Microbiological Analysis

Intraluminal fluid contamination was significantly lower (*P*=.03) in the interventional group (3 of 147 catheters) than in the control group (10 of 137 catheters). The 2 groups did not differ significantly in the rate of colonization of the catheter tip (9 of 147 vs 12 of 137; *P*=.40) or in the number of catheter-related BSIs (0 of 147 vs 2 of 137; *P*=.21; Table 2). Logistical regression analysis indicated that the incidence of colonization of the catheter tip was significantly related to both the length of time the catheter was in place (odds ratio, 0.737; 95% CI, 0.580–0.936; *P*=.01) and the score on the Acute Physiology and Chronic Health Evaluation II (odds ratio, 0.879; 95% CI, 0.781–0.989; *P*=.03). Contamination of intraluminal fluid was also significantly associated with the length of time the catheter was in place (odds ratio, 0.506; 95% CI, 0.350–0.731; *P*<.001), and use of the VAMP device was a strong predictor of a decrease in the risk for contamination of intraluminal fluid (odds ratio, 0.069; 95 CI, 0.013–0.592; *P*=.01; Table 3).

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Table 2

Results of microbiological analysis of the 2 types of arterial catheter systems

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Table 3

Risk factors associated with the occurrence of catheter tip colonization and intraluminal fluid contamination

Microorganisms Identified

In the VAMP group, all colonization of catheter tips and contamination of intraluminal fluid was caused by coagulase-negative staphylococci. In the control group, various species of microorganisms were detected, but coagulase-negative staphylococci were still the most common bacteria found in the arterial catheter systems. Table 4 indicates microorganisms identified for each group.

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Table 4

Results of microbiological analysis of the 2 types of arterial catheter systems

Discussion

Arterial catheters are commonly used for hemodynamic monitoring and for collecting samples of arterial blood. Previously, the risk for infection associated with use of arterial catheters was considered low.[6–8] The 2002 guidelines[22] of the Centers for Disease Control and Prevention even commented that arterial catheters had a "low infection risk" and were "rarely associated with bloodstream infection." However, in a prospective study[25] of 212 intensive care unit patients with placement of both arterial and central venous catheters, the cumulative incidence of catheter-related BSI for arterial catheters was 7.7%, comparable to an incidence of 9.4% for central venous catheters (P=.45). Several studies[9–11] confirmed that risk for infection associated with arterial catheters was similar to the risk associated with central venous catheters. Thus, prevention of catheter-related BSI has become an important issue in medical practice. Effective methods to minimize the risk of arterial contamination or infection include use of a rigorous aseptic technique for placement of the catheter, selection of an optimal site for the catheter, prompt removal of any unnecessary catheter, and keeping the catheter system closed.[13,19,21,26]

Coagulase-negative staphylococci are the most common bacteria found in arterial catheter systems.

Unlike adult patients, children in the intensive care unit are more susceptible to nosocomial infection. Because most studies[13,21] on catheter-related BSI were done in adults, we investigated the effect of using a VAMP device in the management of critically ill children. Although we found no significant difference between the VAMP group and the control group in colonization of catheter tips or occurrence of catheter-related BSI, contamination of intraluminal fluid was significantly lower in the group with the VAMP device. This result is similar to the findings of Oto et al[21] and Crow et al.[13] Oto et al found that catheter-related contamination of intraluminal fluid decreased from 8.4% for an arterial catheter system with a conventional 3-way stopcock to 1.8% when an arterial catheter with a VAMP device was used (P=.03). Crow et al reported that the incidence of contamination of intraluminal fluid was lower with a closed blood-sampling system (7%) than with a 3-way stopcock system (61%).

As mentioned earlier, frequent opening of the arterial catheter system for blood sampling and backflow of blood into the pressure tubing are 2 important causes of catheter-related BSI.[13–15] When the conventional 3-way stopcock system is used, frequent acquisition of blood samples through the open arterial catheter system, reinjection of blood into the artery, and the inevitable presence of residual blood within the stopcock port could lead to a high risk for microbial contamination of the catheter. In contrast, an arterial catheter system with a VAMP device is a completely closed infusion system. No part of the VAMP system must be opened when a blood sample is obtained, so no pathway exists for transfer of microorganisms to intravascular fluid

Although microbial contamination of intraluminal fluid was significantly lower in the VAMP group than in the control group in our study, use of the VAMP system did not decrease the incidence of colonization of catheter tips. This result agrees with the findings of Oto et al,[21] who observed no significant difference (P=.48) in the rate of colonization of catheter

tips: 7.3% in the test group and 10.3% in the control group. We can only speculate that the reason for this result in our study is the short length of time the catheters were in place and a relatively low rate of colonization of catheter tips. Researchers[7,27,28] have reported that colonization of catheter tips may be more closely related to the insertion site of the arterial catheter and the length of time the catheter is in place than to the catheter system. In our study, further logistic regression analysis indicated that the length of time the catheter was in place was an important factor in the colonization of catheter tips, and we found no significant difference between the 2 groups in the length of time the catheter was in place. Meanwhile, the rate of colonization of catheter tips in our study was relatively low. In a study by Thorpe and Thomas,[29] the contamination rate was higher than the rate in our investigation for both a blood conservation system (30%) and a traditional 3-way stopcock system (37%). Infections of short-term catheters (those in place <10 days) are due mainly to microbial colonization of the skin around the insertion site.[21] In our study, the microorganisms detected on the catheter tips (median time in place, 7 days) in both groups were mostly coagulase-negative staphylococci, organisms primarily found on the skin.

The occurrence of catheter-related BSI for arterial catheters did not differ significantly between the 2 groups in our study. We identified 2 instances of catheter-related BSI in the control group and no instances in the VAMP group. Although no conclusion can be made about the direct effect of a VAMP device in preventing catheter-related BSI in arterial catheter systems, we speculate that use of a VAMP device could lower the risk for catheter-related BSI in children. Because of the unique closed-loop design, use of a VAMP device has obvious advantages in children, especially children who have had heart surgery who require repeated blood sampling and continuous blood pressure monitoring. Use of a VAMP device could prevent microbial contamination of intraluminal fluid and save the blood normally discarded when blood samples are obtained for blood gas analysis. Because children, especially infants, are more susceptible than adults to nosocomial infections such as catheter-related BSI in the intensive care unit,[12,30,31] a small step forward in preventing catheter-related BSI could be highly beneficial for patients in the PICU. Our results did not directly prove the effect of a VAMP device in reducing catheter-related BSI in children after cardiac surgery, but the VAMP device could be still used as part of "bundle care" for use of intravascular catheters to minimize the risk of catheter-related contamination.

The VAMP device could be used as part of "bundle care" for use of intravascular catheters to minimize the risk of catheter-related contamination.

Limitations

Our investigation had several major limitations. First, the study was done at a single center and with a limited study cohort. Further large-scale, well-designed, randomized control trials are needed to verify the validity of our results. Second, although we tried to ensure equal treatment of both groups with the blood-sampling technology and routine care, physicians and nurses were aware of the device, and they might have been more careful or cautious with patients in the VAMP group. In addition, with the semiquantitative method described by Maki et al,[24] only the external surface of a catheter tip is sampled, and the VAMP device might prevent internal colonization better than it prevents external colonization because the device forms a closed system. The quantitative catheter segment culture technique reported by Cleri et al[32] might be a more suitable method for investigating the effect of a VAMP device on colonization of catheter tips.

Conclusion

In conclusion, compared with the conventional 3-way stopcock device, use of a VAMP device could decrease the incidence of arterial catheter–related contamination of intraluminal fluid. The VAMP device may be an effective method of preventing catheter-related BSI in the PICU. CCN

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Footnotes

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To learn more about reducing the risk for catheter-related infections, read "Simulation-Based Training for Nurses in Sterile Techniques During Central Vein Catheterization" by Gerolemou et al in the *American Journal of Critical Care*, January 2014;23:40–48. Available at **www.ajcconline.org**.

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The scope of the claims open —

(57) [Claims]
[Claim 1]
A blood isolation device comprising
an inlet port, an

outlet port, an

isolation chamber and a sampling channel, wherein each of the isolation chamber and the sa mpling channel has an isolation chamber connected to the inlet port via a bifurcation, the isol ation chamber having a vent containing an air permeable blood barrier, and the sampling chan nel having a distal end connected to the outlet port; a sampling channel, and a housing contai ning

and defining the inlet port, the outlet port, the isolation chamber, and the sampling channel, wherein the isolation chamber, the sampling channel, and the bifurcation point are connecte d to the flow of blood. A first portion of blood flows into the isolation chamber toward the air p ermeable blood barrier for sequestration within the isolation chamber and a second portion of the blood flows into the isolation chamber and the blood isolated within the isolation chamber. A blood isolation device sized and configured to bypass the first portion and direct the samplin g channel toward the outlet port. 2. A blood isolation device, comprising: an inlet port;

an isolation chamber having an exit port,

a vent containing an air permeable blood barrier, a sampling channel

having a distal end connected to said exit port, said

entrance port, said exit port, said isolation chamber, and said a housing containing and defini ng a sampling flow path

,

each of said isolation chamber and said sampling flow path being connected to said inlet port via a bifurcation point, said bifurcation point connecting said first portion of blood to said isola tion fluid; a second portion of blood flowing into the chamber to expel air in the isolation cha mber through the air permeable blood barrier and to be isolated in the isolation chamber; a bl ood isolation device sized and configured to bypass the first portion of the blood that has been drawn and directed into the sampling flow path toward the outlet port.

3.

The blood isolation device of claim 1, wherein the air permeable blood barrier comprises an air permeable material that at least partially seals upon contact with blood.

4.

The blood isolation device of claims 1 or 2, wherein the isolation chamber includes an isolati on channel defined within the housing.

5. The housing

includes a lower member mating with an upper member, each of said lower member and sai d upper member being associated with each of said inlet port, said outlet port, said isolation c

hamber and said sampling channel. 4. A blood isolation device according to any one of claims 1 to 3, which defines part of a

6.

A blood isolation device connected to a blood collection path having a patient needle and a sample collection device, comprising:

an inlet port connected to the patient needle,

an isolation chamber and a sampling channel, wherein each of the isolation chamber and the sampling channel is connected to the inlet port through a branch point, and the isolation chamber is air permeable a vent including an air permeable blood barrier, the isolation chamber and the bifurcation configured to direct a first portion of blood into the isolation chamber toward the air permeable blood barrier; Having a distal end connected with an outlet port, the sampling channel and the branch point bypass the isolation chamber and the first portion of the blood with the second portion of blood isolated within the isolation chamber. , an isolation chamber and a sampling channel configured to allow the sampling channel to be directed toward the outlet port, the outlet port being connected with the sample-collecting device

;

A blood isolation device comprising a housing containing and defining an outlet port, said isolation chamber, and said sampling flow path .

7.

A blood isolation device connected to a blood collection path having a patient needle and a sample collection device, wherein an

inlet port connected to the patient needle and

an outlet port connected to the sample collection device;

an isolation chamber having a vent containing an air permeable blood barrier; a sampling channel

having a distal end connected to said outlet port;

said inlet port, said outlet port, said isolation chamber and said sampling channel; a housing containing and defining

;

Each of the isolation chamber and the sampling channel are connected to the inlet port via a branch point, the junction allowing a first portion of blood to flow into the isolation chamber and through the air permeable blood barrier to the isolation chamber. to expel the air inside and into the isolation chamber

allowing a second portion of blood to be sequestered, bypassing said isolation chamber and a first portion of said blood isolated within said isolation chamber, towards said outlet port and said sampling device; A blood isolation device sized and configured to allow it to be directed into a tract.

8.

A blood isolation device according to claim 6 or 7, wherein said entry port is connected to sai

d patient needle through said first portion of said blood collection path.

9.

A blood isolation device according to any one of claims 6 to 8, wherein said outlet port is con nected to said sample collection device via a second portion of said blood collection pathway.

10.

The blood isolation device of claim 6 or 7, wherein said air permeable blood barrier comprise s an air permeable material that at least partially seals upon contact with blood.

11.

The blood isolation device of claim 6 or 7, wherein said isolation chamber includes an isolatio n channel defined within said housing.

12. The blood isolation of claim 11,

wherein said isolation channel has a proximal end connected with said inlet port and a distal end with said vent containing an air permeable blood barrier. Device.

13. A

body fluid isolation device, comprising

an inlet port,

an outlet port connected to said inlet port, and an

isolation chamber connected to said inlet port via a branch point, wherein said air permeable body fluid barrier comprises: an isolation chamber having a vent containing

a housing containing and defining the inlet port, the outlet port, and the isolation chamber,

wherein the isolation chamber and the junction direct a first portion of bodily fluid from the i nlet port to the air permeable bodily fluid barrier; The air permeable bodily fluid barrier compr ises an air permeable material that forms a barrier to bodily fluids upon contact with bodily flu ids, such that contact with bodily fluids results in an increase in air flow within the isolating ch ambers. and a second portion of bodily fluid from the inlet port to the outlet port through the bifurcation bypasses the isolation chamber and the first portion of the bodily fluid. Become a b ody fluid isolation device.

14. A

body fluid isolation device, comprising

an inlet port,

an outlet port connected to said inlet port, and an

isolation chamber connected to said inlet port via a branch point, wherein said air permeable body fluid barrier comprises: and a housing containing and defining said inlet port, said outlet port, and said isolation chamber , said isolation chamber and said branch point

being adapted for a first flow of bodily fluid from said inlet port. configured to direct one po rtion toward said isolation chamber toward said air permeable body fluid barrier, said air perm eable body fluid barrier comprising an air permeable material that forms a barrier to body flui ds upon contact therewith, such that: Formation of the barrier permits isolation of a first porti

on of bodily fluid within the isolation chamber and allows a second portion of bodily fluid from the inlet port to pass through the junction toward the outlet port and into the isolation chamb er and into the isolation chamber. A bodily fluid isolation device configured to allow a first port ion of the bodily fluid to be bypassed.

15.

The body fluid isolation device of claim 13 or 14, wherein the air permeable body fluid barrie r comprises an air permeable material that seals upon contact with body fluids.

16.

A body fluid isolation device according to claim 13 or 14, wherein said isolation chamber incl udes an isolation channel defined within said housing.

17. The method according to claim

13 or 14, further comprising a blood collection path connected to said inlet port, said blood c ollection path conveying a second portion of said body fluid from said inlet port to said outlet port through said branch point. A bodily fluid isolation device as described.

18. The housing

includes a lower member mating with an upper member, the lower member and the upper m ember each defining a portion of each of the inlet port, the outlet port and the isolation cham ber. 15. A body fluid isolation device according to claim 13 or 14, wherein

19. A body fluid isolation device according to claim 13 or 14,

further comprising .

20. The housing

includes a lower member mating with an upper member, each of said lower member and sai d upper member being associated with each of said inlet port, said outlet port, said isolation c hamber and said sampling channel. 20. A bodily fluid isolation device according to claim 19, w hich defines a portion of a.

21.

A blood isolation system comprising:

a blood collection path having a patient needle and a sample collection device; and a

blood isolation device

, said blood isolation device comprising:

an isolation chamber having an inlet port connected to the patient needle; an

outlet port connected to the sample collection device; an

isolation chamber having a vent containing an air permeable blood barrier; and a

distal end connected to the outlet port. a sampling channel, and a housing containing

and defining said inlet port, said outlet port, said isolation chamber, and said sampling chann el, said isolation chamber and said sampling channel each diverging through said branch poi nt. Connected with an inlet port, the junction allows a first portion of blood to flow into the iso

lation chamber, expel air within the isolation chamber through the air permeable blood barrier, and be sequestered within the isolation chamber. and a second portion of blood bypasses the i solation chamber and the first portion of the blood isolated within the isolation chamber and is directed into the sampling channel toward the exit port and the sample collection device. A bl ood isolation system sized and configured to enable. 22. The blood isolation system of claim 2 1 , wherein said entry port is connected to said patient needle through said first portion of s aid blood collection path. 23. The blood isolation system of claim 21 , wherein said exit port i s connected to said sample collection device via a second portion of said blood collection path way. 24. The blood isolation system of claim 21, wherein said air permeable blood barrier co mprises an air permeable material that at least partially seals upon contact with blood. [Claim 25]

25. The blood isolation system of Claim 24, wherein the isolation chamber includes an isolati on channel defined within the housing. 26. The blood isolation of claim 25, wherein said isola tion channel has a proximal end connected with said inlet port and a distal end with said vent containing an air permeable blood barrier

.

system.

detailed description open —

Description:

CROSS -REFERENCE TO RELATED APPLICATIONS This application is entitled "Blood Sample Op timization System and Blood Contaminant Isolation Apparatus and Method," filed on Apr. 27, 2016

. U.S. Nonprovisional Application No. 15/140,443, entitled "Blood Sample Optimization Syste m and Blood Contaminant Isolation Apparatus and , 448, and both of these U.S. nonprovision al applications are U.S. Provisional 62/196,797, U.S. Provisional Application No. 62/ 238,636 e

ntitled "Blood Isolation System for Clean Blood Collection," filed Oct. 7, 2015; No. 62/318,194, entitled "Blood Sample Optimization System and Blood Contaminant Isolation Apparatus and Method," filed herein, the disclosure of which is incorporated herein by reference in its entirety. shall be included in the Bacteremia is the presence of microorganisms in the blood. Sepsis, on the other hand, is bacteremia with clinical symptoms and signs such as fever, tachycardia, tachypnea and hypotension. Bacteremia and sepsis are associated with high mortality, hospitalization incidence and length of stay and associated costs. many bacteremia

, sepsis, fungemia, and other pathogens do occur in hospitals or other health care facilities, and
catheters and venipunctures are sources of contamination as potential carriers of these pathogens.

[0003] Blood cultures are the standard test used
to detect microbial pathogens associated with bacteremia and sepsis in the blood of patients
.
The term blood culture refers to a single venipuncture from a peripheral site or central or arterial line in which blood is inoculated into one or more blood culture bottles
or vessels
. One bottle is considered one blood culture and two or more are considered a set. Multiple sets are obtained from multiple venipunctures and are associated with different sites in the patient.

[0004]
Although these methods enable microbial identification and susceptibility testing, which are important factors in the management of sepsis, their

lack of rapid results and low sensitivity to nasty pathogens pose challenges for improvement . This has .

[0005]

The collection of blood samples for blood culture is an important component of modern patient care, both positively impacting patient outcome by providing an accurate diagnosis and eliminating unnecessary antibacterial treatments. It can also adversely therapy affect .

One consequence of blood culture collection is contamination. Contamination of blood cultures can lead to false positive culture results and and/or significantly increase healthcare-related costs. Sources of blood culture contamination include inadequate skin disinfection, inadequate collection tube disinfection, and contamination of the initial blood draw, which can skew results. Blood culture collection kits generally include a "butterfly" set, infusion set, or other type of venipuncture device provided and an aerobic

It consists of a blood culture bottle and an anaerobic blood culture bottle. A variety of different bottles are also available depending on inspection requirements . These bottles are specially designed to optimize the collection of both aerobic and anaerobic organisms. In conventional kits, the bottle used is commonly known as a "vacutainer", which is used to create a vacuum inside the tube to facilitate the collection of a predetermined amount of liquid, such as blood. A blood collection tube formed from a sterile glass .

False positive blood cultures are generally the result of poor sampling techniques. They cause antibiotics to be used when they are not needed, increasing hospital costs and patient anxiety. Blood cultures are taken from a needle prick into the skin, after which a Vacutainer® . Contamination can result from improper or . It can also result from the piercing of the skin by the needle during insertion, which draws pierced skin cells and associated contaminants into the sample . [0009] Blood flow through a hypodermic needle is laminar, which causes a flow velocity gradient across the flow tube when . Strong aspiration of the blood or use of a very small hypodermic needle causes lysis and

release of potassium from the red blood cells, thereby obtaining a blood sample.

The pull may become abnormal.

[0010]

In another example, some patients have delicate veins which are subject to pressure drop or for the patient's condition. Can collapse under vacuum. Such venous collapse is dangerous and very difficult to control because such a condition cannot be known in advance . Various strategies have been implemented to reduce the contamination rate of blood cultures, such as staff training in sterile collection techniques , feedback on contamination rates, and the introduction of blood culture collection kits . Skin antisepsis can reduce contamination concerns, but more than 20% of skin microbes are located deep in the dermis and are not affected by antisepsis. Changing needles prior to bottle inoculation is not recommended as it increases the risk of needlestick injuries without reducing contamination rates. [0012] Some conventional systems and techniques for reducing contamination of blood cultures involve discarding the initial aliquot of blood taken from central venous catheters, venous punctures and other vascular access systems. . However, these systems either require the user to mechanically manipulate the intravascular device or require a complicated series of steps that are difficult to ensure. SUMMARY OF THE INVENTION [Problem to be Solved by the Invention]

The present specification presents systems

and . In some implementations, the systems and methods can eliminate variability in user disi nfection
and also eliminate the risk of skin cells entering blood culture samples. Other than potentially indicating when to attach a Vacutainer® or other blood collection device (i.e., a syringe) to ob tain a contaminant-free blood sample, the systems and methods disclosed
herein are does not require changes to existing clinical processes. [0014] In some implemen tations of the systems and methods disclosed herein, blood sampling is accomplished passivel y through the use of the patient's own blood pressure, thereby reducing the risk of venous ru pture and reducing current practice. Eliminates additional user steps beyond duties. The syste m and method can be adapted to suit short-path direct puncture or butterfly venipuncture sys tems. catheter

It can also be used with samples taken through the tube.
SUMMARY OF THE INVENTION In
one
aspect, a blood isolation device is presented. A blood isolation device includes an inlet port a nd an outlet
port . The blood isolation device further includes an isolation chamber connected to the inlet p ort, the
isolation chamber having a vent including an air permeable blood barrier. The blood isolation device
further includes a sampling channel having a proximal end connected with the inlet port and a distal end connected with the outlet port.
[0016]
In another aspect, a blood isolation device is described that is connected to a blood collectio n path. The blood collection path has a
patient needle and a sample collection device. The blood isolation device includes an entry por t connected to the patient needle and an
isolation chamber connected to the entry port, the isolation chamber having a vent including a n air permeable blood barrier
. The blood isolation device further includes a sampling channel having a proximal end connec ted to the inlet port
, and an outlet port connected to the distal end of the sampling channel and the sample collec

tion device . [0017] In yet another aspect, a blood isolation device is described that interfac es with a blood collection system. The blood collection system includes a patient needle for all owing a blood sample to be drawn from a patient and a sample needle that is sealed and adap ted to receive an evacuated blood collection tube. A blood isolation device includes an inlet po rt connected to a patient needle for receiving a blood sample from . blood isolation device

The device is an isolation
chamber isolating an initial
portion of the blood sample before the sample needle is unsealed by the evacuated blood coll ection tube. further includes an isolation chamber for The blood isolation
device
further includes a sampling channel having a proximal end connected to the inlet port, the sa mpling channel carrying a subsequent portion of the blood sample when the sample needle is opened by the evacuated blood collection tube. . The blood isolation device further includes an exit port connected
with the distal end of the sampling channel for carrying subsequent portions of the blood sam ple to the sample needle . [0018] In yet another aspect, a blood sample optimization system is disclosed and described. The blood sample optimization system includes a blood collection s ystem for enabling and obtaining one or more samples of a patient's blood, a blood collection system for potentially contaminated by the venipuncture process and a false pathogen in the patient's blood. a blood isolation device for receiving and isolating an initial portion of one or more samples of patient blood that may result in a positive identification . A blood collection s ystem includes a patient needle configured for venipuncture of a patient to enable withdrawa l of a sample of the patient's blood , a blood collection channel connected to the patient needl e for carrying the blood sample, and a blood sample. a sample needle configured to receive th e evacuated blood collection container for withdrawing and containing a subsequent portion of the sample . [0020]

In yet another aspect, a blood isolation device is disclosed and described. In some implementations, a blood isolation device can include an
inlet port, an outlet port connected to the inlet port, and an isolation chamber connected to the inlet port . The isolation chamber can have a vent
containing an air permeable blood barrier . A blood isolation device is connected along the blood collection path between the patient needle and the sample needle and includes an entry port for receiving a blood sample . A blood isolation device is an isolation chamber connected with an inlet port for receiving and an air permeable blood barrier to isolate at least a first portion of the initial volume of blood sample. further comprising an isolation chamber having a vent containing a . The blood sequestration device is a sampling , the sequestration chamber receiving at least a first portion of an initial volume of blood sample.

Further includes a sampling channel that, when isolated, conveys subsequent amounts of the blood sample to the evacuated blood collection container.
The blood isolation device further includes an outlet port connected to the distal end of the sampling channel for outputting a subsequent volume of blood
sample . The details of one or more embodiments are set forth in the accompanying drawings and the description below
.
Other features
and advantages will be apparent from the specification and drawings, and from the claims.
BRIEF DESCRIPTION OF THE DRAWINGS
[0023]
These and other aspects will now be described in detail with reference to the following drawings.
1 shows a blood sample optimization system; FIG.

FIG. 2 shows a blood sample optimization system according to an alternative implementation;
FIG. 3 shows a blood sample optimization system according to another alternative implement ation;
FIG. 4 shows a blood sample optimization system according to another alternative implement ation;
FIG. 5 shows a blood sample optimization system according to another alternative implement ation;
FIG. 6 shows a blood sample optimization system according to an alternative implementation;
FIG. 7 is a flowchart of a method for optimizing blood culture quality;
FIG. 8A illustrates a blood isolation system for non-contaminated blood collection, according t o some implementations;
FIG. 8B illustrates a blood isolation system for clean blood collection, according to some imple mentations.
FIG. 8C illustrates a blood isolation system for clean blood collection, according to some imple mentations;
FIG. 8D illustrates a blood isolation system for clean blood collection, according to some imple mentations.
FIG. 8E illustrates a blood isolation system for clean blood collection, according to some imple mentations.
FIG. 9 shows a path splitter for use in a blood sequestration system;
FIG. 10A shows a blood isolation system for non-contaminated blood collection according to a n alternative implementation;
FIG. 10B shows a blood isolation system for non-contaminated blood collection according to a n alternative implementation;
FIG. 10C shows a blood isolation system for non-contaminated blood collection according to a n alternative implementation;
FIG. 10D shows a blood isolation system for non-contaminated blood collection according to a n alternative implementation;
FIG. 11A shows a blood isolation system for non-contaminated blood collection according to a nother alternative implementation;
FIG. 11B shows a blood isolation system for non-contaminated blood collection according to a nother alternative implementation;
FIG. 11C shows a blood isolation system for non-contaminated blood collection according to a nother alternative implementation;
FIG. 11D shows a blood isolation system for non-contaminated blood collection according to a nother alternative implementation;
FIG. 11E shows a blood isolation system for non-contaminated blood collection according to a nother alternative implementation;
FIG. 12A shows a blood sample optimization system including a blood isolation device accordi

ng to yet another alternative implementation;

12B shows a blood sample optimization system including a blood isolation device according to yet another alternative implementation; FIG.

FIG. 12C shows a blood sample optimization system including a blood isolation device accordi ng to yet another alternative implementation;

FIG. 12D shows a blood sample optimization system including a blood isolation device accordi ng to yet another alternative implementation;

FIG. 13A shows blood sample optimization system 1300 according to yet another alternative i mplementation.

FIG. 13B shows blood sample optimization system 1300 according to yet another alternative i mplementation.

FIG. 13C shows blood sample optimization system 1300 according to yet another alternative i mplementation.

FIG. 13D shows blood sample optimization system 1300 according to yet another alternative i mplementation.

FIG. 14A illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14B illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14C. False positives in blood cultures or tests performed on patient blood samples.

FIG. 10 illustrates yet another implementation of a blood collection system that isolates initial aliquots or samples of contaminants to reduce them.

FIG. 14D illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14E shows yet another implementation of a blood collection system that isolates contami nants in the initial aliquot or sample to reduce false positives in blood cultures or tests perfor med on patient blood samples.

15A-B illustrate a blood isolation device and method of using the same according to yet anoth er implementation.

15B illustrates a blood isolation device and method of using the same according to yet anothe r implementation; FIG.

FIG. 15C illustrates a blood isolation device and method of using the same according to yet an other implementation;

FIG. 15D illustrates a blood isolation device and method of using the same according to yet an other implementation;

FIG. 15E illustrates a blood isolation device and method of using the same according to yet an

other implementation;

Figure 15F illustrates a blood isolation device and method of using the same according to yet another implementation;

FIG. 15G shows a blood isolation device and method of using the same according to yet anoth er implementation;

FIG. 16A shows a blood isolation device according to yet another implementation;

16B shows a blood isolation device according to yet another implementation; FIG.

16C shows a blood isolation device according to yet another implementation; FIG.

16D shows a blood isolation device according to yet another implementation; FIG.

Figure 17A shows a lower member of a housing for a blood isolation device;

Figure 17B shows a lower member of a housing for a blood isolation device;

Figure 17C shows a lower member of a housing for a blood isolation device;

Figure 17D shows a lower member of a housing for a blood isolation device;

Figure 17E shows a lower member of a housing for a blood isolation device;

Figure 18A shows a top member of a housing for a blood isolation device;

Figure 18B shows a top member of a housing for a blood isolation device;

Figure 18C shows a top member of a housing for a blood isolation device;

Figure 18D shows a top member of a housing for a blood isolation device;

Figure 18E shows a top member of a housing for a blood isolation device;

Figure 18F shows a top member of a housing for a blood isolation device;

Figure 19A shows a blood isolation device having an upper member that mates with a lower member.

Figure 19B shows a blood isolation device having an upper member that mates with a lower member.

FIG. 20 shows a blood sample optimization system including a blood sequestration device;

Figure 21 shows a non-vented blood isolation device using a wicking material chamber.

Figure 22A shows the material composition of a filter for isolating blood in an isolation chamb er of a blood isolation device;

Figure 22B shows the material composition of a filter for isolating blood in an isolation chamb er of a blood isolation device;

FIG. 23A shows another implementation of a blood isolation device using vacuum force from a blood collection device;

Figure 23B shows another implementation of a blood isolation device using vacuum force from a blood collection device. Like numbers in the various drawings indicate like elements.

DETAILED DESCRIPTION OF THE INVENTION

[0024]

The present invention provides blood

sample optimization that reduces or eliminates contaminants in a drawn blood sample and, as a result, reduces or eliminates false positive readings in blood cultures or other tests of the dr

awn blood sample.

A system and method are described. In some implementations, the blood sample optimization system includes a patient needle for vascular access to the patient's bloodstream and a blood collection container such as a vacutainer or evacuated blood collection tube or other and a blood

isolation device positioned between the patient needle and the sample needle. The blood isola tor will remove the first aliquot of potentially contaminated blood.

and bypasses

the isolation chamber to carry potentially uncontaminated blood between the patient needle a nd the sample needle after the first aliquot of blood has been isolated in the isolation chambe r.

A sampling channel can be further included.

FIG .

1 shows a blood sample optimization system according to some implementations. The syste m includes a patient needle 1 for puncturing the patient's

skin to access the patient's vein and intravenous blood therein

.

The system is housed within

a resealable boot 10, luer-activated valve, or other collection interface or device and initially s ealed by the resealable boot 10, luer-activated valve, or other collection interface or device. It further includes a sample needle (ie

, a resealably sealed needle for use with a Vacutainer® or the like) 5, which may be included. The resealable boot 10 can be pushed

by or around the sample needle 5 by using a Vacutainer® bottle (not shown) for collecting th e patient's blood.

The system

can further include a low volume chamber 30 leading to the sample needle 5, but

also includes a hole or one or more channels 45 leading to the isolation chamber 55 formed b y the housing 50. FIG. Isolation chamber 55 is a chamber for receiving and holding an initial aliquot of the patient's blood, which can be

.

, channels, passages, locks, or other structures. Initial blood draws

generally contain or are more

susceptible to contain microorganisms or other pathogens that cause bacteremia and sepsis t han subsequent blood draws. The isolation chamber 55 can be contained within a rigid housin g, can be a container formed in or defined by the

housing itself, or

can be realized as a tube or lumen.

Isolation chamber 55 can have a predetermined volume, regardless of how it is formed and i mplemented. In some implementations

, the predetermined volume is based on the volume of the patient needle, i.e.,

ranges from a volume less than the volume of the patient needle to any volume to a volume g reater than 20 times the volume of the patient needle. can be done

.

The predetermined volume of isolation chamber 55 can also be set to conserve or minimize th e amount of blood that is isolated and disposed of . Isolation chamber 55 may be formed, co ntained, or housed within chamber housing 50 and may be made of plastic, rubber, steel, alu minum, or other suitable material

. For example, isolation chamber 55 can be formed from flexible tubing or other elastomeric material . The isolation chamber 55 further includes an air permeable blood barrier 20 that all ows air to exit the isolation chamber 55 . As used herein, the term "air permeable blood barri er " refers to an air permeable but substantially blood impermeable substance, material or str ucture.

means. Representative examples are hydrophobic membranes and coatings, hydrophilic mem branes or hydrophilic

coatings combination with hydrophobic membranes or coatings, meshes, filters, mechanical v alves

, antimicrobial materials, or the isolation chamber 55 is Any other means capable of expelling air from isolation chamber 55 when filled with blood may be included. In various exemplary e mbodiments

, the air permeable blood barrier can be formed by one or more materials

that allow , such materials comprising: Completely or partially sealed to prevent or block the passage of air and/or

liquids . In other words,

the material forms an air permeable barrier prior to contact with the liquid. After contact with liquid, the material

substantially or completely prevents further passage of air and/or liquid. Holes or channels 4 5 may be of any desired length, cross-sectional shape or size and/or be formed away from lo w volume chamber 30 at any desired angle or orientation

. can be done. The hole or channel 45 may also include a one-way flap or valve 60 that retain

s the first aliquot of blood sample within the isolation chamber 55 . In some particular implem entations , the holes or channels 45 allow unidirectional blood flow from the low volume cham ber 30 to the isolation chamber 55 .

can include a "duckbill" valve or flapper valve 60 or the like for Air permeable blood barrier 20 may also be constructed of a material that allows air to escape but seals upon cont act with blood , thereby not allowing outside air to enter isolation chamber 55 . This seal eliminates the need for valves.

Valve 60 can be any type of valve or opening/closing mechanism. Chamber 30 is designed to retain substantially no residual blood and can be configured to retain or pass a ce rtain volume or percentage of blood to isolation chamber 55 . Similarly, the isolation chamber 55 may also include any type of coating, such as an antimicrobial coating, or a coating that assists in identifying a nd/or diagnosing components of the isolated primary blood draw . Housings 50 and 40 may be formed from any suitable material, including plastics such as acrylonitrile butadiene styrene (ABS) or other thermoplastic or polymeric materials, rubber, steel, or aluminum . The air permeable blood barrier 20 is activated upon contact with blood from the first draw o r when the expulsion of air is stopped, or any combination of events and blood in the isolation chamber 55. , color-providing substances or other signaling mechanisms. Air permeable barri ers may also include hydrophobic membranes or covers that block or prevent inadvertent or p remature sealing of the filter by external fluid sources, splashes, etc.

An outer layer can be included. The isolation chamber 55 can also be translucent or transpare nt to allow the user .

FIG.

2 shows a blood sample optimization system according to some alternative implementations. In the implementation shown in FIG. 2 , an isolation chamber 55 or waste chamber surrounds the patient needle 1 and an open-ended
cuff or housing is connected to the waste chamber and surrounds the sample needle housing base and
housing . The patient needle 1 and the sample needle 5 are connected to each other by a boo t 56
which forms a continuous blood collection flow path therethrough. Boot 56
includes a single hole or channel leading from the blood collection channel to isolation chambe r 55 .
The device can include multiple holes or channels in other implementations . Each hole or cha nnel can include a one-way valve
and can be sized and adapted for a predetermined amount of blood flow.
Isolation
chamber 55 contains an air permeable blood barrier. The
filter
may further include sensors or indicators, respectively, for sensing and/or indicating when a p redetermined volume of blood has been collected in the isolation chamber 55 .
The instructions alert the user to attach an evacuated blood collection tube or bottle, such as a Vacutainer®, to the sample needle 5 . The housing for the isolation chamber 55
can be of any size or shape, and the internal space within the housing or
can include any type of material to define the volume. The interior space is initially filled with air only, but
can also be coated with agents or substances such as decontamination agents, coagulants, an d the like. When the evacuated blood collection tube is attached to the sample needle 5, blood automatically
flows into the patient needle 1, through the blood collection channel and the sample needle 5 into the bottle. The sample needle 5
is
covered by a resealable boot, coating or membrane that seals the sample needle when no blo od collection bottle is attached to the sample needle.
FIG.
3 shows a blood sample optimization system according to some alternative implementations. In the illustrated implementation
, sample needle 5 is surrounded by a resealable boot or membrane and is also
connected . A blood flow path is formed through the sample needle and the patient needle.
The connection between
the sample needle and the patient needle includes a 'T' or 'Y' connector 102 that includes a flo w path, port or opening leading from the main blood flow path to the isolation chamber 104 .

The T or Y connector 102 includes a flap or one-way valve and has holes sized and adapted for a predetermined flow rate of blood .

Isolation chamber 104 is formed from a tube

or can be formed by a rigid housing, initially filled with air. The isolation

chamber 104 receives blood

flowing . The isolation chamber 104 preferably includes an air permeable blood barrier 106 at the distal end of the tube forming the isolation chamber 104

and connected at the proximal end to the T or Y connector 102 . The T or Y connector 102 can branch at any desired angle

for most efficient blood flow , minimizing or eliminating mixing of the initial aliquot of blood wi th the main blood sample. To this end, the openings and junctions between the channels and t he main blood flow channel can be shaped to minimize. In some alternative implementation s, the sample needle is attached to any length of tubing whose opposite end is connected to a T or . I can . The isolation chamber 104 can be of any shape or volume so long as the initial al iquot contains a predetermined amount of blood sample . The T or Y connector 102 can also i nclude openings or channels parallel to the main blood flow channel. The air permeable blood barrier may further include an indicator 107 or other mechanism to indicate when a predeter mined amount of blood has been collected in the isolation chamber or when the released air h as reached a certain threshold, i.e. zero. can. The tube also includes a clip 109 that can be us ed to pinch and prevent fluid flow through the tube

can be done. Once the air permeable blood barrier and primary chamber are sealed, the first aliquot of blood is confined to the isolation chamber 104 and an evacuated blood collection tu be, such as a Vacutainer® bottle, is

used to obtain the sample. It is attached to the sample needle 5 . The blood collection tube ca n be removed and the sample needle 5 resealed. Any number of subsequent blood collection t ubes can be attached for additional blood draws or samples. When all blood draws are comple ted, the system is discarded, leaving the first aliquot of blood trapped in isolation chamber 10

4 . FIG. 5 shows a blood sample optimization system according to some alternative impleme ntations. In the illustrated implementation , the sample needle 5 is connected by tubing to the patient needle. A "T" or "Y" connector 120 is added at any desired location along the tube to i nclude an opening, port or flow path leading to isolation chamber 204, substantially as describ ed above. FIG. 6 illustrates a blood sample according to some alternative implementations in which an isolation chamber 304 configured as the primary collection channel receives the first aliquot of blood and is provided adjacent to the blood collection channel. An optimization syst em is shown. The isolation chamber 304 can surround the blood collection channel, patient ne edle 1 and/or sample needle 5 . The primary collection channel may include T or Y connectors 120, or other types of openings or channels. The isolation chamber 304 is an air permeable bl ood barrier

and may also include an indication that a fluid, such as blood, has been contacted, as describe d above. In some implementations, either or both of the patient needle 1 or the sample nee dle 5 can be replaced with luer lock
or luer lock female connectors. However, in various implementations , the connector at the sa mple needle end of the blood sample optimization system is first sealed and the first aliquot al low to divert the blood of the In this way, the system passively and automatically uses the pat ient's own blood pressure to overcome the ambient air pressure in the isolation chamber, forc e air through the air permeable blood barrier, and replace the air in the isolation chamber with blood. FIG . 7 is a flowchart of an exemplary method for optimizing blood culture quality. At 702 , a clinician inserts a needle into a patient's vein. At 704, blood flows into the isolation ch amber, forcing . In some implementations, the volume of the isolation chamber is less than 0.

1 cubic centimeters (cc).

From full to 5 cubic centimeters (cc) or more. The isolation chamber is sized and adapted to c
ollect
a second portion of the blood sample and other subsequent portions or a first portion of the bl
ood sample that is more susceptible to contamination than subsequent collections .
The isolation chamber has an air permeable blood barrier
through which air can be expelled by the blood expelled from the patient's veins
so that such blood is
a vacutainer Before being drawn into or otherwise entering a ® or other bottle, it inevitably a
nd
automatically flows into the isolation chamber. As the isolation chamber fills, blood collects o
r otherwise contacts an air permeable blood barrier that
blocks or prevents blood from passing through. At 706, once the blood contacts the entire inte
rnal surface area of the air permeable blood barrier, the air permeable blood barrier is closed
and air no longer flows out or in. At 708, the clinician is provided an indication or can view the
full chamber indicating that an evacuated blood collection tube , such as a Vacutainer®, can b
e attached. The indicator may include visibility of the primary chamber to see if the primary c
hamber is full , eg, a blood barrier that changes color, or other indicator . Since the fill time of
the isolation chamber may be substantially instantaneous, such an indication, if present, may
simply be that the isolation chamber is filled. [0042]

Before the evacuated blood collection tube is attached, communication between the needle, the sampling channel, and the isolation chamber
is restricted by the sealing of the isolation chamber's blood barrier, thus isolation does not allow air to re-enter
the system . Sealing of the communication path is accomplished by mechanical twisting or other
action , small hole or tortuous path,
obviating the need for a separate valve or mechanical action or manipulation by the clinician. At 710, the evacuated blood collection tube is removed, a self-
sealing membrane seals the sample needle, and at 712, a further subsequent evacuated blood collection tube
can be attached. At 714, once the sample has been taken, the device is removed from the patient and discarded
.

[0043]

Figures 8A-8E illustrate an exemplary blood sample optimization
system . Blood sample optimization system 800 includes an
entry port 802 that can be connected to tubing, a patient needle (or both), or other vascular or venous access device, and a
first exit to isolation chamber tubing 806 and sample collection tubing.
a path splitter 804 with a second exit to 808 ; One or both of isolation chamber tube 806 and sample collection
tube 808 can be formed from tubing. In some implementations , isolation chamber tube 806 is sized
to accommodate a specific amount of initial blood sample .
The sample collection tube 808 is used once the isolation chamber tube 806 is full.
When prompted, accept a blood sample. The sample collection tube 808 can be
connected to a Vacutainer® base or housing 810, or other blood sample collection device . Blood isolation system 800 further includes blood isolation device 812, which includes housing 818, shown in more detail in FIGS . It includes a sampling channel 820 that defines a pathway or is connected at either end with a clean sample collection tube 808 . The sampling flow path 820 can be curved through the housing 818 to better secure and stabilize the housing 818 in position along the clean sample collection tube 808 . Blood isolation device 812 further includes an isolation chamber 822 or other chamber connected with isolation chamber tube 806 . Isolation chamber 822 terminates . The air-permeable blood barrier 824 also reacts upon full contact with blood as an indicator that proper collection of a blood sample (i.e., an uncontami

nated blood sample) can begin.

It may contain a colorant that changes to a different color. Other indicators such as small light s, sound generating mechanisms, etc.
can be used. In some implementations, the air permeable blood barrier is positioned perpendi cular to
the orientation , but
may be positioned at any distance or orientation to conserve space and materials used for ho using 818. can Housing 818 and its contents
can be formed from any rigid or semi-rigid material or range of materials.
FIG.
9
shows a path splitter 900 for use in, for example, blood isolation systems such as those show n in FIGS. 8A-8E. Path splitter 900 includes inlet port 902 , main conduit outlet port 904
and isolation channel outlet port 906 .
The entry port 902 can be connected to a main tube that is also connected to the patient nee dle system or directly to the patient needle. The main line outlet port 904 can be connected to a
main line tube to a blood collection system, such as a Vacutainer® base or housing, or directl y to such a blood collection system.
The isolation channel
outlet port 906
can be connected to an isolation tube for receiving and isolating the first sample of blood up t o a measured volume or predetermined threshold. Alternatively, the isolation flow path outlet port
906 can connect to the isolation chamber. The isolation channel outlet port 906
is preferably angled from 20 to 70 degrees from the main conduit outlet port 904, while the m

ain conduit outlet port
Port 904 is preferably in line with inlet port 902 . Once an initial blood
sample
has been isolated in an isolation tube or isolation chamber according to the mechanisms and t echniques described herein, subsequent blood samples flow into inlet port 902 unobstructed. directly out of the main conduit outlet port 904 at . 10A-10D show blood isolation device 100 0 according to another implementation
.
Blood isolation device 1000 includes
inlet port 1002 , main outlet port 1004 , and isolation flow port 1006
. Entry port 1002 can be connected with a patient needle or associated tubing.
The main exit port 1004 can be connected to a blood sampling device such as a Vacutainer®, associated tubing, or a luer-
actuated valve. An isolation flow port 1006
separates from the main exit port 1004 into an isolation chamber 1008 . In some implementa tions, isolation
chamber 1008 is formed as a spiral channel within housing or other container 1001 .
Isolation chamber 1008 is connected
at its distal end to air permeable blood barrier 1010, substantially as described above . Air w ithin the isolation chamber 1008 is expelled by the first aliquot of blood directed into the isolat ion flow path
port 1006
through .
Once the isolation chamber 1008 is filled, further
blood draws through the main exit port 1004 are accomplished and these samples are clean.
11A -
11E show blood isolation device 1100 according to another alternative implementation. Bloo d isolation device 1100 includes an
inlet port 1102 similar to the inlet ports described above, a main outlet port 1104
and an isolation flow port 1106 separate from main outlet port 1104 and inlet port 1102 .
The isolation flow port is connected to isolation chamber 1108 .
In the implementation shown in FIGS. 11A-11E , the blood isolation device
includes a base member 1101 having a flow path therein that functions as an isolation chamb er 1108 .
The flow path can be formed as a tortuous path through the base member 1101 while the bas e member 1101
is shaped and shaped to rest on the patient's limb. A portion of isolation chamber 1108 may p rotrude from or near the top surface of the base member just prior to exiting air permeable . Indicator 1109 can be made of a transparent material or a material that changes color when

in contact with blood . In some implementations, the blood isolation device 1100 includes a n ormally closed needle, vacutainer.RTM.

A blood collection device 1120, such as a shield or other collection device, may be included. Bl ood collection device 1 120 is manufactured and sold with blood isolation device 1100 for effic iency and convenience so that the
first aliquot of blood that may be contaminated by the patient needle insertion process can be isolated. be able to. Accordingly, the blood collection device 1120 can collect and ensure a cle an blood sample so as to reduce the risk of false positive tests . [0052] Figures 12A-12D illust rate a blood sample optimization system 1200 according to yet another alternative impleme ntation . System 1200 includes a blood isolation device 1202 for attachment to a blood collect ion device 1204, such as a Vacutainer® or other collection and sampling device. Blood isolatio n device 1202 receives an initial aliquot or volume of blood before a Vacutainer® container or vial is attached to the collection needle of blood collection device 1204 and transfers that initi al aliquot or volume to blood isolation device 1202 . Constructed and . [0053] In some imple mentations, the blood isolation device 1202 can include an inlet port 1212, a main outlet port, and an isolation flow path port. Entry port 1212 can be connected to a patient needle or assoc iated tubing . The main exit port 1214 is an evacuated blood collection container or vacutaine r.

can be connected to a normally closed needle or device to allow connection with other collecti on devices such as ®, associated tubing, luer connectors, syringes,
luer actuated valves
. The isolation flow port separates the isolation chamber 1218 from the main exit port. In so me implementations, isolation chamber 1218 is formed
. The isolation chamber 1218 can be a tortuous channel, such as a U-shaped channel, an S-sh aped channel, a spiral channel, or any other tortuous channel. Isolation device 1202 can inclu de a housing or other enclosure and one or more channels formed therein . As shown in FIGS. 12A and 12B, isolation device 1202 includes body 1206 and cap 1208 . One or more cavities o r channels are formed in the body 1206, and the cavities or channels are further formed with one or more arms 1210 extending from the cap 1208, the one or more arms 1210 extending f rom the cavities or channels of the body 1206. A primary collection port and a main outlet por t . [0055] Figures 13A-13D illustrate a blood sample optimization system 1300 according to yet another alternative implementation . System 1300 includes a blood isolation device 1302 f or attachment to a blood collection device 1304, such as a Vacutainer® or other body fluid col lection and sampling device. Blood isolation device 1302 is a Vacutainer® container or vial blo od collection device 1304 .

to receive an initial aliquot or volume of blood and sequester that
initial
constructed and arranged. Blood isolation device 1302 includes housing 1301 having inlet po rt 1314 , main outlet port 1312 and isolation flow path port 1316
. Entry port 1314 can be connected to a patient needle or associated tubing. The main exit po rt 1312 is a normally closed needle or needle to allow connection with other collection devices such as evacuated blood collection containers or vacutainers, associated tubing, luer connecto

rs , syringes, luer actuated valves. It can be connected to a device . An isolation flow port 131 6 separates from the main inlet port 1314 into an isolation chamber 1318 . In the embodime nt shown in FIGS. 13A-13D, isolation chamber 1318 is formed as a cavity or chamber within h ousing 1301 or by walls defining housing 1301 .

be done. The isolation chamber 1318 can be a
tortuous
defined by the cooperation and connection of the housing 1301 and the cap 1307. The cap 13 07
can
include protrusions 1305 that provide one or more walls or directors for the tortuous flow path within the isolation chamber 1318 . Projections 1305 from cap 1307
can be straight or curved,
can extend from cap 1307 at any angle or orientation. be able to.
When the cap 1307 is connected with the housing 1301 to complete the formation of
the isolation chamber 1318 , the projection 1305 forms at least a portion of the tortuous flow path
formed by the tortuous flow path within the isolation chamber 1318 . An initial aliquot or volu me of blood or
other bodily fluid is sequestered in the sequestration channel .
Isolation chamber 1318
includes air permeable blood barrier 1310 substantially as described above
.
Air within the isolation chamber 1318 is expelled through the air permeable blood barrier 131 0 by the first aliquot of blood supplied into the isolation chamber 1318 by the patient's blood pressure
. Once the isolation chamber 1318 is filled and the air within the isolation chamber 1318 is ex pelled,
a
The patient's blood pressure forces more blood into the blood isolation device 1302, and in pa

rticular the exit port 1312 , until a force such as a vacuum or other pressure is provided
Inadequate to drive or provide.
Additional blood draws can be taken through the main exit port 1312 and these samples are not contaminated because any contaminants are sequestered in the isolation chamber 1318 along with the blood of the first aliquot.
FIGS. 14A-14E further illustrate a blood collection system 1400 for isolating contaminants of initial aliquots or samples to reduce false positives in blood cultures or tests performed on patient blood samples. Show another implementation.
Blood collection system 1400 includes a blood isolation device 1401 that can be connected between blood sample collection device 1 403 and a patient needle (not shown) . The blood sample collection device 1403 can . Blood isolation device 1401 includes an entry port 1402 that can be connected to a patient needle that is inserted into the patient's vasculature for access to and collection of a blood sample . Inlet port 1402 can also be connected to a tube or other conduit that is also connected to a patient needle . Inlet port 1402 defines an opening to blood isolation device 1401, which opening can be of the same cross-sectional dimensions as a tube or other conduit connected to the patient needle or the patient needle itself.

be. For example, the opening can be , but may be 0.01 inch (0.254 mm) to 0.2 inch (5.08 mm) or less. can have diameters equal to or greater than Blood isolation device 1401 further includes an exit port 1404 that defines an opening from blood isolation device 1 401 and to blood sampling device 1403 . Exit port 1404 can also be connected to a tube or other conduit that is also connected to blood isolation device 1403 . The exit port 1404 may be a connector such as an unthreaded interference or glue joint for attachment to a variety of devices including, but not limited to,
threaded caps,
luer connectors (male or female), tubing, and the like.

A device
can also be included. Blood isolation device 1401 further includes a sampling
serves as a blood sample pathway once the first aliquot of blood has been isolated. do. Sampli ng channel 1406 can be a channel or conduit of any size , shape or configuration. In some im plementations, sampling channel 1406 has a cross-sectional area substantially similar to the o pening of inlet port 1402 . other fruits

In practice, sampling channel 1406
can gradually diverge from inlet port 1402 to outlet port 1404 . Blood isolation device 1401 f urther includes isolation chamber 1408 , which is connected to and separated from sampling c hannel 1406 anywhere between inlet port 1402 and outlet port 1404
. or diverted, but preferably connected to the proximal end of the sampling channel 1406 near the inlet port 1402 and separated or diverted from . The isolation chamber 1408 is initially ma intained at atmospheric pressure and includes an air outlet 1412 at or near the distal end of t he isolation chamber 1408 opposite the turning point from the sampling channel 1406 . Air ou tlet 1412 includes air permeable blood barrier 1412 . The air permeable blood barrier 1412 ca n be covered with a protective cover 1416, as shown in FIG. 14B . The protective cover 1416 can be sized and configured to prevent a user from touching the air permeable blood barrier 1 412 with their fingers or other external instruments , while still allowing the patient's own blo od pressure to force the isolation chamber. A forced blood supply into 1408 allows air to exit t he air permeable . The protective cover 1416 also prevents or prevents accidental exposure of the air permeable blood barrier to surrounding fluids or droplets.

can be configured.
This can be done in a variety of mechanical ways including, but not limited to, adding a hydro phobic membrane to the protective cover . As shown in FIGS. 14C and 14D, the sampling cha nnel 1406 is cylindrical or frusto-conical in shape from smaller diameters to larger diameters t o minimize the possibility of
. can be done. Similarly, the sampling channel 1406 is formed with a minimal amount or no s harp bends or sharp angles that could lyse red blood cells. Sampling channel 1406 splits near inlet port 1402 through diverting path 1409 into isolation chamber 1408 . Diversion pathway 1409 can , but is preferably similar to the cross-sectional shape of at least a portion of inlet p ort 1402 . In some implementations, sampling channel 1406 and isolation chamber 1408 are formed by grooves, channels, locks or other pathways formed in housing 1414 . Housing 1 41 4 can be made of plastic, metal or other rigid or semi-rigid material. The housing 1414 can ha ve a lower member that sealably mates with the upper member. One or both of the lower and upper members includes a sampling channel 1406 and an isolation chamber 1408 as well as a diversion channel 1409, an inlet port 1402 and an outlet port 1404.

can be read. In some other embodiments,
one or more of diverting path 1409, inlet port 1402, and/or outlet port 1404 are
at least partially closed by a cap member connected to either end of housing 1414. can be for med in
In
membersome
can be connected together by laser welding, heat sealing, gluing, snapping, screwing, bolting, or the like. In other implementations,
some

can be coated or filled with agents or substances such as decontamination agents, coagulants, and the like. For example, when the sequestration chamber 1408 fills and the first aliquot of b lood
returns to the diversion path 1409 , the final volume of sequestered blood clots, creating a barrier between the sequestration chamber 1408 and the sampling channel 1406 .
A coagulant can be provided in the turning path 1409 to create . 15A-15G show a blood isola tion device 1500. FIG
.
The blood isolation device 1500
is
a needle that is normally closed to allow connection with other collection devices such as evac uated blood collection containers or vacutainers, associated tubing, luer connectors, syringes, luer actuated valves, and the like. or connected to
the device .
Blood isolation device 1500 includes an entry port 1502 that can be connected to a patient ne edle that is inserted into the patient's vasculature
for access to and withdrawal of a blood sample . Entry port 1502 can also be . Entry port 15 02 defines an opening to blood isolation device 1500, which opening can be of the same cross -sectional dimensions as a tube or other conduit connected to the patient needle or the patien t needle itself. For example, the opening can be circular with , but may be 0.01 inch (0.254 m m) to 0.2 inch (5.08 mm) or It can have a larger diameter. Inlet port 1502 may also include a sealed or fluid tight connector or connection such as a threaded or luer fitting or the like . In some implementations, a tube or other conduit that is coupled to the patient needle can be int egrated with the entry port 1502, such as by co-molding, gluing, laser welding, or heat bondi ng the parts together. This allows the blood isolation device 1500 to be manufactured and sol d as a single unit with the patient needle, eliminating the need to connect the patient needle t o the blood isolation device 1500 during blood draw or sampling. The blood isolation device 1 500 has open connections from the blood isolation device 1500 and to the blood sampling de vice.

Further includes an exit port 1504 defining a mouth. Exit port 1504
may also be connected to a tube or other conduit that is also connected to a blood isolation d evice and may include a sealed or fluid tight connector or connection such as a threaded or lu er
fitting . Thus
, as noted above, the blood isolation device 1500 is manufactured and sold as a single unit wit h the patient needle and/or tubing and blood
sample device, and
is attached to the patient needle and blood sample collection device during blood collection or sampling. to the blood isolation device 1500
. Blood isolation device 1500 further includes a sampling
functions as a blood sample channel once the first aliquot of blood has been isolated. do. Sam pling channel 1506 can be a channel or conduit of any size , shape, or configuration. In some implementations, sampling channel 1506 has a cross-sectional area substantially similar to th e opening of inlet port 1502 . In other implementations, sampling channel 1506 can gradually diverge from inlet port 1502 to . Blood isolation device 1500 further includes isolation chamb er 1508 , which is connected to sampling channel 150 at any location between inlet port 1502 and outlet port 1504 .

6 and separated or diverted from the sampling channel 1506 , preferably connected
to and separated or diverted
from . In some implementations, the diversion channel includes a Y-junction. The isolation cha mber 1508
is preferably maintained at atmospheric pressure and includes a

vent . Vent 1510 includes air permeable blood barrier 1512 . FIG. 15C shows blood isolation d evice 1500

with isolation chamber 1508 filled with an initial aliquot or sample of blood from a patient . A ir permeable blood barrier 1512 may be covered with protective cover 1516 . The protective c over 1516 can be sized and configured to prevent a user from touching the air permeable bloo d barrier 1 512 with their fingers or other external instruments , while still allowing the patien t's own blood pressure to force the isolation chamber. A forced blood supply allows air to exit t he air permeable blood barrier 1512 as the air is expelled from the isolation chamber. Protecti ve cover 1516 protects the filter from accidental contact with surrounding fluids or splashes.

can be configured to inhibit or prevent exposure to This can be

done in a variety of mechanical ways including, but not limited to, adding a hydrophobic mem brane to the protective cover. FIG. 15B is a perspective view of blood isolation device 1500 fr om the top of housing blood isolation device 1500 , showing the sampling flow path before th e sample collection device is activated. A first aliquot of blood fills isolation . Figure 15G is a p erspective view of the blood isolation device 1500 from the bottom of the housing 1501 and t he exit port 1504 of the blood isolation device 1500, initially while the sampling channel 1506 is empty before the sample collection device is activated. aliquot of blood fills isolation chamb er 1508 . FIG. 15C is another perspective view of blood isolation device 1500 from the top of housing 1501 including inlet port 1502 and vent 1510 of blood isolation device 1500 , with the isolated blood substantially within isolation chamber 1508 . Blood is drawn through sampling c hannel 1506 while remaining at . FIG . 15D is a cross-sectional view of blood isolation device 1500 according to some implementations, showing housing 1501 defining sampling channel 1 506 and isolation chamber 1508 . Figure 15E and

and 15F illustrate various form factors of housings for blood isolation devices according to one or more implementations described herein . Isolation chamber 1508 can have a larger cross-sectional area than sampling channel 1506 , and the cross-sectional area or length can be con figured such that a predetermined or specific blood volume is isolated or locked
. can. The sampling channel 1506 can be sized to fit tubing for either or both the patient need le tubing or the blood collection device tubing. Housing 1501 can be formed from multiple pi eces or from a single unitary piece. In some implementations, as shown in FIG. 15D, housing 1501 includes an upper member 1520 and a lower member 1522 that mate with each other, o ne or both of which are formed, for example, by an injection molding process or by etching, H aving grooves, channels, locks, conduits drilling or the like. The upper member 1520 may be attached by laser welding, thermal bonding, ultrasonic welding , adhesives, screws, rivets, bol ts, etc., or by latches, grooves, tongues, or the like. Other mating mechanisms, such as pins, flanges, etc., can connect with lower member 1522 . In some implementations, upper memb er 1520 includes grooves, channels, locks, guides, etc., as shown in FIG. 15D .

A tube or other passageway can be included, while the lower member 1522 is sized and adapted to
fit into at least one of a groove, channel, lock or other passageway in the upper member 1520.
can include raised protrusions 1524 . Protrusions 1524 can provide surface features such as
partial . In some implementations,
the protrusions 1524
can be formed with one or more slanted sides or faces to more closely fit within corresponding grooves, channels, locks or other pathways. can. In still other implementations, both the upper member 1520 and the lower member
can include grooves, channels, locks or other pathways, as well as one or more protrusions 1524 . In some implementations, sampling channel 1506 and isolation chamber 1508 are formed by grooves, channels, locks or other pathways formed in housing 1501
. Housing 1 501 may be made of any suitable material including rubber, plastic, metal or other material.

can be Housing 1501 can be formed from a transparent or translucent material, or from an opaque or non-
translucent material.
In other implementations, the housing 1501 can
be largely opaque or non-transparent, but the housing surfaces directly adjacent the sampling channel 1506 and/or the isolation chamber 1508 are transparent or translucent and initially A visual cue or sign that the isolation
chamber 1508 is filled to the required or desired degree
and/or is isolated while a subsequent uncontaminated blood sample is
taken Gives the
practitioner . Other visual cues or signs of isolation include, but are not limited to,
contact, penetration, or partial penetration of blood, causing the air permeable blood barrier 1512 to
turn
color-coded tabs or indicators, audible, vibratory, or other signals at any location along or adjacent to the isolation chamber . After venipuncture by a patient needle (not shown), which can collect many pathogens from the patient's skin, the patient's own blood pressure overcomes the atmospheric pressure in isolation chamber 1508 to form an air permeable blood
barrier
. As the air in the isolation chamber 1508 is expelled through 1512, the initial volume of pati

ent blood with these pathogens enters the blood isolation device 1500 inlet port 1502 and the most

It flows into isolation chamber 1508 by following the path of least resistance. The patient's blo od pressure
is not sufficient to overcome the rising air pressure within the sealed sampling channel 1506 . Ultimately, an isolation chamber 1508 of predetermined volume
is filled with blood that drives air out through the air permeable blood barrier 1 512 . When bl ood
impinges , the blood interacts with the material of air permeable blood barrier 1512
to completely or partially seal vent 1510 . A signal or indication can be provided that the pract itioner can now
utilize the VACUTAINER® capsule or other blood sampling device to obtain the next volume of the patient's blood for sampling.
The blood in the isolation chamber 1508
is now effectively isolated within the isolation chamber.
Upon filling blood isolation channel 1508 and prior to use of a Vacutainer
™ or other blood
sampling device, the patient's blood pressure
causes compression of air within sampling channel 1506, possibly A small amount of blood tra vels past the turning point to the isolation chamber 1508 and into
the sampling channel 1506 ,
queuing clean blood to be drawn through the sampling channel 1506 .
Figures 16-19
show yet another implementation of a blood isolation device. Figures 16A-16D illustrate a bl ood sample collection device, such as an evacuated blood collection container such as
a Vacutainer® (not shown), and a patient.
A blood isolation device 1600 that can be connected between a needle (not shown) and/or ass ociated tubing is
shown. FIG. 17 shows the lower member of the blood isolation device and FIG. 18 shows the upper member of the blood isolation
device , the upper and lower members
being interfitted and configured as described in more detail below. Inlet ports, outlet ports, iso lation chambers and sampling channels
can . Figures 19A and 19B show the upper and lower members mating together. 16-19 show one exemplary method of constructing the blood isolation devices described herein, and it sho uld be understood that other forms of construction are possible. 16A-16D, blood isolation de

vice 1600 has an entry port that can . 1602 included. Inlet port 1602 can also be connected t o a tube . The inlet port 1602 defines an opening to the blood isolation device 1600, which op ening can be of the same cross-sectional dimensions as the tubing or other conduit connected to the patient needle or the patient needle itself. For example, the opening can be circular wit h a diameter of about 0.045 inch (1.143 mm), but may be 0.01 inch (0.254 mm) to 0.2 inch (5.08 mm) or less. can have a diameter of

.

Inlet port 1602 may

also include a sealed or fluid tight connector or connection such as a threaded or luer fitting or the like . In some implementations, a tube or other conduit coupled

to the patient needle can be integrated with the entry port 1602, such as by co-molding, gluin g, laser welding, or heat bonding the parts together. This allows the blood isolation device 160 0 to be manufactured and sold as a single unit along with the patient needle and/or tubing, eli minating the need to connect the patient needle to the blood isolation device 1600 during blo od draw or sampling. . Blood isolation device 1600 further includes an exit port 1604 that de fines an opening . Exit port 1604 may also be connected to a tube or other conduit that is also connected to a blood isolation device and may include a sealed or fluid tight connector or con nection such as a threaded or luer fitting . Thus , as noted above, the blood isolation device 1 600 is manufactured and sold as a single unit with the patient needle and/or tubing and blood sample device, and is attached to the patient needle and blood sample collection device durin g blood collection or sampling. to the blood isolation device 1600 . Blood isolation device 160 0 has a sampling port between inlet port 1602 and outlet port 1604 .

and an isolation chamber 1608 connected to and separated or diverted from the sampling
. Sampling channel 1606 functions as a blood collection path once the first aliquot of blood is sequestered in sequestration chamber 1608 . Sampling channel 1606 can be a channel or conduit of any size, shape or configuration
. In some implementations, sampling channel 1606
has a cross-sectional area substantially similar to the opening of inlet port 1602 . In other implementations, sampling channel 1606
can gradually widen from inlet port 1602 to outlet port 1604 . The isolation chamber 1608 widens toward the path of the isolation channel so that blood first attempts to enter the reservoir as opposed to entering the
smaller diameter of the sampling channel 1606, as shown in more detail in FIGS . It can have a larger cross-section to form a reservoir. In some exemplary implementations, the diversion between sampling channel 1606 and isolation chamber 1608 is accomplished by diversion junction 1607 . Turning junction 1607 can be substantially Y-shaped, T-shaped, or U-shaped. In some preferred exemplary implementations , redirection junction 1607 is configured such that flow from . isolation chamber

1608 can also include or form a curve or ramp to move the initial blood flow toward and into the isolation chamber 1608 . The isolation chamber 1608 is preferably maintained at atmospheric pressure and includes a vent 1610 at or near the distal end of the isolation chamber 1608 . Vent 1610 can include an air permeable blood . Blood isolation device 1600 can include

a housing 1601 that can be formed from multiple pieces or a single unitary piece . In some implementations, as shown in FIGS. 17A-17D and 18A-18F, housing 1601 includes an upper member 1620 and a lower . Blood isolation device 1600 includes a gasket or other sealing member such that when upper member 1620 is mechanically attached to lower member 1622, the interface therebetween is sealed by A member (not shown) may also be included.

17A-17D show the lower member 1622 of the housing for the blood isolation device 1600. FIG.

The lower member 1622 includes pre-formed grooves, channels, locks, or the like by an injection molding process or by etching, cutting, drilling, etc., to form the sampling channels 1606, the isolation chambers 1608, and the turning junctions
1607.

Conduits or other pathways may be included
.

Isolation chamber 1608
has a larger cross-section than sampling channel 1606
so that blood preferentially moves into the isolation chamber first as opposed
to can be done.

FIGS.
18A-18F may be connected by any mating or connecting mechanism such as using laser welding, thermal bonding, gluing, screws, rivets, bolts, etc.,
or by latches, grooves, tongues, pins, flanges, etc.

Upper member 1620 is
shown . Top member 1620 can include
some or all of grooves, channels, locks, conduits or other pathways to form sampling channels 1606 , isolation chambers 1608 and turning junctions 1607 .

In still other implementations,
both upper member 1620 and lower member 1622 can include grooves, channels, locks or other pathways. In some implementations, sampling channel 1606 and isolation chamber 1608 are located in a housing

.

formed by grooves, channels, locks or other pathways formed in 1601; Housing 1
601 can be made of rubber, plastic, metal or any other suitable material
. Housing 1601 can be formed from a transparent or translucent material, or
from .
In other implementations, housing 1601 can be largely opaque or non-translucent, but housing surfaces directly adjacent sampling channel 1606 and/or isolation chamber 1608 can be transparent or translucent. , first a visual cue or sign that the isolation
chamber 1608 has been filled to the required or desired degree
, and/or subsequently while a clean blood sample is
taken through the sampling channel 1606. ,
giving the practitioner a visual cue or sign that the sequestered blood remains sequestered .
Other visual cues or signs of isolation include, but are not limited to,
contact, penetration, or partial penetration of blood, causing the air permeable blood barrier 1
612 to turn a different color
; Color-coded tabs or indicators at any location along or adjacent to the isolation chamber
, audible, vibratory, or other signals may be included. As shown in FIGS. 18A-18F, air perme
able blood barrier 1612
can be covered or surrounded by protective member 1616 . Protective material

1616 can be sized and configured to prevent a user from
touching , while still
expelling air from the isolation chamber 1608.
allows air to exit the air permeable blood barrier 1612 . In some implementations, protective member 1616
includes protrusions that extend from the top surface of top member 1620 up and around air permeable blood barrier 1612 . The protective cover 1616 can be configured
to block or prevent accidental exposure of the filter to ambient fluids or splashes . This can be done in a variety of mechanical ways
including, but not limited to, adding a hydrophobic membrane to the protective cover . In use, blood isolation device 1600 includes sampling channel 1606 and isolation chamber 1608 . Bo th paths are initially filled with air at atmospheric pressure, but sampling channel 1 606 is initi ally sealed by The isolation chamber 1608 terminates in a vent 1610 to the atmosphere that i ncludes an air permeable blood barrier 1612 . [0093]

After
venipuncture with a patient needle (not shown), which can collect many pathogens from the patient's skin, an initial volume of the patient's blood with these pathogens is delivered to inle t port 1602 of blood isolation device 1600 .
pass through. This initial volume of potentially contaminated blood
preferentially enters isolation chamber 1608 by finding the path of least resistance. The patie nt's
own blood pressure overcomes the atmospheric pressure in the vented isolation chamber 160 8
and expels air within the isolation chamber 1608 through the air permeable blood barrier 161 2, but builds up in the sealed
sampling channel 1606. insufficient to overcome the air pressure that is present. In
various exemplary embodiments, the isolation chamber 1608 and sampling channel 1606 are configured such that the force generated by the patient's blood pressure is sufficient to overco me the effects of gravity regardless of the orientation of the blood isolation device. can be con figured to Ultimately , the isolation chamber 1608 fills with blood that drives . When blood c ontacts the air permeable blood barrier, the blood interacts with the material of air permeable blood barrier 1612 to completely or partially seal vent 1610 . A signal or indication can be pro vided that the practitioner can now utilize the Vacutainer® or other blood collection device .
Once the blood isolation path 1608 is satisfied, a Vacutainer™ or other blood sample collecti on is performed .

Prior to use of the aspiration device, the patient's blood pressure
causes , possibly
moving a small amount of blood past the turning point into the sampling channel 1606 and int

o the sampling channel.

Queue .

FIG .

19A is a side view of blood isolation device 1600 and FIG. 19B is a cross-sectional view of bl ood isolation device 1600

showing upper member 1620 mating with lower member 1622 .

FIG.

20 illustrates a patient needle 2002 for vascular access to a patient's bloodstream, a blood s ample collection device 2004 facilitating the collection of one or more blood

samples patient needle 2002 and the blood

sample . Blood sample

optimization . In some implementations, the blood sample collection device 2004

includes a protective shield that includes a sealed collection needle such that once a sealed va cuum container is placed on the collection needle and the container is pierced once by the coll ection

needle, the patient needle is exposed to the patient needle. A blood sample is drawn from 200 2 through conduit 2006 with vacuum pressure

or force.

Blood sample optimization system 2000 further includes a blood isolation device 2008 located at any point on conduit 2006 between

patient needle 2002 and blood sampling device 2004, as described herein. . [0099]

FIG. 21 shows a non-vented blood isolation device 2100 that uses wicking material chamber s . Blood isolation device 2100 includes a housing 2101

having a sampling channel 2104 at least partially surrounded or abutted by an isolation cham ber 2102 filled with wicking material .

A first aliquot of blood is

drawn from the patient needle into the sampling channel 2104 where it immediately escapes i nto the

wicking . The wicking material and/or isolation chamber 2102 is filled with a predetermined vo lume such

that subsequent or subsequent blood draws flow past the wicking material and

through the sampling channel 2104 directly to a sampling device such as a vacutainer.

Dimensioned and adapted to receive and retain blood. The wicking

material can include substances such as solidifying agents, decontaminating agents, or other additives. As described herein, air permeable blood barriers can be of a wide variety of differ

ent constructions and materials

.

can be made using a fee. As shown in Figures 22A and 22B, the
air permeable blood barrier 2202 of the blood isolation device 2200
can include a polymeric bead matrix 2204 that has been treated to render at least some of th e beads hydrophilic. Air permeable blood
barrier 2202
further comprises a self-sealing material 2206 such as carboxymethylcellulose (CMC) or cellul ose gum, or other sealing material. Air permeable blood barrier
2202
may further include voids 2208 that allow air flow prior to or during partial contact with a fluid such as blood. Upon contact with fluid, self-sealing material 2206
expands close void 2208 and occlude air flow through void 2208, completely or
partially sealing, as shown in FIG. 22B. Figures 23A and 23B show an entry port 2302 for co nnection with a patient needle, an exit port 2304 for connection with a blood sampling device, an isolation chamber 2306, an isolation chamber 2306 and a contamination to be isolated
. 23 shows yet another implementation of a blood isolation device 2300 having a sampling ch annel 2308 that bypasses the isolation . The isolation chamber 2306 includes a hydrophobic pl ug 2312 at the distal end of the isolation chamber 2306 furthest from the inlet port 2302 . Ap plied from exit port 2304, such as from a Vacutainer® or the like.

The applied vacuum or other suction force
draws blood into inlet port 2302 and directly into isolation chamber 2306 where a first aliquot of blood contacts hydrophobic plug 2312
, isolating the first aliquot of blood. Return to chamber 2306 and isolate there. A small amoun t of
blood
can enter sampling channel 2308 which is initially closed by valve 2308 . When valve 2308 is released, a subsequent volume of blood, under additional vacuum or other force, flows into inl et port 2302, bypasses isolation chamber 2306, and through
sampling channel 2308 to the outlet port.
It flows towards 2304 and is sent to the collection device. Sampling channel 2308 can have

any suitable geometry and can be formed from plastic
tubing or any other suitable material. Valve 2308 can be a clip or other enclosing device to pin ch, deflect, bend, or otherwise close the sampling channel before the first aliquot of blood is s equestered in sequestration chamber 2306 . can. [0103] While various embodiments have b een described in detail above, other modifications are possible. Other embodiments may be wi thin the scope of the following claims.

drawing open ----

[Fig. 1]

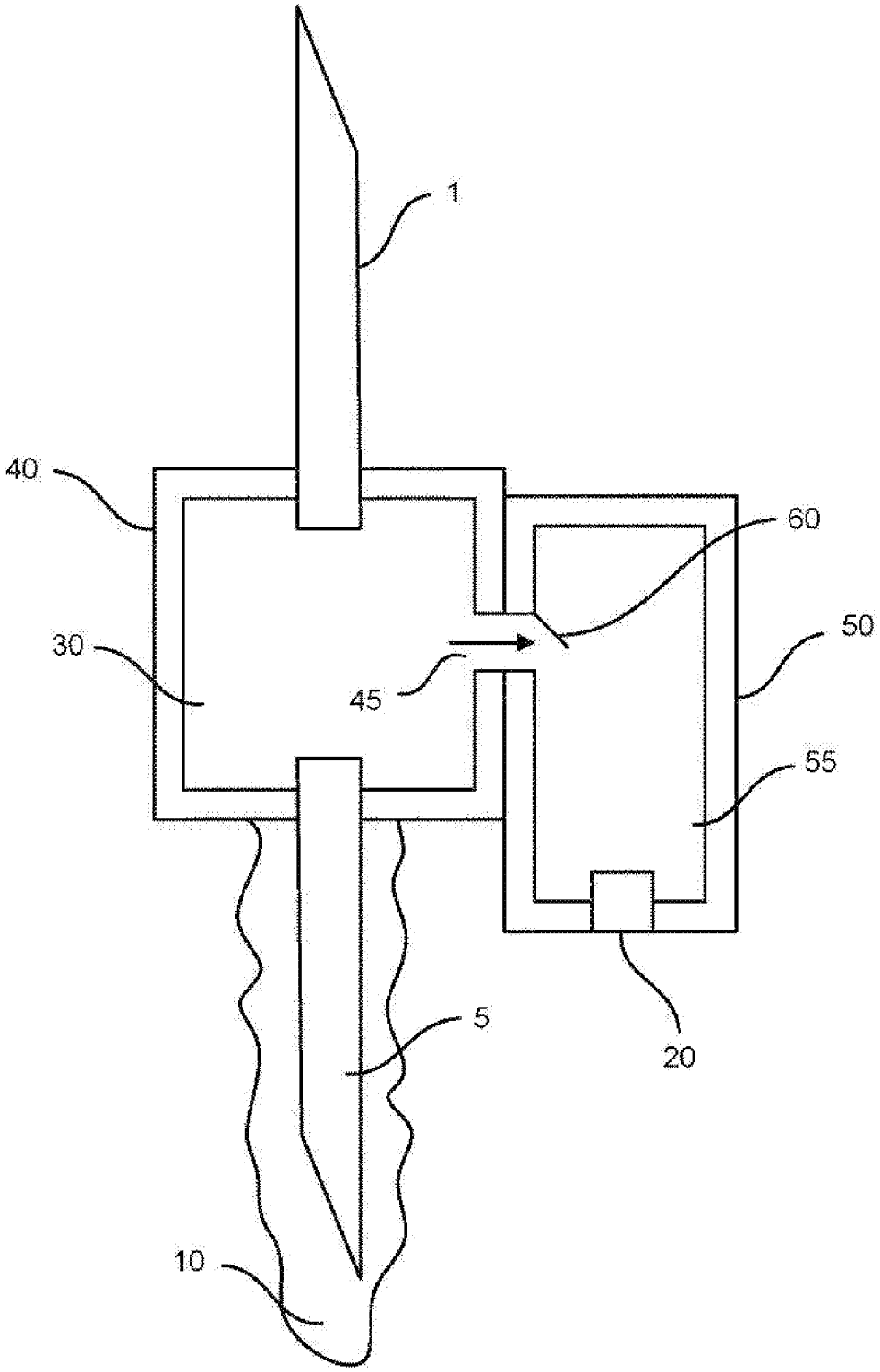


FIG. 1

[Figure 2]



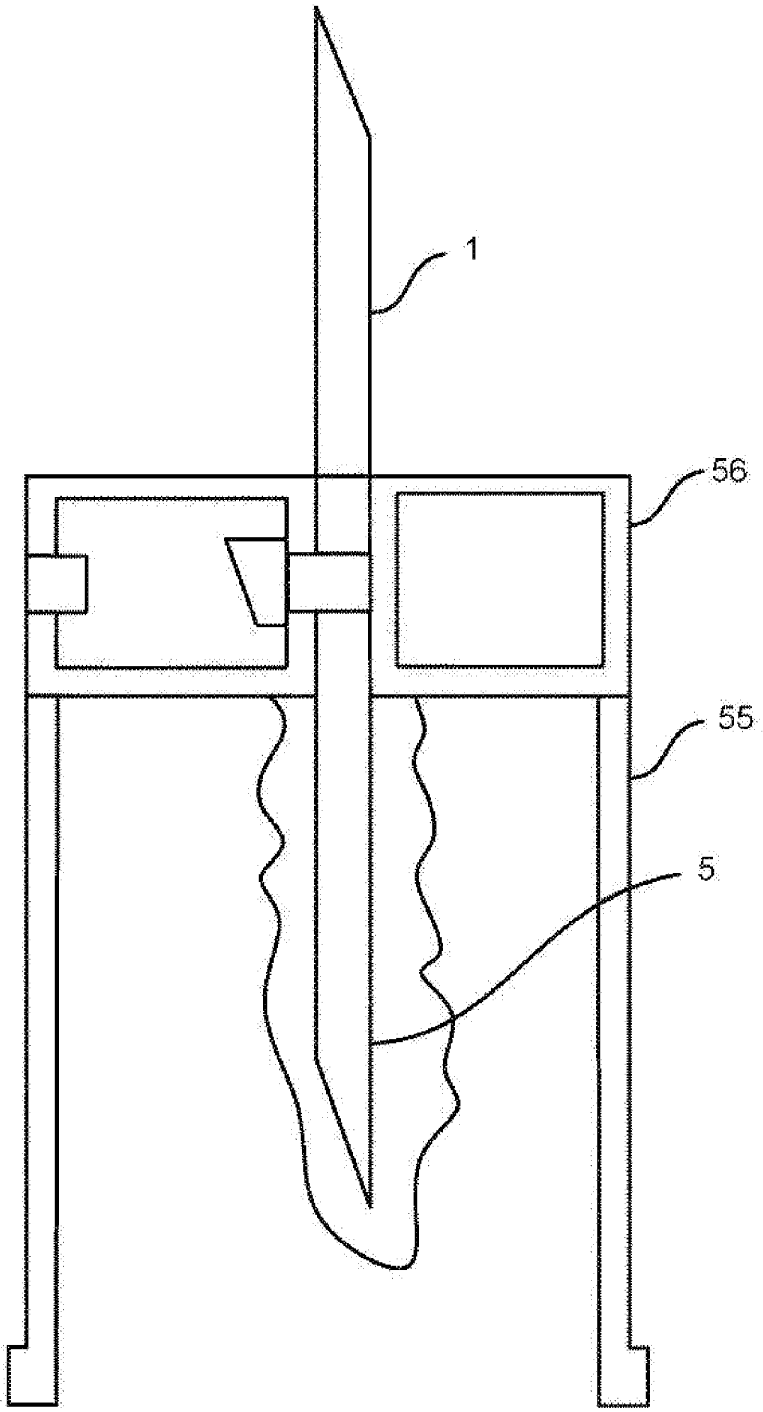


FIG. 2

[Figure 3]

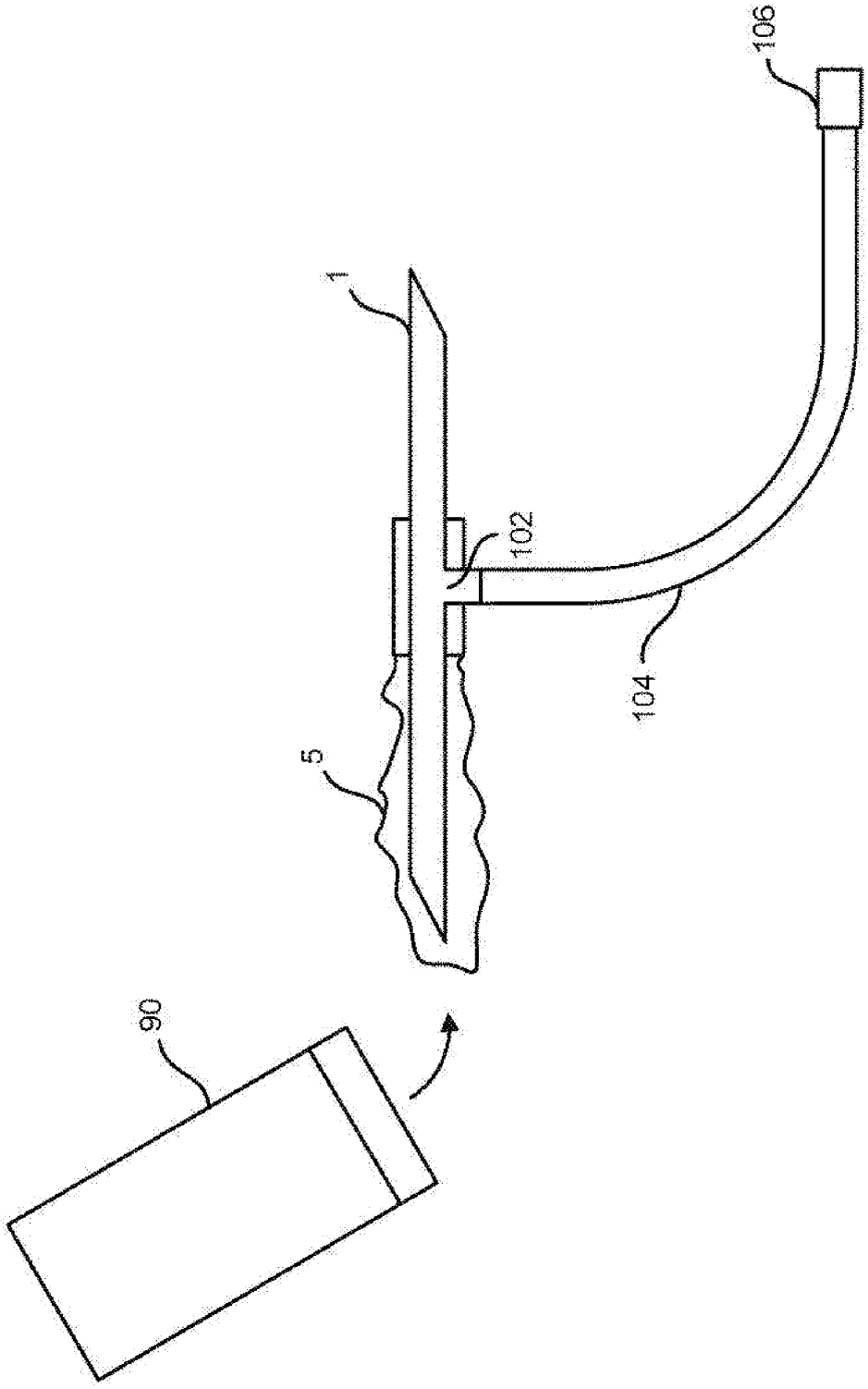


FIG. 3

[Figure 4]

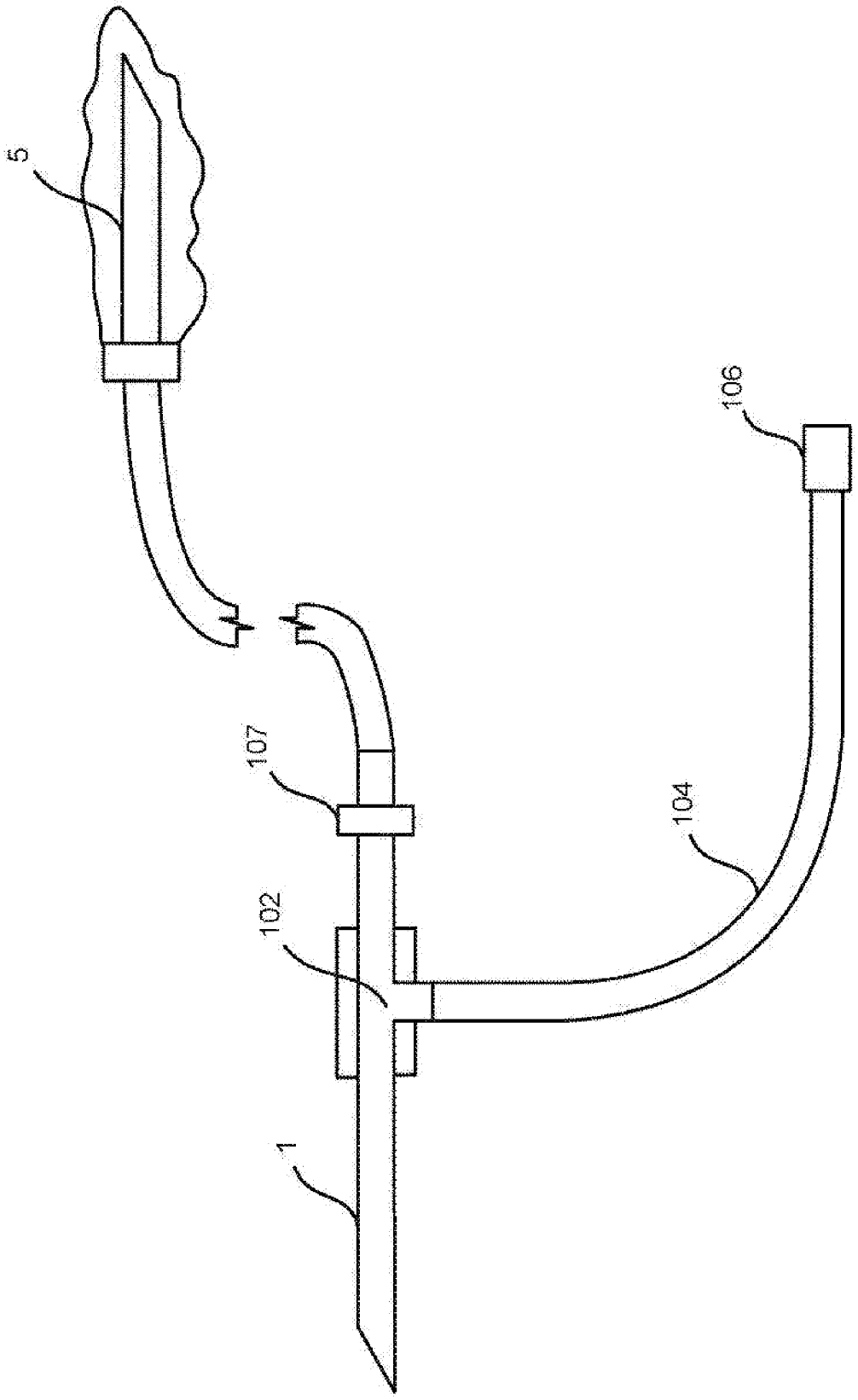


FIG. 4

[Figure 5]

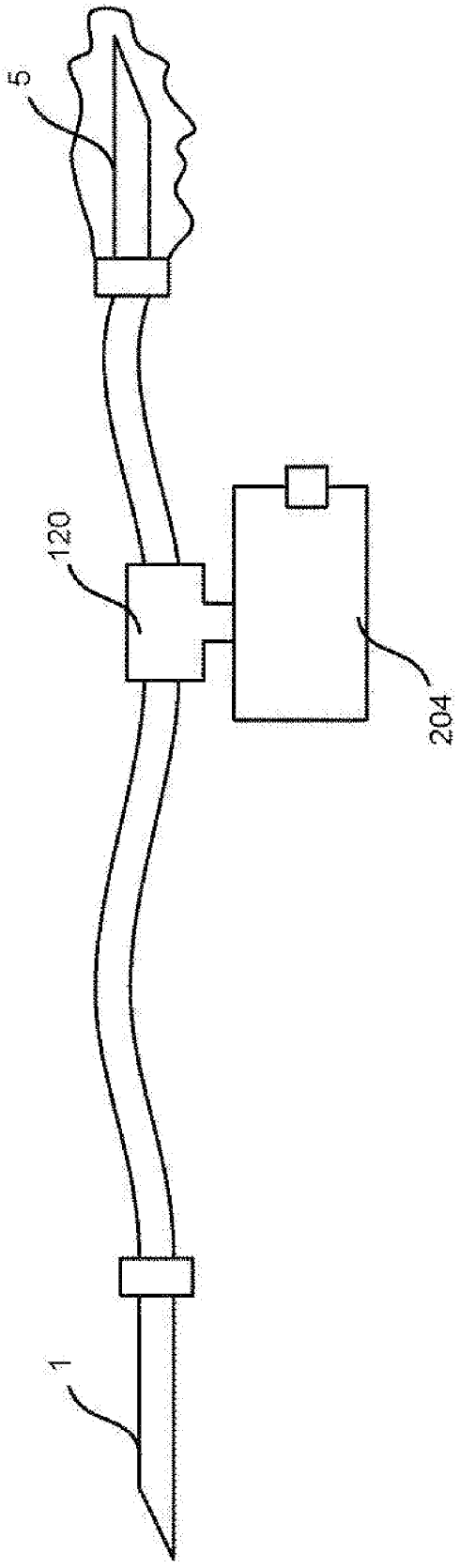


FIG. 5

[Fig. 6]

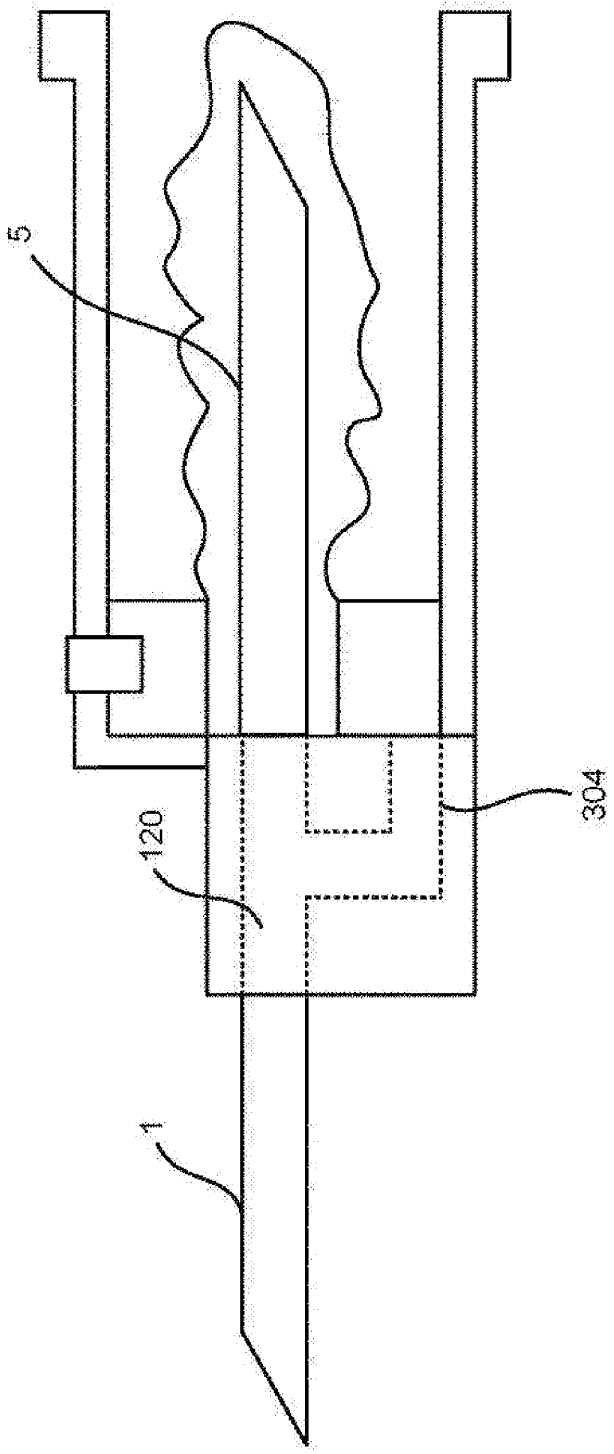


FIG. 6

[Fig. 7]

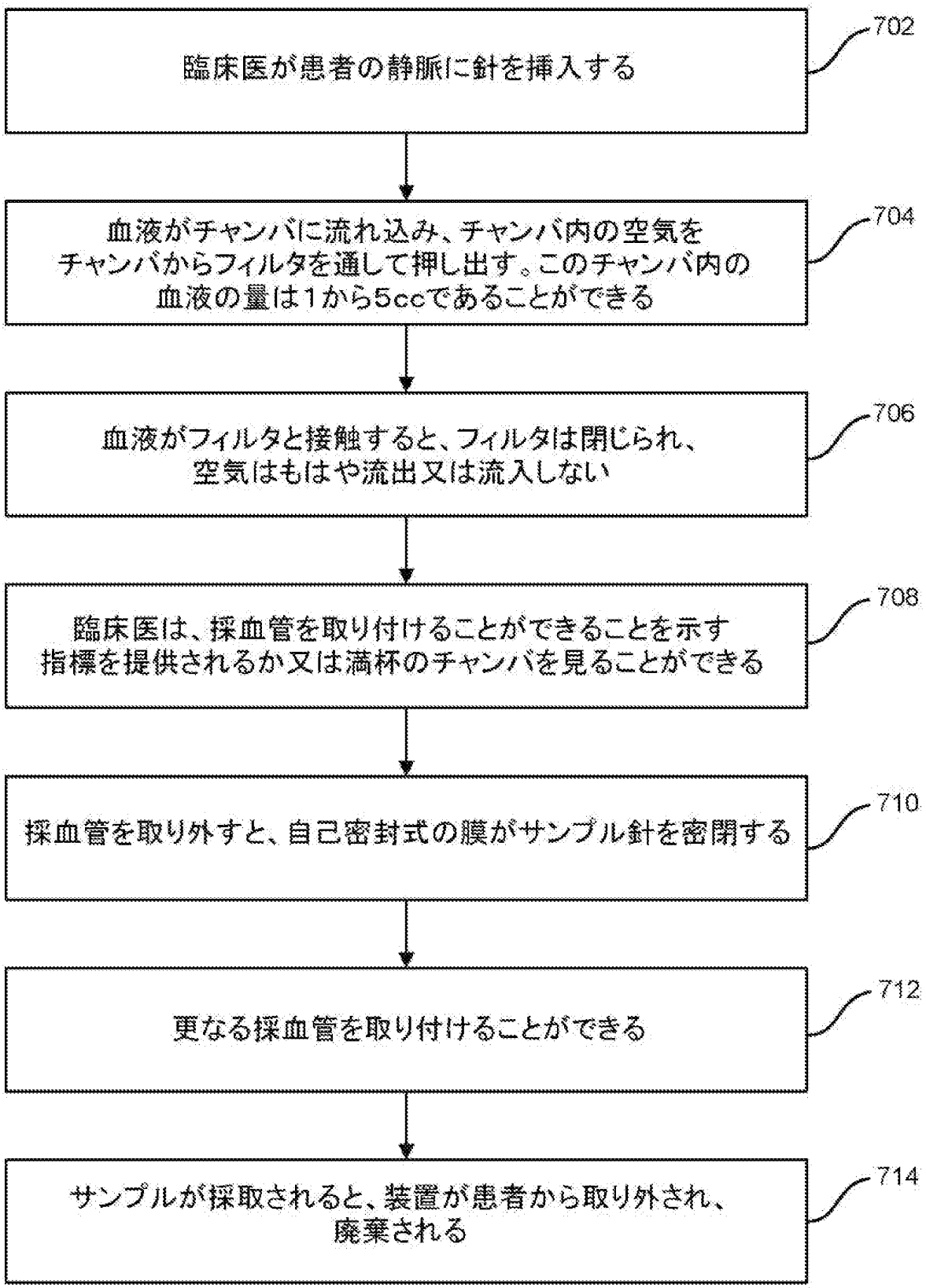

臨床医が患者の静脈に針を挿入する
702
血液がチャンバに流れ込み、チャンバ内の空気を
チャンバからフィルタを通して押し出す。このチャンバ内の
血液の量は1から5ccであることができる
704
血液がフィルタと接触すると、フィルタは閉じられ、
空気はもはや流出又は流入しない
706
臨床医は、採血管を取り付けることができることを示す
指標を提供されるか又は満杯のチャンバを見ることができる
708
採血管を取り外すと、自己密封式の膜がサンプル針を密閉する
710
更なる採血管を取り付けることができる
712
サンプルが採取されると、装置が患者から取り外され、
廃棄される
714

FIG. 7

[Fig. 8A]

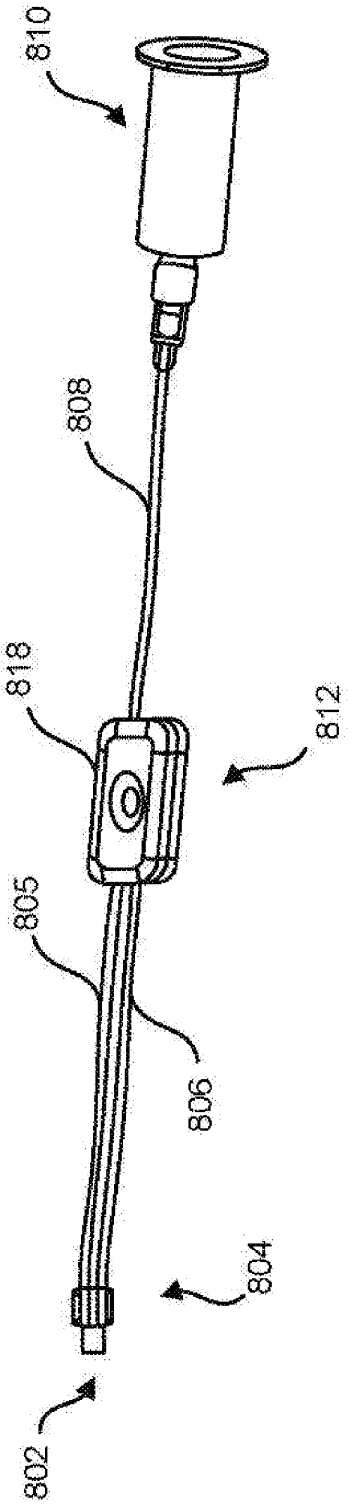


FIG. 8A

[Fig. 8B]

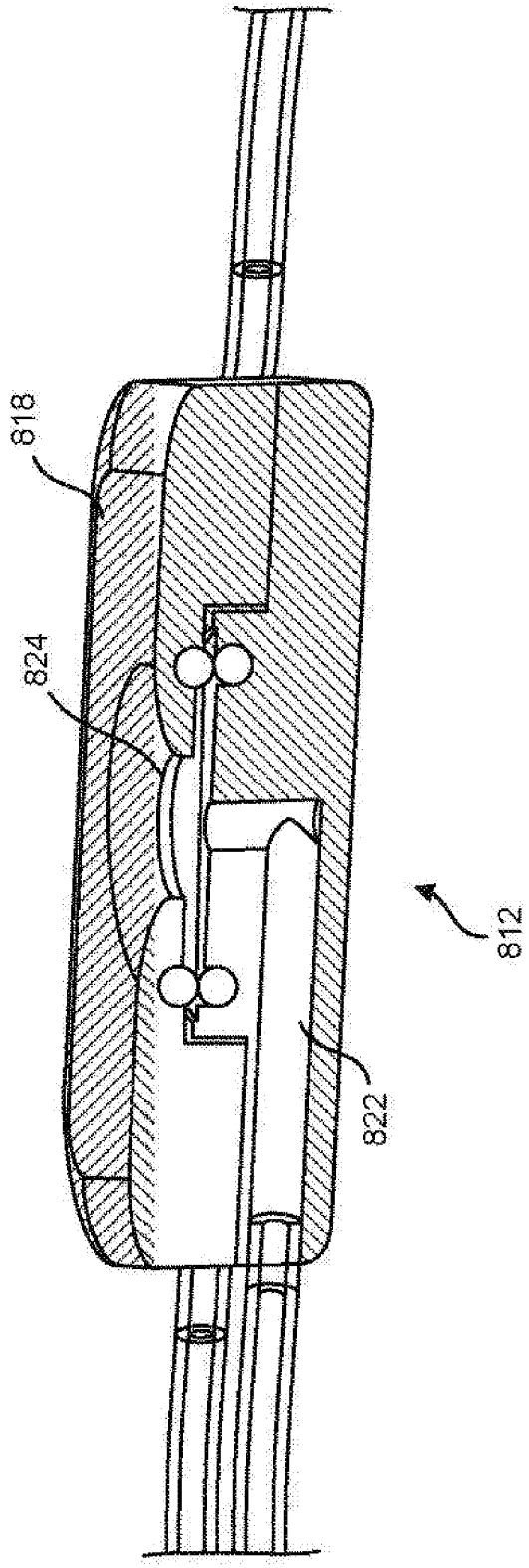


FIG. 8B

[Fig. 8C]

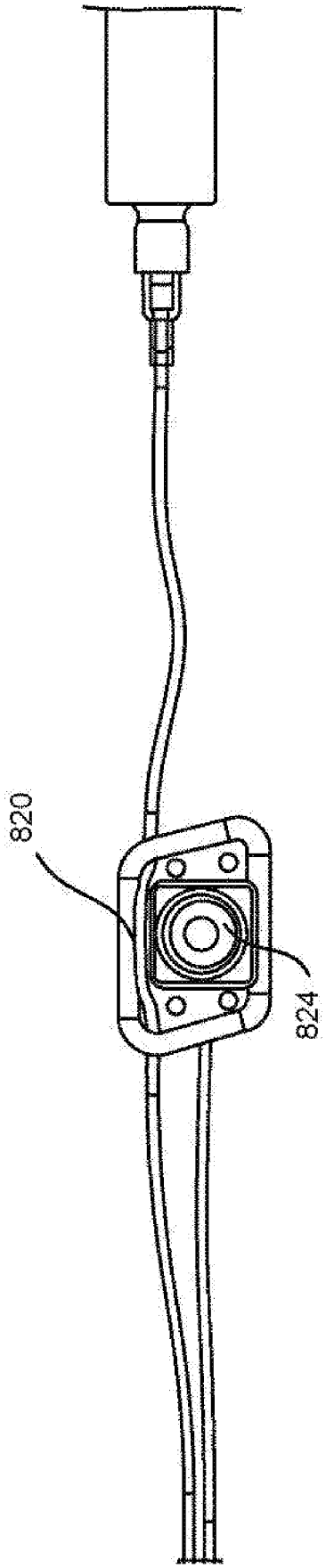


FIG. 8C

[Fig. 8D]



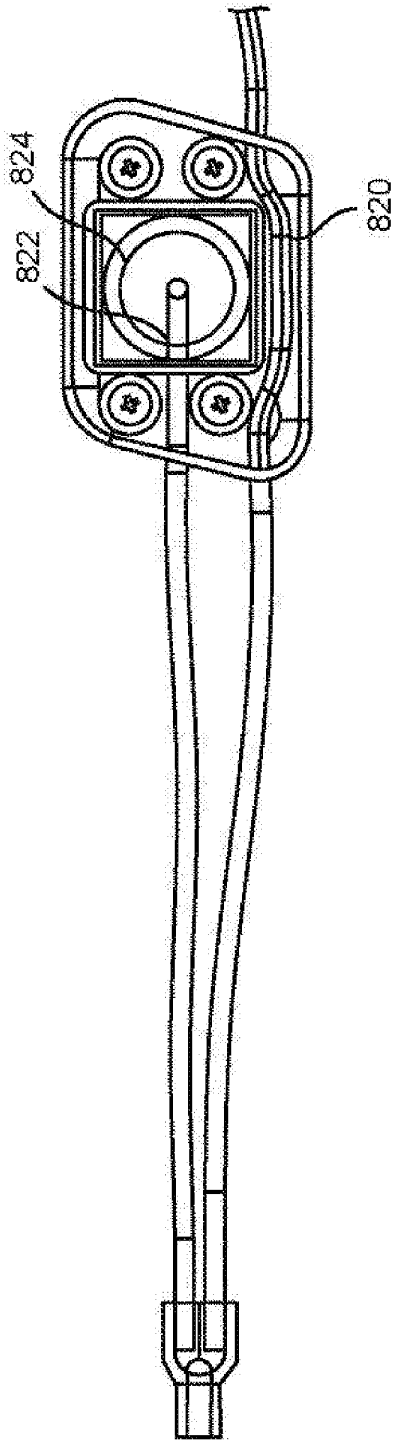


FIG. 8D

[Fig. 8E]

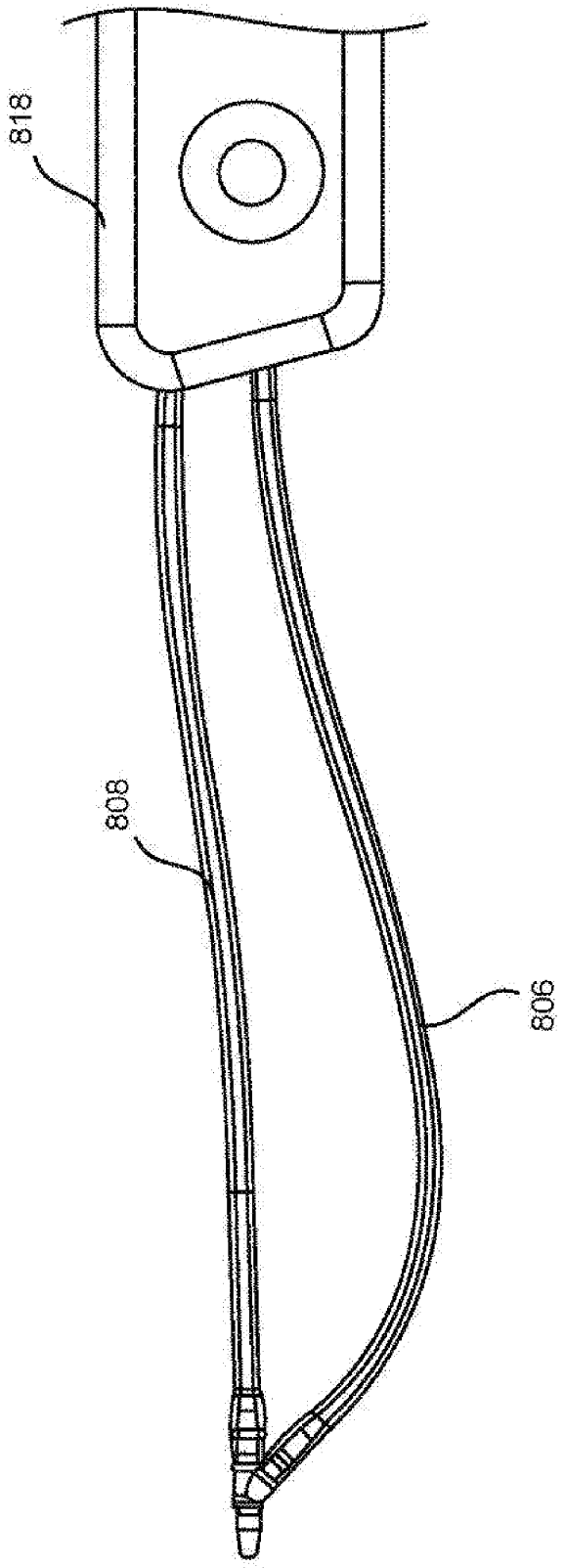


FIG. 8E

[Fig. 9]

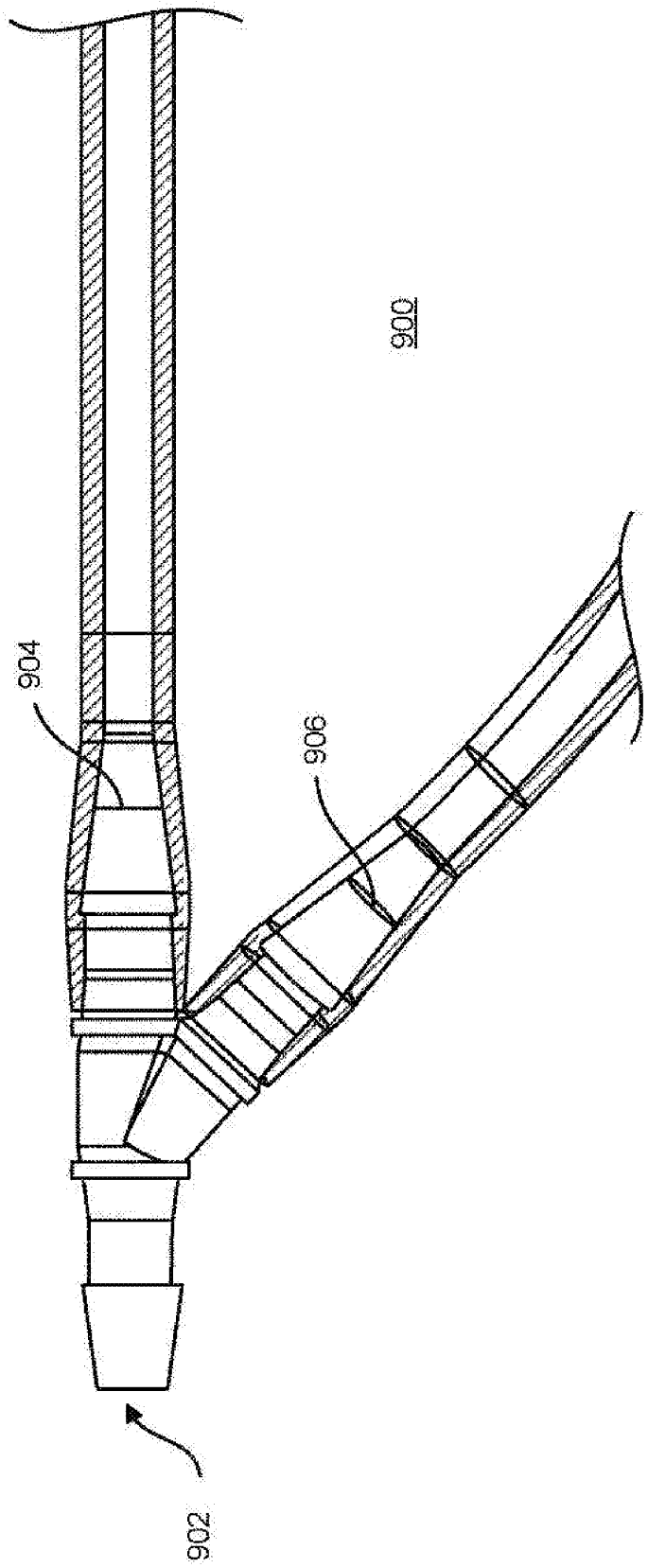


FIG. 9

[Fig. 10A]

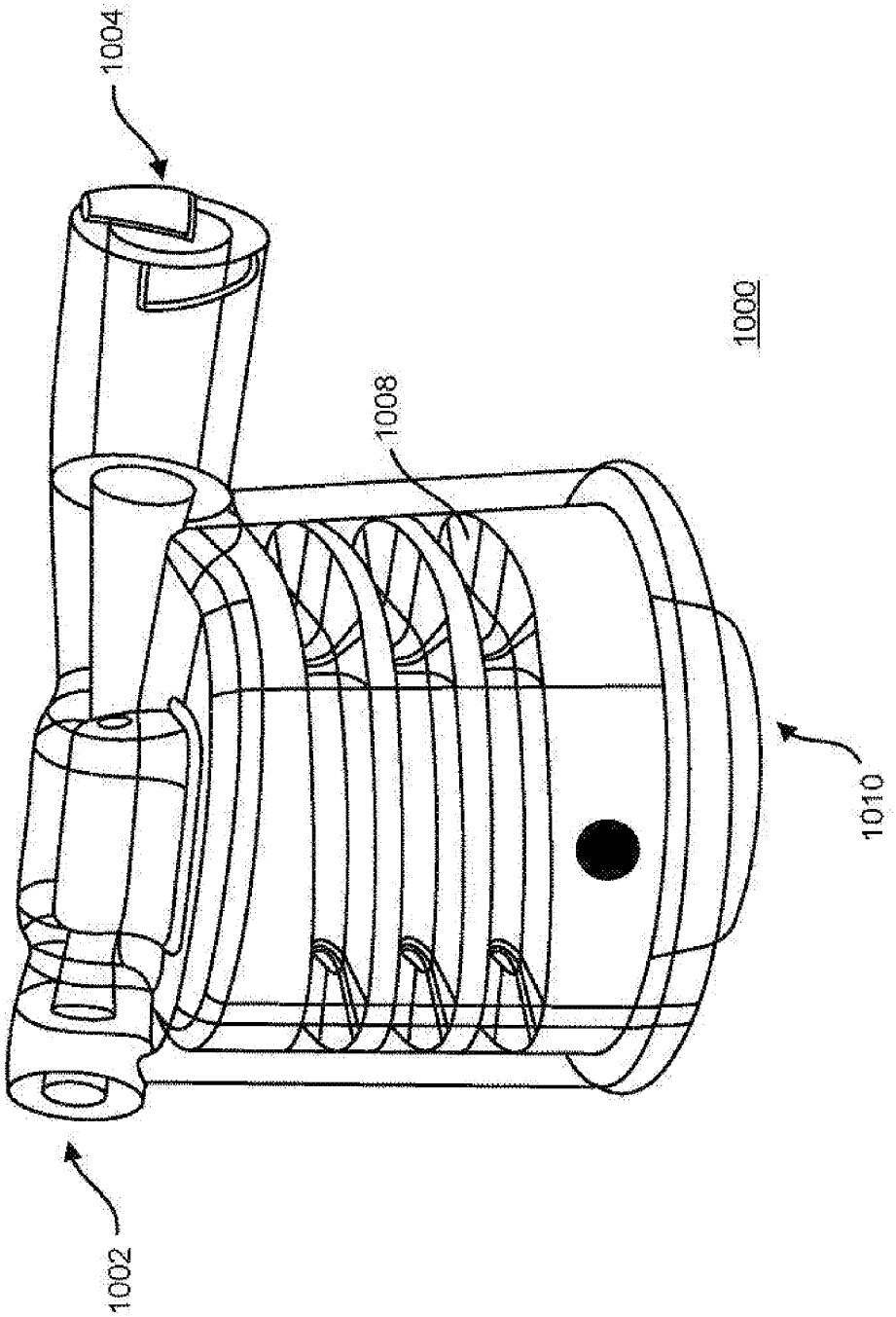


FIG. 10A

[Fig. 10B]

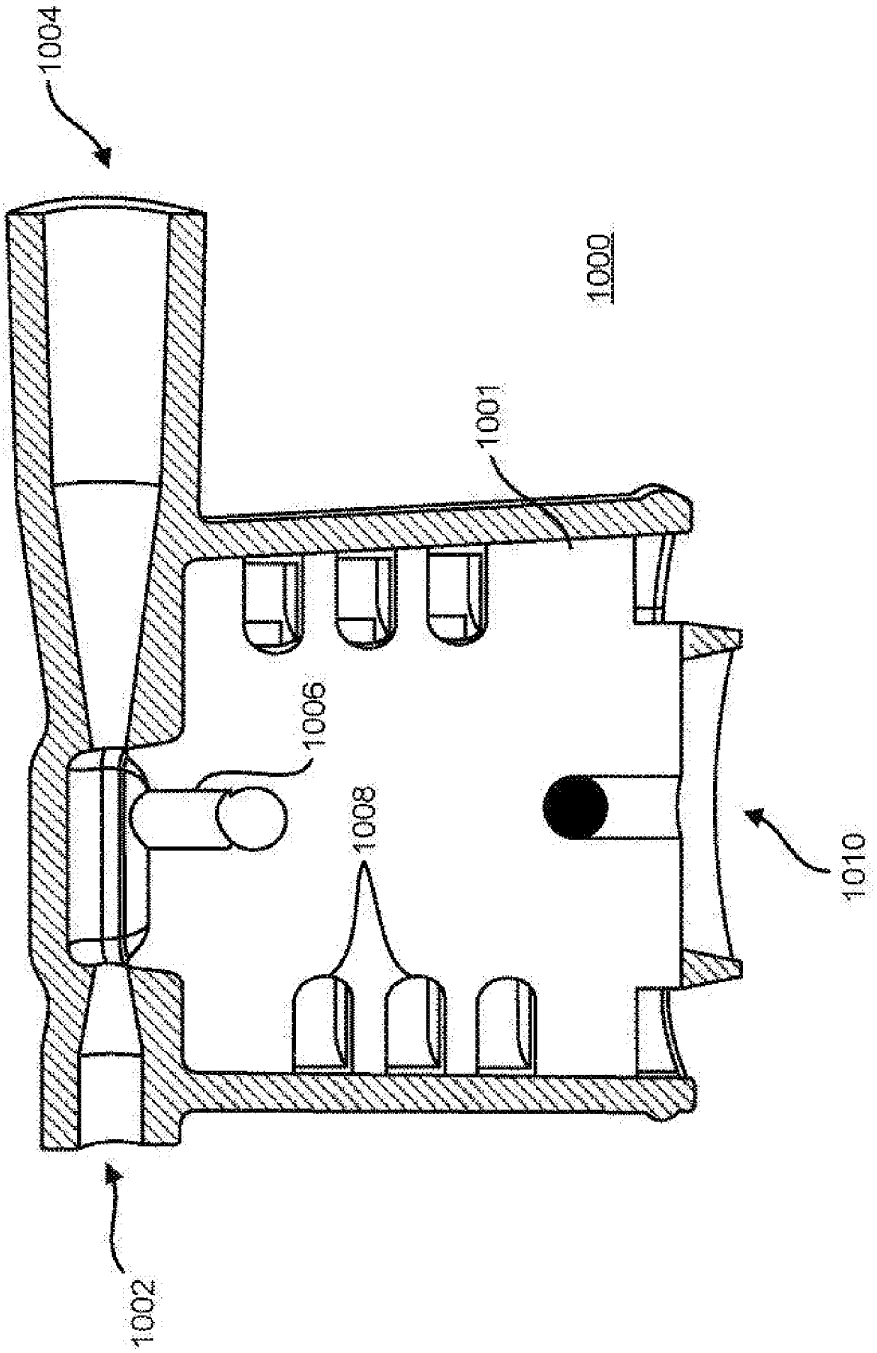


FIG. 10B

[Fig. 10C]

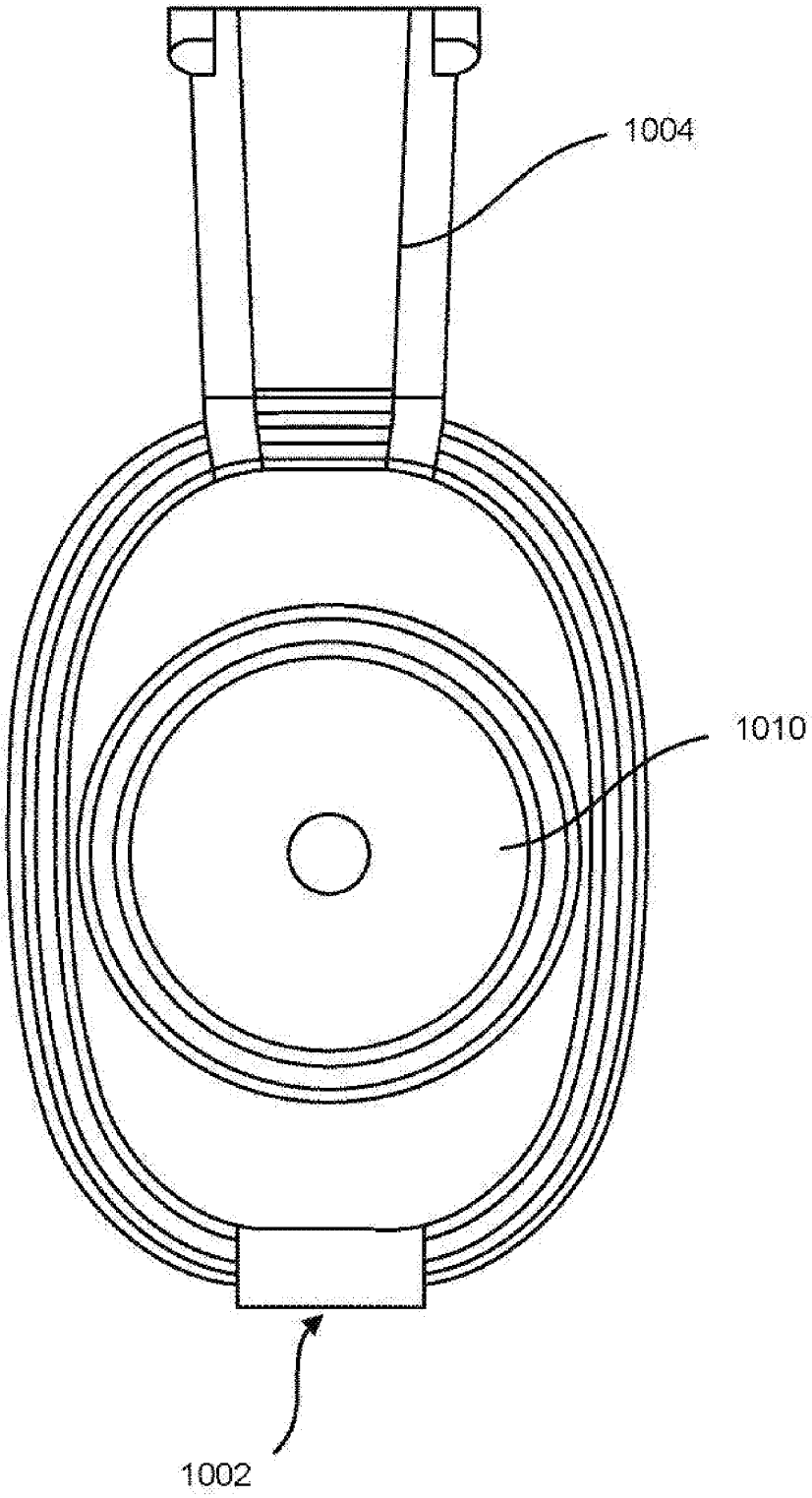
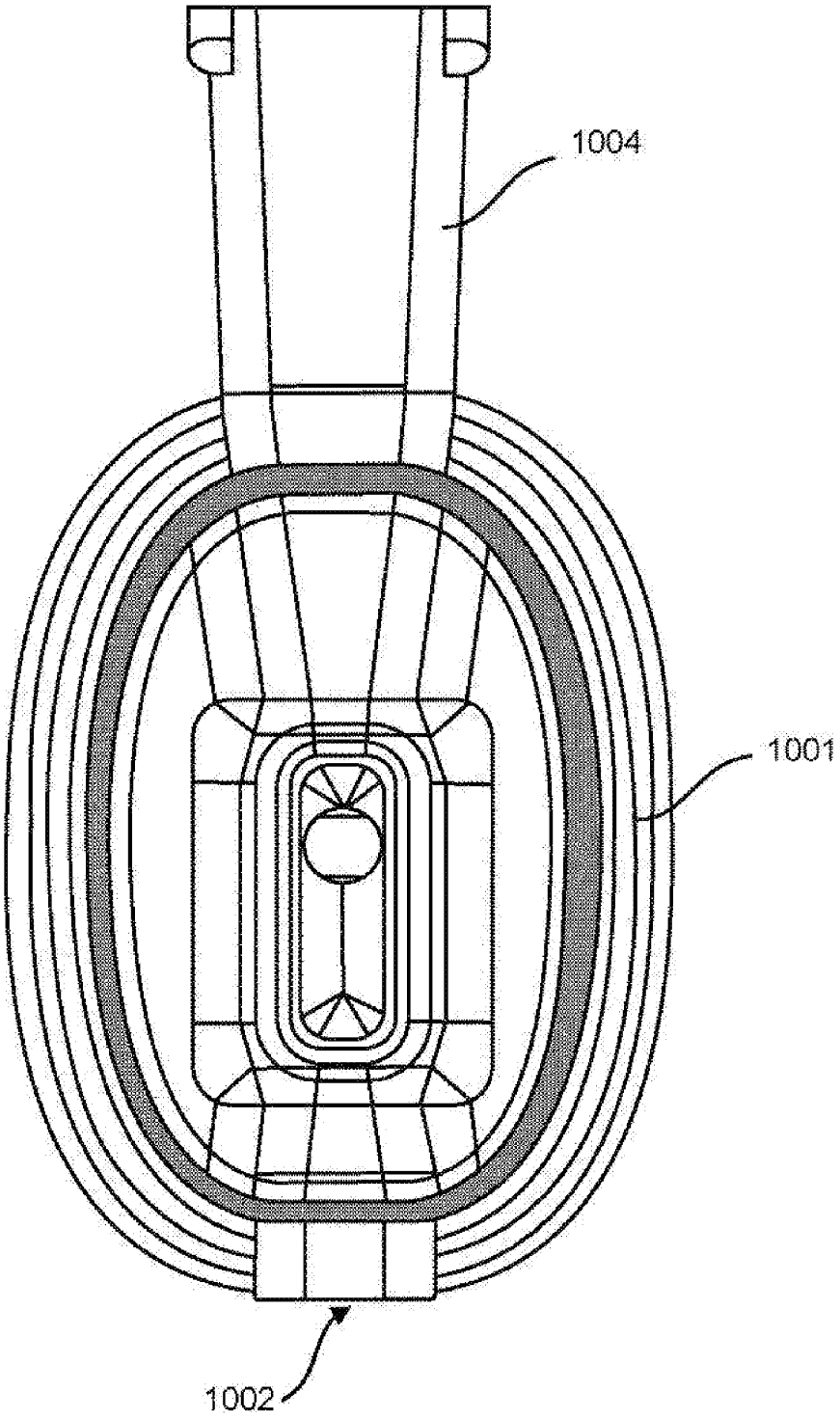


FIG. 10C

[Fig. 10D]




1004
1001
1002

[Fig. 11A]

FIG. 10D

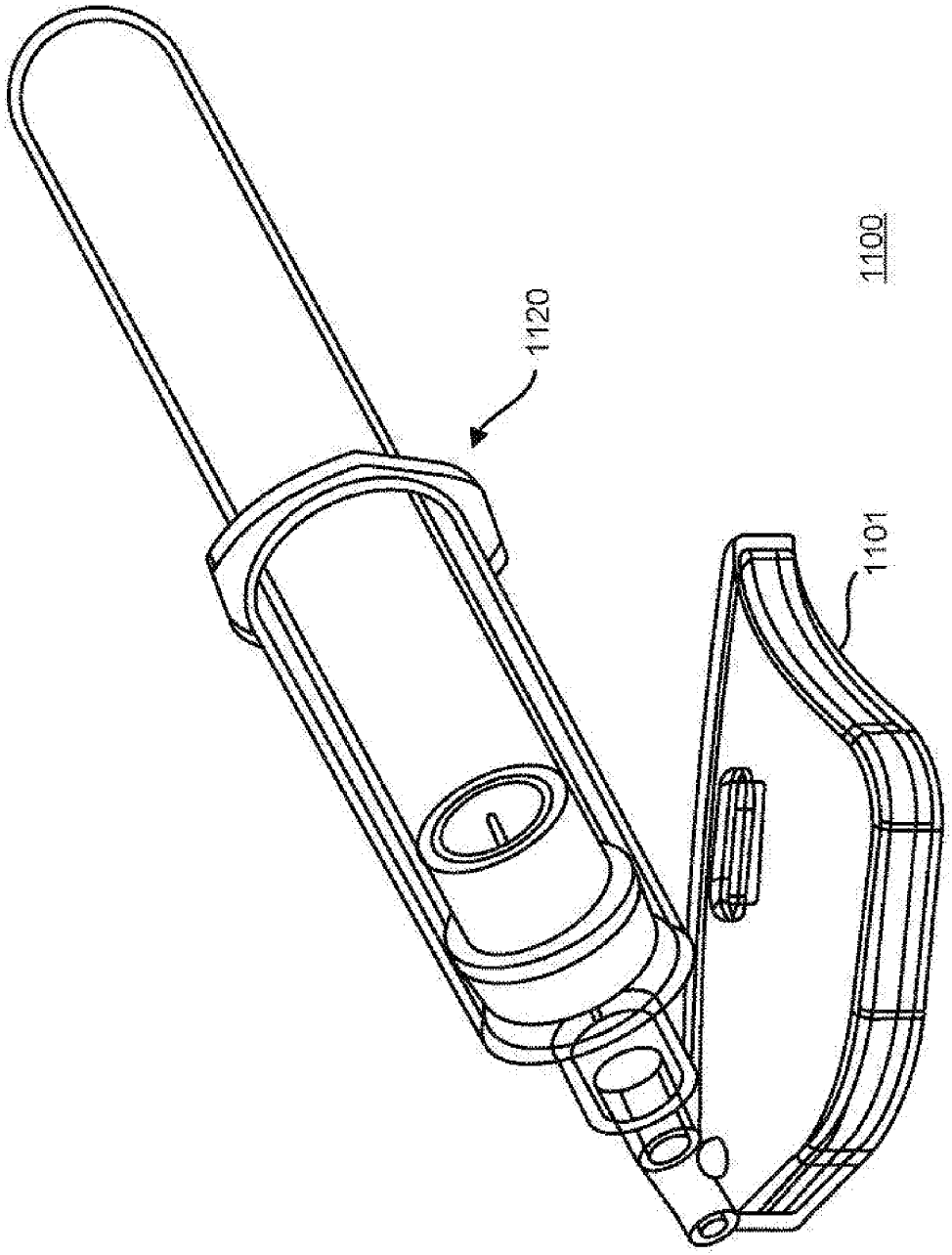


FIG. 11A

[Fig. 11B]

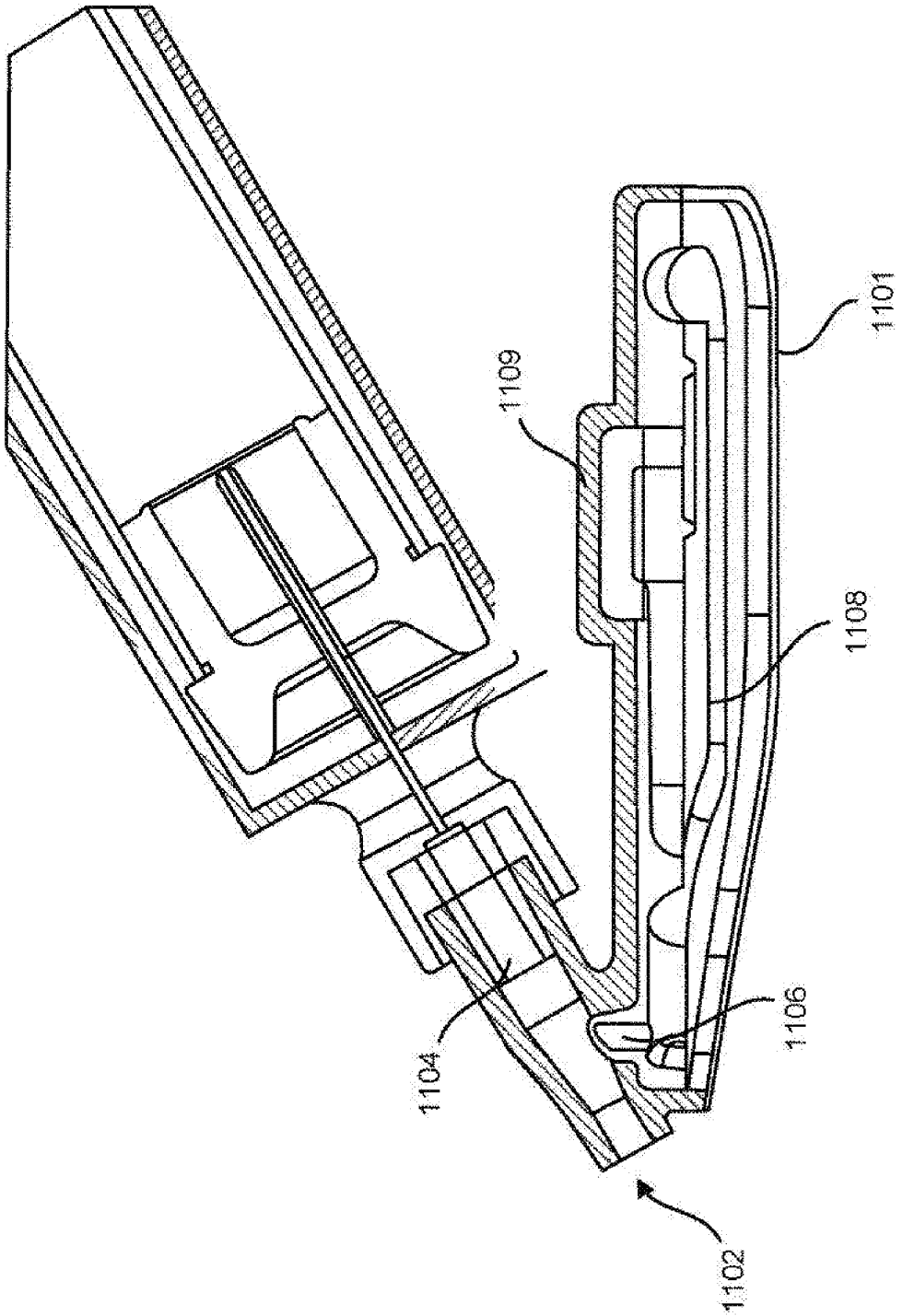
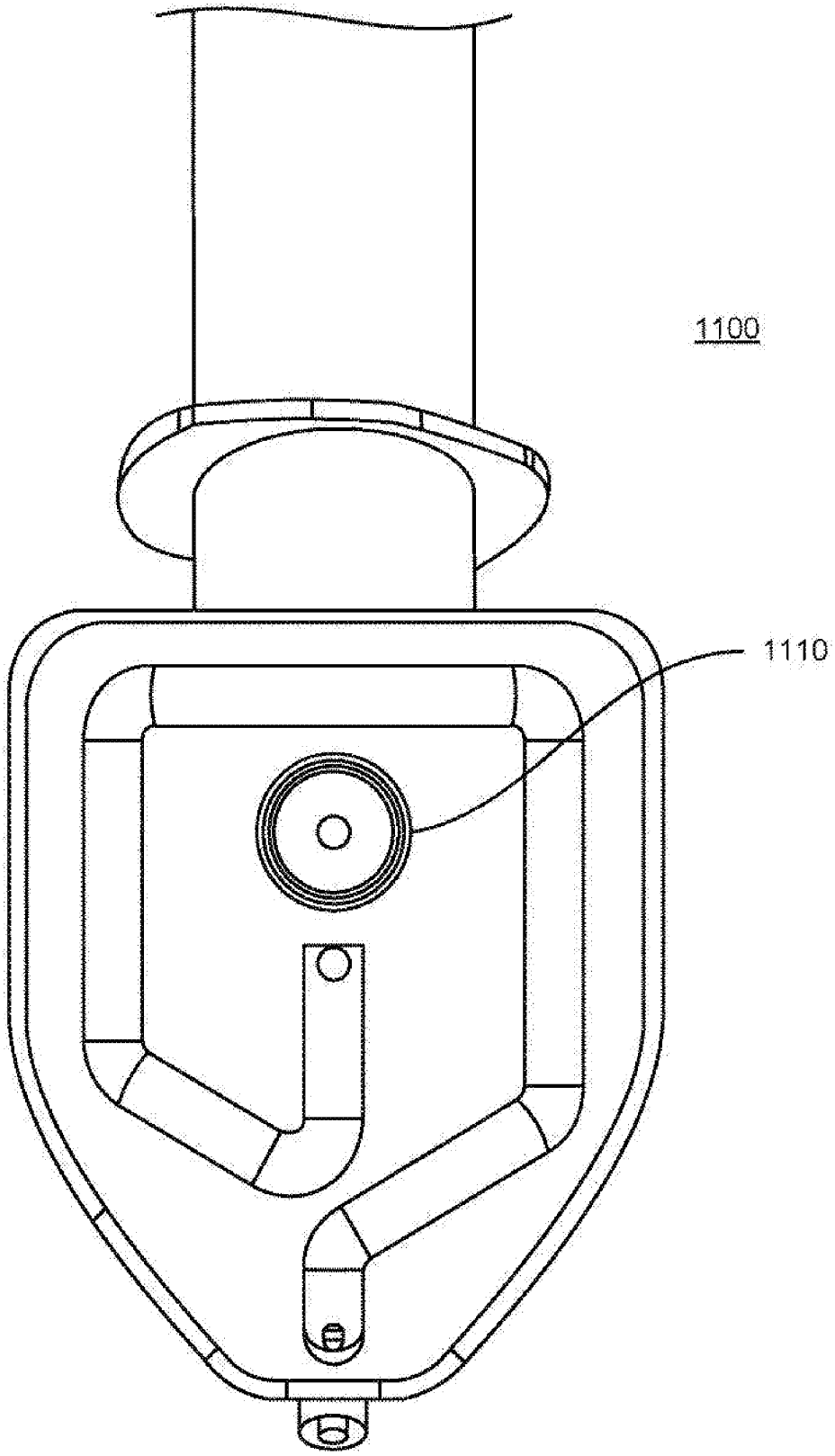


FIG. 11B

[Fig. 11C]


1100
1110

[Fig. 11D]

FIG. 11C

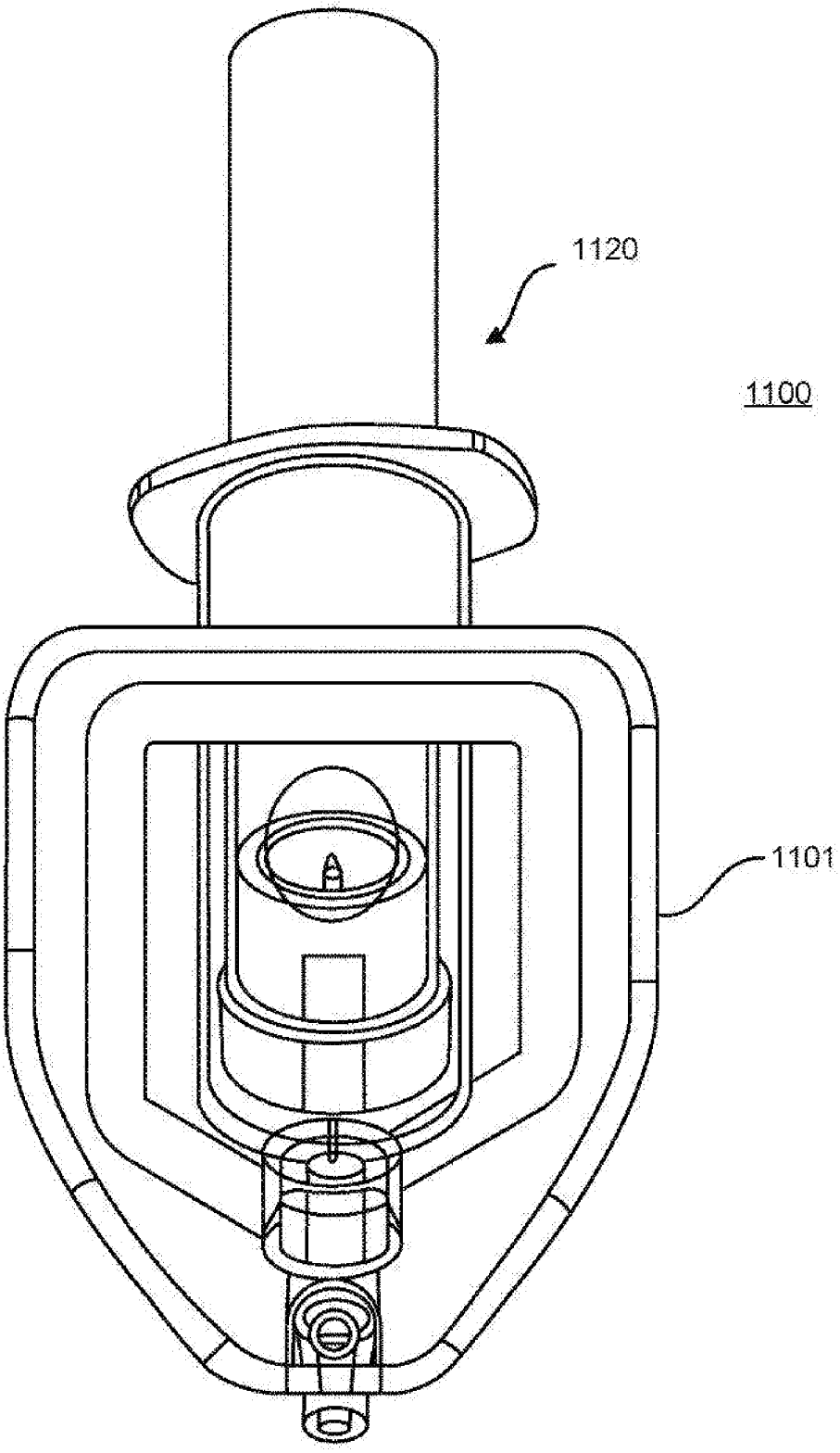


FIG. 11D

[Fig. 11E]

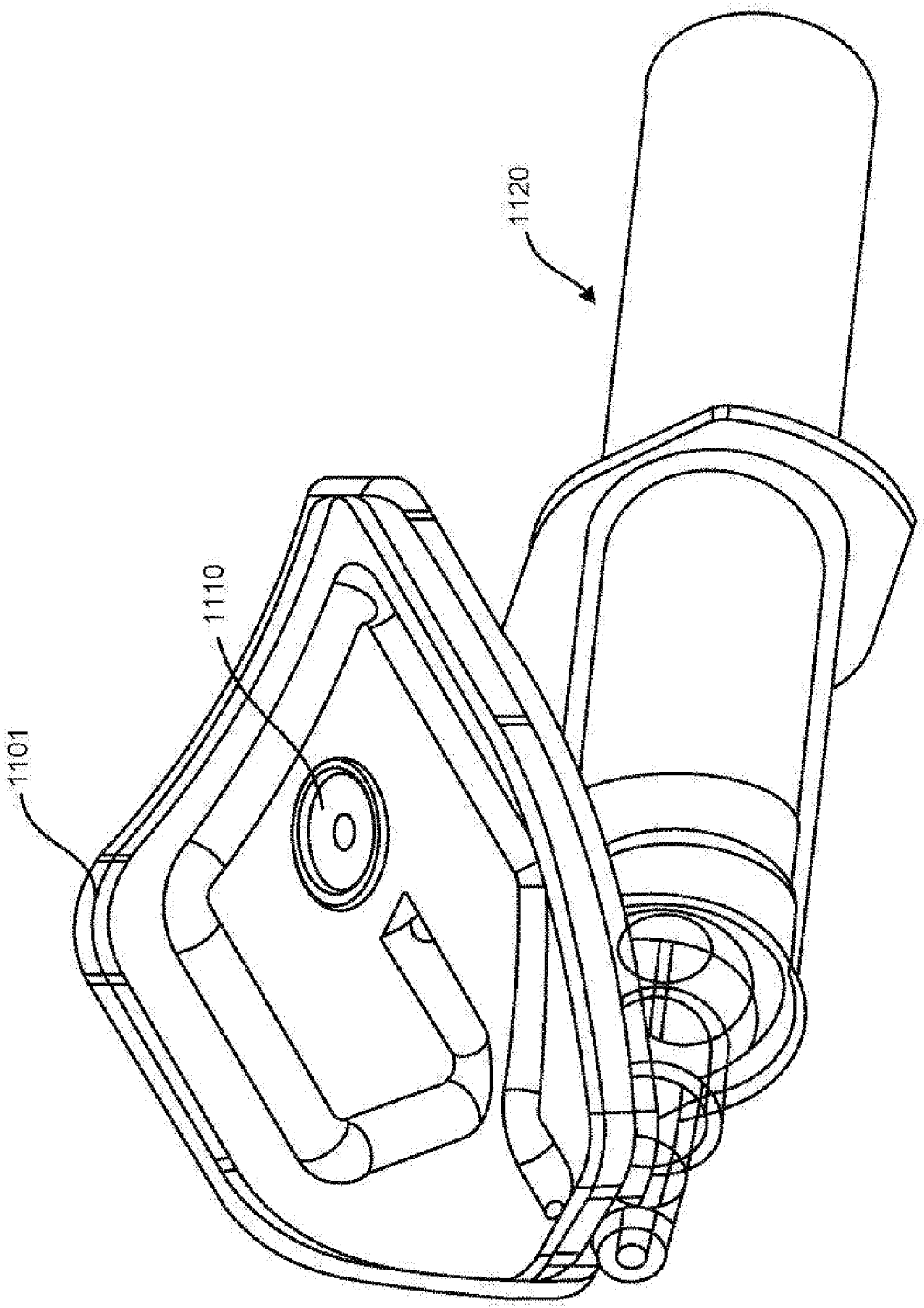


FIG. 11E

[Fig. 12A]

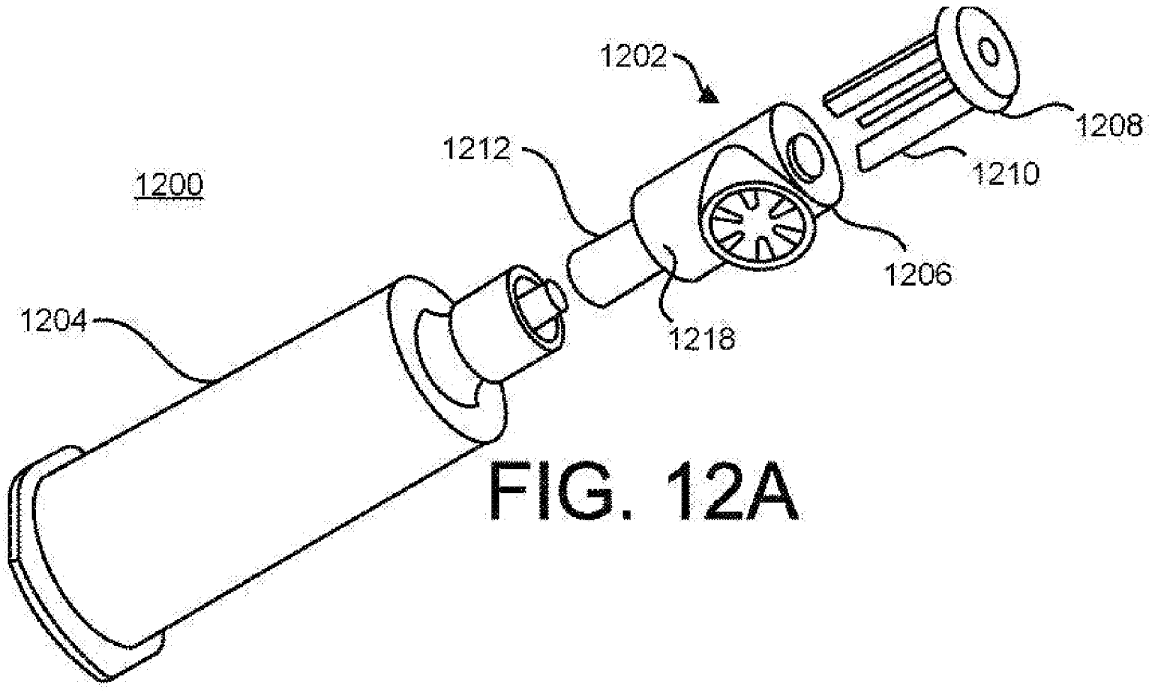


FIG. 12A

[Fig. 12B]

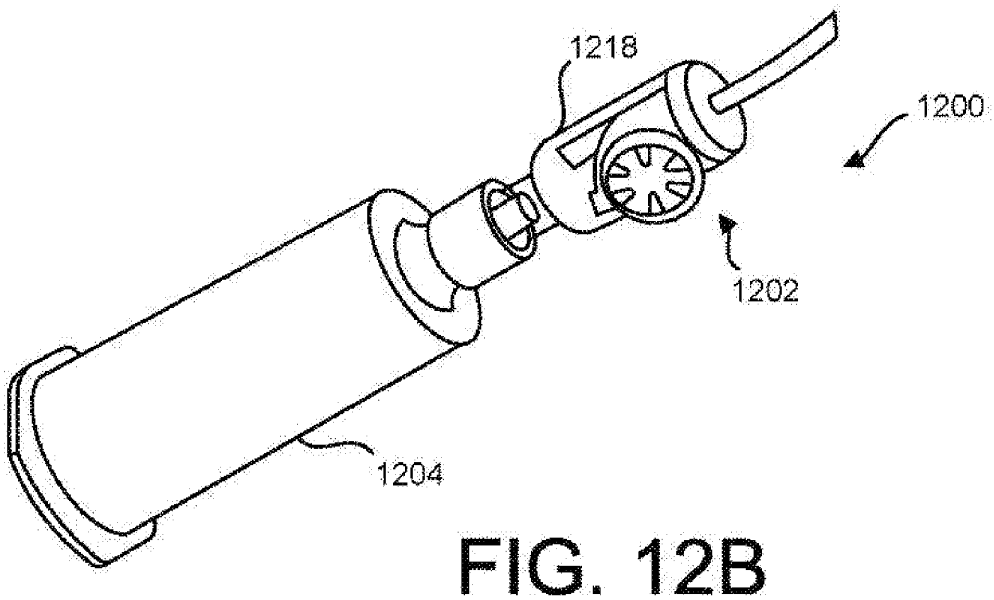


FIG. 12B

[Fig. 12C]

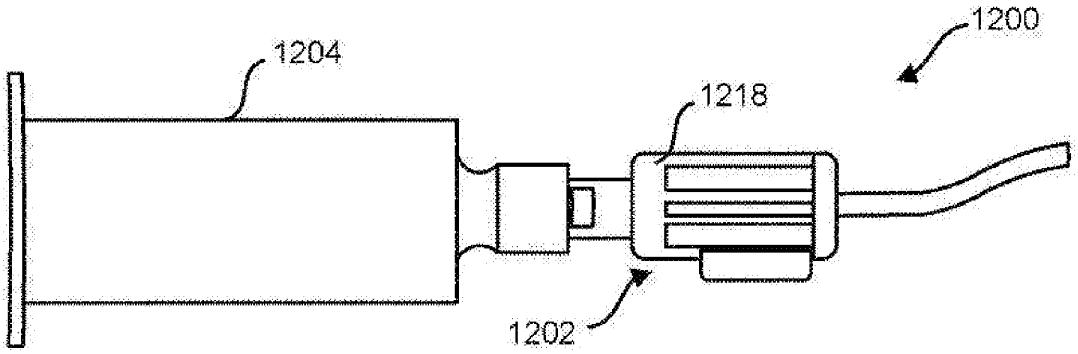


FIG. 12C

[Fig. 12D]

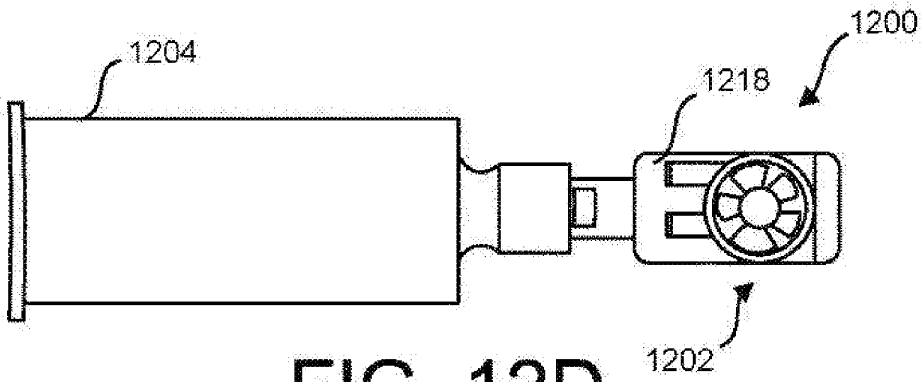


FIG. 12D

[Fig. 13A]

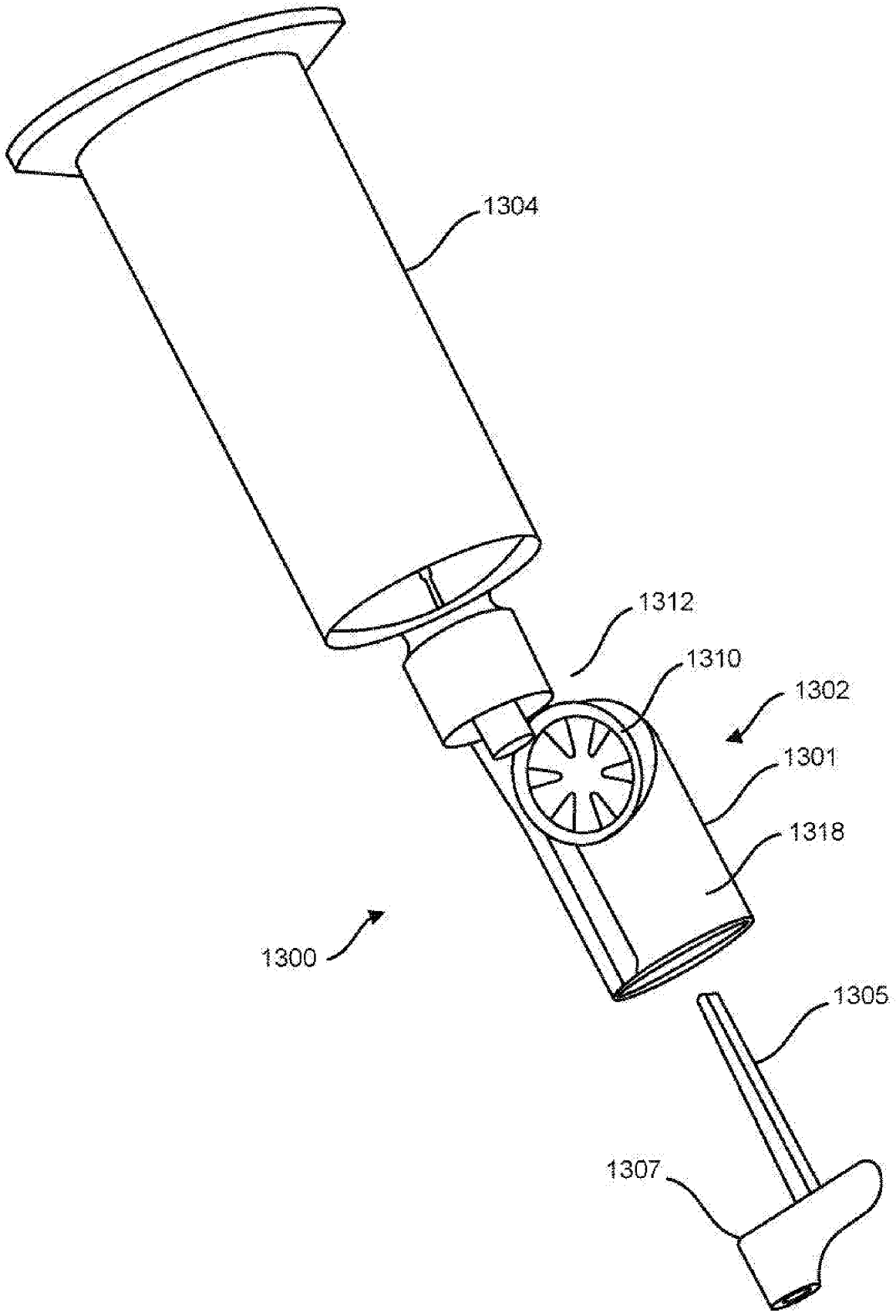


FIG. 13A

[Fig. 13B]

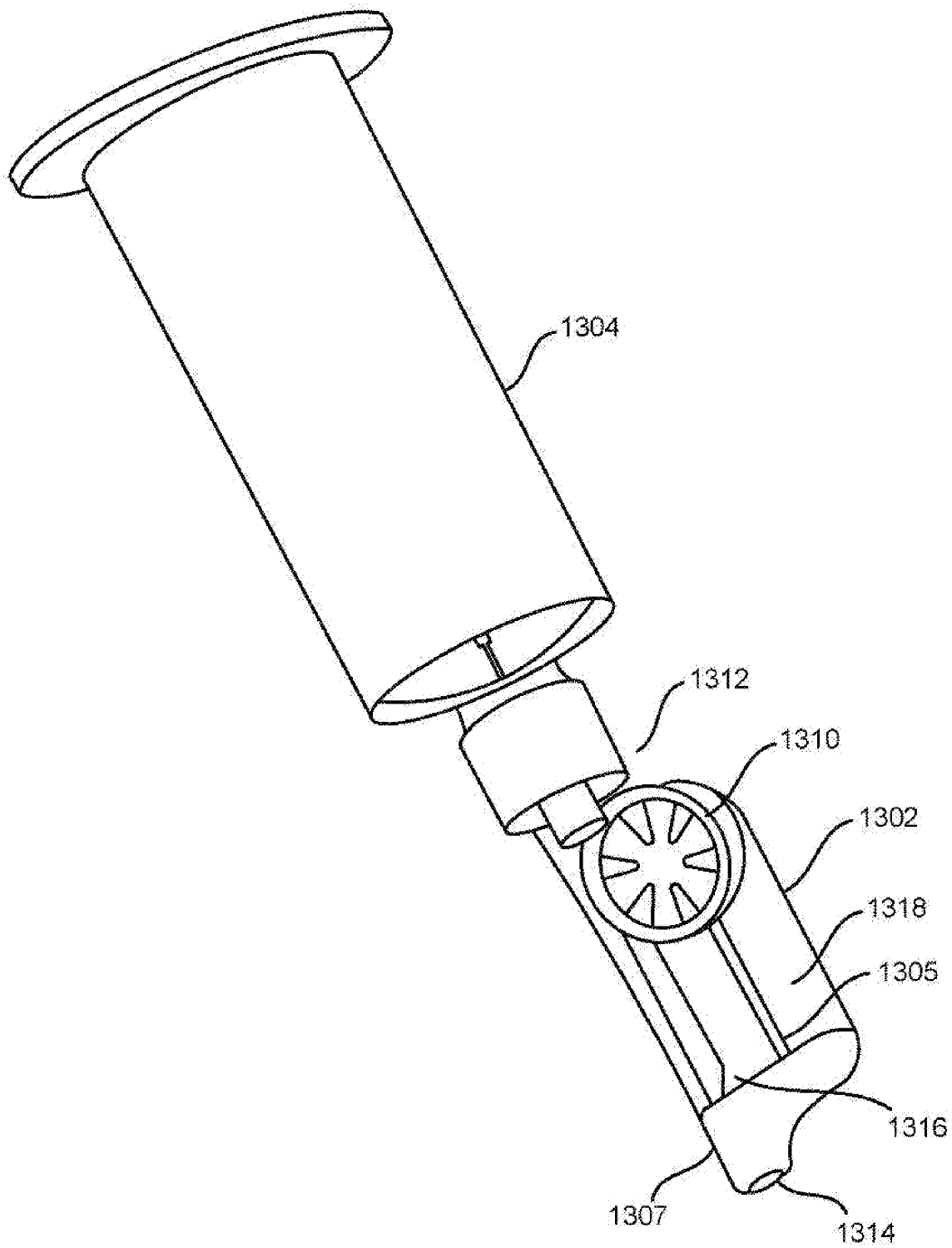


FIG. 13B

[Fig. 13C]

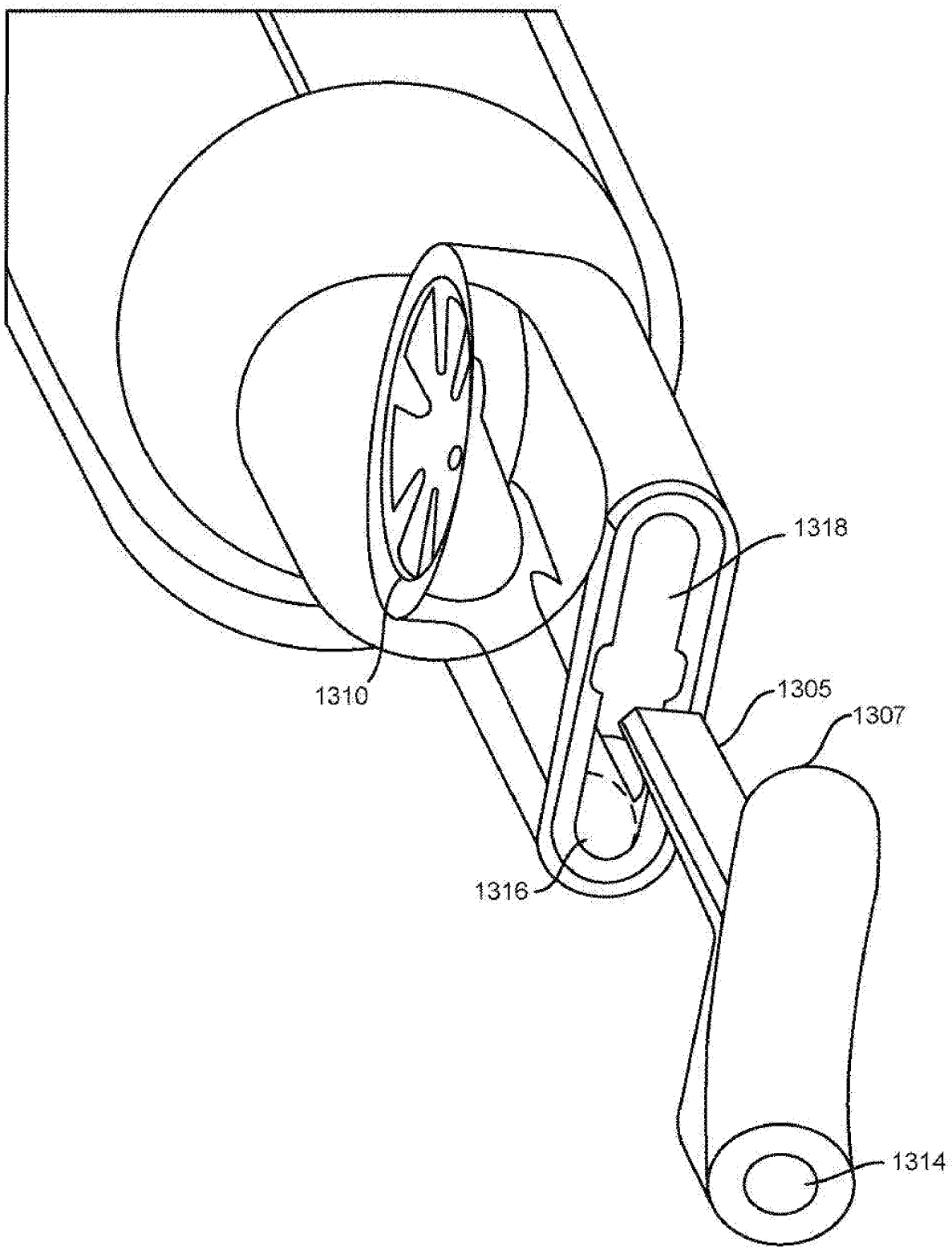
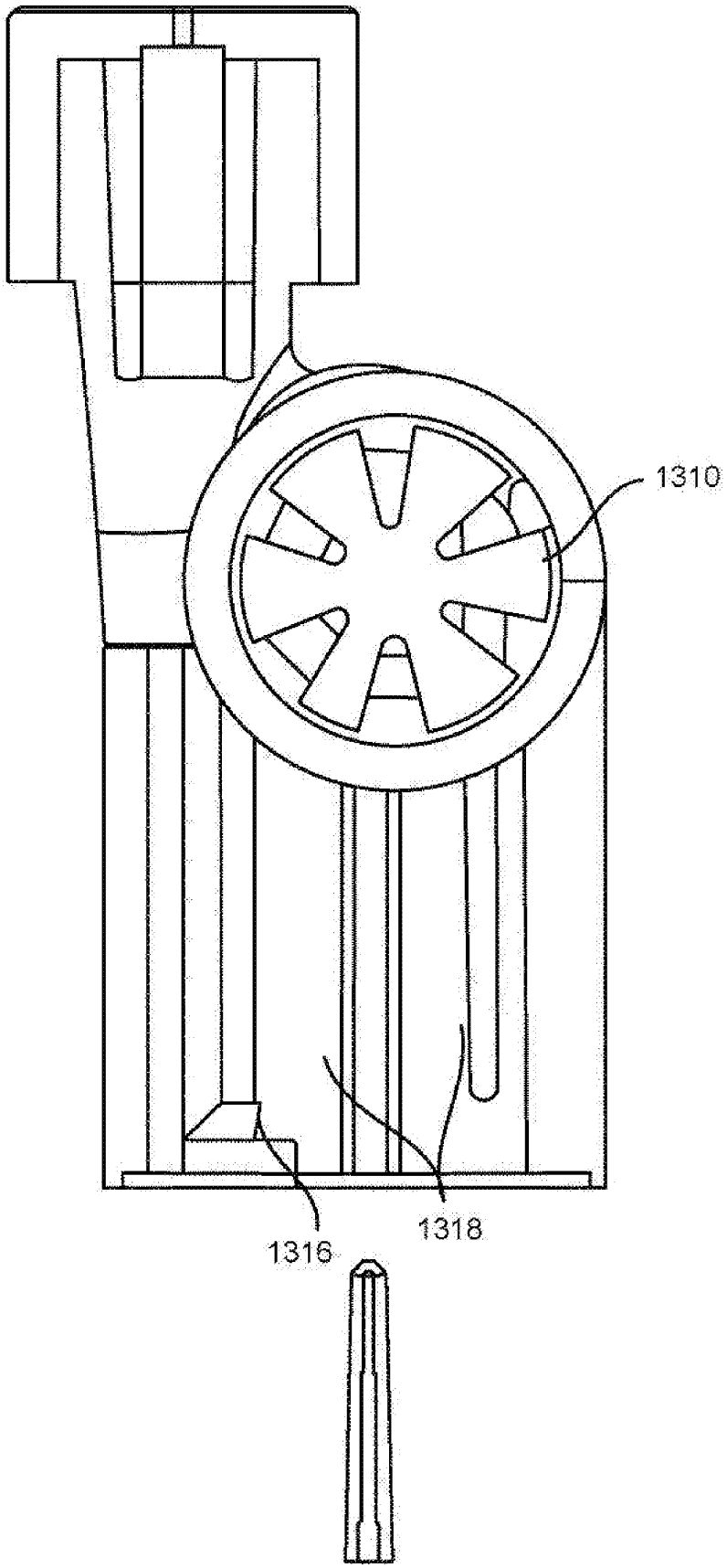


FIG. 13C

[Fig. 13D]


1310
1316
1318

[Fig. 14A]

FIG. 13D

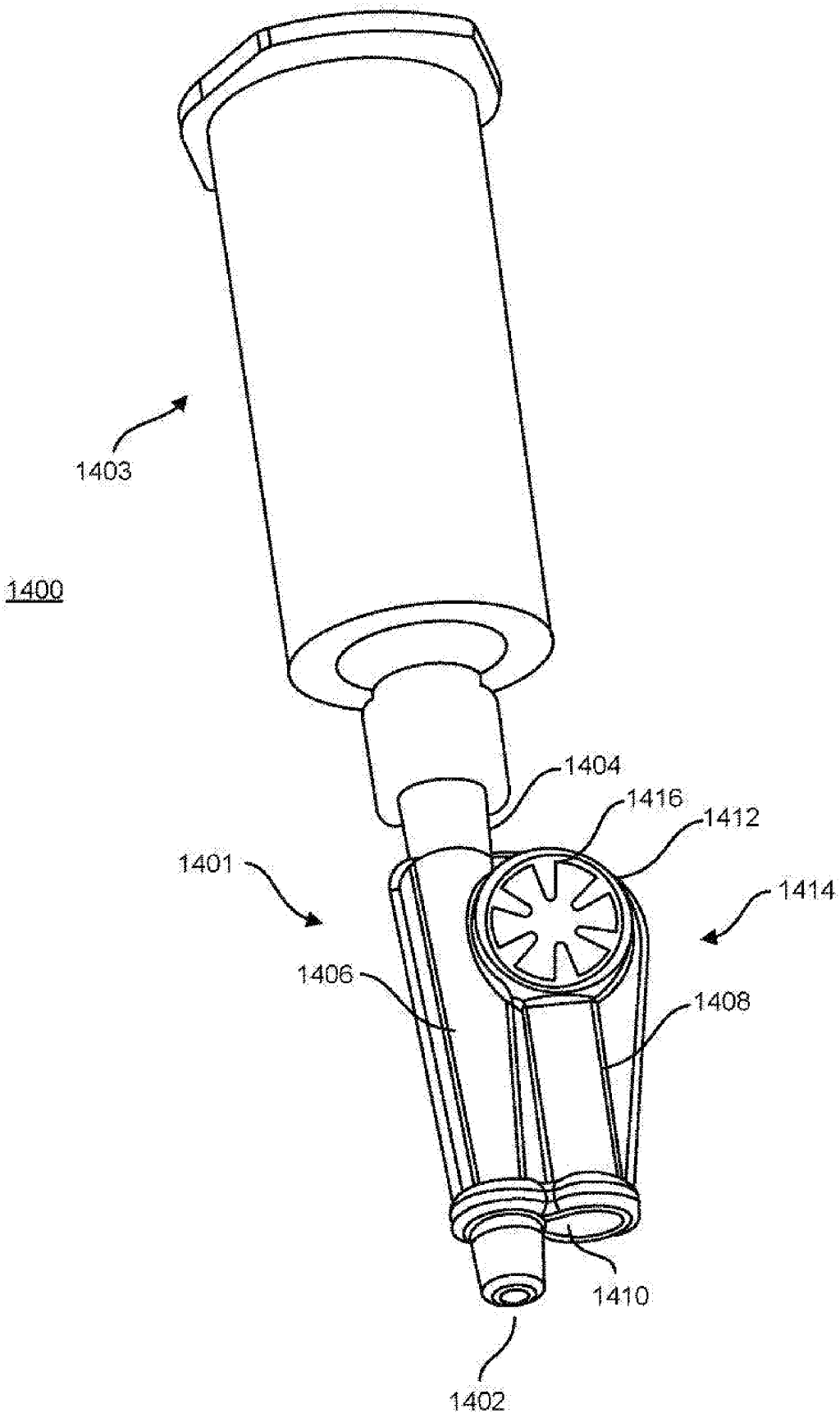
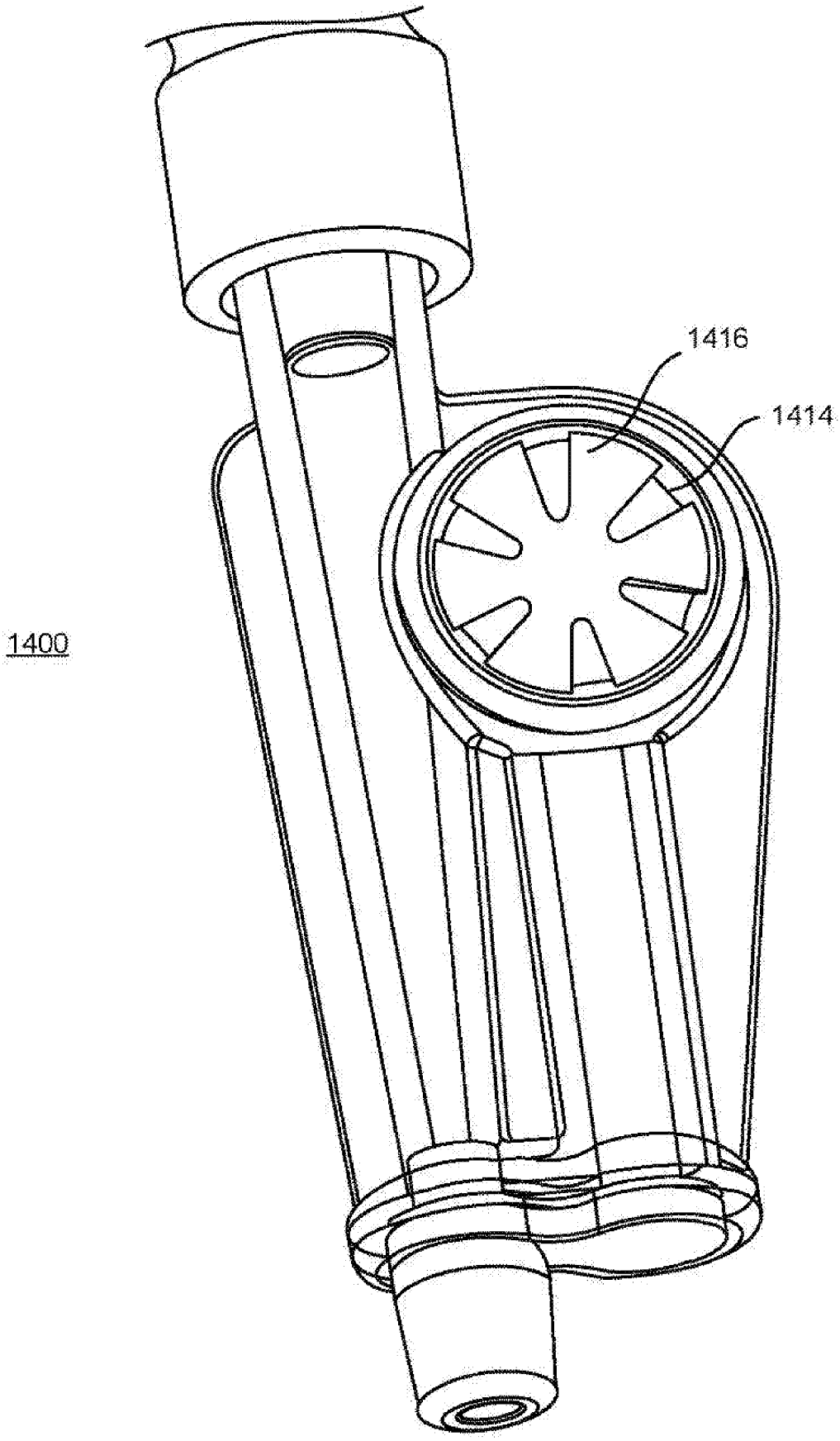


FIG. 14A

[Fig. 14B]


1416
1414
1400

[Fig. 14C]

FIG. 14B

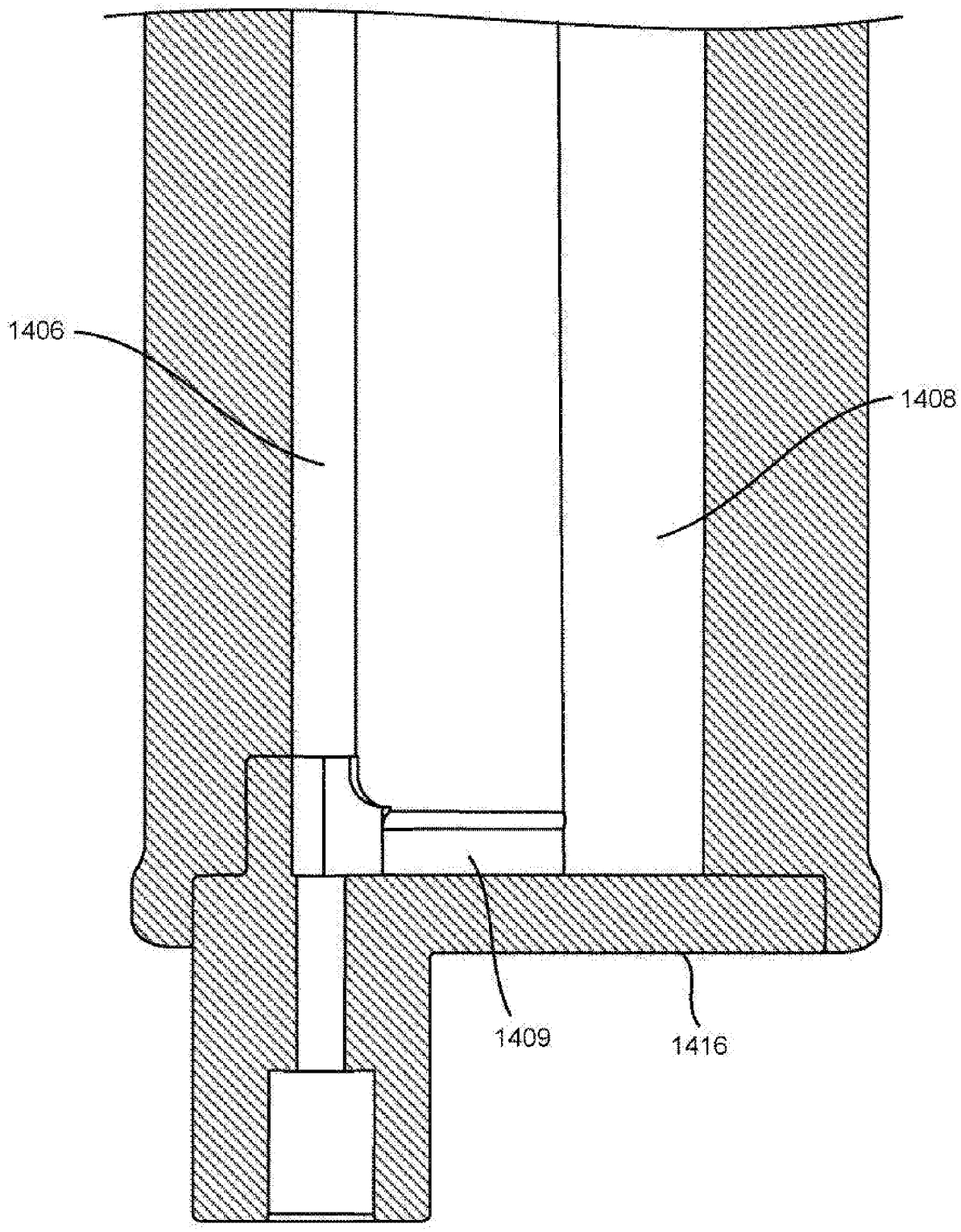
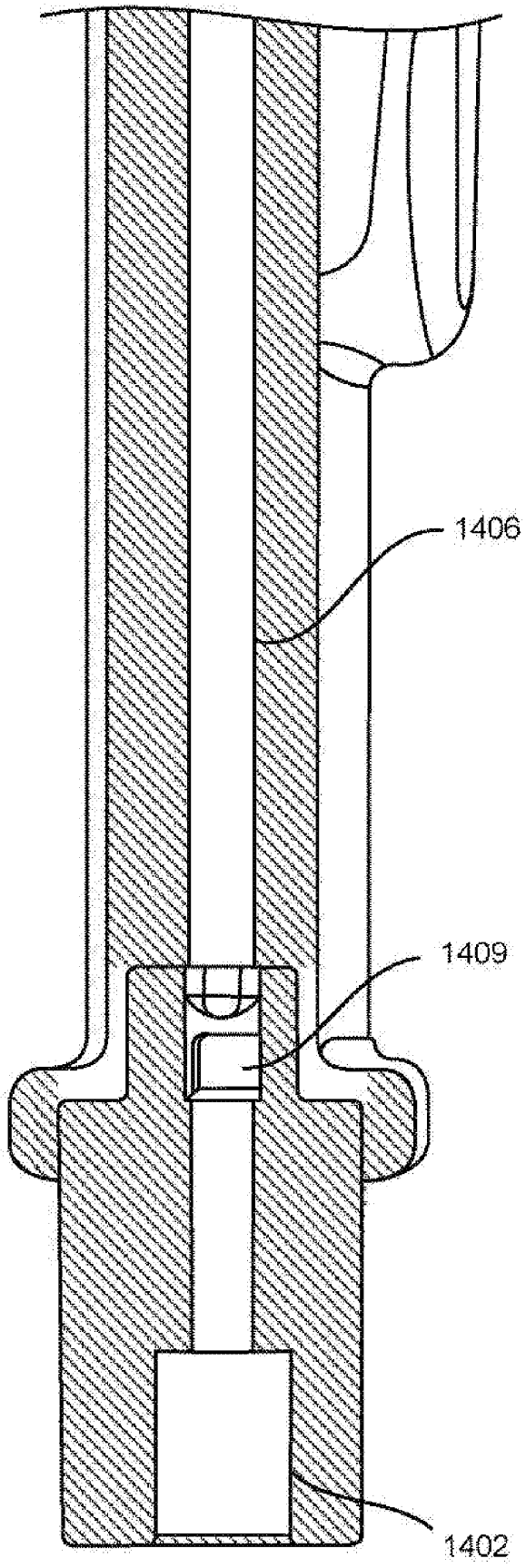


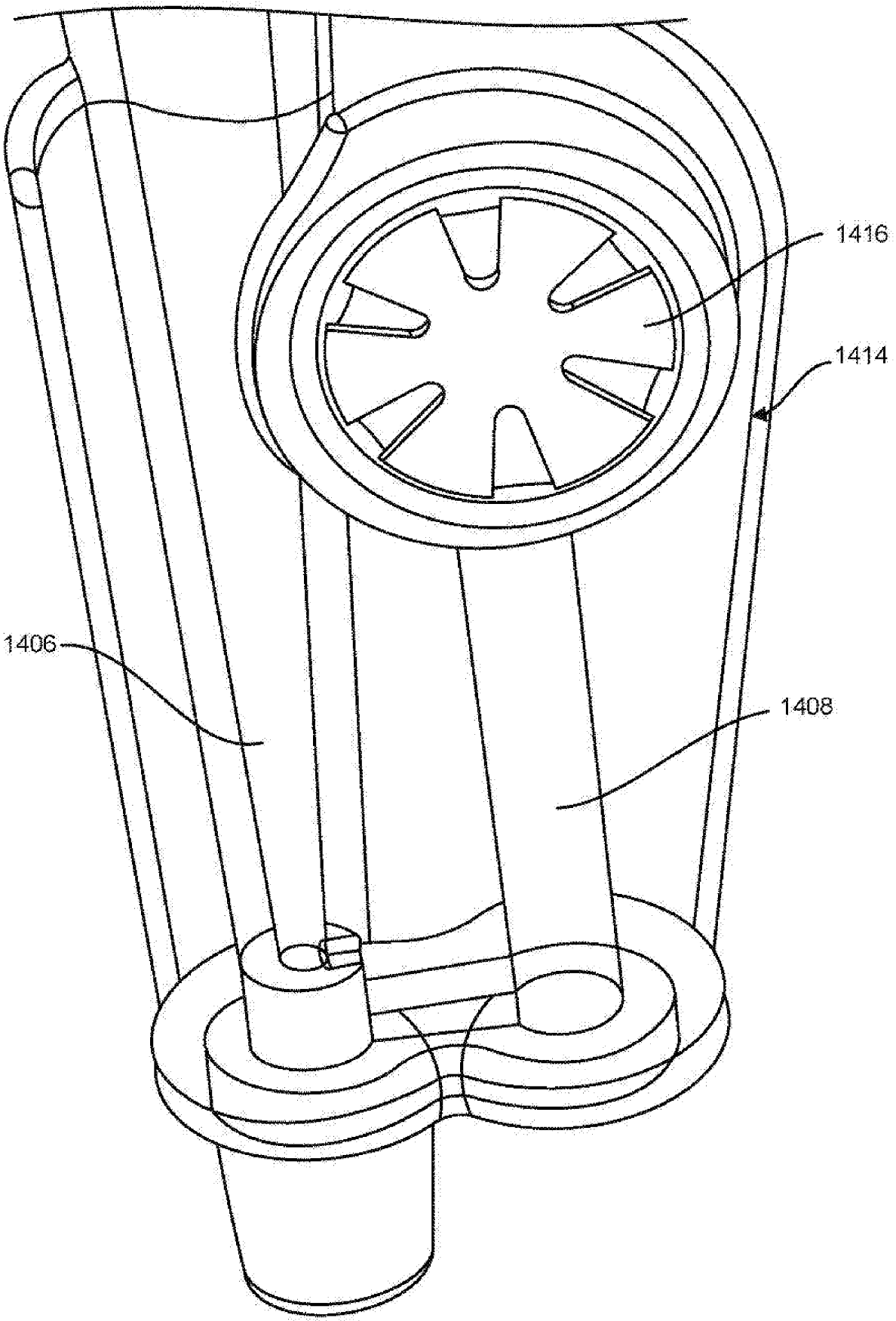
FIG. 14C

[Fig. 14D]


1406
1409
1402

[Fig. 14E]

FIG. 14D


1416
1414
1406
1408

[Fig. 15A]

FIG. 14E

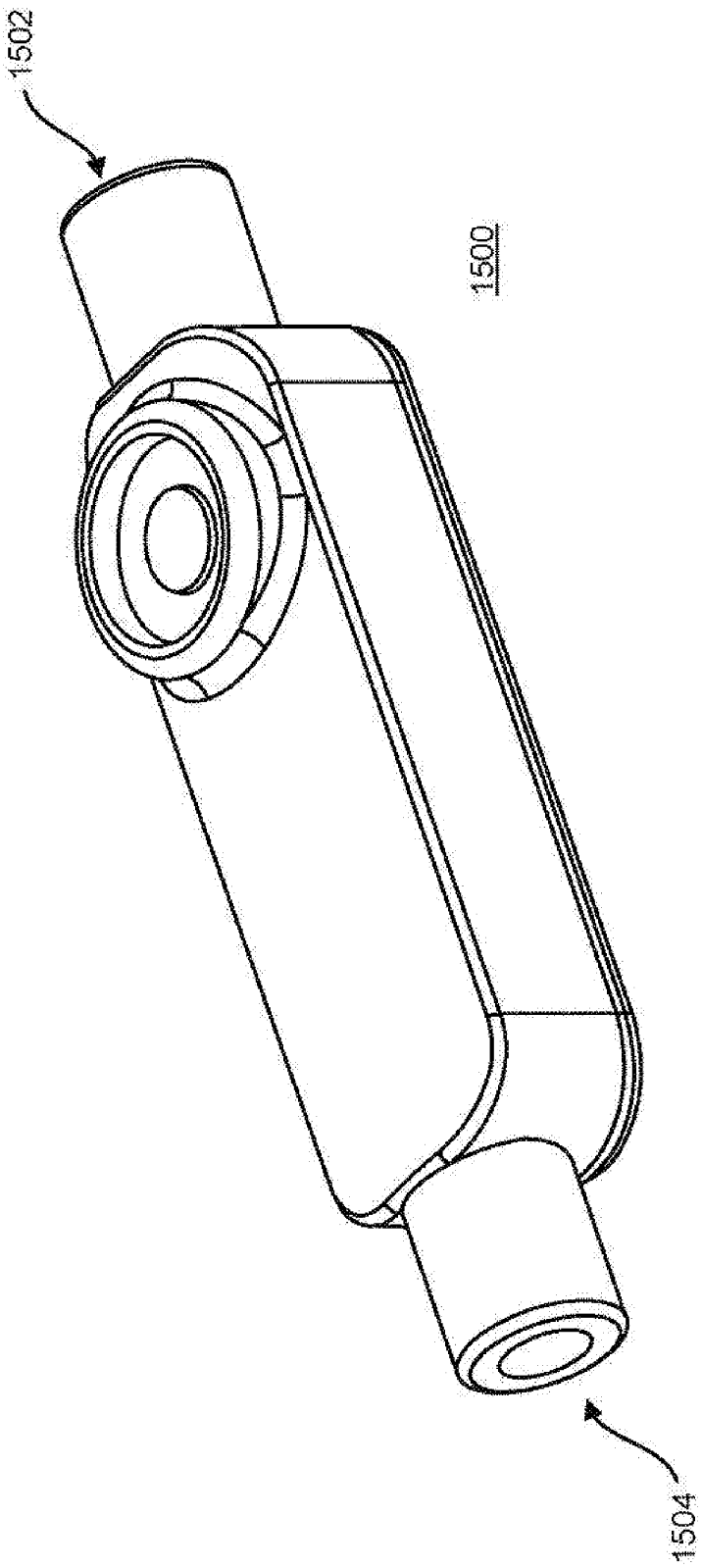


FIG. 15A

[Fig. 15B]

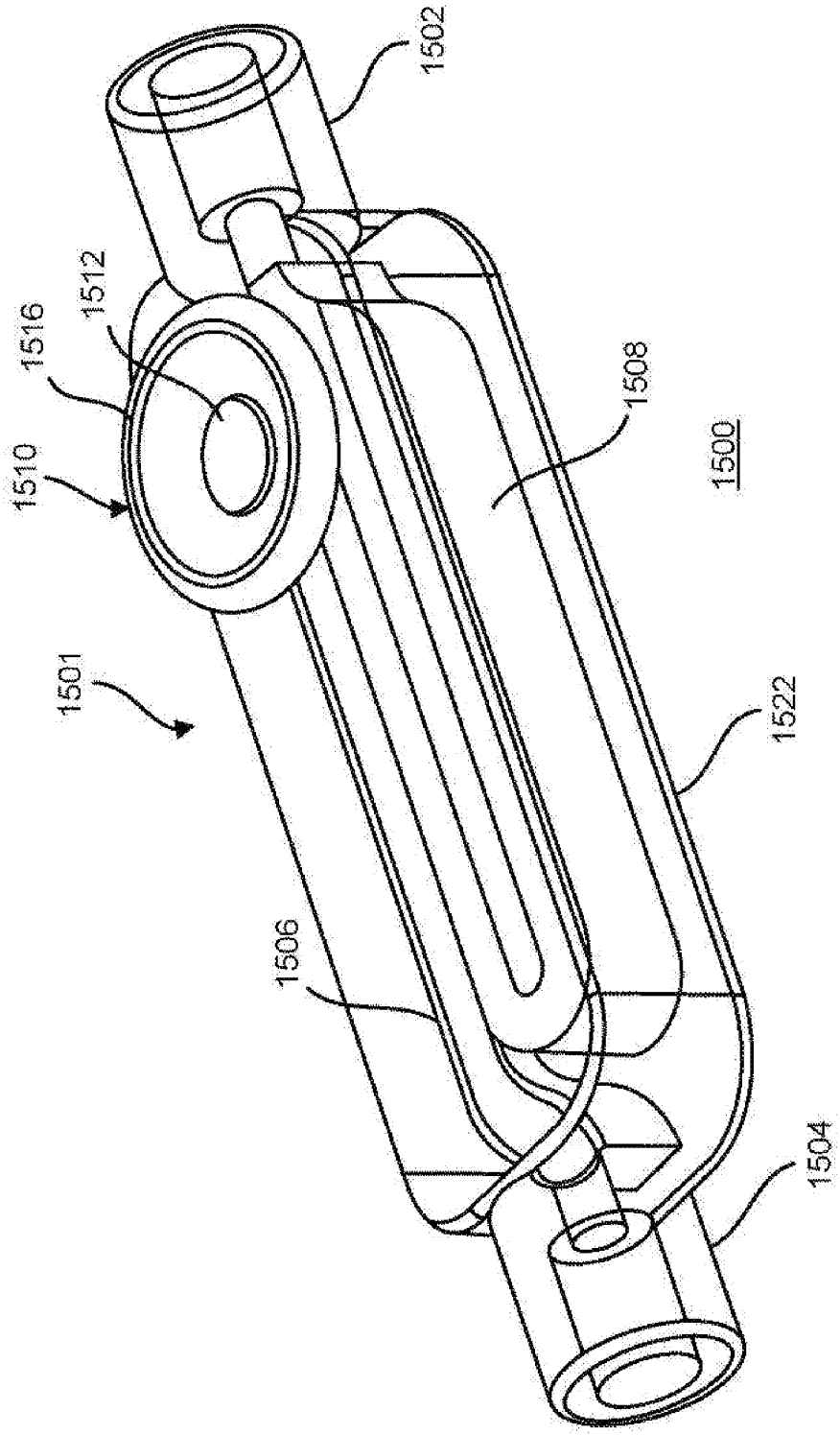


FIG. 15B

[Fig. 15C]

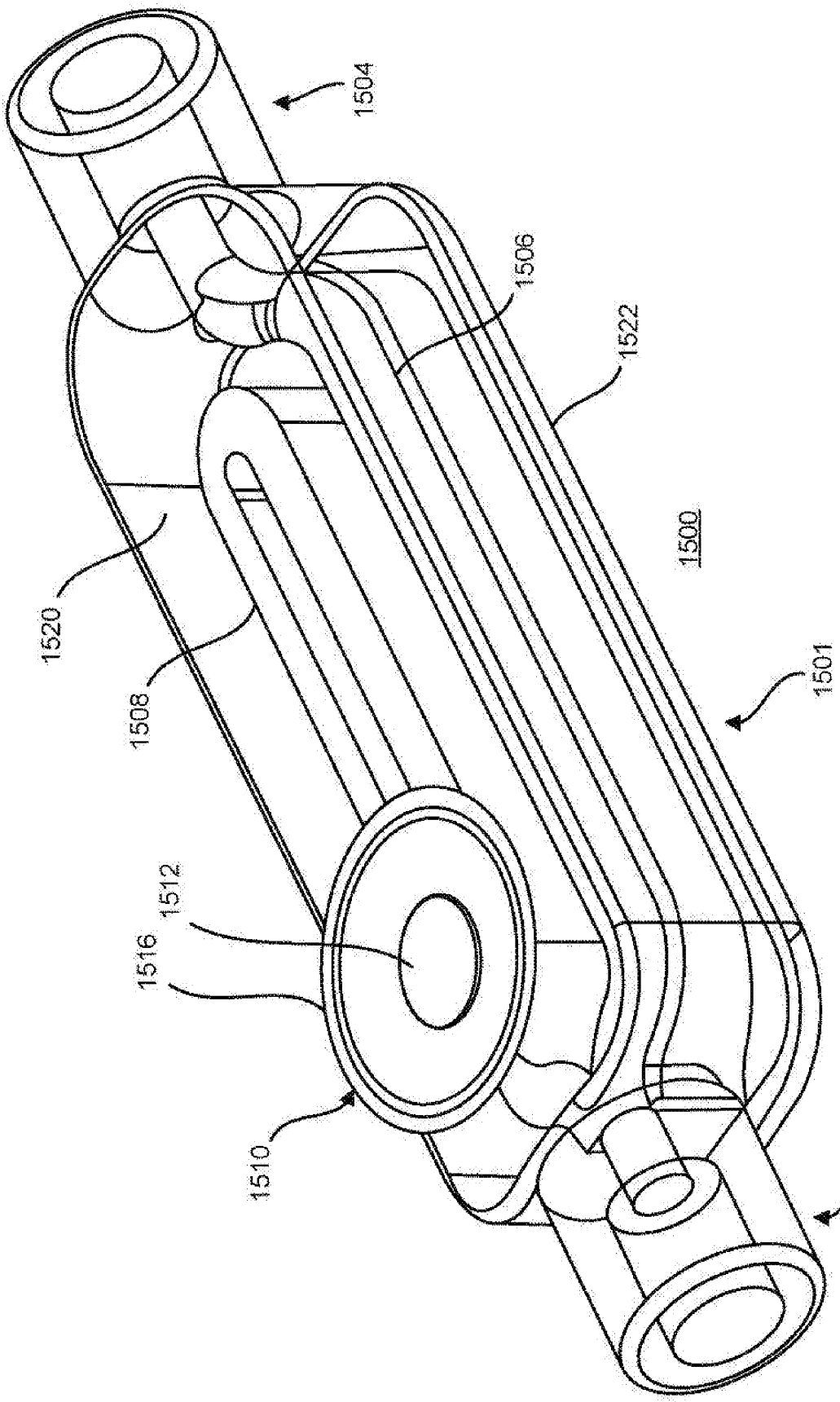


FIG. 15C

[Fig. 15D]

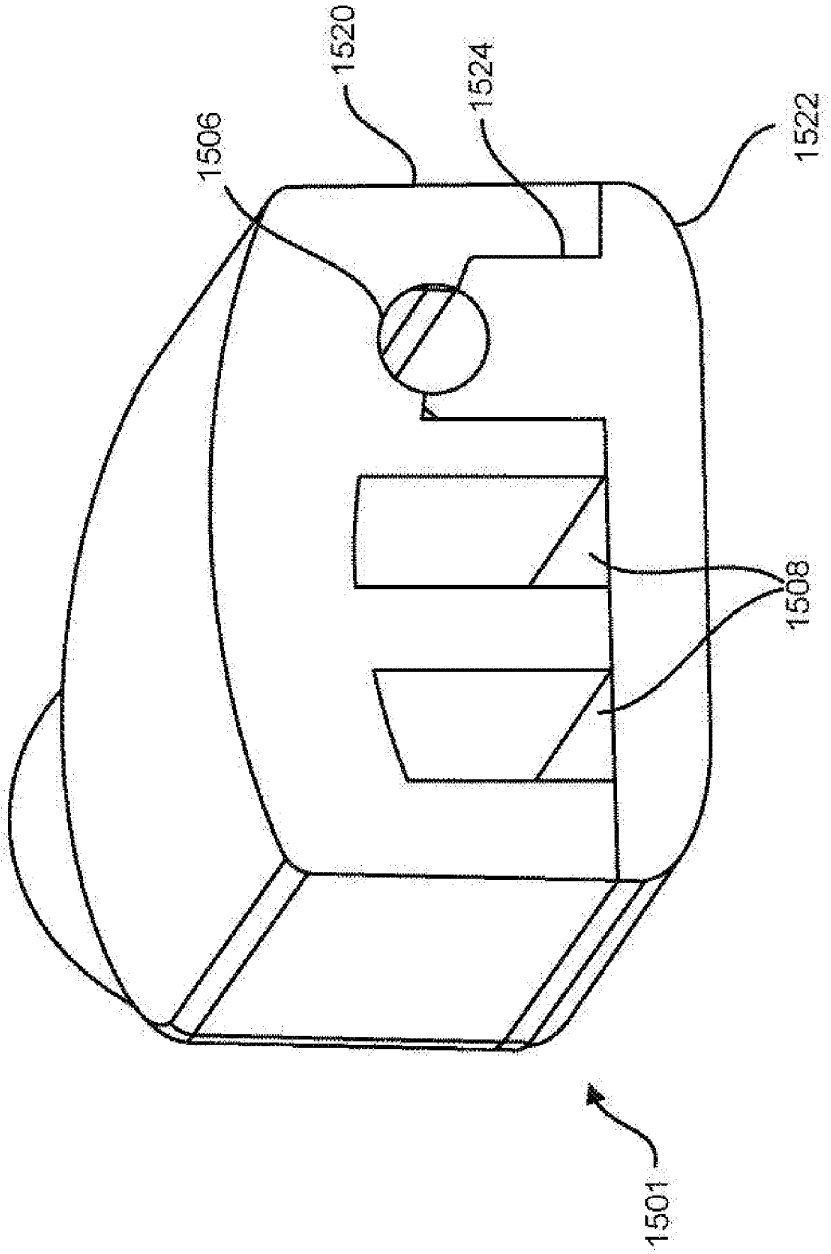


FIG. 15D

[Fig. 15E]

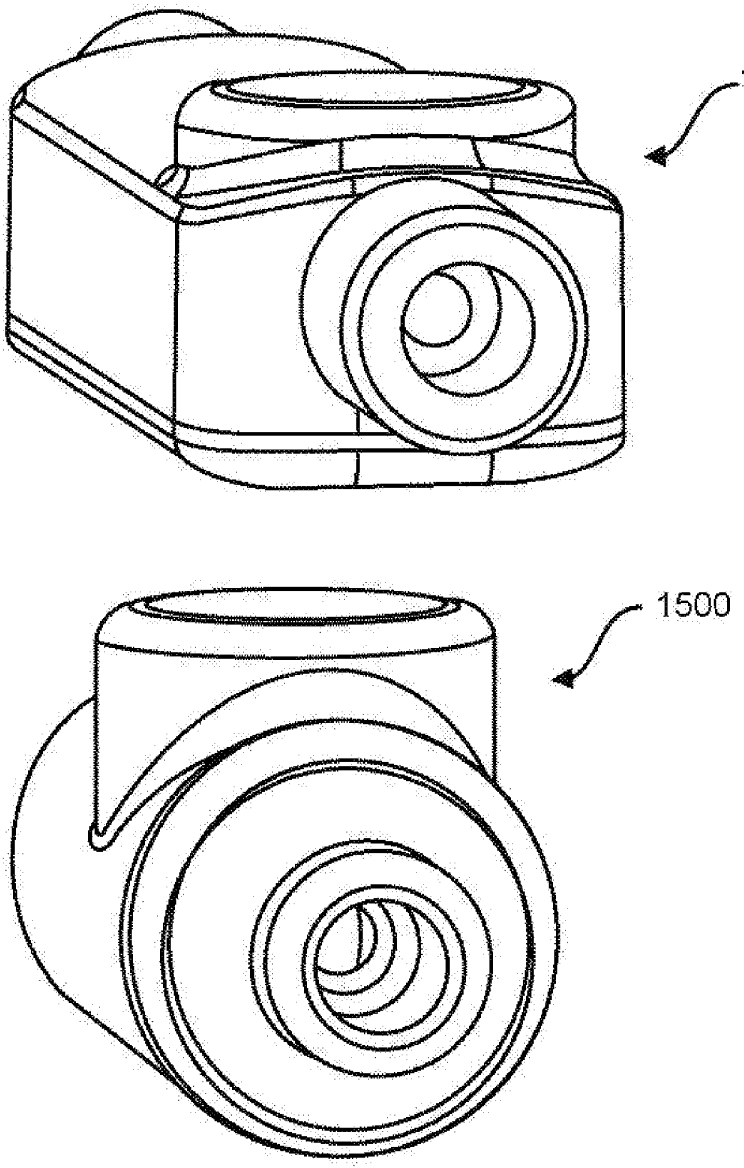


FIG. 15E

[Fig. 15F]

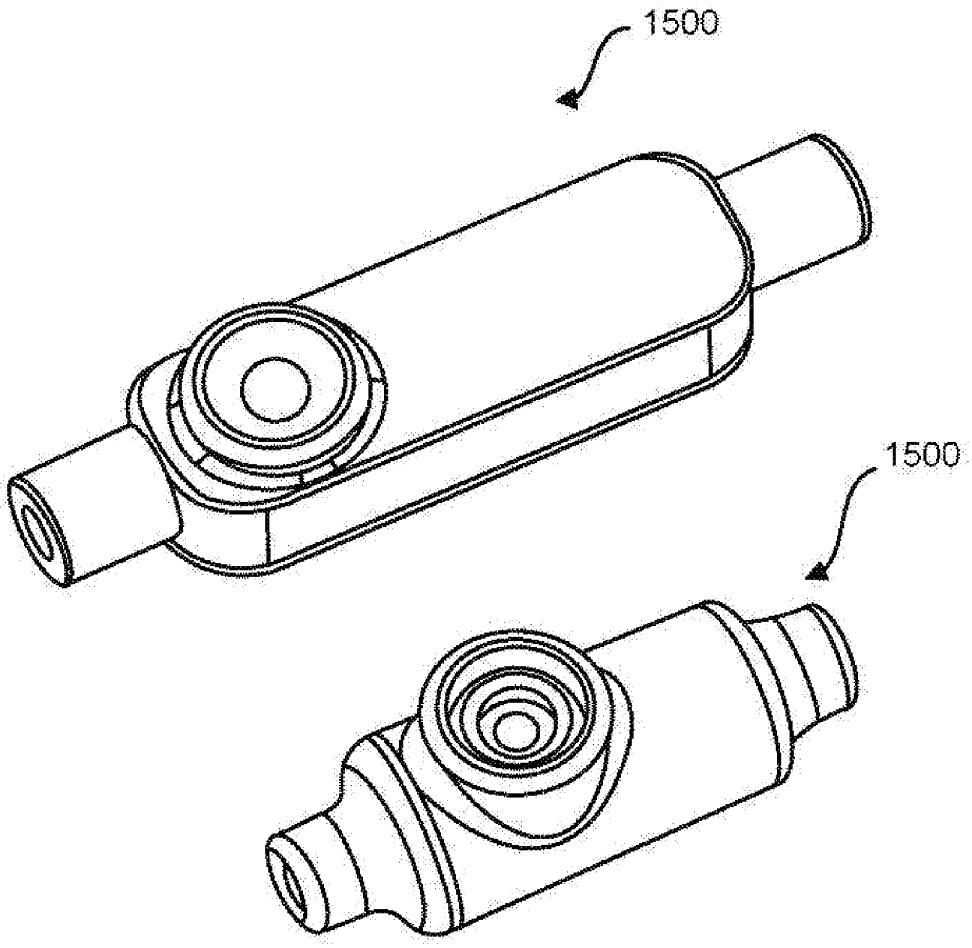


FIG. 15F

[Fig. 15G]

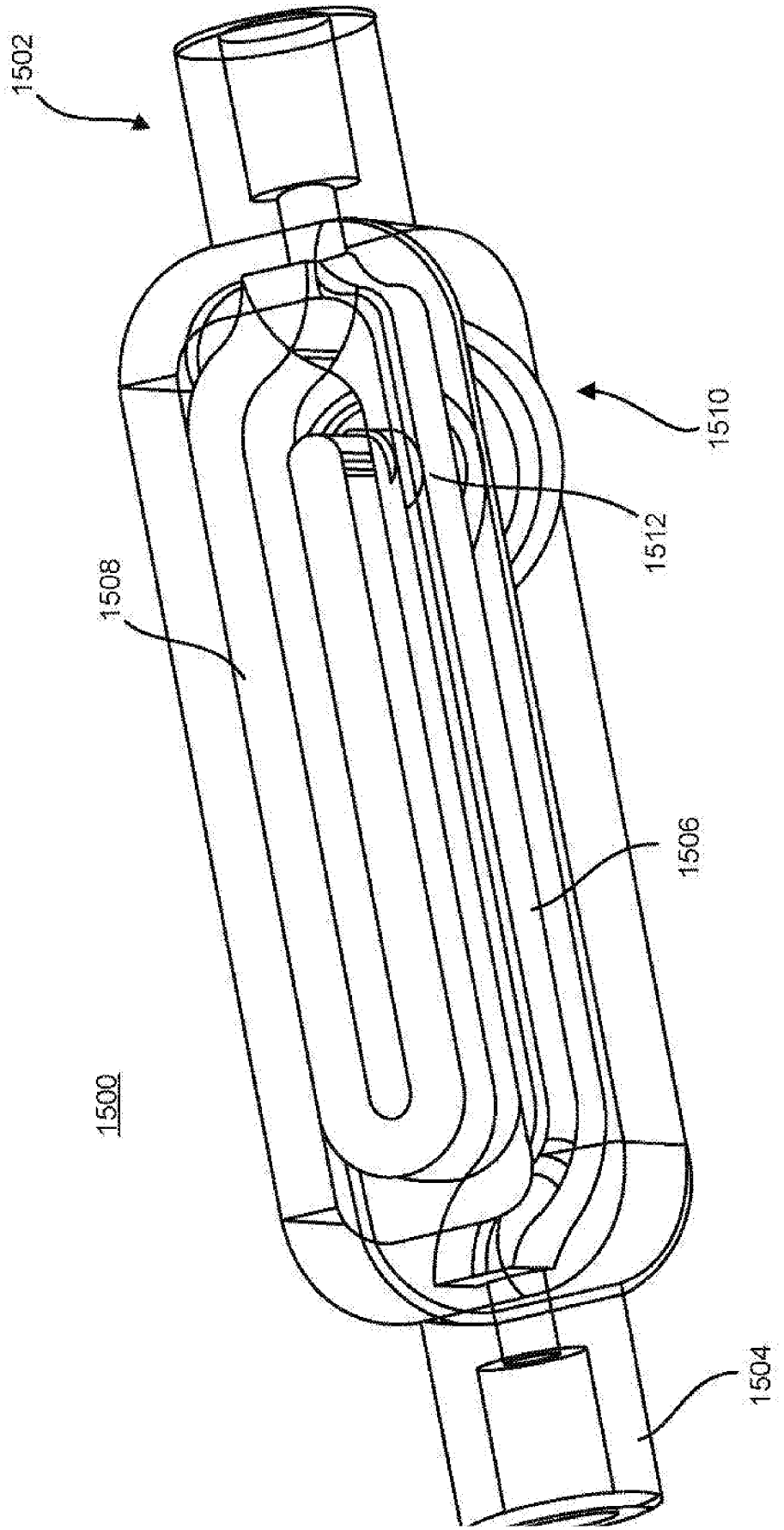


FIG. 15G

[Fig. 16A]

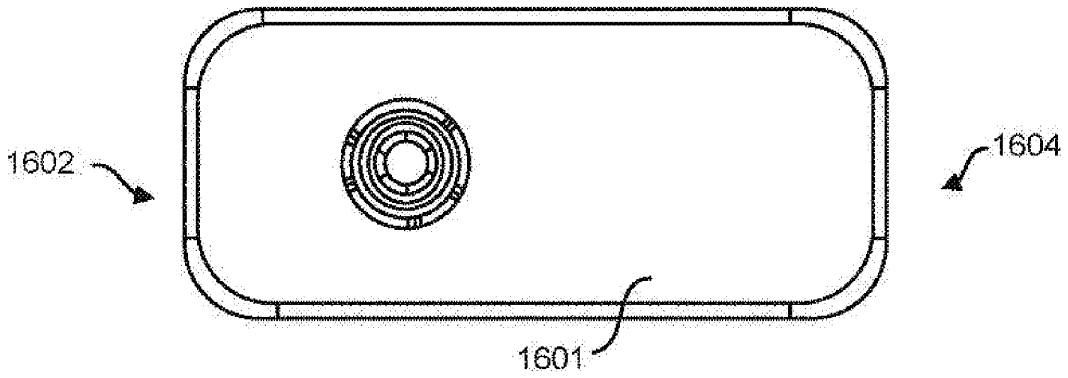


FIG. 16A

[Fig. 16B]

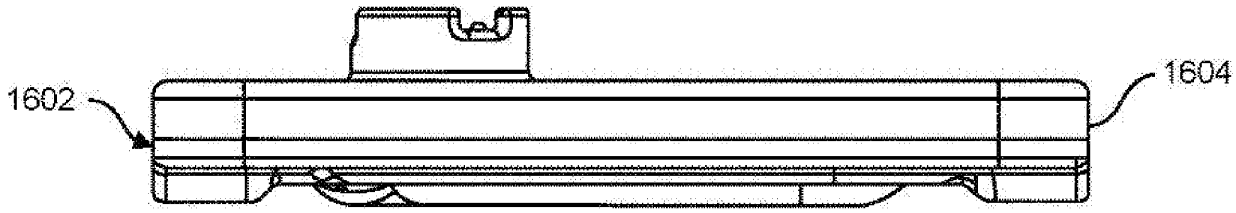


FIG. 16B

[Fig. 16C]

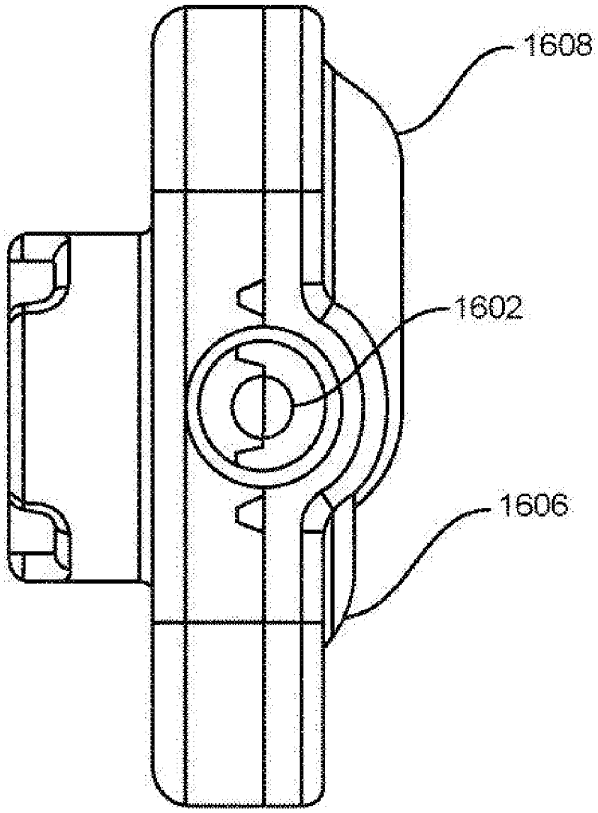


FIG. 16C

[Fig. 16D]

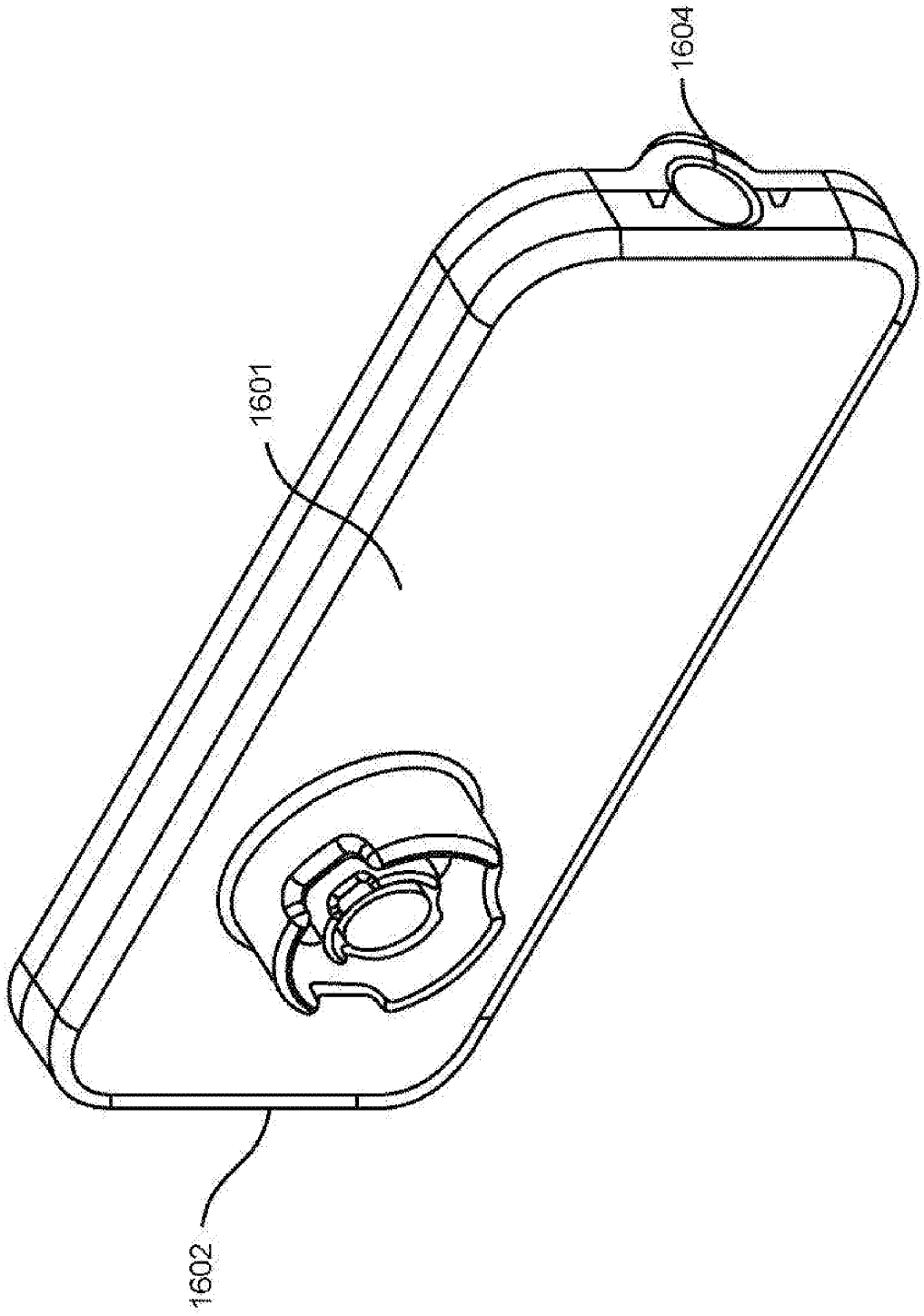


FIG. 16D

[Fig. 17A]

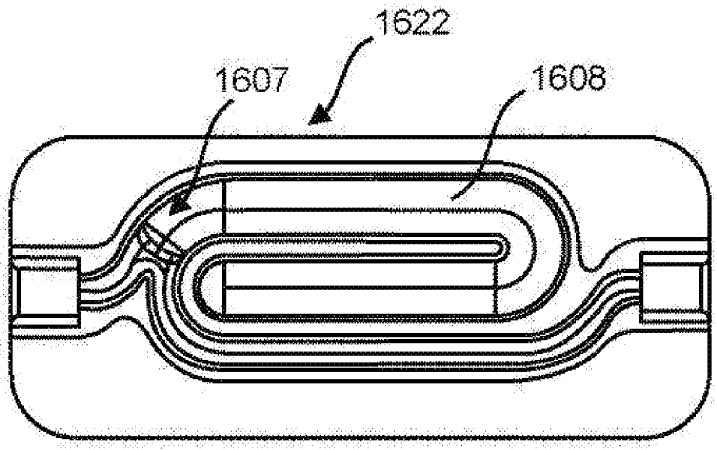


FIG. 17A

[Fig. 17B]

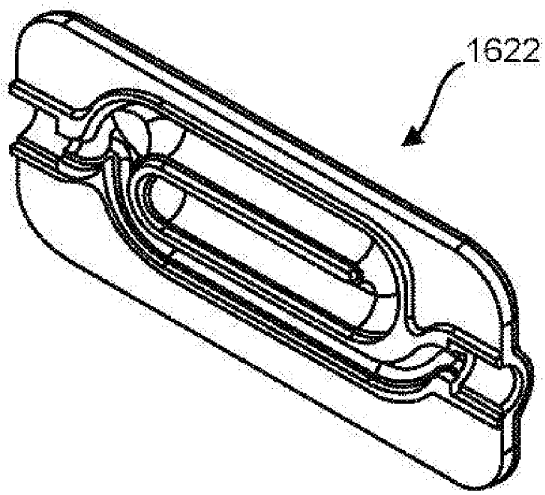


FIG. 17B

[Fig. 17C]

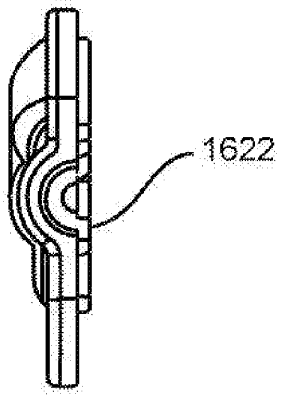


FIG. 17C

[Fig. 17D]

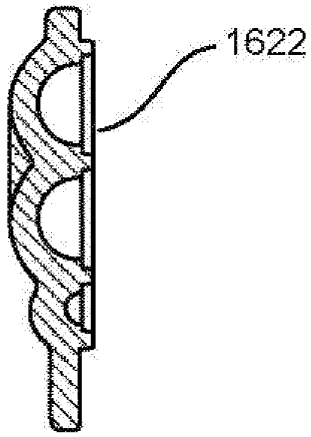


FIG. 17D

[Fig. 17E]

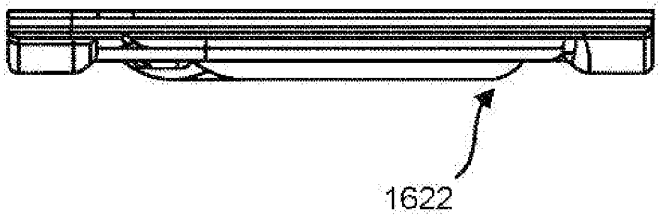


FIG. 17E

[Fig. 18A]

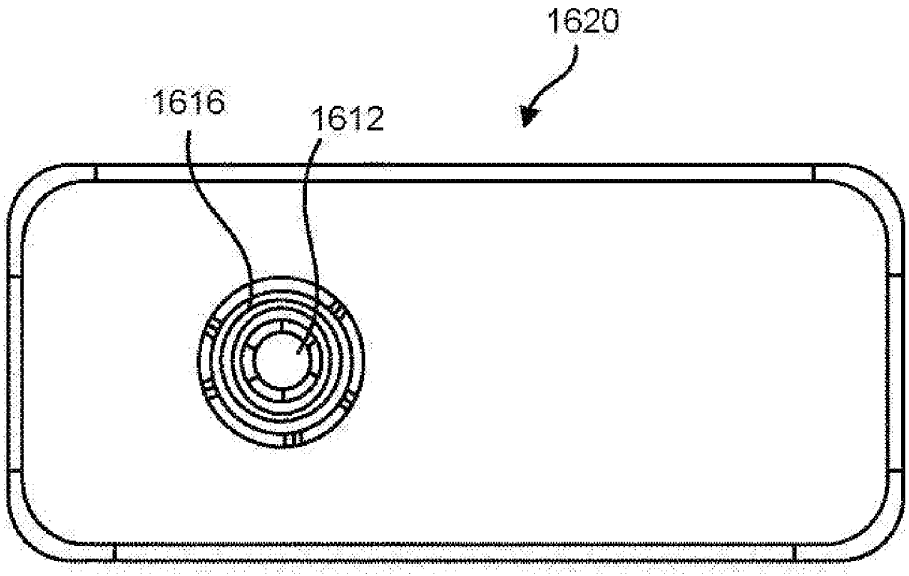


FIG. 18A

[Fig. 18B]

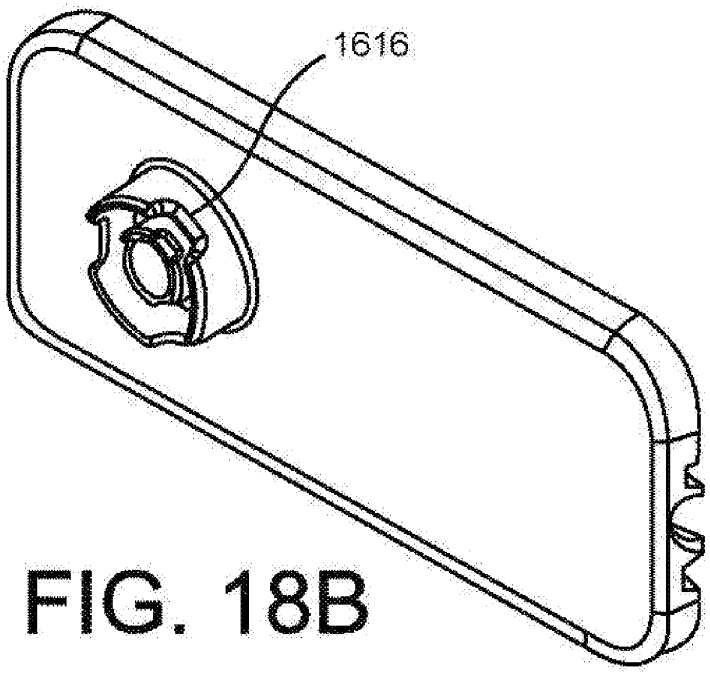


FIG. 18B

[Fig. 18C]

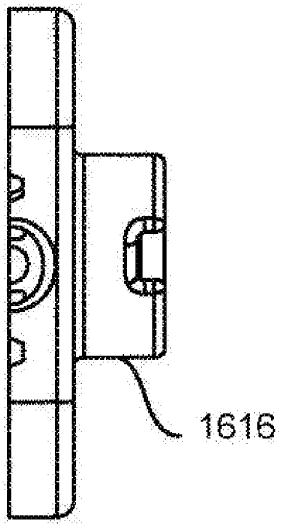


FIG. 18C

[Fig. 18D]

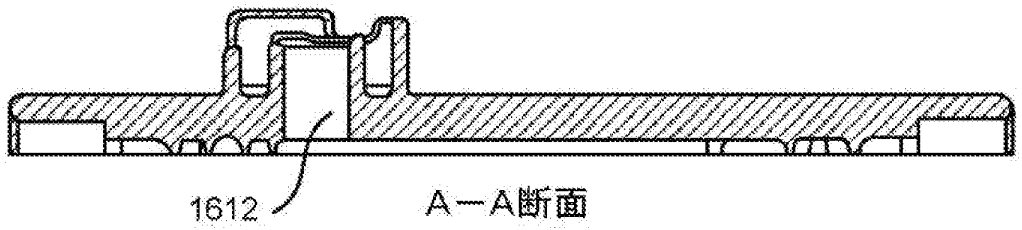


FIG. 18D

[Fig. 18E]

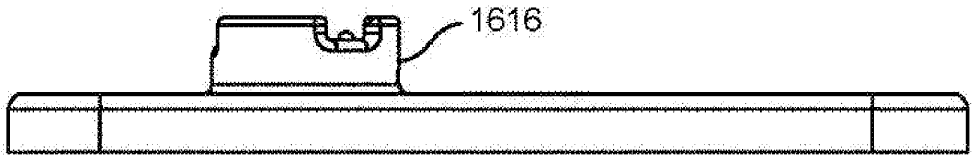


FIG. 18E

[Fig. 18F]

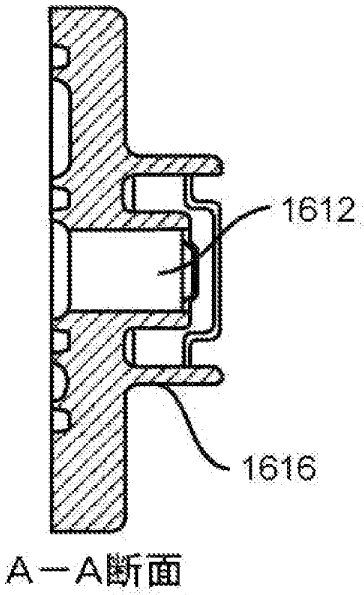


FIG. 18F

[Fig. 19A]

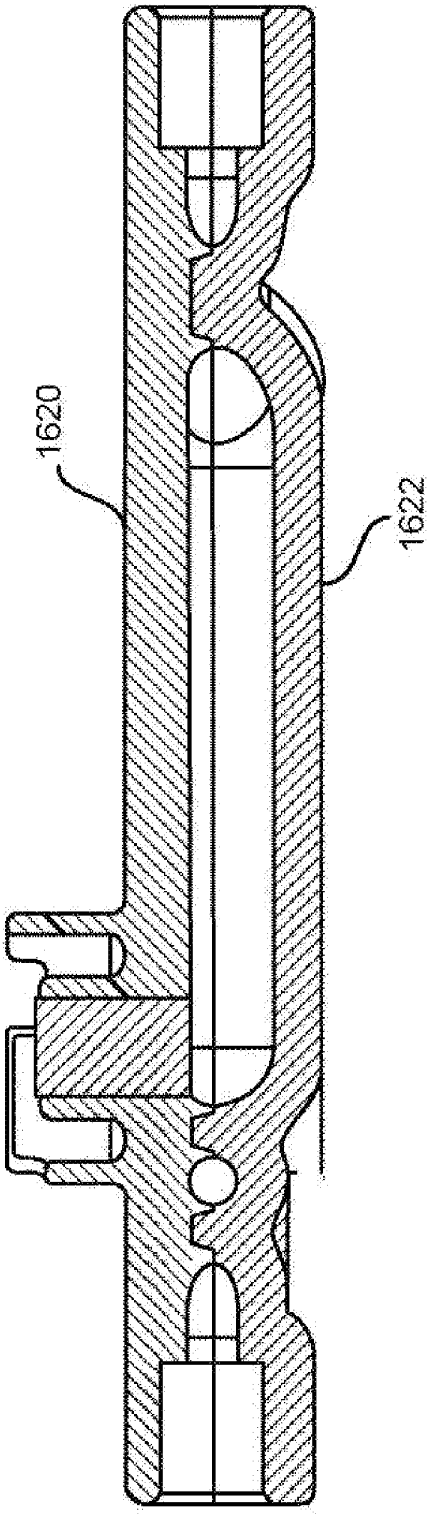


FIG. 19A

[Fig. 19B]

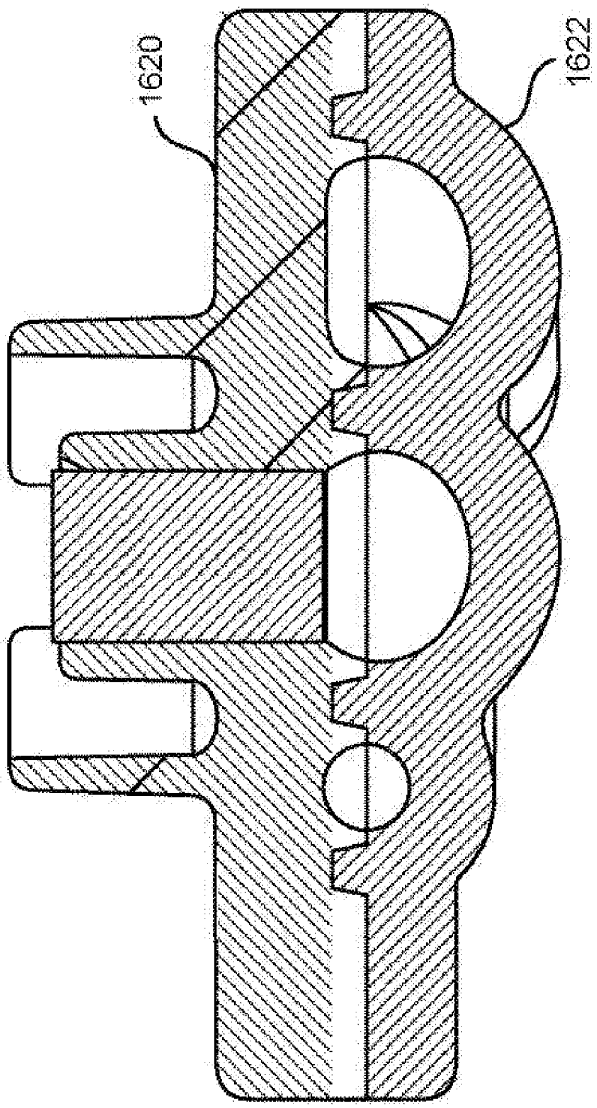


FIG. 19B

[Fig. 20]

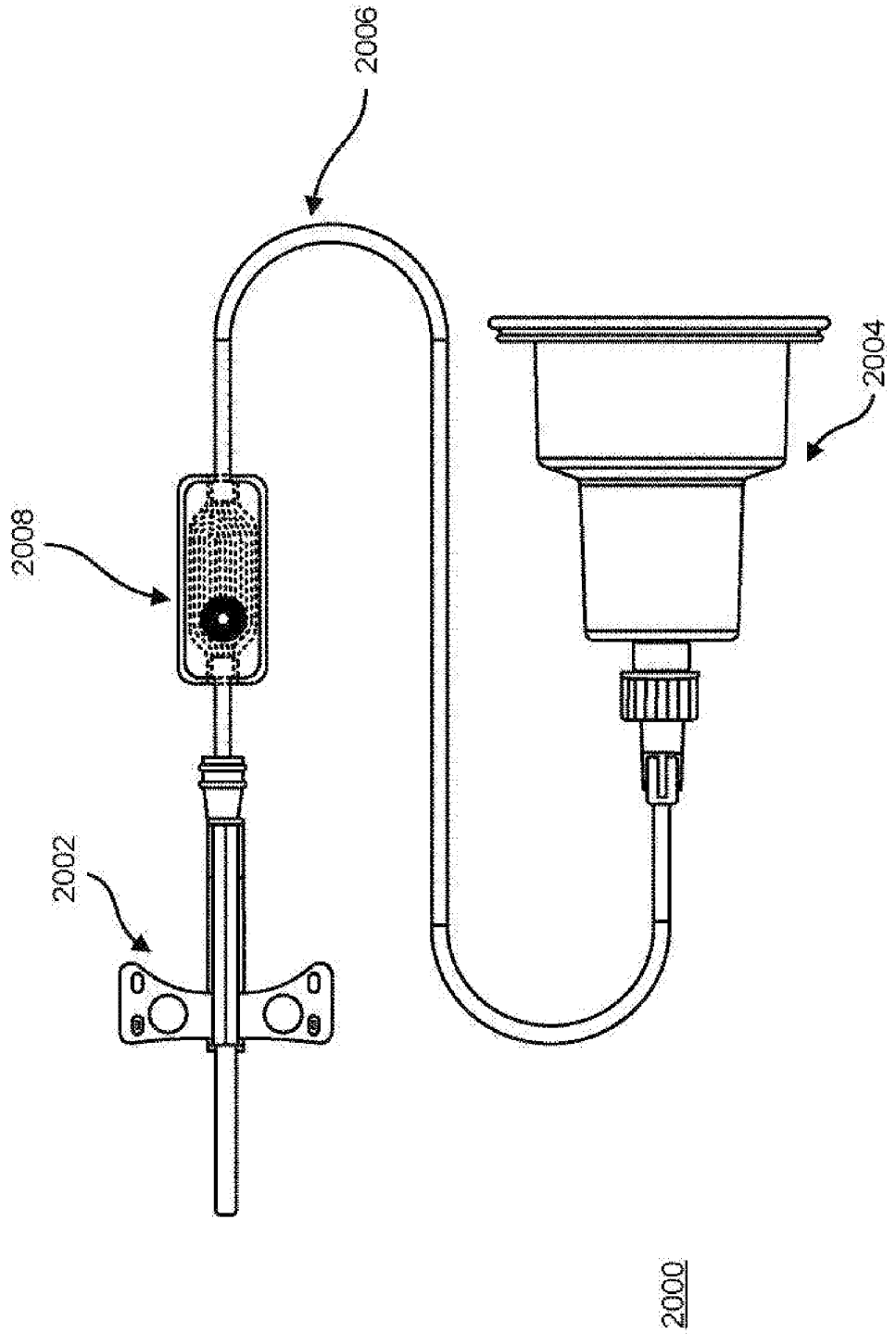


FIG. 20

[Fig. 21]

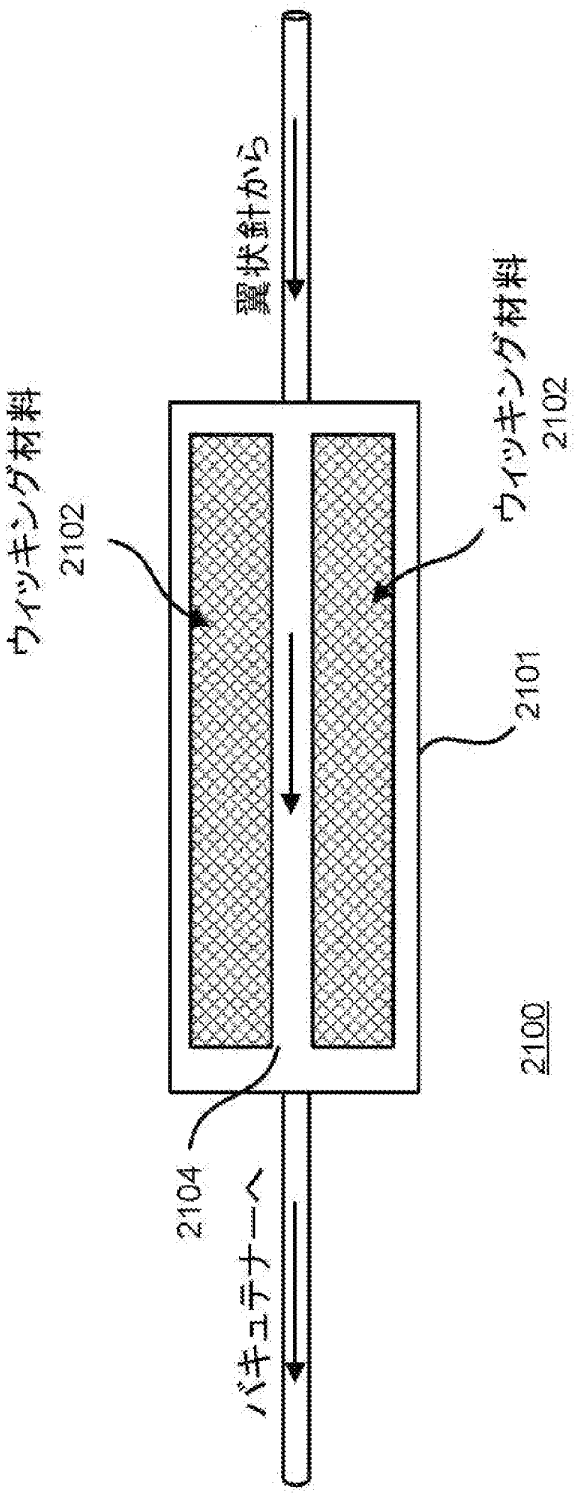


FIG. 21

[Fig. 22A]

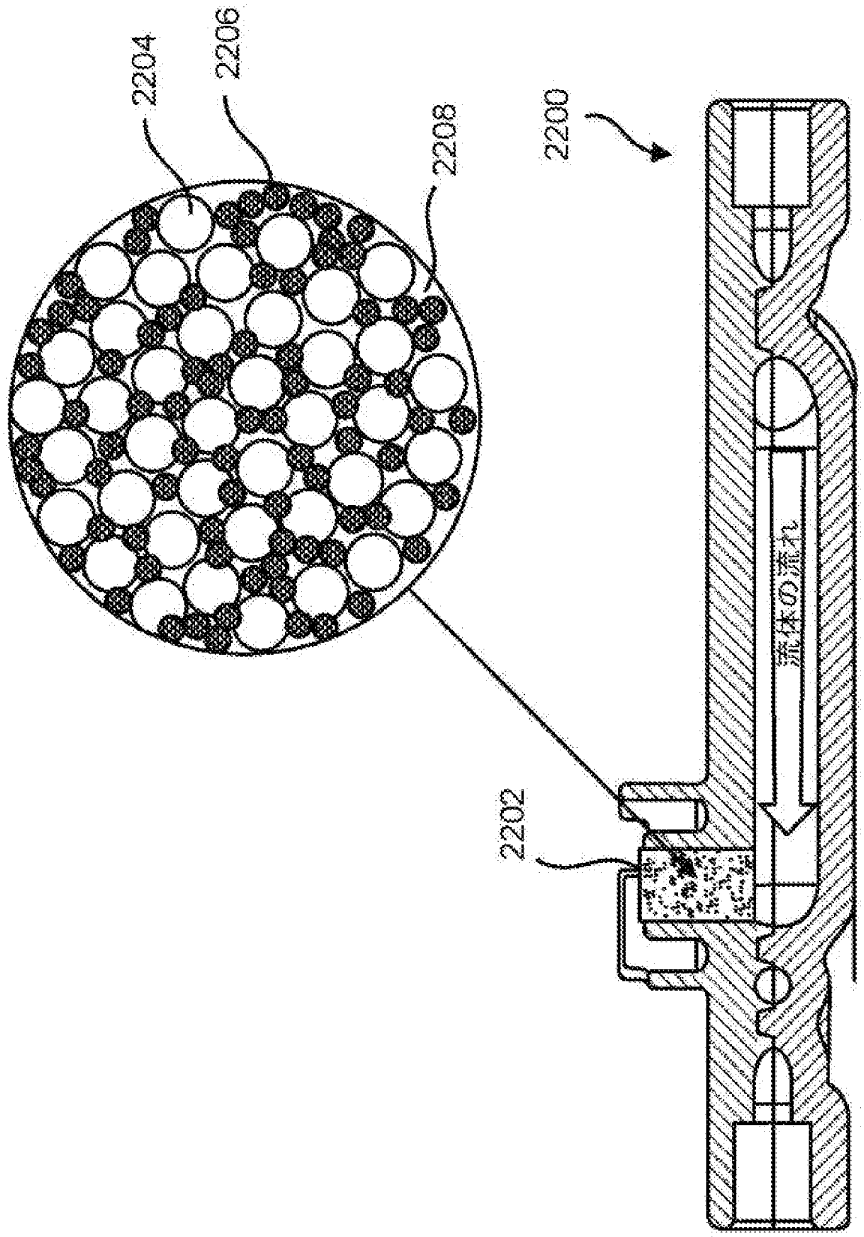


FIG. 22A

[Fig. 22B]

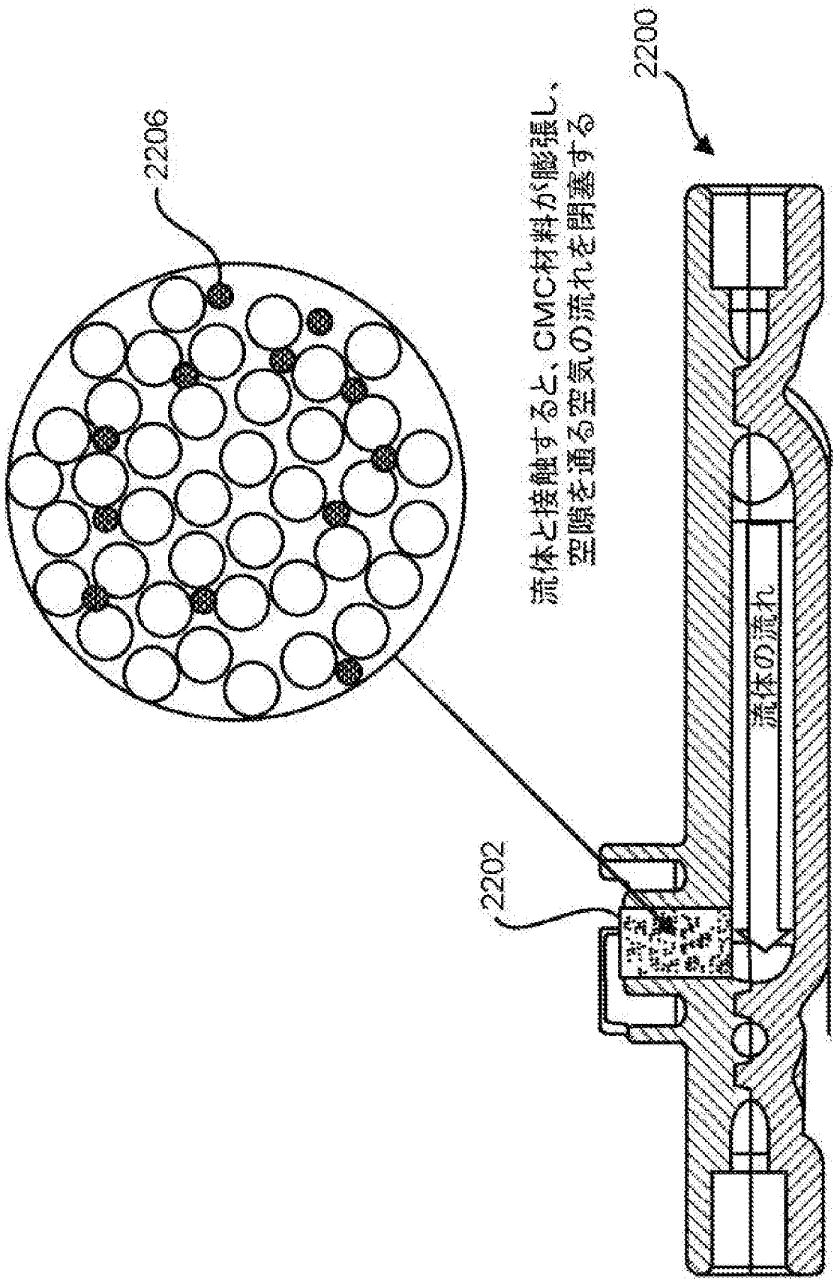


FIG. 22B

[Fig. 23A]

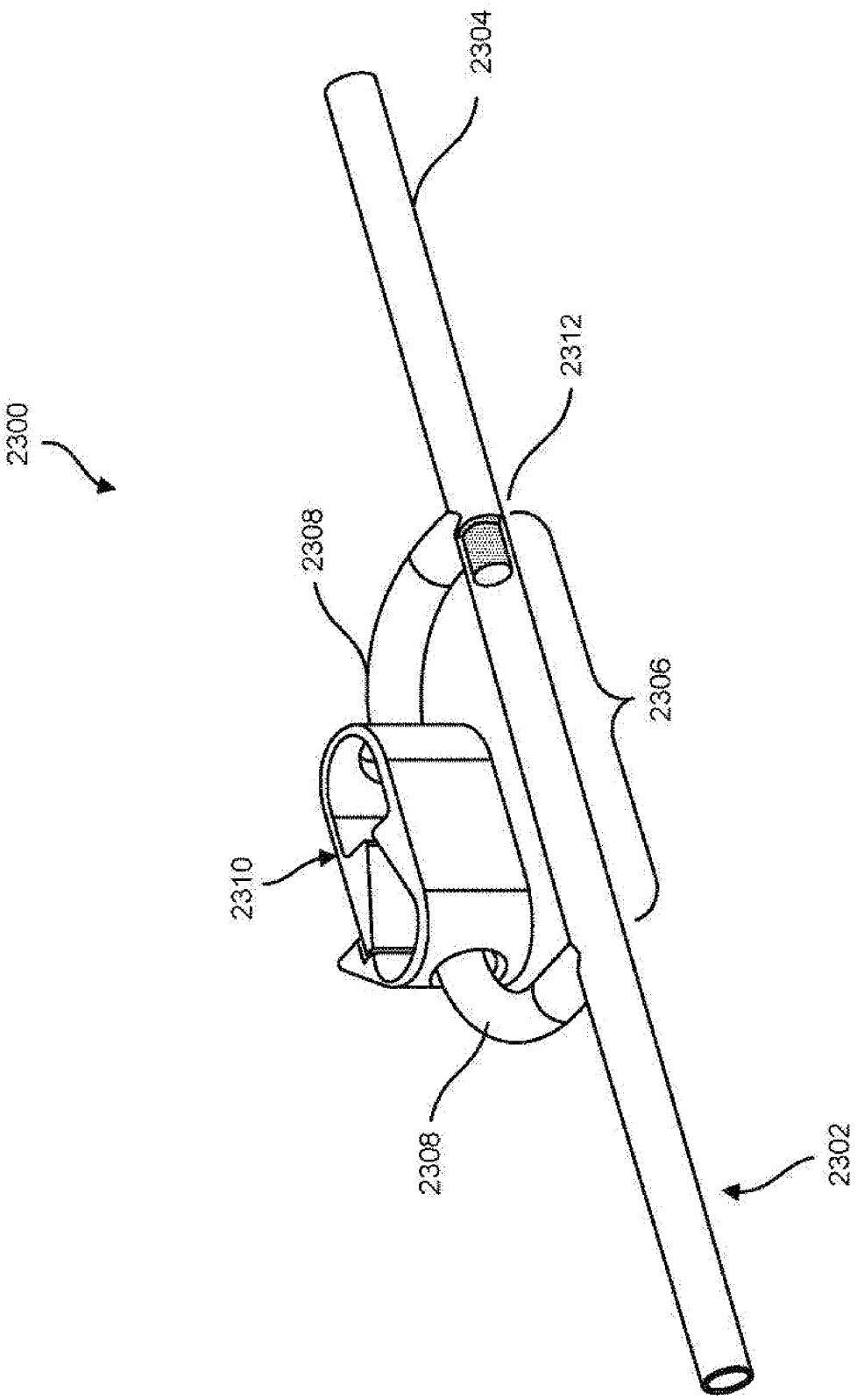


FIG. 23A

[Fig. 23B]

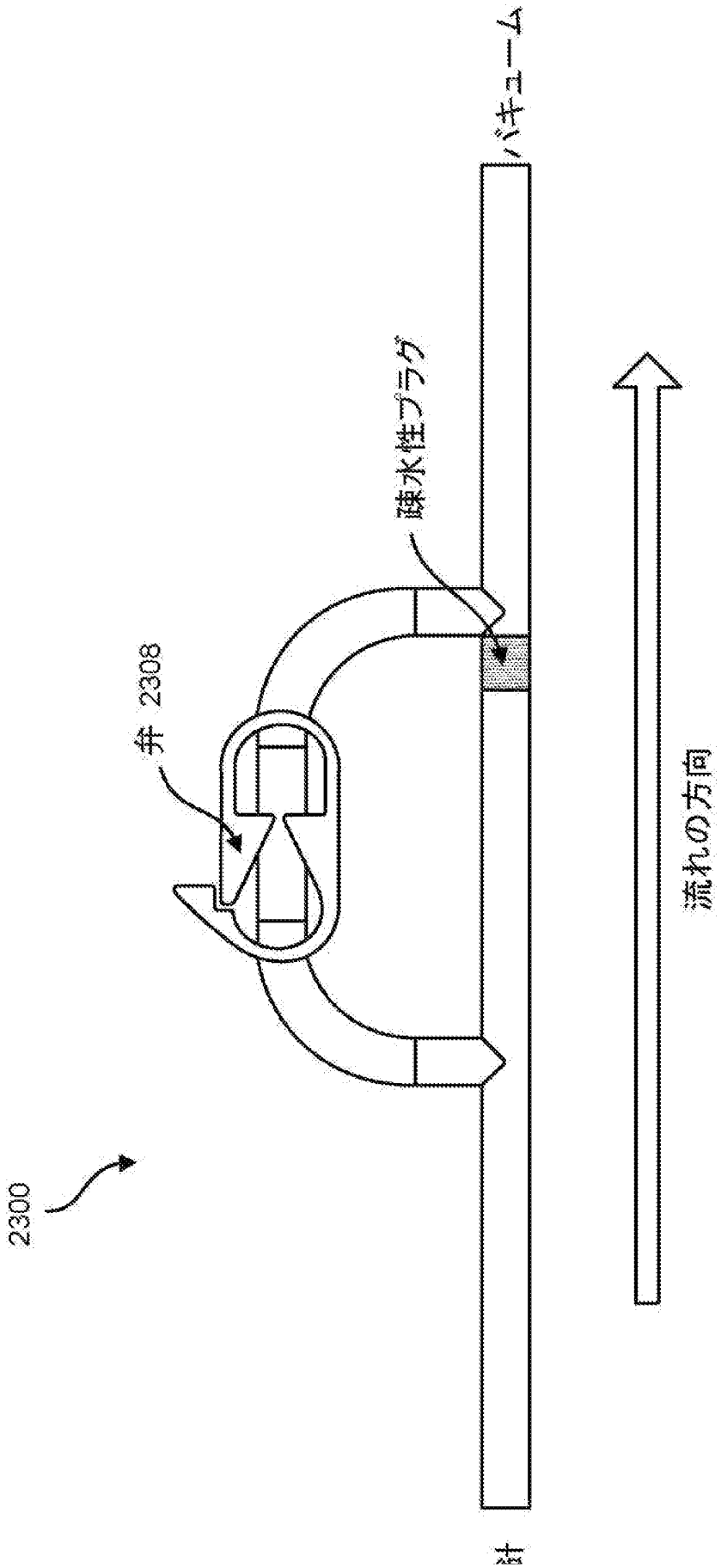


FIG. 23B

drawing open

1 2 3 Four Five 6 7 8A 8B 8C ...

Magnify and Rotate

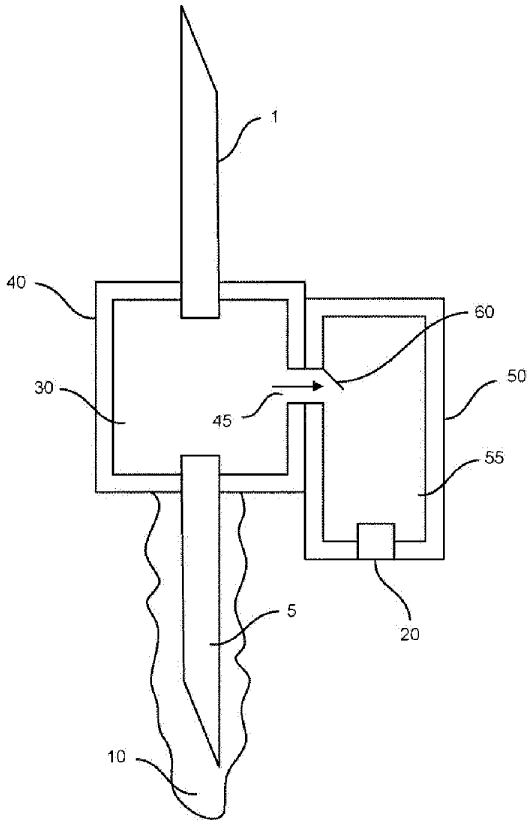


FIG. 1

Figure 1

1 / 1 display

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最終頁に続く

(54)【発明の名称】血液隔離装置、体液隔離装置、及び血液隔離システム

【特許請求の範囲】
【請求項１】
血液隔離装置であって、
入口ポートと、
出口ポートと、
隔離チャンバ及びサンプリング流路であって、前記隔離チャンバ及び前記サンプリング流路のそれぞれが分岐点を介して前記入口ポートと接続され、前記隔離チャンバは空気透過性血液バリアを含む通気口を有し、前記サンプリング流路は前記出口ポートと接続される遠位端を有する、隔離チャンバ及びサンプリング流路と、
前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路を収容し且つ画定するハウジングと
を含み、
前記隔離チャンバ、前記サンプリング流路、及び前記分岐点は、血液の第１部分が前記隔離チャンバ内での隔離のために前記空気透過性血液バリアに向かって前記隔離チャンバに流れ込み、血液の第２部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液の第１部分を迂回し、前記出口ポートに向かって前記サンプリング流路に向けられるように寸法設定され且つ構成される、血液隔離装置。
【請求項２】
血液隔離装置であって、
入口ポートと、

出口ポートと、
空気透過性血液バリアを含む通気口を有する隔離チャンバと、
前記出口ポートと接続される遠位端を有するサンプリング流路と、
前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路を収容し且つ画定するハウジングと
を含み、
前記隔離チャンバ及び前記サンプリング流路のそれぞれが分岐点を介して前記入口ポートと接続され、前記分岐点は、血液の第１部分が前記隔離チャンバに流れ込み、前記空気透過性血液バリアを通して前記隔離チャンバ内の空気を追い出し、前記隔離チャンバ内に隔離されることを可能にし、血液の第２部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液の第１部分を迂回し、前記出口ポートに向かって前記サンプリング流路に向けられることを可能にするように寸法設定され且つ構成される、血液隔離装置。
【請求項３】
前記空気透過性血液バリアは、血液と接触すると少なくとも部分的に密封する空気透過性材料を含む、請求項１又は２に記載の血液隔離装置。
【請求項４】
前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項１又は２に記載の血液隔離装置。
【請求項５】
前記ハウジングは、上部部材と嵌合する下部部材を含み、前記下部部材及び前記上部部材のそれぞれは、前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路のそれぞれの一部を画定する、請求項１から３のいずれか一項に記載の血液隔離装置。
【請求項６】
患者針とサンプル採取装置とを有する採血経路と接続される血液隔離装置であって、
前記患者針と接続される入口ポートと、
隔離チャンバ及びサンプリング流路であって、前記隔離チャンバ及び前記サンプリング流路のそれぞれが分岐点を介して前記入口ポートと接続され、前記隔離チャンバは空気透過性血液バリアを含む通気口を有し、前記隔離チャンバ及び前記分岐点は、血液の第１部分を前記空気透過性血液バリアに向かって前記隔離チャンバに向けるように構成され、前記サンプリング流路は出口ポートと接続される遠位端を有し、前記サンプリング流路及び前記分岐点は、血液の第２部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液の第１部分を迂回し、前記出口ポートに向かって前記サンプリング流路に向けられることを可能にするように構成され、前記出口ポートは前記サンプル採取装置と接続される、隔離チャンバ及びサンプリング流路と、
前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路を収容し且つ画定するハウジングと
を含む、血液隔離装置。
【請求項７】
患者針とサンプル採取装置とを有する採血経路と接続される血液隔離装置であって、
前記患者針と接続される入口ポートと、
前記サンプル採取装置と接続される出口ポートと、
空気透過性血液バリアを含む通気口を有する隔離チャンバと、
前記出口ポートと接続される遠位端を有するサンプリング流路と、
前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路を収容し且つ画定するハウジングと
を含み、
前記隔離チャンバ及び前記サンプリング流路のそれぞれが分岐点を介して前記入口ポートと接続され、前記分岐点は、血液の第１部分が前記隔離チャンバに流れ込み、前記空気透過性血液バリアを通して前記隔離チャンバ内の空気を追い出し、前記隔離チャンバ内に

隔離されることを可能にし、血液の第２部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液の第１部分を迂回し、前記出口ポート及び前記サンプル採取装置に向かって前記サンプリング流路に向けられることを可能にするように寸法設定され且つ構成される、血液隔離装置。

【請求項８】

前記入口ポートは、前記採血経路の第１の部分を介して前記患者針と接続される、請求項６又は７に記載の血液隔離装置。

【請求項９】

前記出口ポートは、前記採血経路の第２の部分を介して前記サンプル採取装置と接続される、請求項６から８のいずれか一項に記載の血液隔離装置。

【請求項１０】

前記空気透過性血液バリアは、血液と接触すると少なくとも部分的に密封する空気透過性材料を含む、請求項６又は７に記載の血液隔離装置。

【請求項１１】

前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項６又は７に記載の血液隔離装置。

【請求項１２】

前記隔離流路は、前記入口ポートと接続される近位端と、空気透過性血液バリアを含む前記通気口を有する遠位端とを有する、請求項１１に記載の血液隔離装置。

【請求項１３】

体液隔離装置であって、

入口ポートと、

前記入口ポートと接続される出口ポートと、

分岐点を介して前記入口ポートと接続される隔離チャンバであって、空気透過性体液バリアを含む通気口を有する隔離チャンバと、

前記入口ポート、前記出口ポート、及び前記隔離チャンバを収容し且つ画定するハウジングと

を含み、

前記隔離チャンバ及び前記分岐点は、前記入口ポートからの体液の第１部分を前記空気透過性体液バリアに向かって前記隔離チャンバに向けるように構成され、前記空気透過性体液バリアは、体液と接触すると体液に対するバリアを形成する空気透過性材料を含み、その結果、体液との接触により、前記隔離チャンバ内の前記体液の第１部分の隔離が可能になり、前記分岐点を通る前記入口ポートから前記出口ポートへの体液の第２部分が前記隔離チャンバ及び前記体液の第１部分を迂回することが可能になる、体液隔離装置。

【請求項１４】

体液隔離装置であって、

入口ポートと、

前記入口ポートと接続される出口ポートと、

分岐点を介して前記入口ポートと接続される隔離チャンバであって、空気透過性体液バリアを含む通気口を有する隔離チャンバと、

前記入口ポート、前記出口ポート、及び前記隔離チャンバを収容し且つ画定するハウジングと

を含み、

前記隔離チャンバ及び前記分岐点は、前記入口ポートからの体液の第１部分を前記空気透過性体液バリアに向かって前記隔離チャンバに向けるように構成され、前記空気透過性体液バリアは、体液と接触すると体液に対するバリアを形成する空気透過性材料を含み、その結果、前記バリアの形成は、前記隔離チャンバ内の体液の第１部分の隔離を可能にし、前記入口ポートからの体液の第２の部分が前記出口ポートに向かって前記分岐点を通って前記隔離チャンバ及び前記体液の第１部分を迂回することを可能にするように構成される、体液隔離装置。

【請求項１５】
前記空気透過性体液バリアは、体液と接触すると密封する空気透過性材料を含む、請求項１３又は１４に記載の体液隔離装置。
【請求項１６】
前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項１３又は１４に記載の体液隔離装置。
【請求項１７】
前記入口ポートと接続される採血経路を更に含み、前記採血経路は、前記分岐点を通して前記体液の第２部分を前記入口ポートから前記出口ポートに運ぶ、請求項１３又は１４に記載の体液隔離装置。
【請求項１８】
前記ハウジングは、上部部材と嵌合する下部部材を含み、前記下部部材及び前記上部部材のそれぞれは、前記入口ポート、前記出口ポート、及び前記隔離チャンバのそれぞれの一部を画定する、請求項１３又は１４に記載の体液隔離装置。
【請求項１９】
前記分岐点を介して前記入口ポートと接続される近位端を有するサンプリング流路をさらに含む、請求項１３又は１４に記載の体液隔離装置。
【請求項２０】
前記ハウジングは、上部部材と嵌合する下部部材を含み、前記下部部材及び前記上部部材のそれぞれは、前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路のそれぞれの一部を画定する、請求項１９に記載の体液隔離装置。
【請求項２１】
血液隔離システムであって、
患者針とサンプル採取装置とを有する採血経路と、
血液隔離装置と
を含み、前記血液隔離装置は、
前記患者針と接続される入口ポートと、
前記サンプル採取装置と接続される出口ポートと、
空気透過性血液バリアを含む通気口を有する隔離チャンバと、
前記出口ポートと接続される遠位端を有するサンプリング流路と、
前記入口ポート、前記出口ポート、前記隔離チャンバ、及び前記サンプリング流路を収容し且つ画定するハウジングと
を含み、
前記隔離チャンバ及び前記サンプリング流路のそれぞれが分岐点を介して前記入口ポートと接続され、前記分岐点は、血液の第１部分が前記隔離チャンバに流れ込み、前記空気透過性血液バリアを通して前記隔離チャンバ内の空気を追い出し、前記隔離チャンバ内に隔離されることを可能にし、血液の第２部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液の第１部分を迂回し、前記出口ポート及び前記サンプル採取装置に向かって前記サンプリング流路に向けられることを可能にするように寸法設定され且つ構成される、血液隔離システム。
【請求項２２】
前記入口ポートは、前記採血経路の第１の部分を介して前記患者針と接続される、請求項２１に記載の血液隔離システム。
【請求項２３】
前記出口ポートは、前記採血経路の第２の部分を介して前記サンプル採取装置と接続される、請求項２１に記載の血液隔離システム。
【請求項２４】
前記空気透過性血液バリアは、血液と接触すると少なくとも部分的に密封する空気透過性材料を含む、請求項２１に記載の血液隔離システム。
【請求項２５】

前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項２４に記載の血液隔離システム。
【請求項２６】
前記隔離流路は、前記入口ポートと接続される近位端と、空気透過性血液バリアを含む前記通気口を有する遠位端とを有する、請求項２５に記載の血液隔離システム。
【発明の詳細な説明】
【背景技術】
【０００１】
関連出願との相互参照
本出願は、２０１６年４月２７日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国非仮出願第１５／１４０，４４３号及び２０１６年４月２７日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国非仮出願第１５／１４０，４４８号の優先権の利益を主張するものであり、これらの米国非仮出願の両方が２０１５年７月２４日に出願された「血液培養改良システム及び方法」と題する米国仮特許出願第６２／１９６，７９７号、２０１５年１０月７日に出願された「非汚染採血用の血液隔離システム」と題する米国仮出願第６２／２３８，６３６号、及び２０１６年４月４日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国仮特許出願第６２／３１８，１９４号の優先権を主張しており、これらの開示はその全体が参照により本明細書に含まれるものとする。
【０００２】
菌血症は、血液中に微生物が存在することである。一方、敗血症は、発熱、頻脈、頻呼吸及び低血圧などの臨床症状及び臨床兆候がある場合の菌血症である。菌血症及び敗血症は、高い死亡率、入院発生率及び入院期間と関連する費用の増加とを伴う。多くの菌血症、敗血症、真菌血症及び他の病原体が実際に病院又は他の医療施設内で発生し、カテーテル及び静脈穿刺がこれらの病原体の潜在的なキャリアとしての汚染源である。
【０００３】
血液培養は、患者の血液中の菌血症及び敗血症に関連する微生物病原体を検出するのに使用される標準検査である。血液培養という用語は、血液が１つ以上の血液培養ボトル又は容器に接種される、末梢部位又は中心ライン又は動脈ラインからの１回の静脈穿刺を指す。１つのボトルが１つの血液培養と見なされ、２つ以上がセットと見なされる。複数のセットは複数の静脈穿刺から得られ、患者の異なる部位に関連する。
【０００４】
これらの方法は、敗血症を管理する上で重要な要素である微生物同定及び感受性検査を可能にするが、迅速な結果が得られないことと危険な病原体に対する感度が低いことが、改良されたシステムの開発及び補助的な分子検査又はプロテオミクス検査につながっている。
【０００５】
血液培養を行うための血液サンプルの採取は、現代の患者ケアの重要な要素であり、正確な診断を提供することによって患者の結果に良い影響を与えることも、不必要な抗菌療法を長引かせ、入院期間を長くし、コストを増加させることによって結果に悪影響を与えることもある。
【０００６】
血液培養の採取の１つの結果は、汚染である。血液培養の汚染は、偽陽性の培養結果及び／又は医療関連コストの著しい増加につながる可能性がある。血液培養の汚染の原因は、不適切な皮膚消毒、不適切な採取管の消毒、最初の採血の汚染を含み、これらは結果を歪める可能性がある。
【０００７】
血液培養採取キットは、一般に、ＢＤ、スミス、ビー・ブラウンなどの会社によって提供される「バタフライ」セット、輸液セット、又は他のタイプの静脈穿刺装置と、好気性

血液培養ボトル及び嫌気性血液培養ボトルとで構成される。様々な異なるボトルも検査要件に応じて利用可能である。これらのボトルは、好気性生物と嫌気性生物の両方の回収を最適化するように特別に設計されている。従来のキットでは、使用されるボトルは一般に「バキュテナー（登録商標）」として知られており、これは、所定の量の血液などの液体の採取を容易にするべく管の内部に真空を作り出すために排気される蓋を備える滅菌ガラス管又は滅菌プラスチック管から形成される採血管である。

【０００８】

偽陽性の血液培養は、一般的に、不十分なサンプリング技術の結果である。それらは、必要でないときに抗生物質を使用させ、病院費及び患者の不安を増大させる。血液培養は、皮膚内への針刺しから採取され、その後で血液のサンプルを取り込むためにバキュテナー（登録商標）が取り付けられる。汚染は、穿刺部位及びその周辺の皮膚領域の不適切又は不完全な消毒によって生じ得る。それはまた、挿入中の針による皮膚のくりぬきから、くりぬかれた皮膚細胞と関連する汚染物質とがサンプル中に引き込まれることで生じることもある。

【０００９】

皮下注射針を通る血流は層流であり、このため、皮下注射針に圧力降下が加えられるときに流管にわたって流速勾配が発生する。血液を強く吸引するか又は非常に小さな皮下注射針を使用すると、溶解及び赤血球からのカリウムの放出が起こり、それにより血液サンプルが異常になる可能性がある。

【００１０】

他の例では、一部の患者は繊細な静脈を有し、繊細な静脈は、特に患者の状態に対してあまりにも急速に引き出される注射器のプランジャによって加えられるような圧力低下又は真空の下で崩壊し得る。このような状態は事前に知ることが不可能であるため、このような静脈崩壊は危険であり、制御することは非常に困難である。

【００１１】

血液培養の汚染率を低下させるために、例えば、無菌採取技術に関するスタッフの訓練、汚染率に関するフィードバック、及び血液培養採取キットの導入など、様々な戦略が実施されている。皮膚消毒は汚染の心配を減らすことができるが、２０％以上の皮膚の微生物は真皮の深部に位置し、消毒の影響を受けない。ボトル接種の前に針を交換することは、汚染率を低下させることなく針刺し損傷を受ける危険性を高めるので推奨されない。

【００１２】

血液培養の汚染を低減するための一部の従来のシステム及び技術は、中心静脈カテーテル、静脈穿刺及び他の血管アクセスシステムから採取された最初のアリコートの血液を捨てることを含む。しかしながら、これらのシステムは、ユーザーが血管内装置を機械的に操作することを必要とするか又は確実にすることが困難な複雑な一連のステップを踏むこと必要とする。

【発明の概要】

【発明が解決しようとする課題】

【００１３】

本明細書は、血液培養の汚染、細胞の溶解、及び静脈崩壊を低減するためのシステム及び方法を提示する。一部の実施では、システム及び方法は、ユーザーの消毒のばらつきをなくし、また皮膚細胞が血液培養サンプルに入り込む危険性をなくすこともできる。本明細書に開示されたシステム及び方法は、汚染物質のない血液サンプルを採取するためにバキュテナー（登録商標）又は他の採血装置（すなわち、注射器）をいつ取り付けるべきかを潜在的に示す以外は、既存の臨床プロセスの変更を必要としない。

【００１４】

本明細書に開示されたシステム及び方法の一部の実施では、採血は、患者自身の血圧の使用によって受動的に成し遂げられ、それによって静脈崩壊の危険性を低減し、現行の実務を超える更なるユーザーのステップを排除する。システム及び方法は、短経路の直接刺し又はバタフライ静脈穿刺システムに適合するように適用されることができる。カテーテ

ルを通して採取されたサンプルと共に使用されることもできる。
【課題を解決するための手段】
【００１５】
一態様では、血液隔離装置が提示されている。血液隔離装置は、入口ポートと出口ポートとを含む。血液隔離装置は、入口ポートと接続される隔離チャンバであって、空気透過性血液バリアを含む通気口を有する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端と、出口ポートと接続される遠位端とを有する、サンプリング流路を更に含む。
【００１６】
別の態様では、採血経路と接続される血液隔離装置が記載されている。採血経路は、患者針とサンプル採取装置とを有する。血液隔離装置は、患者針と接続される入口ポートと、入口ポートと接続される隔離チャンバであって、空気透過性血液バリアを含む通気口を有する隔離チャンバとを含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路と、サンプリング流路の遠位端及びサンプル採取装置と接続される出口ポートとを更に含む。
【００１７】
更に別の態様では、採血システムと接続される血液隔離装置が記載されている。採血システムは、患者から血液サンプルを取り出せるようにするための患者針と、密封され且つ真空採血管を受け入れるように適合されたナンプル針とを含む。血液隔離装置は、患者からの血液サンプルを受け入れるために患者針と接続される入口ポートを含む。血液隔離装置は、入口ポートと接続され且つ空気透過性血液バリアを含む通気口を有する隔離チャンバであって、サンプル針が真空採血管によって開封されるより前に血液サンプルの最初の部分を受け入れ且つ隔離する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路であって、真空採血管によってナンプル針が開封されると血液サンプルの後続の部分を運ぶサンプリング流路を更に含む。血液隔離装置は、血液サンプルの後続の部分をサンプル針に運ぶためにサンプリング流路の遠位端と接続される出口ポートを更に含む。
【００１８】
更に別の態様では、血液サンプル最適化システムが開示され、記載されている。血液サンプル最適化システムは、患者の血液の１つ以上のサンプルを取り出せるようにし且つ得るための採血システムと、静脈穿刺プロセスによって汚染されている恐れがあり且つ患者の血液中の病原体の偽陽性同定をもたらす可能性がある患者の血液の１つ以上のサンプルの最初の部分を受け入れ且つ隔離するための血液隔離装置とを含む。
【００１９】
採血システムは、患者の血液のサンプルを取り出せるようにするために患者の静脈穿刺用に構成された患者針と、血液ナンプルを運ぶために患者針と接続される採血経路と、血液サンプルの後続の部分を採取し且つ収容するために真空採血容器を受け入れるように構成されたサンプル針とを含む。
【００２０】
更に別の態様では、血液隔離装置が開示され、記載されている。一部の実施では、血液隔離装置は、入口ポートと、入口ポートと接続される出口ポートと、入口ポートと接続される隔離チャンバとを含むことができる。隔離チャンバは、空気透過性血液バリアを含む通気口を有することができる。
【００２１】
血液隔離装置は、患者針とサンプル針との間で採血経路に沿って接続され、血液サンプルを受け入れるための入口ポートを含む。血液隔離装置は、血液サンプルの最初の量を受け入れるために入コポートと接続される隔離チャンバであって、血液サンプルの最初の量の少なくとも最初の部分を隔離するために空気透過性血液バリアを含む通気口を有する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路であって、隔離チャンバが血液ナンプルの最初の量の少なくとも最初の部分を

隔離すると血液サンプルの後続の量を真空採血容器に運ぶサンプリング流路を更に含む。血液隔離装置は、サンプリング流路の遠位端と接続される出口ポートであって、血液サンプルの後続の量を出力する出口ポートを更に含む。

【００２２】

１つ以上の実施形態の詳細が、添付の図面及び以下の説明に記載されている。他の特徴及び利点は、明細書及び図面並びに特許請求の範囲から明らかになるであろう。

【図面の簡単な説明】

【００２３】

以下、これら及び他の態様について、以下の図面を参照して詳細に説明する。

【図１】血液サンプル最適化システムを示す。

【図２】代替的な実施に従う血液サンプル最適化システムを示す。

【図３】別の代替的な実施に従う血液サンプル最適化システムを示す。

【図４】別の代替的な実施に従う血液サンプル最適化システムを示す。

【図５】別の代替的な実施に従う血液サンプル最適化システムを示す。

【図６】代替的な実施に従う血液サンプル最適化システムを示す。

【図７】血液培養の質を最適化するための方法のフローチャートである。

【図８Ａ】一部の実施に従う非汚染採血用の血液隔離システムを示す。

【図８Ｂ】一部の実施に従う非汚染採血用の血液隔離システムを示す。

【図８Ｃ】一部の実施に従う非汚染採血用の血液隔離システムを示す。

【図８Ｄ】一部の実施に従う非汚染採血用の血液隔離システムを示す。

【図８Ｅ】一部の実施に従う非汚染採血用の血液隔離システムを示す。

【図９】血液隔離システムに用いる経路スプリッタを示す。

【図１０Ａ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１０Ｂ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１０Ｃ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１０Ｄ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１１Ａ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１１Ｂ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１１Ｃ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１１Ｄ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１１Ｅ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。

【図１２Ａ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。

【図１２Ｂ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。

【図１２Ｃ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。

【図１２Ｄ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。

【図１３Ａ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。

【図１３Ｂ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。

【図１３Ｃ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。

【図１３Ｄ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。

【図１４Ａ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。

【図１４Ｂ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。

【図１４Ｃ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を

低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｄ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｅ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１５Ａ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｂ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｃ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｄ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｅ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｆ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｇ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１６Ａ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｂ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｃ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｄ】更に別の実施に従う血液隔離装置を示す。
【図１７Ａ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｂ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｃ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｄ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｅ】血液隔離装置用のハウジングの下部部材を示す。
【図１８Ａ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｂ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｃ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｄ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｅ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｆ】血液隔離装置用のハウジングの上部部材を示す。
【図１９Ａ】下部部材と嵌合する上部部材を有する血液隔離装置を示す。
【図１９Ｂ】下部部材と嵌合する上部部材を有する血液隔離装置を示す。
【図２０】血液隔離装置を含む血液サンプル最適化システムを示す。
【図２１】ウィッキング材料チャンバを使用する通気口付きでない血液隔離装置を示す。
【図２２Ａ】血液隔離装置の隔離チャンバ内の血液を隔離するためのフィルタの材料構成を示す。
【図２２Ｂ】血液隔離装置の隔離チャンバ内の血液を隔離するためのフィルタの材料構成を示す。
【図２３Ａ】採血装置による真空力を使用する血液隔離装置の別の実施を示す。
【図２３Ｂ】採血装置による真空力を使用する血液隔離装置の別の実施を示す。　様々な図面における同様の符号は同様の要素を示す。
【発明を実施するための形態】
【００２４】
本明細書は、採取される血液サンプル中の汚染物質を低減又は排除し、その結果、採取される血液サンプルの血液培養又は他の検査における偽陽性の判断を減少又は排除する血液サンプル最適化システム及び方法を記載している。一部の実施では、血液サンプル最適化システムは、患者の血流への血管アクセスのための患者針と、バキュテナー（登録商標）のような真空採血容器又は真空採血管などの採血容器か又は他のサンプリング装置に血液サンプルを供給するためのサンプル針と、患者針とサンプル針との間に位置する血液隔離装置とを含む。血液隔離装置は、汚染されている可能性のある最初のアリコートの血液

を隔離するための隔離チャンバを含み、最初のアリコートの血液が隔離チャンバ内に隔離された後に患者針とサンプル針との間の汚染されていない可能性のある血液を運ぶために隔離チャンバを迂回するサンプリング流路を更に含むことができる。

【００２５】

図１は、一部の実施に従う血液サンプル最適化システムを示す。システムは、患者の皮膚を穿刺してその中の患者の静脈及び静脈内の血液にアクセスするための患者針１を含む。システムは、再密封可能なブーツ１０、ルアー作動弁、又は別の採取インターフェース又は装置内に収容され且つ再密封可能なブーツ１０、ルアー作動弁、又は別の採取インターフェース又は装置によって当初は密封されていることができる、サンプル針（すなわち、バキュテナー（登録商標）などと共に使用するための再密封可能に密封された針）５を更に含む。再密封可能なブーツ１０は、患者の血液を採取するためのバキュテナー（登録商標）ボトル（図示せず）を用いることによって、サンプル針５のそばに又はサンプル針５の周りに押し付けることができる。システムは、サンプル針５に通じる低容量チャンバ３０を更に含むことができるが、ハウジング５０によって形成される隔離チャンバ５５に通じる穴又は１つ以上の流路４５も含む。

【００２６】

隔離チャンバ５５は、隔離チャンバ５５の容積に応じて、所定の又は測定された量であることができる、患者の血液の最初のアリコートを受け入れ且つ保持するためのチャンバ、流路、通路、ロック、又は他の構造である。最初の採血は、一般的に、後続の採血に比べて菌血症及び敗血症を引き起こす微生物又は他の病原体を含有しているか又はより含有の影響を受けやすい。隔離チャンバ５５は、硬いハウジング内に収容されるか、ハウジング自体に形成され又はハウジング自体によって画定された容器であることができ、或いはチューブ又は内腔として実現されることができる。隔離チャンバ５５は、どのように形成され且つ実施されるかにかかわらず、所定の容積を有することができる。一部の実施では、所定の容積は、患者針の容積に基づくこと、すなわち、患者針の容積よりも少ない容積から任意の容積から患者針の容積の２０倍以上大きい容積までの範囲であることができる。隔離チャンバ５５の所定の容積は、隔離され且つ処分される血液の量を節約又は最小化するように設定されることもできる。

【００２７】

隔離チャンバ５５は、チャンバハウジング５０内に形成、包含、又は収容されることができ、プラスチック、ゴム、鋼、アルミニウム又は他の適切な材料で作られることができる。例えば、隔離チャンバ５５は、可撓性チューブ又は他のエラストマー材料から形成されることができる。隔離チャンバ５５は、空気が隔離チャンバ５５から出ることを可能にする空気透過性血液バリア２０を更に含む。本明細書で使用される「空気透過性血液バリア」という用語は、空気透過性であるが実質的に血液不透過性の物質、材料又は構造体を意味する。代表的な例は、疎水性膜及び疎水性コーティング、疎水性膜又は疎水性コーティングと組み合わせた親水性膜又は親水性コーティング、メッシュ、フィルタ、機械的弁、抗菌性材料、又は隔離チャンバ５５が血液で満たされるときに隔離チャンバ５５から空気を追い出すことができる他の任意の手段を含むことができる。様々な例示的な実施形態において、空気透過性血液バリアは、空気が液体と接触するまで通過することを可能にする１つ以上の材料によって形成されることができ、このような材料は、空気及び／又は液体の通過を防止又は阻止するために完全に又は部分的に密封される。言い換えれば、液体との接触より前に、材料は空気透過性のバリアを形成している。液体との接触後、材料は、空気及び／又は液体の更なる通過を実質的に又は完全に防止する。

【００２８】

穴又は流路４５は、任意の所望の長さ、断面形状又はサイズであることができ、且つ／又は任意の所望の角度又は向きで低容量チャンバ３０から離れるように形成されることができる。穴又は流路４５はまた、最初のアリコートの血液サンプルを隔離チャンバ５５内に保持する一方向フラップ又は一方向弁６０を含むことができる。一部の特定の実施では、穴又は流路４５は、低容量チャンバ３０から隔離チャンバ５５への一方向の血液の流れ

のための「ダックビル」弁又はフラッパ弁６０などを含むことができる。空気透過性血液バリア２０は、空気が出ることを可能にするが血液と接触すると密封する材料で構成することもでき、それによって外気が隔離チャンバ５５に入ることを許容しない。この密封は弁を不要にする。

【００２９】

弁６０は、任意のタイプの弁又は開閉機構であることができる。チャンバ３０は、実質的に残留血液を保持しないように設計されており、特定の容積又は割合の血液を隔離チャンバ５５に保持し又は通過させるように構成することができる。同様に、隔離チャンバ５５は、抗凝固コーティングのような任意のタイプのコーティング、又は隔離された最初の採血の成分の同定及び／又は診断を支援するコーティングも含むことができる。

【００３０】

ハウジング５０及び４０は、アクリロニトリルブタジエンスチレン（ＡＢＳ）又は他の熱可塑性材料又はポリマー材料などのプラスチック、ゴム、鋼、又はアルミニウムを含む任意の適切な材料から形成されることができる。空気透過性血液バリア２０は、最初の採血による血液と接触すると又は空気の追い出しが停止されたときに、又は事象と隔離チャンバ５５内の血液との任意の組み合わせの場合に活性化される、色提供物質又は他の信号伝達機構を含むことができる。空気透過性のバリアはまた、外部流体源、しぶき等によるフィルタの不注意による又は早過ぎる密封を阻止又は防止する疎水性膜又はカバーなどの外層を含むことができる。隔離チャンバ５５はまた、チャンバが充填されたことをユーザーが視覚的に確認することを可能にするために半透明又は透明であることができる。

【００３１】

図２は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図２に示す実施では、隔離チャンバ５５又は廃棄チャンバが患者針１を取り囲み、端部が開放されたカフ又はハウジングが廃棄チャンバと接続され、サンプル針ハウジングベース及びハウジングを取り囲んでいる。患者針１とサンプル針５とは、ブーツ５６によって互いと接続されており、ブーツ５６は、それを貫通する連続的な採血流路を形成している。ブーツ５６は、採血流路から隔離チャンバ５５に通じる単一の穴又は流路を含む。装置は、他の実施では、複数の穴又は流路を含むことができる。各穴又は流路は、一方向弁を含むことができ、所定の量の血流のために寸法設定され且つ適合されることができる。

【００３２】

隔離チャンバ５５は、空気透過性血液バリアを含む。フィルタは、所定容積の血液が隔離チャンバ５５に集められたときに、それぞれ、感知及び／又は指示するためのセンサ又は指標を更に含むことができる。その指示は、バキュテナー（登録商標）などの真空採血管又はボトルをサンプル針５に取り付けるようにユーザーに警告する。隔離チャンバ５５用のハウジングは、任意のサイズ又は形状であることができ、ハウジング内の内部空間又は容積を画定するために任意のタイプの材料を含むことができる。内部空間は、最初は空気のみで満たされているが、汚染除去剤、凝固剤などの薬剤又は物質でコーティングされることもできる。真空採血管がサンプル針５に取り付けられると、血液は自動的に患者針１に、採血流路及びサンプル針５を通ってボトルに流入する。サンプル針５は、採血ボトルがサンプル針に取り付けられていないときにサンプル針を密封する再密封可能なブーツ、コーティング又は膜によって覆われている。

【００３３】

図３は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図示の実施では、サンプル針５は、再密封可能なブーツ又は膜によって取り囲まれ、更に患者針１と接続される。サンプル針及び患者針を通って血液流路が形成される。サンプル針と患者針との間の接続は、主血液流路から隔離チャンバ１０４へと導く流路、ポート又は開口部を含む「Ｔ」又は「Ｙ」コネクタ１０２を含む。

【００３４】

Ｔ又はＹコネクタ１０２は、フラップ又は一方向弁を含み、所定の流量の血液のために寸法設定され且つ適合された穴を有する。隔離チャンバ１０４は、チューブから形成され

又は硬いハウジングによって形成されることができ、最初は空気で満たされている。隔離チャンバ１０４は、自動的に、すなわち、患者自身の血圧による圧力下で患者から流出する血液を受け入れる。隔離チャンバ１０４は、好ましくは隔離チャンバ１０４を形成し且つ近位端がＴ又はＹコネクタ１０２に接続されたチューブの遠位端に、空気透過性血液バリア１０６を含む。Ｔ又はＹコネクタ１０２は、最も効率的な血流のために任意の所望の角度で分岐することができ、最初のアリコートの血液と主要な採血サンプルとの混合を最小限に抑え又は排除するために、開口部及び流路と主血液流路との間の接合部分を最小化するように形成されることができる。

【００３５】

一部の代替的な実施では、サンプル針は、図４に示すように、その反対側の端部がＴ又はＹコネクタ１０２と接続している任意の長さのチューブに取り付けられることができる。隔離チャンバ１０４は、最初のアリコートに所定量の血液サンプルを含む限り、任意の形状又は容積であることができる。Ｔ又はＹコネクタ１０２はまた、主血液流路に対して平行な開口部又は流路を含むことができる。空気透過性血液バリアは、所定量の血液が隔離チャンバに集められたとき、又は放出される空気が特定の閾値、すなわちゼロに達したときを示す指標１０７又は他の機構を更に含むことができる。チューブはまた、挟んでチューブを通る流体の流れを防止するのに使用することができるクリップ１０９を含むことができる。

【００３６】

空気透過性血液バリア及び一次チャンバが密封されると、最初のアリコートの血液が隔離チャンバ１０４に閉じ込められ、サンプルを得るためにバキュテナー（登録商標）ボトルのような真空採血管がサンプル針５に取り付けられる。採血管は取り外すことができ、サンプル針５は再密封される。更なる採血又はサンプルのために、任意の数の後続の採血管を取り付けることができる。全ての採血が完了すると、最初のアリコートの血液が隔離チャンバ１０４に閉じ込められたまま、システムは廃棄される。

【００３７】

図５は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図示の実施では、サンプル針５が患者針とチューブによって接続されている。「Ｔ」又は「Ｙ」コネクタ１２０が、チューブに沿って任意の所望の位置に追加され、実質的に上記のように、隔離チャンバ２０４に通じる開口部、ポート又は流路を含む。

【００３８】

図６は、一次採取流路として形成された隔離チャンバ３０４が最初のアリコートの血液を受け入れ、採血流路に隣接して設けられている、一部の代替的な実施に従う血液サンプル最適化システムを示す。隔離チャンバ３０４は、採血流路、患者針１及び／又はサンプル針５を取り囲むことができる。一次採取流路は、Ｔ又はＹコネクタ１２０、又は他のタイプの開口部又は流路を含むことができる。隔離チャンバ３０４は空気透過性血液バリアを含み、上記のように、血液などの流体が接触したことの指標を含むこともできる。

【００３９】

一部の実施では、患者針１又はサンプル針５のいずれか又は両方をルアーロック雄コネクタ又はルアーロック雌コネクタで置き換えることができる。しかしながら、様々な実施で、血液サンプル最適化システムのサンプル針端部にあるコネクタを最初に密封し、周囲空気圧で加圧され且つ空気透過性血液バリアの空気出口を含む隔離チャンバへ最初のアリコートの血液をそらすことを可能にする。このようにして、システムは受動的且つ自動的に患者自身の血圧を用いて隔離チャンバの周囲空気圧に打ち勝ち、空気透過性血液バリアを通して空気を押し出し、隔離チャンバ内の空気を血液に置き換える。

【００４０】

図７は、血液培養の質を最適化するための例示的な方法のフローチャートである。７０２において、臨床医が患者の静脈に針を挿入する。７０４において、血液が隔離チャンバに流れ込み、隔離チャンバ内の空気を隔離チャンバから空気透過性血液バリアを通して押し出す。一部の実施では、隔離チャンバの容積は、０．１立方センチメートル（ｃｃ）未

満から５立方センチメートル（ｃｃ）以上である。隔離チャンバは、血液ナンブルの第２部分及び他の後続の部分又は後続の採取よりも汚染しやすい血液サンプルの第１部分を採取するように寸法設定され且つ適合されている。隔離チャンバは空気透過性血液バリアを有し、この血液バリアを通して空気を患者の静脈から押し出された血液で追い出すことができるので、このような血液は、血液サンプルを受け入れ且つ保管するためのバキュテナー（登録商標）又は他のボトルに引き込まれるか又は他の方法で入る前に、必然的に且つ自動的に隔離チャンバに流入する。

【００４１】

隔離チャンバがいっぱいになると、血液は、血液が通過するのを阻止又は防止する空気透過性血液バリアに集まるか、さもなければ接触する。７０６において、血液が空気透過性血液バリアの全内部表面積と接触すると、空気透過性血液バリアは閉じられ、空気はもはや流出又は流入しない。７０８において、臨床医は、バキュテナー（登録商標）などの真空採血管を取り付けることができることを示す指標を提供されるか又は満杯のチャンバを見ることができる。指標は、一次チャンバがいっぱいであるか否かを確認するための一次チャンバの可視性、例えば、色を変える血液バリア、又は他の指標を含むことができる。隔離チャンバの充填時間は、実質的に瞬間的であり得るので、このような指標は、存在する場合、隔離チャンバが満たされているというだけである可能性がある。

【００４２】

真空採血管が取り付けられる前、針、サンプリング流路、及び隔離チャンバの間の連通は、隔離チャンバの血液バリアの密封によって制限され、従って隔離によって空気がシステムに再び入ることを可能にしない。連通経路の密封は、機械的にねじること又は他の動作、小さな穴又は曲がりくねった経路によって達成され、臨床医による別個の弁又は機械的な動作又は操作の必要性をなくす。７１０において、真空採血管を取り外すと、自己密封式の膜がサンプル針を密封し、７１２で、更なる後続の真空採血管を取り付けることができる。７１４において、サンプルが採取されると、装置が患者から取り外され、廃棄される。

【００４３】

図８Ａ～８Ｅは、一部の実施に従う、非汚染採血用の例示的な血液サンプル最適化システム８００を示す。血液サンプル最適化システム８００は、チューブ、患者針（又は両方）、又は他の血管又は静脈アクセス装置に接続されることができる入口ポート８０２と、隔離チャンバチューブ８０６への第１出口とサンプル採取チューブ８０８への第２出口とを有する経路スプリッタ８０４とを含む。隔離チャンバチューブ８０６及びサンプル採取チューブ８０８の一方又は両方は、チューブから形成されることができる。一部の実施では、隔離チャンバチューブ８０６は、特定の量の当初血液サンプルを収容するように寸法設定される。サンプル採取チューブ８０８は、ひとたび隔離チャンバチューブ８０６が満たされると、血液サンプルを受け入れる。サンプル採取チューブ８０８は、バキュテナー（登録商標）ベース又はハウジング８１０、又は他の血液サンプル採取装置に接続されることができる。

【００４４】

血液隔離システム８００は血液隔離装置８１２を更に含み、血液隔離装置８１２は、図８Ｂ～８Ｄにより詳細に示すようにハウジング８１８を含み、ハウジング８１８は、非汚染サンプル採取チューブ８０８用の経路を固定するか又はいずれかの端部が非汚染サンプル採取チューブ８０８と接続されるサンプリング流路８２０を含む。サンプリング流路８２０は、非汚染サンプル採取チューブ８０８に沿った位置でハウジング８１８をより良好に固定し且つ安定させるように、ハウジング８１８を通って曲線状であることができる。

【００４５】

血液隔離装置８１２は、隔離チャンバチューブ８０６と接続される隔離チャンバ８２２又は他のチャンバを更に含む。隔離チャンバ８２２は、空気透過性血液バリア８２４で終端している。空気透過性血液バリア８２４はまた、血液サンプル（すなわち、非汚染血液サンプル）の正式な採取を開始することができる指標として、血液との完全な接触時に異

なる色に変わる着色剤を含むことができる。小さい光、音発生機構などの他の指標を使用することができる。一部の実施では、空気透過性血液バリアは、隔離チャンバ８２２の方向から直角に配置されているが、ハウジング８１８に使用される空間及び材料を節約するために任意の距離又は向きに配置されることができる。ハウジング８１８及びその内容物は、任意の剛性材料又は半剛性材料又は一連の材料から形成されることができる。

【００４６】

図９は、例えば、図８Ａ～８Ｅに示すような血液隔離システムに用いる経路スプリッタ９００を示す。経路スプリッタ９００は、入口ポート９０２と、主管路出口ポート９０４と、隔離流路出口ポート９０６とを含む。入口ポート９０２は、同様に患者針システムに接続される主チューブに、又は直接患者針に接続されることができる。主管路出口ポート９０４は、バキュテナー（登録商標）ベース又はハウジングなどの採血システムへの主管路チューブに、又は直接そのような採血システムに接続されることができる。隔離流路出口ポート９０６は、測定された量又は所定の閾値まで血液の第１サンプルを受け入れ且つ隔離するための隔離チューブに接続されることができる。代わりに、隔離流路出口ポート９０６は、隔離チャンバに接続することができる。隔離流路出口ポート９０６は、好ましくは、主管路出口ポート９０４から２０～７０度の角度に曲げられ、一方、主管路出口ポート９０４は、好ましくは、入口ポート９０２と一直線である。所定の量の最初の血液サンプルが、本明細書に記載された機構及び技術に従って隔離チューブ又は隔離チャンバ内に隔離されると、後続の血液サンプルは、入口ポート９０２に流入し、障害物なしで主管路出口ポート９０４から直接流出する。

【００４７】

図１０Ａ～１０Ｄは、別の実施に従う血液隔離装置１０００を示す。血液隔離装置１０００は、入口ポート１００２と、主出口ポート１００４と、隔離流路ポート１００６とを含む。入口ポート１００２は、患者針又は関連するチューブと接続されることができる。主出口ポート１００４は、バキュテナー（登録商標）、関連するチューブ、又はルアー作動弁などの血液サンプル採取装置に接続されることができる。隔離流路ポート１００６は、主出口ポート１００４から隔離チャンバ１００８に分離する。一部の実施では、隔離チャンバ１００８は、ハウジング又は他の容器１００１内に螺旋流路として形成される。

【００４８】

隔離チャンバ１００８は、実質的に上記のように、遠位端が空気透過性血液バリア１０１０に接続される。隔離チャンバ１００８内の空気は、空気透過性血液バリア１０１０を通して、隔離流路ポート１００６内に案内される最初のアリコートの血液によって追い出される。ひとたび隔離チャンバ１００８が満たされると、主出口ポート１００４を通る更なる採血が成し遂げられ、これらのサンプルは汚染されていない。

【００４９】

図１１Ａ～１１Ｅは、他の代替的な実施に従う血液隔離装置１１００を示す。血液隔離装置１１００は、上述の入口ポートと同様の入口ポート１１０２と、主出口ポート１１０４と、主出口ポート１１０４及び入口ポート１１０２から分離する隔離流路ポート１１０６とを含む。隔離流路ポートは、隔離チャンバ１１０８に接続されている。図１１Ａ～１１Ｅに示す実施では、血液隔離装置は、隔離チャンバ１１０８として機能する流路を内部に有するベース部材１１０１を含む。流路は、ベース部材１１０１を通る曲がりくねった経路として形成されることができ、一方、ベース部材１１０１は、患者の四肢に載るように成形され且つ形成される。

【００５０】

隔離チャンバ１１０８の一部は、血液隔離指標１１０９として機能するように、空気透過性血液バリア１１１０に出る直前に、ベース部材から又はベース部材の上面付近に突出することができる。指標１１０９は、透明な材料、又は血液と接触すると変色する材料で形成されることができる。

【００５１】

一部の実施では、血液隔離装置１１００は、常時閉じている針、バキュテナー（登録商

標）シールド又は他の採取装置などの採血装置１１２０を含むことができる。採血装置１１２０は、患者針の挿入プロセスによって汚染される恐れがある最初のアリコートの血液を隔離することができるように、効率及び利便性のために血液隔離装置１１００と共に製造及び販売されることができる。従って、採血装置１１２０は、偽陽性の検査のリスクを低減するように非汚染血液サンプルを採取し且つ非汚染サンプルを確実にすることができる。

【００５２】

図１２Ａ～１２Ｄは、更に他の代替的な実施に従う血液サンプル最適化システム１２００を示す。システム１２００は、バキュテナー（登録商標）又は他の採取及びサンプリング装置のような採血装置１２０４に取り付けるための血液隔離装置１２０２を含む。血液隔離装置１２０２は、バキュテナー（登録商標）容器又はバイアルが採血装置１２０４の採取針に取り付けられる前に、最初のアリコート又は量の血液を受け入れ、且つその最初のアリコート又は量を血液隔離装置１２０２の隔離流路内に隔離するように、構成され且つ配置されている。

【００５３】

一部の実施では、血液隔離装置１２０２は、入口ポート１２１２と、主出口ポートと、隔離流路ポートとを含むことができる。入口ポート１２１２は、患者針又は関連するチューブに接続されることができる。主出口ポート１２１４は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁との接続を可能にするために、常時閉じている針又は装置に接続されることができる。隔離流路ポートは、主出口ポートから隔離チャンバ１２１８に分離する。

【００５４】

一部の実施では、隔離チャンバ１２１８は、隔離装置１２０２の本体内の流路として形成される。隔離チャンバ１２１８は、Ｕ字形流路、Ｓ字形流路、螺旋流路、又は任意の他の曲がりくねった流路などの曲がりくねった流路であることができる。隔離装置１２０２は、ハウジング又は他の収容体、及びその中に形成された１つ以上の流路を含むことができる。図１２Ａ及び１２Ｂに示すように、隔離装置１２０２は、本体１２０６とキャップ１２０８とを含む。本体１２０６には１つ以上の空洞又は流路が形成され、空洞又は流路にはキャップ１２０８から延びる１つ以上のアーム１２１０が更に形成され、１つ以上のアーム１２１０は、本体１２０６の空洞又は流路に当接して一次採取ポート及び主出口ポートを形成している。

【００５５】

図１３Ａ～１３Ｄは、更に他の代替的な実施に従う血液サンプル最適化システム１３００を示す。システム１３００は、バキュテナー（登録商標）又は他の体液採取及びサンプリング装置などの採血装置１３０４に取り付けるための血液隔離装置１３０２を含む。血液隔離装置１３０２は、バキュテナー（登録商標）容器又はバイアルが採血装置１３０４の採取針に取り付けられる前に、最初のアリコート又は量の血液を受け入れ、且つその最初のアリコート又は量の血液又は他の体液を血液隔離装置１３０２の隔離流路内に隔離するように、構成され且つ配置されている。

【００５６】

血液隔離装置１３０２は、入口ポート１３１４と、主出口ポート１３１２と、隔離流路ポート１３１６とを有するハウジング１３０１を含む。入口ポート１３１４は、患者針又は関連するチューブに接続されることができる。主出口ポート１３１２は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁との接続を可能にするために、常時閉じている針又は装置に接続されることができる。隔離流路ポート１３１６は、主入口ポート１３１４から隔離チャンバ１３１８に分離する。

【００５７】

図１３Ａ～１３Ｄに示す実施例では、隔離チャンバ１３１８は、ハウジング１３０１内の空洞又はチャンバとして形成され、又はハウジング１３０１を画定する壁によって形成

される。隔離チャンバ１３１８は、Ｕ字形流路、Ｓ字形流路、螺旋流路などの曲がりくねった流路、又はハウジング１３０１とキャップ１３０７との協働及び接続によって画定される任意の他の曲がりくねった流路であることができ、キャップ１３０７は、隔離チャンバ１３１８内の曲がりくねった流路のための１つ以上の壁又はディレクタを提供する突出部１３０５を含むことができる。キャップ１３０７からの突出部１３０５は、真っ直ぐであるか湾曲していることができ、様々な流路、開口部又は溝が埋め込まれていることができ、キャップ１３０７から任意の角度又は向きで延びることができる。隔離チャンバ１３１８の形成を完了するためにキャップ１３０７がハウジング１３０１と接続されると、突出部１３０５は曲がりくねった流路の少なくとも一部を形成し、隔離チャンバ１３１８内に曲がりくねった流路によって形成される隔離流路に最初のアリコート又は量の血液又は他の体液を隔離する。

【００５８】

隔離チャンバ１３１８は、実質的に上記のように空気透過性血液バリア１３１０を含む。隔離チャンバ１３１８内の空気は、患者の血圧によって隔離チャンバ１３１８内に供給される最初のアリコートの血液によって空気透過性血液バリア１３１０を通して追い出される。隔離チャンバ１３１８が満たされ、隔離チャンバ１３１８内の空気が追い出されると、バキュテナー（登録商標）のような血液サンプル採取装置によって提供されるような真空又は他の圧力のような力が次のアリコート又は量の血液又は体液を引き抜くために提供されるまで、患者の血圧は、血液隔離装置１３０２、特に、出口ポート１３１２に更なる血液を追い込み又は提供するのには不十分である。主出口ポート１３１２を通して更なる採血を行うことができ、あらゆる汚染物質が最初のアリコートの血液と共に隔離チャンバ１３１８内に隔離されているので、これらのサンプルは汚染されない。

【００５９】

図１４Ａ～１４Ｅは、患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システム１４００の更に別の実施を示す。採血システム１４００は、血液サンプル採取装置１４０３と患者針（図示せず）との間に接続されることができる血液隔離装置１４０１を含む。血液サンプル採取装置１４０３は、バキュテナー（登録商標）などであることができる。血液隔離装置１４０１は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１４０２を含む。入口ポート１４０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。

【００６０】

入口ポート１４０２は、血液隔離装置１４０１への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有する円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる。血液隔離装置１４０１は、血液隔離装置１４０１から及び血液サンプル採取装置１４０３への開口部を画定する出口ポート１４０４を更に含む。出口ポート１４０４は、同様に血液隔離装置１４０３と接続されるチューブ又は他の導管と接続されることもできる。出口ポート１４０４は、ねじ付きキャップ、ルアーコネクタ（雄型又は雌型）、チューブなどを含むがそれらに限定されない様々な装置の取り付け用のねじが切られていない締め代又は接着継手などのコネクタ装置を更に含むことができる。

【００６１】

血液隔離装置１４０１は、入口ポート１４０２と出口ポート１４０４との間にサンプリング流路１４０６を更に含み、サンプリング流路１４０６は、最初のアリコートの血液が隔離されると血液サンプル経路として機能する。サンプリング流路１４０６は、任意のサイズ、形状又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１４０６は、入口ポート１４０２の開口部と実質的に同様の断面積を有する。他の実

施では、サンプリング流路１４０６は、入口ポート１４０２から出口ポート１４０４まで徐々に広がることができる。

【００６２】

血液隔離装置１４０１は隔離チャンバ１４０８を更に含み、隔離チャンバ１４０８は、入口ポート１４０２と出口ポート１４０４との間の任意の位置でサンプリング流路１４０６に接続され且つサンプリング流路１４０６から分離又は方向転換されるが、好ましくは入口ポート１４０２の近くのサンプリング流路１４０６の近位端に接続され且つ近位端から分離又は方向転換される。隔離チャンバ１４０８は、最初は大気圧に維持され、サンプリング流路１４０６からの方向転換点と反対側の隔離チャンバ１４０８の遠位端又はその近傍に空気出口１４１２を含む。空気出口１４１２は、空気透過性血液バリア１４１２を含む。図１４Ｂに示すように、空気透過性血液バリア１４１２は、保護カバー１４１６で覆われていることができる。保護カバー１４１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１４１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも患者自身の血圧によって隔離チャンバ１４０８内に強制的に血液が供給されることによって空気が隔離チャンバから追い出されるときに空気が空気透過性血液バリア１４１２から出ることを可能にする。また、保護カバー１４１６は、空気透過性血液バリアが周囲の流体又は飛沫に偶発的に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００６３】

図１４Ｃ及び１４Ｄに示すように、サンプリング流路１４０６は、赤血球を溶解する可能性を最小限に抑えるために、より小さい直径からより大きい直径になる円筒形又は円錐台形であることができる。同様に、サンプリング流路１４０６は、赤血球を溶解する可能性がある急カーブ又は鋭角が最小限の量で又はなしで形成される。サンプリング流路１４０６は、方向転換経路１４０９を通して入口ポート１４０２の近くで隔離チャンバ１４０８へと分離する。方向転換経路１４０９は、任意の断面形状又はサイズを有することができるが、好ましくは、入口ポート１４０２の少なくとも一部の断面形状と同様である。

【００６４】

一部の実施では、サンプリング流路１４０６及び隔離チャンバ１４０８は、ハウジング１４１４に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１４１４は、プラスチック、金属又は他の剛性又は半剛性材料で作られることができる。ハウジング１４１４は、上部部材と密封可能に嵌合する下部部材を有することができる。下部部材及び上部部材の一方又は両方は、サンプリング流路１４０６及び隔離チャンバ１４０８、並びに方向転換経路１４０９、入口ポート１４０２、及び出口ポート１４０４を含むことができる。一部の他の実施態様では、方向転換経路１４０９、入口ポート１４０２、及び／又は出口ポート１４０４のうちの１つ以上が、ハウジング１４１４のいずれかの端部に接続されるキャップ部材によって少なくとも部分的に形成されることができる。一部の実施では、上部部材及び下部部材、並びにキャップ部材は、レーザ溶接、ヒートシール、接着、スナップ止め、ねじ止め、ボルト止めなどによって互いに連結されることができる。他の実施では、方向転換経路１４０９及び／又は隔離チャンバ１４０８の内面の一部又は全部が、汚染除去剤、凝固剤などの薬剤又は物質でコーティング又は充填されることができる。例えば、隔離チャンバ１４０８が満たされて最初のアリコートの血液が方向転換経路１４０９に戻るとき、隔離された血液の最後の量が凝固し、隔離チャンバ１４０８とサンプリング流路１４０６との間に障壁を作り出すように、方向転換経路１４０９に凝固剤を設けることができる。

【００６５】

図１５Ａ～１５Ｇは、血液隔離装置１５００を示す。血液隔離装置１５００は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁などとの接続を可能にするために常時閉じている針又は装置に接続されることができる。

【００６６】
血液隔離装置１５００は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１５０２を含む。入口ポート１５０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。入口ポート１５０２は、血液隔離装置１５００への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有する円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる。
【００６７】
入口ポート１５０２はまた、ねじ切り又はルアーフィッティングなどのような密封又は流体密封のコネクタ又は接続部を含むことができる。一部の実施では、患者針に結合されているチューブ又は他の導管は、部品同士の共成形、接着、レーザ溶接、又は熱接合などによって、入口ポート１５０２と一体化されることができる。これによって、血液隔離装置１５００は、患者針と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針を血液隔離装置１５００に接続する必要性をなくすことができる。
【００６８】
血液隔離装置１５００は、血液隔離装置１５００から及び血液サンプル採取装置への開口部を画定する出口ポート１５０４を更に含む。出口ポート１５０４は、同様に血液隔離装置と接続されるチューブ又は他の導管と接続されることもでき、ねじ切り又はルアーフィッティングなどの密封又は流体密封コネクタ又は接続部を含むことができる。したがって、上記のように、血液隔離装置１５００は、患者針及び／又はチューブ及び血液サンプル採取装置と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針及び血液サンプル採取装置を血液隔離装置１５００に接続する必要性をなくすことができる。
【００６９】
血液隔離装置１５００は、入口ポート１５０２と出口ポート１５０４との間にサンプリング流路１５０６を更に含み、サンプリング流路１５０６は、最初のアリコートの血液が隔離されると血液サンプル経路として機能する。サンプリング流路１５０６は、任意のサイズ、形状、又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１５０６は、入口ポート１５０２の開口部と実質的に同様の断面積を有する。他の実施では、サンプリング流路１５０６は、入口ポート１５０２から出口ポート１５０４まで徐々に広がることができる。
【００７０】
血液隔離装置１５００は隔離チャンバ１５０８を更に含み、隔離チャンバ１５０８は、入口ポート１５０２と出口ポート１５０４との間の任意の位置でサンプリング流路１５０６に接続され且つサンプリング流路１５０６から分離又は方向転換されるが、好ましくは入口ポート１５０２の近くのサンプリング流路１５０６の近位端に接続され且つ近位端から分離又は方向転換される。一部の実施では、分水路はＹ字路を含む。隔離チャンバ１５０８は、好ましくは大気圧に維持され、隔離チャンバ１５０８の遠位端又はその近傍に通気口１５１０を含む。通気口１５１０は、空気透過性血液バリア１５１２を含む。図１５Ｃは、隔離チャンバ１５０８が患者からの血液の最初のアリコート又はサンプルで満たされた血液隔離装置１５００を示す。
【００７１】
空気透過性血液バリア１５１２は、保護カバー１５１６で覆されていることができる。保護カバー１５１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１５１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも患者自身の血圧によって隔離チャンバ１５０８内に強制的に血液が供給されることによって空気が隔離チャンバから追い出されるときに空気が空気透過性血液バリア１５１２から出ることを可能にする。保護カバー１５１６は、フィルタが周囲の流体又は飛沫に偶発的

に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００７２】

図１５Ｂは、血液隔離装置１５００の出口ポート１５０４及び通気口１５１０を含むハウジング１５０１の上面からの血液隔離装置１５００の斜視図であり、サンプル採取装置が起動される前、サンプリング流路１５０６が空である間に最初のアリコートの血液が隔離チャンバ１５０８を満たすことを示す。図１５Ｇは、血液隔離装置１５００の出口ポート１５０４及びハウジング１５０１の底面からの血液隔離装置１５００の斜視図であり、サンプル採取装置が起動される前、サンプリング流路１５０６が空である間に最初のアリコートの血液が隔離チャンバ１５０８を満たすことを示す。図１５Ｃは、血液隔離装置１５００の入口ポート１５０２及び通気口１５１０を含むハウジング１５０１の上面からの血液隔離装置１５００の別の斜視図であり、隔離された血液は実質的に隔離チャンバ１５０８内にとどまっている間に血液がサンプリング流路１５０６を通って採取されることを示す。

【００７３】

図１５Ｄは、一部の実施に従う血液隔離装置１５００の断面図であり、サンプリング流路１５０６及び隔離チャンバ１５０８を画定するハウジング１５０１を示す。図１５Ｅ及び１５Ｆは、本明細書に記載される１つ以上の実施に従う血液隔離装置用のハウジングの様々なフォームファクタを示す。

【００７４】

隔離チャンバ１５０８は、サンプリング流路１５０６よりも大きい断面積を有することができ、断面積又は長さは、所定の又は特定の血液量が隔離又はロックされるように構成されることができる。サンプリング流路１５０６は、患者針のチューブ又は採血装置のチューブのいずれか又は両方のためのチューブに適合するように寸法設定されることができる。

【００７５】

ハウジング１５０１は、複数の部品又は単一の一体部品から形成されることができる。一部の実施では、図１５Ｄに示すように、ハウジング１５０１は、互いに嵌合する上部部材１５２０と下部部材１５２２とを含み、それらの一方又は両方は、例えば、射出成形プロセスによって又はエッチング、切削、穿孔などによって予め形成された溝、流路、ロック、導管又は他の経路を有する。上部部材１５２０は、レーザ溶接、熱接合、超音波溶接、接着、ねじ、リベット、ボルトなどを使用することなどの任意の嵌合又は接続機構によって、又はラッチ、溝、舌状部、ピン、フランジなどの他の嵌合機構によって、下部部材１５２２と接続されることができる。

【００７６】

一部の実施では、図１５Ｄに示すように、上部部材１５２０は、溝、流路、ロック、導管又は他の経路を含むことができ、一方、下部部材１５２２は、上部部材１５２０の溝、流路、ロック又は他の経路のうちの少なくとも１つに嵌合するように寸法設定され且つ適合された突出部１５２４を含むことができる。突出部１５２４は、例えば、サンプリング流路１５０６及び／又は隔離チャンバ１５０８のいずれかの形成を完了させるために、部分的な溝又は部分的な流路などの表面特徴を提供することができる。一部の実施では、突出部１５２４は、対応する溝、流路、ロック又は他の経路内によりぴったりと嵌合するために、１つ以上の傾斜した側面又は面を形成されることができる。更に他の実施では、上部部材１５２０と下部部材の両方が、溝、流路、ロック又は他の経路、並びに１つ以上の突出部１５２４を含むことができる。

【００７７】

一部の実施では、サンプリング流路１５０６及び隔離チャンバ１５０８は、ハウジング１５０１に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１５０１は、ゴム、プラスチック、金属又は他の材料を含む任意の適切な材料で作られるこ

とができる。ハウジング１５０１は、透明又は半透明の材料から、又は不透明又は非半透明の材料から形成されることができる。他の実施では、ハウジング１５０１は、大部分が不透明又は非透明であることができるが、サンプリング流路１５０６及び／又は隔離チャンバ１５０８に直接隣接するハウジング表面は、透明又は半透明であり、最初に隔離チャンバ１５０８が必要又は所望の程度まで満たされているという視覚的な合図又はサイン、及び／又は、次に汚染されていない血液サンプルがサンプリング流路１５０６を通して採取される間、隔離された血液が隔離されたままであるという視覚的な合図又はサインを施術者に与える。隔離の他の視覚的な合図又はサインは、以下に限定されるものではないが、血液の接触、浸透、又は部分的な浸透で空気透過性血液バリア１５１２が異なる色に変わること、隔離チャンバに沿った又は隔離チャンバに隣接する任意の位置にある色分けされたタブ又は指標、可聴信号、振動信号、又は他の信号を含むことができる。

【００７８】

患者の皮膚から多数の病原体を集める可能性がある患者針（図示せず）による静脈穿刺の後、患者自身の血圧が隔離チャンバ１５０８内の大気圧に打ち勝って空気透過性血液バリア１５１２を通して隔離チャンバ１５０８内の空気を追い出すので、これらの病原体を有する患者の血液の最初の量が、血液隔離装置１５００入口ポート１５０２に入り、最も抵抗の少ない経路をたどることによって隔離チャンバ１５０８に流入する。患者の血圧は、密封されたサンプリング流路１５０６内で高まっている空気圧に打ち勝つのに十分ではない。最終的に、所定の容積を有する隔離チャンバ１５０８は、空気透過性血液バリア１５１２を通して空気を追い出す血液で満たされる。血液が空気透過性血液バリアに衝突すると、血液は空気透過性血液バリア１５１２の材料と相互作用して、通気口１５１０を完全に又は部分的に密封する。施術者がいまやバキュテナー（登録商標）カプセル又は他の血液サンプル採取装置を利用してサンプリングのために患者の血液の次の量を得ることができるという信号又は表示を提供することができる。隔離チャンバ１５０８内の血液は、このとき隔離チャンバ内で事実上隔離されている。

【００７９】

血液隔離経路１５０８を満たすと、バキュテナー（登録商標）又は他の血液サンプル採取装置の使用より前に、患者の血圧は、サンプリング流路１５０６内の空気の圧縮を引き起こし、場合によっては少量の血液が隔離チャンバ１５０８への方向転換点を過ぎてサンプリング流路１５０６に移動し、サンプリング流路１５０６を通して採取される汚染されていない血液を待ち行列に入れる。

【００８０】

図１６～１９は、血液隔離装置の更に別の実施を示す。図１６Ａ～１６Ｄは、バキュテナー（登録商標）（図示せず）のような真空採血容器のような血液サンプル採取装置と患者針（図示せず）及び／又は関連するチューブとの間に接続されることができる血液隔離装置１６００を示す。図１７は、血液隔離装置の下部部材を示し、図１８は、血液隔離装置の上部部材を示し、上部部材及び下部部材は、以下でより詳しく説明するように、相互に嵌合して、入口ポート、出口ポート、隔離チャンバ及びサンプリング流路を形成することができる。図１９Ａ及び１９Ｂは、互いに嵌合する上部部材及び下部部材を示す。図１６～１９は本明細書に記載される血液隔離装置を構成する１つの例示的な方法を示しており、他の形態の構成も可能であることを理解されたい。

【００８１】

図１６Ａ～１６Ｄを参照すると、血液隔離装置１６００は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１６０２を含む。入口ポート１６０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。入口ポート１６０２は、血液隔離装置１６００への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有する円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる

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【００８２】
入口ポート１６０２はまた、ねじ切り又はルアーフィッティングなどのような密封又は流体密封コネクタ又は接続部を含むことができる。一部の実施では、患者針に結合されているチューブ又は他の導管は、部品同士の共成形、接着、レーザー溶接、又は熱接合などによって、入口ポート１６０２と一体化されることができる。これによって、血液隔離装置１６００は、患者針及び／又はチューブと共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針を血液隔離装置１６００に接続する必要性をなくすことができる。
【００８３】
血液隔離装置１６００は、血液隔離装置１６００から及び血液サンプル採取装置への開口部を画定する出口ポート１６０４を更に含む。出口ポート１６０４は、同様に血液隔離装置と接続されるチューブ又は他の導管と接続されることもでき、ねじ切り又はルアーフィッティングなどの密封又は流体密封コネクタ又は接続部を含むことができる。したがって、上記のように、血液隔離装置１６００は、患者針及び／又はチューブ及び血液サンプル採取装置と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針及び血液サンプル採取装置を血液隔離装置１６００に接続する必要性をなくすことができる。
【００８４】
血液隔離装置１６００は、入口ポート１６０２と出口ポート１６０４との間のサンプリング流路１６０６と、入口ポート１６０２と出口ポート１６０４との間の任意の位置でサンプリング流路１６０６に接続され且つサンプリング流路１６０６から分離又は方向転換される隔離チャンバ１６０８とを更に含む。サンプリング流路１６０６は、最初のアリコートの血液が隔離チャンバ１６０８内に隔離されると、採血経路として機能する。サンプリング流路１６０６は、任意のサイズ、形状又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１６０６は、入口ポート１６０２の開口部と実質的に同様の断面積を有する。他の実施では、サンプリング流路１６０６は、入口ポート１６０２から出口ポート１６０４まで徐々に広がることができる。隔離チャンバ１６０８は、図１７及び１９により詳しく示すように、血液がサンプリング流路１６０６のより小さい直径に入るのに対して、まずリザーバに入ろうとするように、隔離流路の経路に向かって大きいリザーバを形成するべくより大きい断面を有することができる。
【００８５】
一部の例示的な実施では、サンプリング流路１６０６と隔離チャンバ１６０８との間の方向転換は、方向転換分岐点１６０７によって行われる。方向転換分岐点１６０７は、実質的にＹ字形、Ｔ字形、又はＵ字形であることができる。一部の好ましい例示的な実施では、図１７Ａ～１７Ｂに示すように、方向転換分岐点１６０７は、入口ポート１６０２からの流れが優先的に隔離チャンバ１６０８に向けられるように構成される。隔離チャンバ１６０８はまた、最初の血液流を隔離チャンバ１６０８に向かって且つ隔離チャンバ１６０８内に移動させるための湾曲部又は傾斜路を含むか又は形成することができる。
【００８６】
隔離チャンバ１６０８は、好ましくは大気圧に維持され、隔離チャンバ１６０８の遠位端又はその近傍に通気口１６１０を含む。通気口１６１０は、上記のように空気透過性血液バリア１６１２を含むことができる。
【００８７】
血液隔離装置１６００は、複数の部品又は単一の一体部品から形成されることができるハウジング１６０１を含むことができる。一部の実施では、図１７Ａ～１７Ｄ及び図１８Ａ～１８Ｆに示すように、ハウジング１６０１は、互いに嵌合する上部部材１６２０と下部部材１６２２とを含む。血液隔離装置１６００は、上部部材１６２０が下部部材１６２２に機械的に取り付けられたときに、両者の間の接合部分がガスケット又は密封部材によって密封されるように、ガスケット又は他の密封部材（図示せず）を含むこともできる。

図１７Ａ～１７Ｄは、血液隔離装置１６００用のハウジングの下部部材１６２２を示す。下部部材１６２２は、サンプリング流路１６０６、隔離チャンバ１６０８、及び方向転換分岐点１６０７を形成するために、射出成形プロセスによって又はエッチング、切削、穿孔などによって予め形成された溝、流路、ロック、導管又は他の経路を含むことができる。

【００８８】

隔離チャンバ１６０８は、血液がサンプリング流路１６０６のより小さい直径に入るのに対して、まず隔離チャンバ内に優先的に移動するように、サンプリング流路１６０６よりも大きい断面を有することができる。

【００８９】

図１８Ａ～１８Ｆは、レーザ溶接、熱接合、接着、ねじ、リベット、ボルトなどを使用することなどの任意の嵌合又は接続機構によって、又はラッチ、溝、舌状部、ゴン、フランジなどの他の嵌合機構によって、下部部材１６２２と接続可能な上部部材１６２０を示す。上部部材１６２０は、サンプリング流路１６０６、隔離チャンバ１６０８、及び方向転換分岐点１６０７を形成するために、溝、流路、ロック、導管又は他の経路の一部又はすべてを含むことができる。更に他の実施では、上部部材１６２０と下部部材１６２２の両方が、溝、流路、ロック又は他の経路を含むことができる。

【００９０】

一部の実施では、サンプリング流路１６０６及び隔離チャンバ１６０８は、ハウジング１６０１に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１６０１は、ゴム、プラスチック、金属又は任意の他の適切な材料で作られることができる。ハウジング１６０１は、透明又は半透明の材料から、又は不透明又は非半透明の材料から形成されることができる。他の実施では、ハウジング１６０１は、大部分が不透明又は非半透明であることができるが、サンプリング流路１６０６及び／又は隔離チャンバ１６０８に直接隣接するハウジング表面は、透明又は半透明であることができ、最初に隔離チャンバ１６０８が必要又は所望の程度まで満たされているという視覚的な合図又はサイン、及び／又は、次に汚染されていない血液サンプルがサンプリング流路１６０６を通して採取される間、隔離された血液が隔離されたままであるという視覚的な合図又はサインを施術者にうえる。隔離の他の視覚的な合図又はサインは、以下に限定されるものではないが、血液の接触、浸透、又は部分的な浸透で空気透過性血液バリア１６１２が異なる色に変わること、隔離チャンバに沿った又は隔離チャンバに隣接する任意の位置にある色分けされたタブ又は指標、可聴信号、振動信号、又は他の信号を含むことができる。

【００９１】

図１８Ａ～１８Ｆに示すように、空気透過性血液バリア１６１２は、保護部材１６１６で覆われているか又は保護部材１６１６によって包囲されていることができる。保護部材１６１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１６１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも空気が隔離チャンバ１６０８から追い出されるときに空気が空気透過性血液バリア１６１２から出ることを可能にする。一部の実施では、保護部材１６１６は、上部部材１６２０の上面から上に空気透過性血液バリア１６１２の周りに延びる突出部を含む。保護カバー１６１６は、フィルタが周囲の流体又は飛沫に偶発的に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００９２】

使用時、血液隔離装置１６００は、サンプリング流路１６０６と隔離チャンバ１６０８とを含む。両方の経路が、最初は大気圧で空気を充填されているが、サンプリング流路１６０６は、最初はバキュテナー（登録商標）又は他のこのような密封された採血装置によって密封されている出口ポート１６０４に向けられ、隔離チャンバ１６０８は、空気透過性血液バリア１６１２を含む大気への通気口１６１０で終端している。

【００９３】

患者の皮膚から多数の病原体を集める可能性がある患者針（図示せず）による静脈穿刺の後、これらの病原体を有する患者の血液の最初の量が、血液隔離装置１６００の入口ポート１６０２を通過する。この汚染されている可能性のある血液の最初の量は、最も抵抗の少ない経路を見出すことによって、隔離チャンバ１６０８に優先的に流入する。患者自身の血圧は、通気口付きの隔離チャンバ１６０８内の大気圧に打ち勝ち、空気透過性血液バリア１６１２を通して隔離チャンバ１６０８内の空気を追い出すが、密封されたサンプリング流路１６０６内で高まっている空気圧に打ち勝つには不十分である。様々な例示的な実施形態では、隔離チャンバ１６０８及びサンプリング流路１６０６は、患者の血圧によって生じた力が、血液隔離装置の向きに関わらず、重力の影響に打ち勝つのに十分であるように構成されることができる。

【００９４】

最終的に、隔離チャンバ１６０８は、空気透過性血液バリア１６１２を通して空気を追い出す血液で満たされる。血液が空気透過性血液バリアと接触すると、血液は空気透過性血液バリア１６１２の材料と相互作用して通気口１６１０を完全に又は部分的に密封する。施術者がいまやバキュテナー（登録商標）又は他の採血装置を利用することができるという信号又は表示を提供することができる。

【００９５】

血液隔離経路１６０８を満たすと、バキュテナー（登録商標）又は他の血液サンプル採取装置の使用より前に、患者の血圧は、サンプリング流路１６０６内の空気の圧縮を引き起こし、場合によっては少量の血液が方向転換点を過ぎてサンプリング流路１６０６に移動しサンプリング流路１５０６を通して採取される汚染されていない血液を待ち行列に入れる。

【００９６】

図１９Ａは、血液隔離装置１６００の側面図であり、図１９Ｂは、血液隔離装置１６００の断面図であり、下部部材１６２２と嵌合する上部部材１６２０を示す。

【００９７】

図２０は、患者の血流への血管アクセスのための患者針２００２と、１つ以上の血液サンプルの採取を容易にする血液サンプル採取装置２００４と、患者針２００２と血液サンプル採取装置２００４との間の流体接続を提供する導管２００６とを含む血液サンプル最適化システム２０００を示す。一部の実施では、血液サンプル採取装置２００４は、密封された採取針を含む保護シールドを含み、採取針に密封された真空容器が置かれ、容器は採取針によって一度穿孔されると、患者針２００２から導管２００６を通して真空圧力又は真空力で血液サンプルを吸い込む。

【００９８】

血液サンプル最適化システム２０００は、本明細書で説明するように、患者針２００２と血液サンプル採取装置２００４との間の導管２００６上の任意の点に位置する血液隔離装置２００８を更に含む。

【００９９】

図２１は、ウィッキング材料チャンバを使用する通気口付きでない血液隔離装置２１００を示す。血液隔離装置２１００は、ウィッキング材料で満たされた隔離チャンバ２１０２によって少なくとも部分的に囲まれ又は当接されるサンプリング流路２１０４を有するハウジング２１０１を含む。最初のアリコートの血液が患者針からサンプリング流路２１０４に引き込まれ、サンプリング流路２１０４において隔離チャンバ２１０２のウィッキング材料の中に直ちに逃がされる。ウィッキング材料及び／又は隔離チャンバ２１０２は、後続の又はそれ以降の採血がウィッキング材料を通り過ぎ、サンプリング流路２１０４を通って直接バキュテナー（登録商標）などのサンプリング装置に流れるように、所定量の血液を受け入れ且つ保持するように寸法設定され且つ適合されている。ウィッキング材料は、固化剤、汚染除去剤、又は他の添加剤などの物質を含むことができる。

【０１００】

本明細書に記載されるように、空気透過性血液バリアは、多種多様な異なる構造及び材

料を用いて作られることができる。図２２Ａ及び２２Ｂに示すように、血液隔離装置２２００の空気透過性血液バリア２２０２は、少なくとも一部のビーズが親水性になるように処理されたポリマービーズマトリックス２２０４を含むことができる。空気透過性血液バリア２２０２は、カルボキシメチルセルロース（ＣＭＣ）又はセルロースガムなどの自己密封材料２２０６、又は他の密封材料を更に含む。空気透過性血液バリア２２０２は、血液などの流体との接触前又は部分接触中の空気の流れを可能にする空隙２２０８を更に含むことができる。図２２Ｂに示すように、流体と接触すると、自己密封材料２２０６が膨張して空隙２２０８を閉鎖し、空隙２２０８を通る空気の流れを閉塞し、完全に又は部分的に密封する。

【０１０１】

図２３Ａ及び２３Ｂは、患者針と接続するための入口ポート２３０２と、血液サンプル採取装置と接続するための出口ポート２３０４と、隔離チャンバ２３０６と、隔離チャンバ２３０６と、隔離するべき汚染されている可能性のある血液の最初のアリコートまで隔離チャンバが満たされると隔離チャンバ２３０６を迂回するサンプリング流路２３０８とを有する、血液隔離装置２３００の更に別の実施を示している。隔離チャンバ２３０６は、入口ポート２３０２から最も遠い隔離チャンバ２３０６の遠位端に疎水性プラグ２３１２を含む。バキュテナー（登録商標）などからのような、出口ポート２３０４から加えられる真空力又は他の吸引力は、血液を入口ポート２３０２内に、そして隔離チャンバ２３０６内に直接吸い込み、そこで最初のアリコートの血液が疎水性プラグ２３１２に接触し、最初のアリコートの血液を隔離チャンバ２３０６に戻してそこで隔離させる。少量の血液が、最初は弁２３０８によって閉鎖されているサンプリング流路２３０８に入ることができる。弁２３０８が解放されると、真空の更なる力又は他の力の下で、後続の量の血液が入口ポート２３０２に流れ、隔離チャンバ２３０６を迂回し、サンプリング流路２３０８を通り抜けて出口ポート２３０４に向かって流れ、採取装置に送られる。

【０１０２】

サンプリング流路２３０８は、任意の適切な幾何学的形状を有することができ、プラスチックチューブ又は任意の他の適切な材料から形成されることができる。弁２３０８は、最初のアリコートの血液が隔離チャンバ２３０６内に隔離される前にサンプリング流路を挟み、脇へそらし、曲げ、又は他の方法で閉じるためにクリップ又は他の包囲装置であることができる。

【０１０３】

様々な実施形態を上記で詳細に説明してきたが、他の変更も可能である。他の実施形態は、添付の特許請求の範囲内に含まれ得る。

【図１】

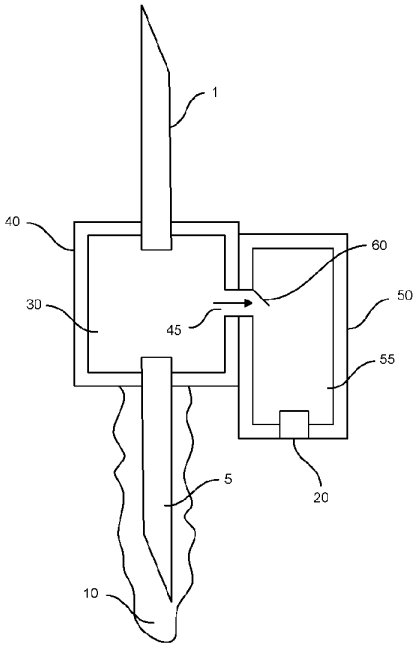


FIG. 1

【図２】

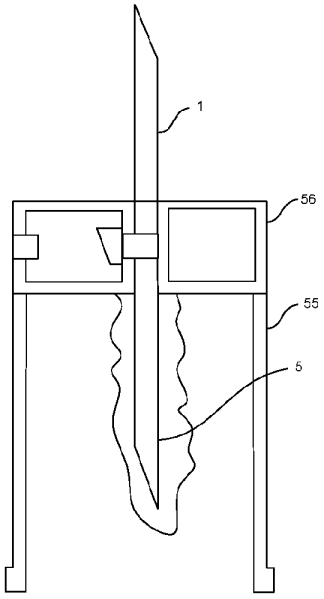


FIG. 2

【図３】

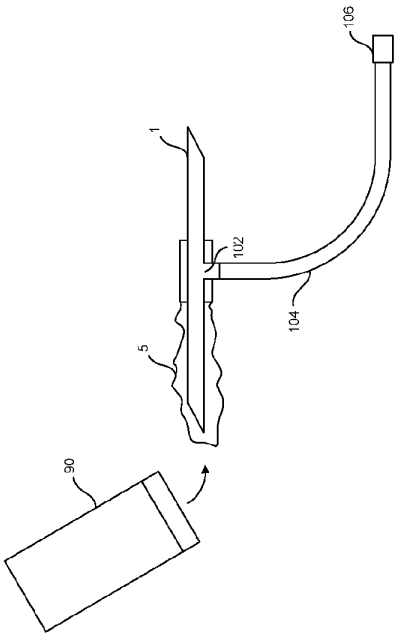


FIG. 3

【図４】

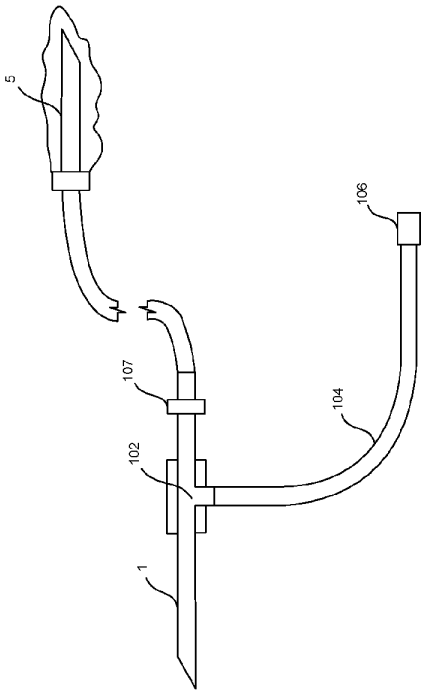


FIG. 4

【図５】

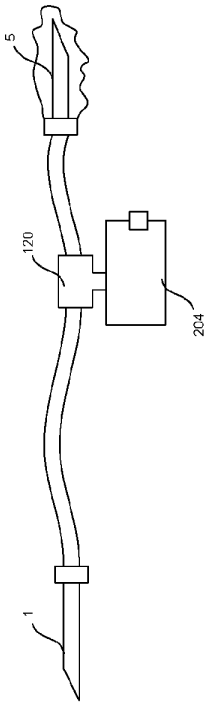


FIG. 5

【図６】

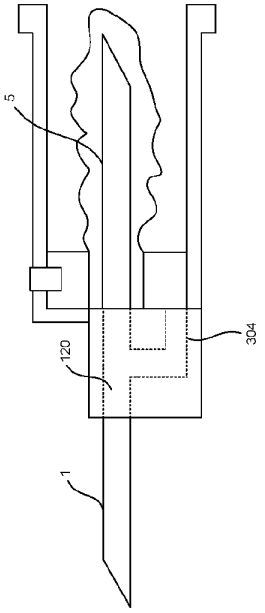


FIG. 6

【図７】

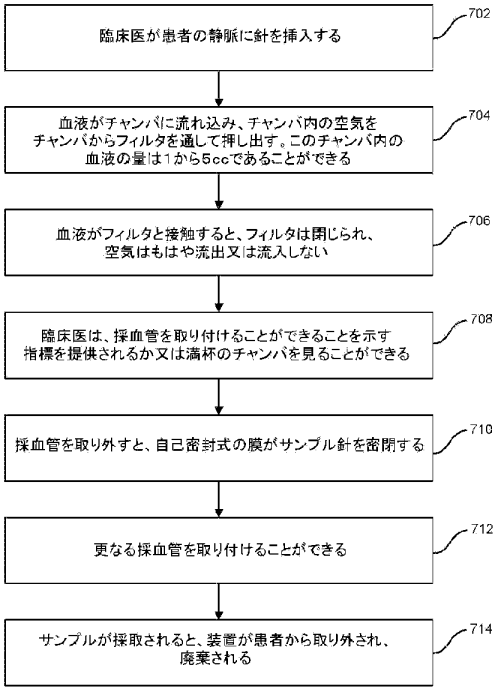


FIG. 7

【図８Ａ】

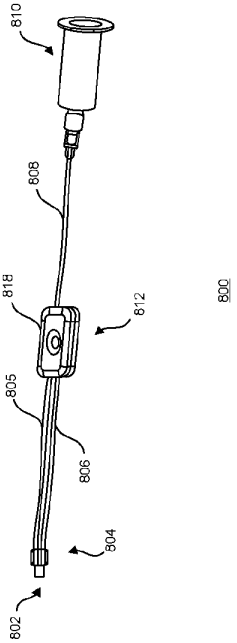


FIG. 8A

【図８Ｂ】

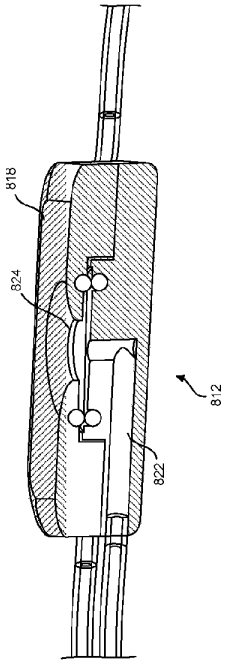


FIG. 8B

【図８Ｃ】

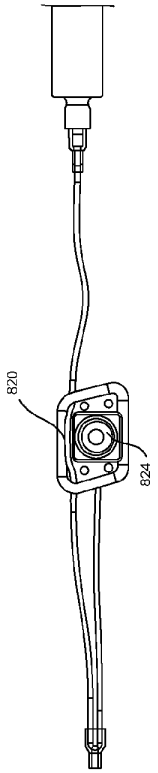


FIG. 8C

【図８Ｄ】

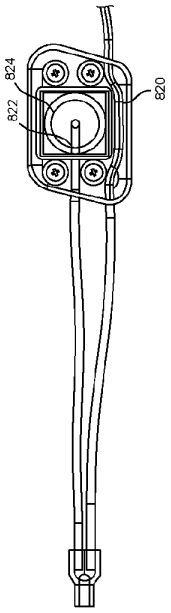


FIG. 8D

【図８Ｅ】

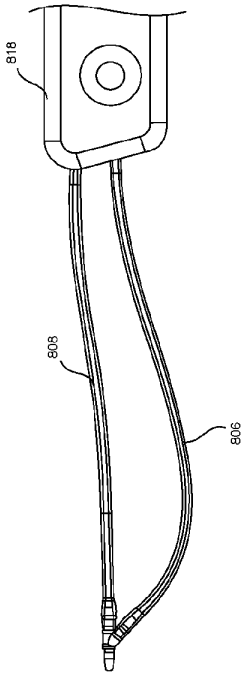


FIG. 8E

【図９】

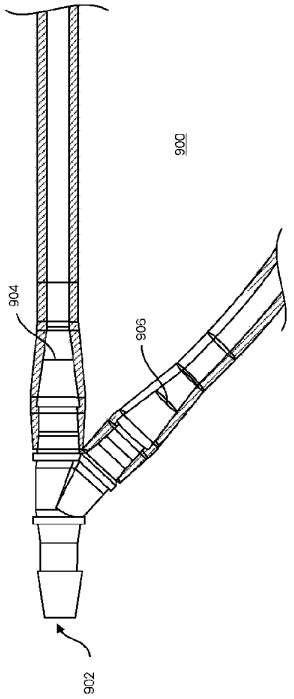


FIG. 9

【図１０Ａ】

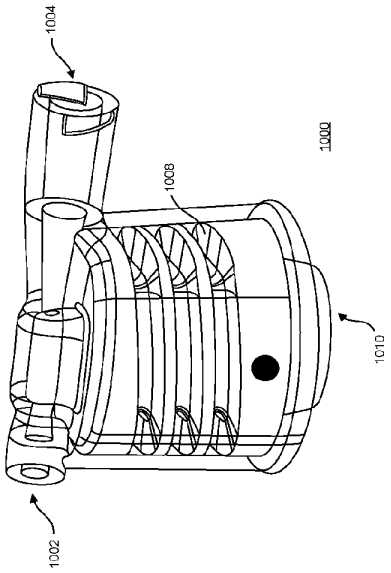


FIG. 10A

【図１０Ｂ】

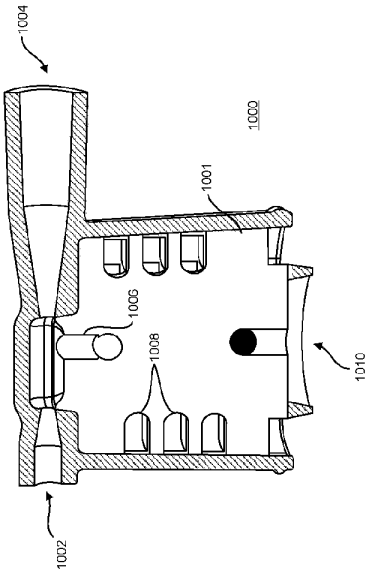


FIG. 10B

【図１０Ｃ】

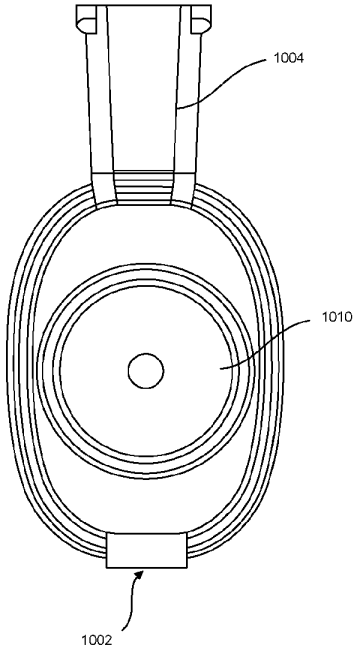


FIG. 10C

【図１０Ｄ】

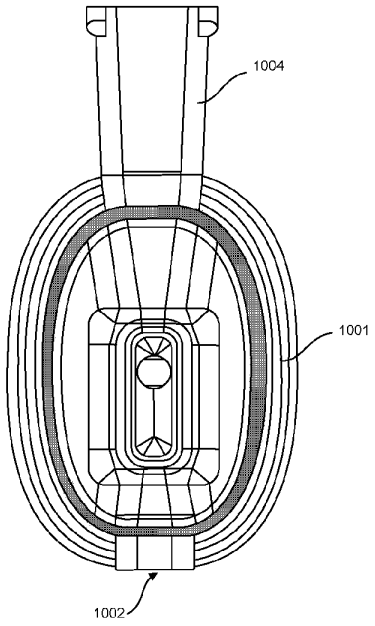


FIG. 10D

【図１１Ａ】

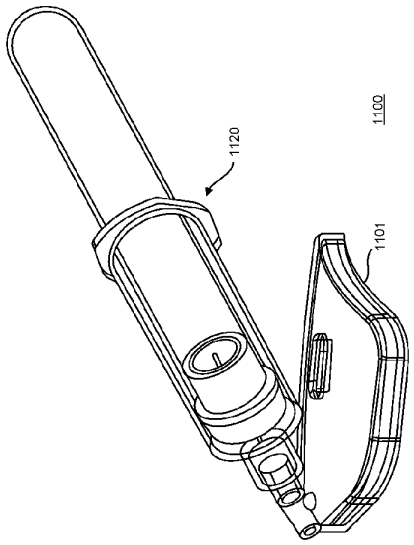


FIG. 11A

【図１１Ｂ】

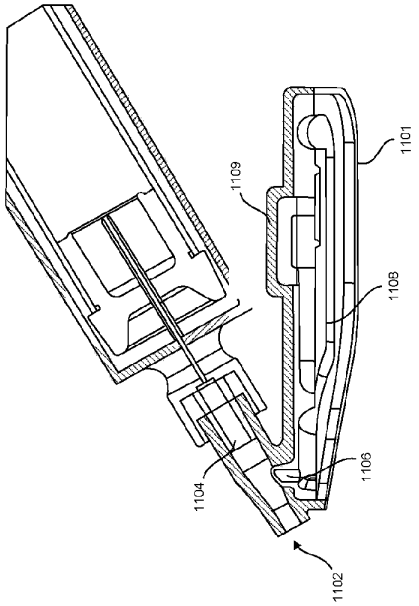


FIG. 11B

【図１１Ｃ】

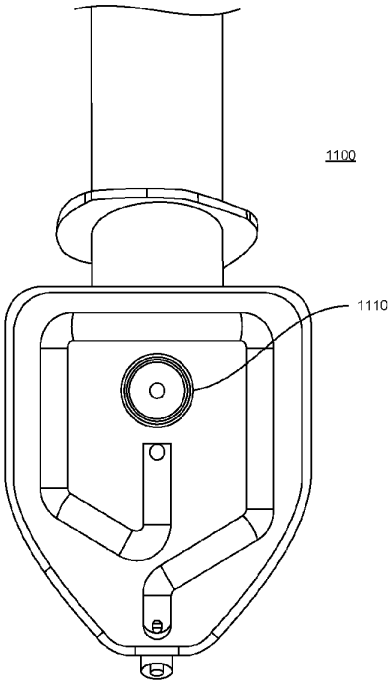


FIG. 11C

【図１１Ｄ】

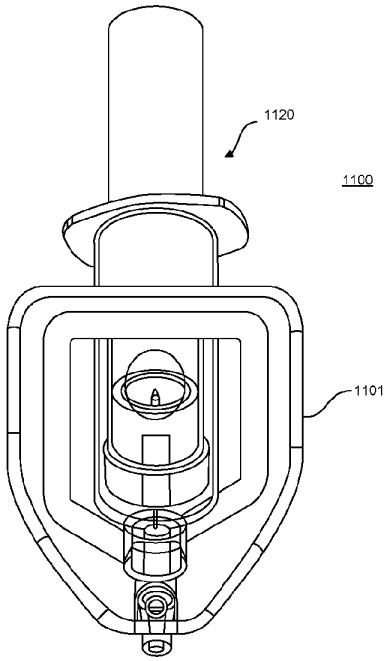


FIG. 11D

【図１１Ｅ】

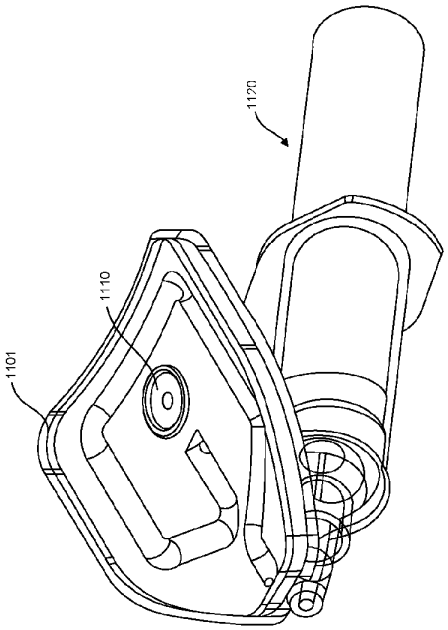


FIG. 11E

【図１２Ａ】

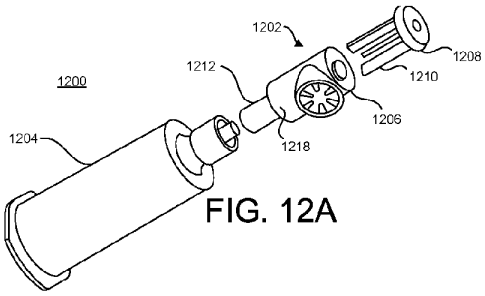


FIG. 12A

【図１２Ｂ】

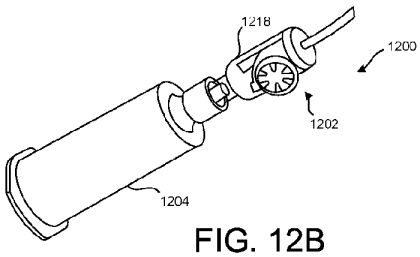


FIG. 12B

【図１２Ｃ】

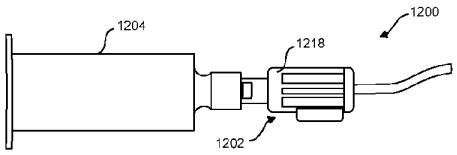


FIG. 12C

【図１２Ｄ】

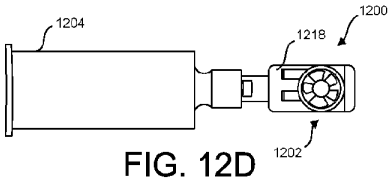


FIG. 12D

【図１３Ａ】

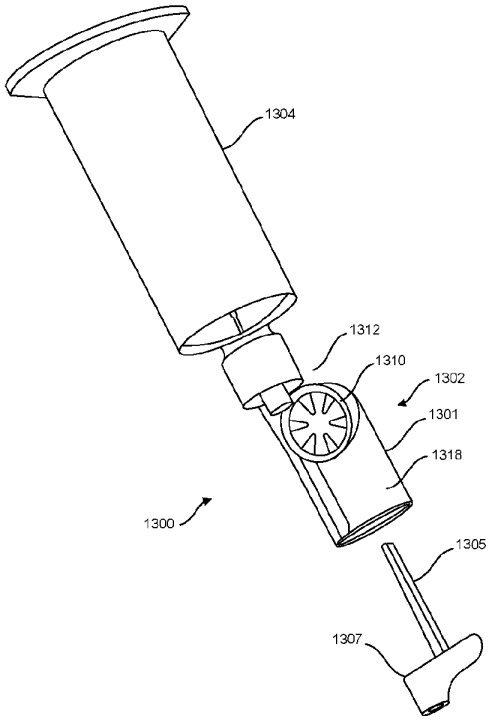


FIG. 13A

【図１３Ｂ】

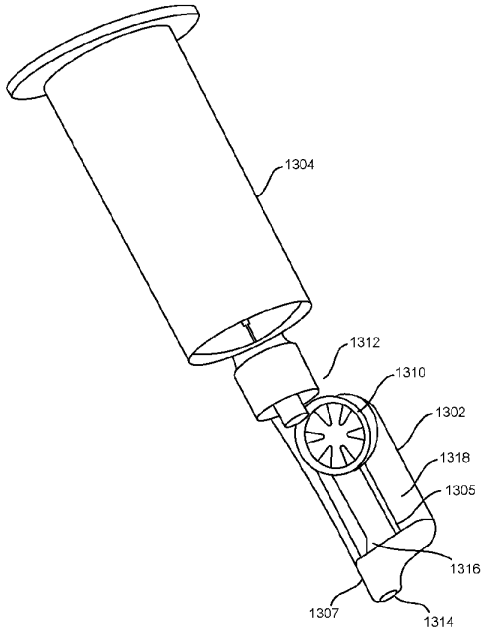


FIG. 13B

【図１３Ｃ】

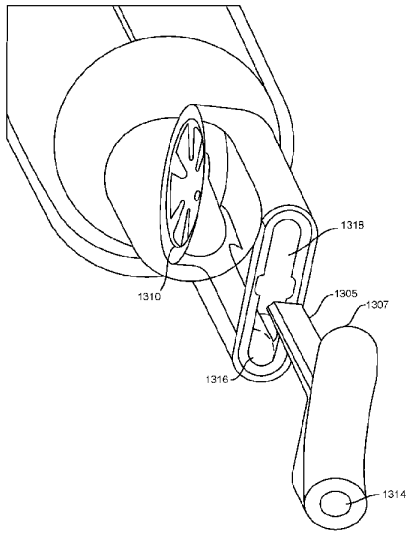


FIG. 13C

【図１３Ｄ】

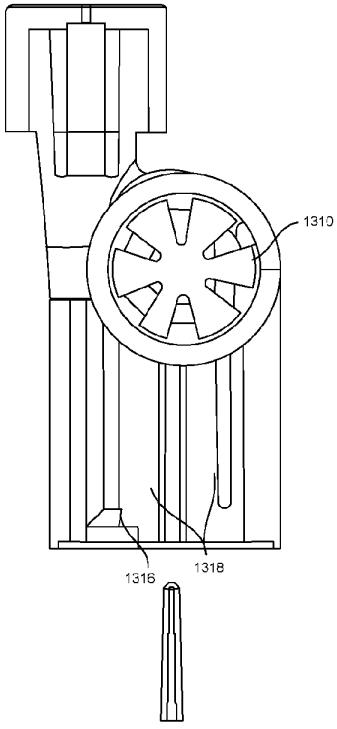


FIG. 13D

【図１４Ａ】

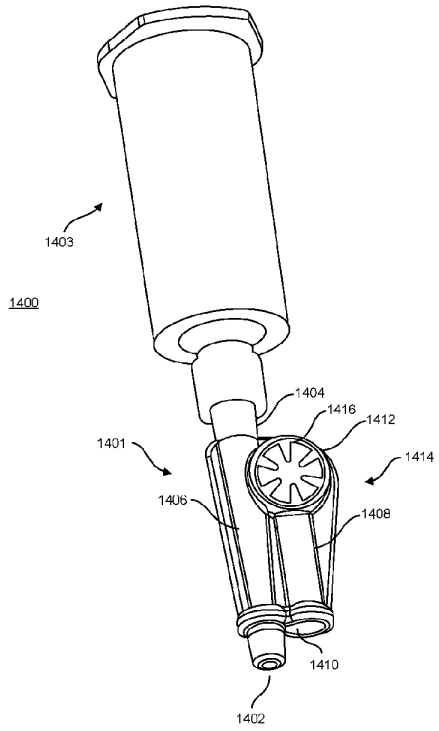


FIG. 14A

【図１４Ｂ】

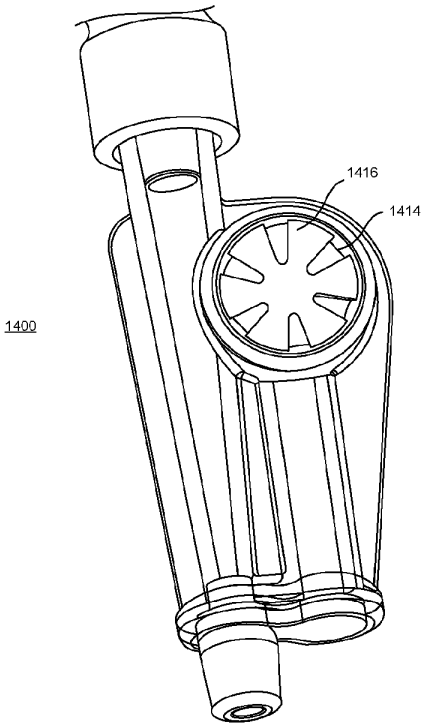


FIG. 14B

【図１４Ｃ】

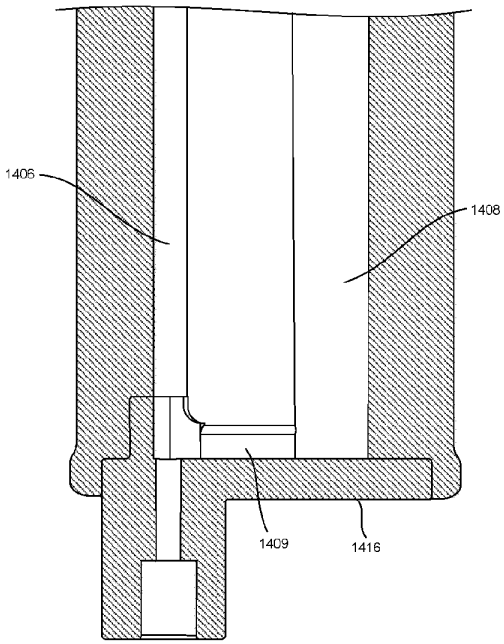


FIG. 14C

【図１４Ｄ】

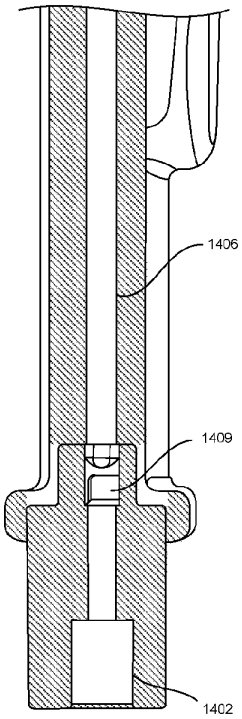


FIG. 14D

【図１４Ｅ】

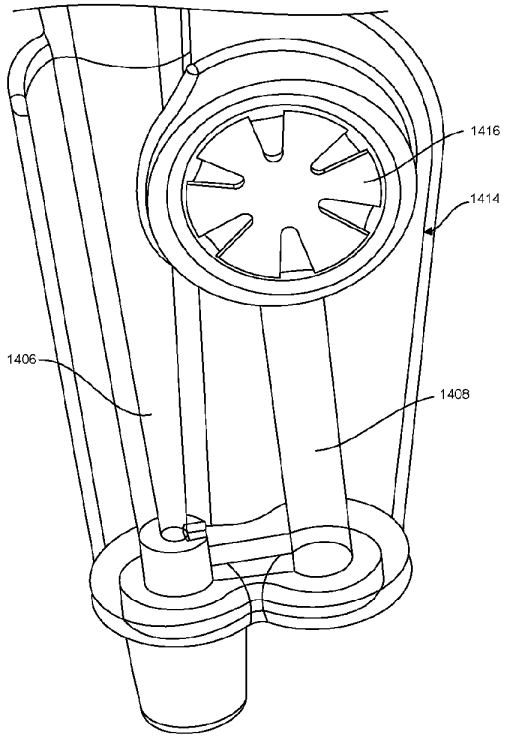


FIG. 14E

【図１５Ａ】

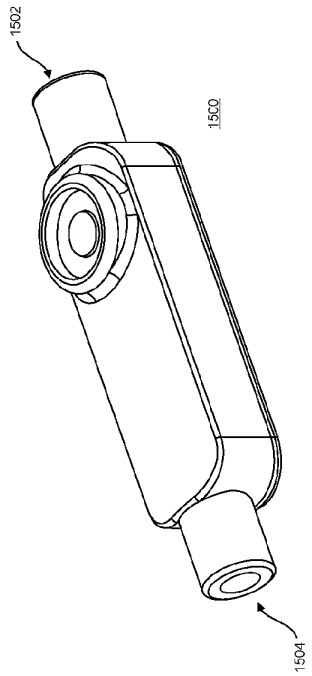


FIG. 15A

【図１５Ｂ】

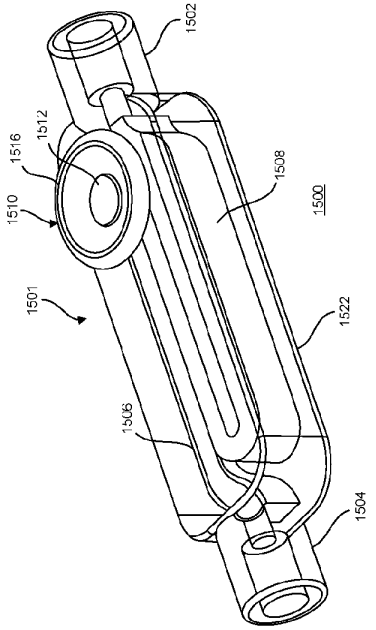


FIG. 15B

【図１５Ｃ】

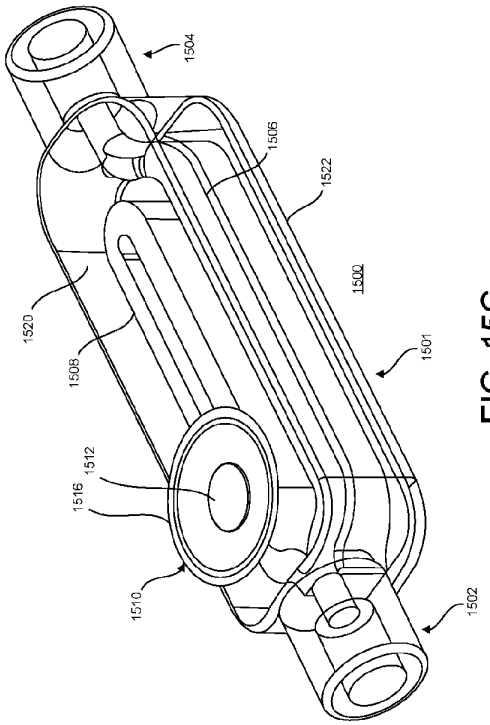


FIG. 15C

【図１５Ｄ】

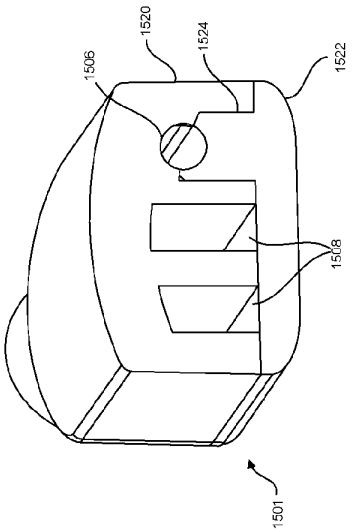


FIG. 15D

【図１５Ｅ】

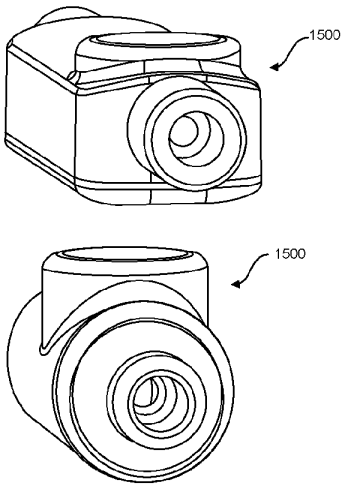


FIG. 15E

【図１５Ｆ】

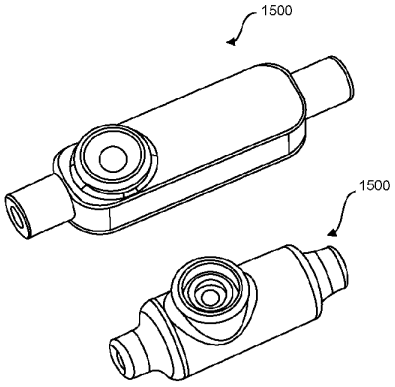


FIG. 15F

【図１５Ｇ】

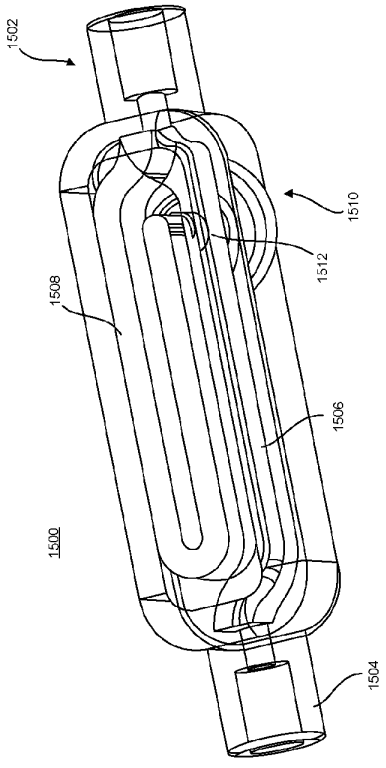


FIG. 15G

【図１６Ａ】

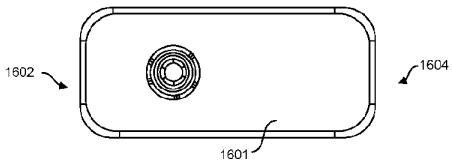


FIG. 16A

【図１６Ｂ】

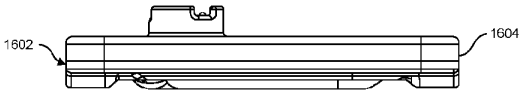


FIG. 16B

【図１６Ｃ】

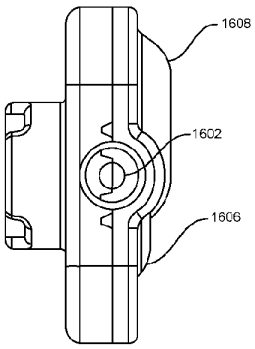


FIG. 16C

【図１６Ｄ】

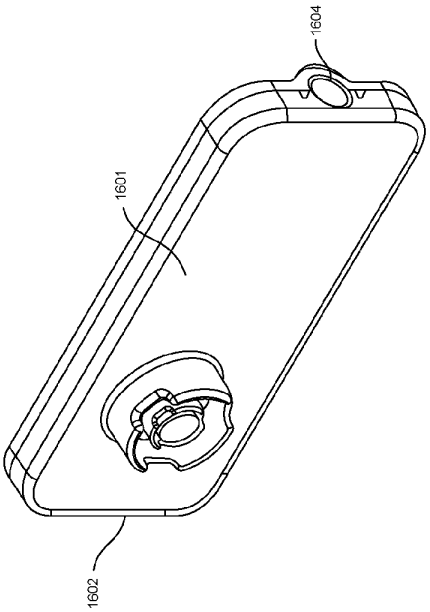


FIG. 16D

【図１７Ａ】

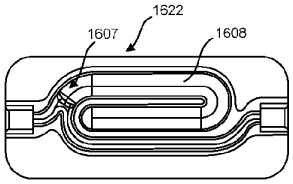


FIG. 17A

【図１７Ｂ】

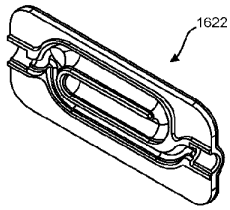


FIG. 17B

【図１７Ｃ】

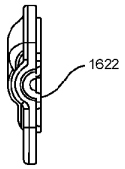


FIG. 17C

【図１７Ｄ】

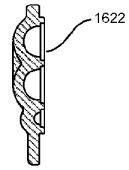


FIG. 17D

【図１７Ｅ】



FIG. 17E

【図１８Ａ】

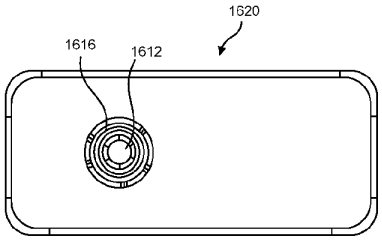


FIG. 18A

【図１８Ｂ】

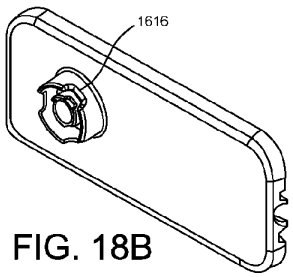


FIG. 18B

【図１８Ｃ】

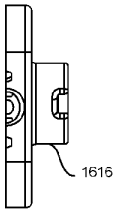


FIG. 18C

【図１８Ｄ】

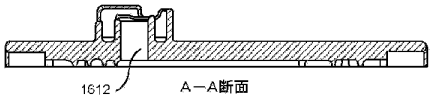


FIG. 18D

【図１８Ｅ】

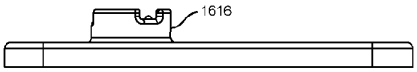


FIG. 18E

【図１８Ｆ】

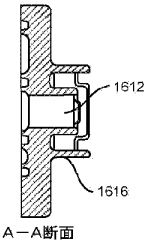


FIG. 18F

【図１９Ａ】

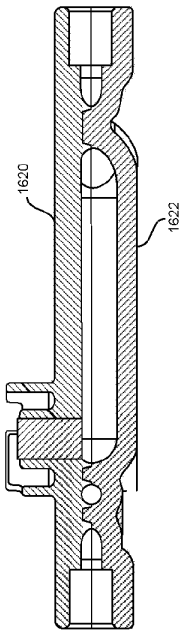


FIG. 19A

【図１９Ｂ】

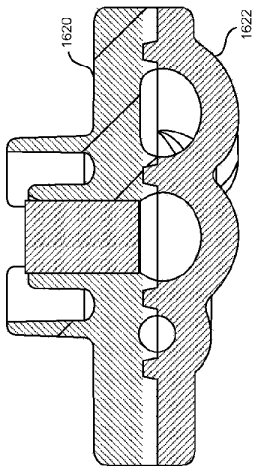


FIG. 19B

【図２０】

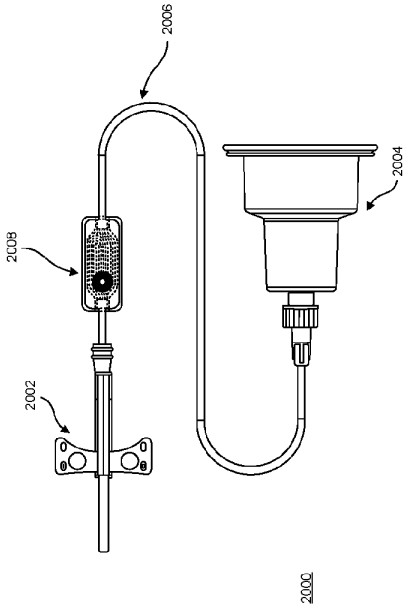


FIG. 20

【図２１】

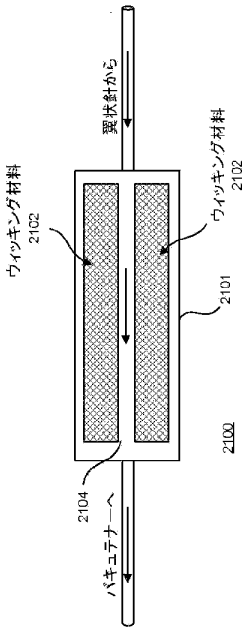


FIG. 21

【図２２Ａ】

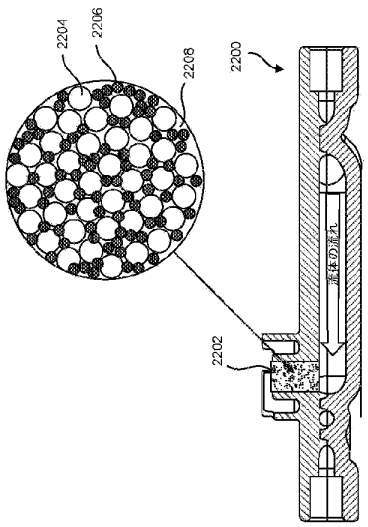


FIG. 22A

【図２２Ｂ】

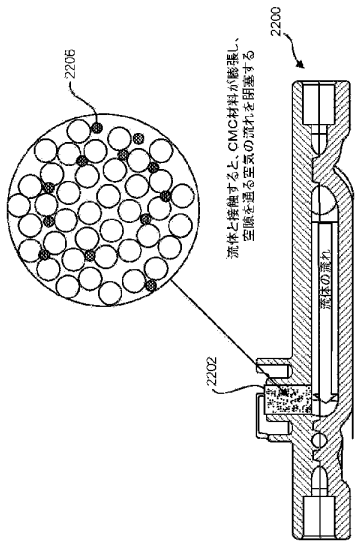


FIG. 22B

【図２３Ａ】

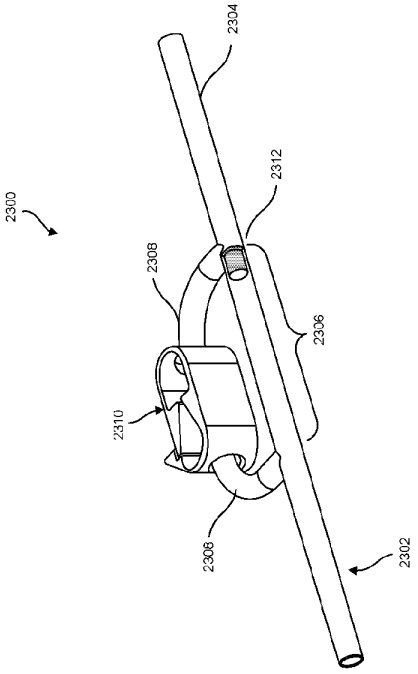


FIG. 23A

【図２３Ｂ】

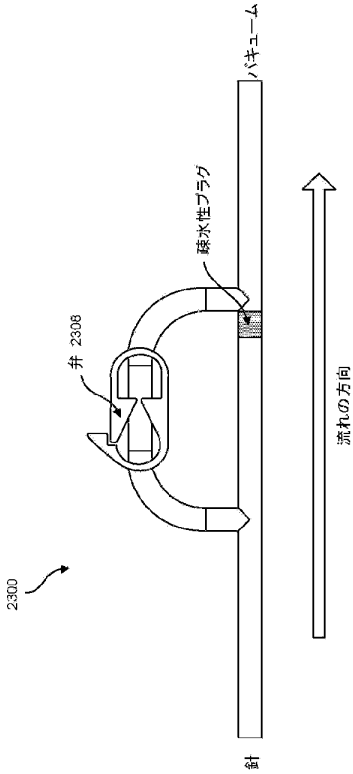


FIG. 23B

フロントページの続き

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早期審査対象出願

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審査官　清水　裕勝

参考文献　特開昭５８－０２５１４６（ＪＰ，Ａ）
　　特開昭５８－０６７２３８（ＪＰ，Ａ）
　　特開２０１２－０１６４９６（ＪＰ，Ａ）
　　特開昭５７－０８９８６９（ＪＰ，Ａ）
　　特表平０９－５０４７２６（ＪＰ，Ａ）
　　特開平０２－２２４７４２（ＪＰ，Ａ）
　　特開２００５－３４９１９６（ＪＰ，Ａ）
　　米国特許第０４２０７８７０（ＵＳ，Ａ）
　　米国特許出願公開第２０１３／０１１６５９９（ＵＳ，Ａ１）
　　米国特許出願公開第２０１１／０３０６８９９（ＵＳ，Ａ１）

調査した分野　　，ＤＢ名
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⑲ 日本国特許庁 (JP)　　⑪ 特許出願公開

⑫ 公開特許公報 (A)　　昭56—43474

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D 06 M 5/02　7199—4L

⑬公開 昭和56年(1981) 4月22日

発明の数 1
審査請求 未請求

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⑤4ポリエステル系繊維構造物の処理方法

⑵特　願 昭54—116657
⑵出　願 昭54(1979) 9月13日
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明　細　書

1. 発明の名称

ポリエステル系繊維構造物の処理方法

2. 特許請求の範囲

(1) 芯成分がポリエステルから成り，鞘成分がアルカリに侵され難い成分から成る，一芯又は多芯の芯鞘型繊維と，アルカリ処理による見掛けの減量速度が，鞘成分除去後の該芯成分繊維より小さいポリエステル系繊維とを用いて繊維構造物と成し，該芯鞘型繊維の鞘成分を除去する前にアルカリ処理を施すに際し，あらかじめ，該鞘成分の軟化点以上，該芯成分ポリエステルの融点以下の温度で熱処理することを特徴とする，ポリエステル系繊維構造物の処理方法。

(2) 芯成分の単糸繊度が1.0デニール以下であることを特徴とする特許請求の範囲第1項記載のポリエステル系繊維構造物の処理方法。

3. 発明の詳細な説明

本発明は，アルカリ処理による見掛けの減量速度に差のある2種以上のポリエステル系繊維を含む繊維構造物の製造方法に関するものである。

ポリエステル系繊維構造物を，アルカリ処理することによつて，繊維間空隙を増大させ，シヤリ感のある柔軟で良好な風合を発現させることは，すでに知られている。

しかし，アルカリ処理による見掛の減量速度に差のある2種以上のポリエステル系繊維を含む繊維構造物においては，一方の繊維の強力低下が過大になり，満足すべき製品は得られなかつた。特に見掛の減量速度の大きい繊維が0.3デニール以下の場合には該極細糸がアルカリ処理によつて完全に溶解されることさえある。

これに対して見掛の減量速度の大きい繊維をアルカリに侵され難い成分で保護したまま処理することが検討されたが，期待に反して十分な効果は得られなかつた。たとえば，極細ポリエステルを芯とし，ポリスチレンを鞘とする一芯又は多芯の芯鞘繊維と普通繊度のポリエステルからなる布帛の鞘成分を溶出する前にアルカリで減量処理することも試みられたが，極細繊維の強度は極端に低

下するのである。本発明者はかかる問題について鋭意検討した結果，強度低下の原因が，該芯鞘繊維の製糸，製布工程で生じた鞘成分の欠陥によるものであることをつきとめ次の発明に到達したのである。つまり本発明は「芯成分がポリエステルから成り，鞘成分がアルカリに侵され難い成分から成る，一芯又は多芯の芯鞘型繊維とアルカリ処理による見掛けの減量速度が，鞘成分除去後の該芯成分繊維より小さいポリエステル系繊維とを用いて繊維構造物と成し，該芯鞘型繊維の鞘成分を除去する前にアルカリ処理を施すに際し，あらかじめ，該鞘成分の軟化点以上，該芯成分ポリエステルの融点以下の温度で熱処理することを特徴とするポリエステル系繊維構造物の処理方法」である。

以下，本発明をさらに詳細に説明する。

本発明における芯成分ポリエステル及びポリエステル系繊維とは，ポリエチレンテレフタレート，ポリブチレンテレフタレート等のポリエステル及び，それらを易染化，カチオン可染化，酸性可染

化，制電化，吸水吸湿化等をした改質ポリエステルをいう。

鞘成分として用いるアルカリに侵され難い成分とは，それ自身がアルカリによつて分解または溶解されないと同時に，アルカリを通しにくいものを指し，ポリスチレン，ポリオレフイン，及びそれらの共重合体などが挙げられる。

見掛けの減量速度とは，苛性ソーダ3％沸騰水溶液中で所定時間処理した時の減量率を測定し，時間を横軸，減量率を縦軸としてグラフを作成し，減量率20％までを最小二乗法で直線近似した場合の直線の傾きで表わされる。一般的には，減量率20％までは直線となるため，見掛けの減量速度は式Ⅰで表わされる。

$$V = \frac{\Delta W}{\tau} \quad \cdots\cdots\cdots\cdots \text{式 I}$$

V：見掛けの減量速度（sec^{-1}）

ΔW：繊維の減量率（％）

τ：処理時間（sec）

アルカリ減量速度の遅速は，一般的には式Ⅱで

示されるアルカリ溶解速度恒数で示されるが，本発明で使用する見掛けの減量速度とは異なるものである。すなわち，繊維を構成するポリマー，製糸方法及びアルカリ処理条件が同じであれば，アルカリ溶解速度恒数は一定であるが，それらが同じであつても，見掛けの減量速度は，繊度が異なれば変化する。例えば，繊度が4倍になれば，繊維表面積が1/2になるため，見掛けの減量速度は1/2になる。

つまり一般的な減量速度は次式による。

$$\sqrt{R} = -\frac{2.07\times10^{4}k}{\sqrt{D}}\tau + 10 \quad \cdots\cdots \text{式 II}$$

R：τ sec後の不溶解重量分率（％）

D：デニール

τ：処理時間（sec）

k：アルカリ溶解速度恒数（m／sec）

また，繊維を構成するポリマー，単糸繊度が同じであつても，製糸方法が異なれば，見掛けの減量速度は変化する。すなわち，芯鞘型の複合繊維の鞘を除去して得られた繊維は構成ポリマー，単

糸繊度が同じであつても，通常の製糸で得た繊維より見掛けの減量速度は大きくなる。

繊維構造物とは，織物，編物，不織布等の形態をいい，その構成繊維としては，芯成分がポリエステルから成り，鞘成分がアルカリに侵され難い成分から成る一芯又は多芯（の芯）鞘型繊維と，アルカリ処理による見掛けの減量速度が，鞘成分除去後の該芯繊維より小さいポリエステル系繊維とが，それぞれ10％以上含まれていればよく，それら2種の繊維の他に，見掛けの減量速度の異なるポリエステル系繊維，ポリアミド系繊維，ポリオレフイン系繊維等の合成繊維，綿，絹，羊毛等の天然繊維，アセテート等の半合成繊維，レーヨン等の再成繊維等が含まれていてもよい。またこれらの繊維以外に樹脂，接着剤，糊剤などが合浸，コーティング，スプレーなどの手段で付与されたものも含まれるものとする。

鞘成分除去の方法としては，例えば，ポリスチレン系ポリマーを用いた時は，各種の芳香族炭化水素や塩素化炭化水素，その他ポリエステルを溶

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解しないような各種の有機溶剤を用いることができる。

アルカリ処理とは，苛性ソーダ，苛性カリ等の所謂アルカリ化合物及び炭酸ソーダ，炭酸カリ等のアルカリ性化合物を用いて，ポリエステルを加水分解させる処理であり，ポリエステルを加水分解できればどのような方法をとつてもよい。

本発明の一つのポイントは，前述したような芯鞘型繊維を用い，該鞘成分を除去する前にアルカリ処理を施すということである。すなわち，芯繊維を鞘成分によつてアルカリから保護し 他方のポリエステル系繊維のアルカリ減量処理を行なうわけである。しかし，芯繊維が鞘成分によつて完全に保護されていれば問題はないが，実際上，製糸やそれに続く工程，例えば製編織等，繊維構造物と成す工程において，鞘成分に多数の亀裂が生じているため，アルカリがその亀裂から侵入しまた，芯繊維の見掛けの減量速度が大きいこともあり，繊維は部分的にアルカリ加水分解を受け局部的脆化を起こす。

そこで，本発明の重要なポイントは，アルカリ処理前に，該鞘成分の軟化点以上，該芯成分ポリエステルの融点以下の温度で熱処理することである。すなわち，そのような熱処理によつて，鞘成分を流動させ，前述の亀裂を消滅させる効果を持つものである。従つて，該鞘成分の軟化点以下では亀裂をふさぐ効果は望めず，また，該芯成分の融点以上の温度では，該芯鞘型繊維が繊維としての形態をとどめないため，上述の範囲の熱処理が必須となる。なお，本発明でいう軟化点とは，ポリマーが流動を開始する温度で，明瞭な融点を持つ場合には，融点と一致する。

次に，本発明を実施例で詳しく説明するが，本発明はこれらに限定されるものではない。

実施例1

下記の糸を使用し，５枚朱子織物を２疋作つた。

(1) 経糸：１５０デニール，４８フイラメントのポリエチレンテレフタレート加工糸。

(2) 緯糸：２４５デニール，４０フイラメントの多芯芯鞘型繊維。芯数は３６芯／１フイラメン

トで芯成分は融点２５５℃のポリエチレンテレフタレート，鞘成分は軟化点１２０℃のポリスチレン，鞘成分の比率は２０％。鞘成分除去後の芯繊維の見掛けの減量速度は経糸の１４倍である。

この織物に通常のリラックス精練処理（９５℃）を施し，１疋はそのまま，他の１疋は１５０℃で乾熱処理し，アルカリ処理によつて，対織物重量比１０％の減量を実現させた。鞘成分をトリクレンで除去後，以後常法によつて染色仕上を行なつた。

１５０℃の乾熱処理を施した製品の緯糸強力は８１０ｇ／マルチフイラメント（強度4.1ｇ／ｄ強）であるのに対し，乾熱処理を施さなかつた製品の緯糸強力は半分以下の３９０ｇ／マルチフイラメント（強度2.0ｇ／ｄ弱）しかなく，毛羽立ちも見られた。

実施例2

下記の糸を使用し，ツイル織物を作つた。

(1) 経糸：１５０デニール，７２７フイラメントのポリエチレンテレフタレート糸。

(2) 緯糸：２００デニール，２４フイラメントの多芯芯鞘型繊維。芯数は３芯／１フイラメントで，芯成分は融点２３０℃の５－ナトリウムスルホイソフタル酸を3.8重量％共重合したポリエチレンテレフタレート，鞘成分は軟化点１０５℃のポリスチレン，鞘成分の比率は２５％。鞘成分除去後の芯繊維の見掛けの減量速度は，経糸の約１０倍である。

この織物に通常のリラックス精練処理（９５℃）を施し，１６０℃で乾熱処理し，アルカリ処理で対織物重量比１５％減量させた。鞘成分をトリクレンで除去後，以後常法によつて染色仕上を行なつた。

比較として，緯糸に１５０デニール，７２７フイラメントの５－ナトリウムスルホイソフタル酸を3.8重量％共重合したポリエチレンテレフタレート糸を使用し，同組織，密度の織物に同様の処理を施し，１５％減量させ，以後常法によつて，染色仕上を行なつた。

本発明法による緯糸強度は4.0ｇ／ｄあるのに

対し，比較法による緯糸強度は1.5ｇ／ｄしかなかつた。

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Bacterial Contamination of Platelets for Transfusion: Recent Advances and Issues

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- Bacterial contamination of blood products has emerged as a serious problem in transfusion medicine in the past 20 years and is second only to ABO-mismatch in causing transfusion-associated death.
- Data from 1985 - 1999 showed that 11% (77/694) of transfusion-associated fatalities reported to the FDA were caused by bacterially contaminated products leading to sepsis.
- As platelets are stored at room temperature, and in a large volume of plasma and a bag that allows oxygen diffusion, it is platelet products that are the most frequently implicated in transfusion-associated fatalities due to bacterial contamination.

The transfusion medicine community has attempted to reduce the amount of bacterial contamination in the blood supply by several methods including improved skin disinfection prior to donation, removal of the skin plug with diversion of the first 10 cc of the collection, ongoing donor screening, and analysis/culture of the donated product. Even with these measures in place, several fatalities due to septic reactions associated with transfusion have occurred and been reported. At the time of this writing, the exact "residual risk" of bacterial contamination is not known.

While packed red blood cell units can be contaminated by bacteria, the fact that they are *not* stored at room temperature and are not in a medium containing a large amount of plasma, leads the incidence of sepsis following transfusion of these units to be much less frequent. For a discussion of pRBC bacterial contamination, the first 3 references are recommended to the reader.[1-3] Below, the authors focus on the risks, strategies, and regulations regarding bacterial contamination of platelet products and its mitigation.

Estimates of Prevalence and Incidence

Prior to routine culturing of platelet units, which became universal following implementation AABB Standard 5.1.5.1 (discussed in more detail below), the estimated numbers of bacterially contaminated units, transfusion-associated septic reactions and deaths were usually made retrospectively based on reported or published reactions and sequelae.

By 2000, it was generally held that between 1:1,000 and 1:4,000 units[3-8] were contaminated with bacteria; the estimate of 1:2,000 to 3,000 became commonly accepted. Sepsis due to bacterial contamination was less common and estimated to occur in 1:20,000 to 1:85,000 units.[8] Estimates at the number of deaths due to this transfusion related complication were more difficult to elucidate.

In 2001, Yomtovian and colleagues estimated that 500 to 750 "severe and possibly fatal" events occurred annually.[4] Other estimates of this figure are more on the order of 100 to 150 deaths per year.[9,10] (The estimated risk of bacterially contaminated red cell units was significantly lower (approximately 1:500,000)[11] and approximately 10 to 1,000 times greater than the combined risk of transfusing HIV, HBV, HCV, and HTLV.[11]

Sources of Bacterial Contamination

Occult donor bacteremia and contamination of the product during collection have been the main avenues for entry of bacteria and have been the focus of prevention efforts. Gram-positive skin flora, introduced to the unit during collection, are the most common contaminates identified in retrospective analysis of platelet units.[12] Three reporting systems have suggested that 70% of contaminates isolated were gram-positive bacteria, while 80% of fatalities due to transfusion-related sepsis were caused by gram-negative organisms.[13-15] This finding was also observed in a recent review of the American Red Cross (ARC) experience with pretransfusion culturing of apheresis-derived platelets (ADP) between March and December 2004 (discussed in detail below).[16] This data showed that gram-positive organisms are implicated in approximately 4/5 of the cases. Gram-negative bacteria comprise the other 20%; however, they account for 40% of deaths due to septic transfusion reactions. Burns and colleagues recently published an extensive list of primary reports of clinically significant sepsis attributed to platelet transfusion from a PubMed literature search of all published cases.[17]

Due to the clinical significance of bacterial contamination, much effort has been made over the years to improve disinfection of skin at the phlebotomy site including the discontinuation of "green soap." Additionally, diversion of the skin plug produced by the needle as it passes through the skin, away from the bag into a pouch used for other viral testing, has been instituted nationwide in the United States. Despite these efforts, bacterial contamination of products continued(s) to be observed and skin flora continued(s) to be the most frequently cultured organisms.

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Asymptomatic donor bacteremia is the reason seemingly healthy volunteers may be allowed to donate while infectious, leading to bacterial contamination of blood products. In this case, even stringent donor screening will not catch this potential source of bacterial contamination. There are many examples of donors who unknowingly donate blood while bacteremic. For example, a case of transfusion associated *Staphylococcus aureus* platelet contamination has been reported in a blood donor who had undergone a tooth extraction 3 hours prior to donation, and was likely the result of transient bacteremia.[12] Haimowitz and colleagues discovered *Streptococcus bovis* at 11.4 hours after incubation of a platelet product donated by an asymptomatic female. After being informed of the result and despite negative follow up blood cultures, she underwent colonoscopy and a 3 cm mass was noted and removed.[18] Jafari and colleagues reported a case of *Salmonella* sepsis transmitted via platelet transfusion to 2 recipients from an asymptomatic donor who upon retrospective questioning reported that he had fever, abdominal pain, diarrhea, and hematochezia 13 days *prior* to donation. The donor owned a pet boa constrictor. The snake was thought to have been colonized with *Salmonella* and the original source of the infection.[19] Finally, there have been several cases of pRBC transfusion-associated *Yersinia enterolitica* septicemia in which many of the donors retrospectively reported diarrhea in the days preceding donation.[20]

An Open Letter to the Blood Community and AABB Standard 5.1.5.1

Physicians concerned that the risk from infected units was too high and that there were technologies that could address the issue at least in part wrote an "open letter" to the transfusion medicine community urging implementation of a method to stem this complication.[21] In 2003, AABB Standard 5.1.5.1 was released after considerable discussion, debate, and a public comment period. To be implemented within 1 year, the Standard read, "The blood bank or transfusion service shall have methods to limit and detect bacterial contamination in all platelet components."

At that time and presently, there were no FDA-approved tests for unit-by-unit bacteria screening at the time and point of transfusion. In addition, it was known that more than 15 tests *could* be used but none met "optimal" criteria including sensitivity and specificity, cost:efficacy, and logistical considerations affecting product supply and outdating. Thus, AABB was in an unenviable position of introducing a standard without guidance (at that time) as to *how* to implement it. **Table 1** below (adapted from reference 22) lists the tests capable of detecting bacteria and some comments regarding each.

Clinical Relevance

Typically at the time of collection, the level of contamination is relatively low (between 1 to 10 colony forming units (CFU)/mL.[2,3] However, once the product is inoculated, the bacteria can proliferate to levels of 10^6/mL or greater.[3] This amount of bacteria transfused during a short period of time can cause bacteremia, fever, chills, hypotension, nausea, vomiting, diarrhea, and oliguria, which may progress to sepsis and ultimately multi-system organ failure and death. Alternatively, the transfusion of contaminated cellular blood products may produce no symptoms or long-term clinical consequences. The severity of the reaction depends on: 1) the species of bacteria present, 2) the inoculum, 3) the rate of bacterial propagation, and 4) underlying disease, leukocyte count, the status of the immune system, and receipt of concomitant antibiotics in the recipient.[3] Gram-negative bacteria tend to cause more severe reactions due to the presence of endotoxin produced by these organisms. While causing only one-fifth of the cases, gram-negative bacteria have been reported to account for 40% of deaths due to septic transfusion reactions.[12,16]

Table 1_Description of Tests Capable of Detecting Bacteria

Methodology	Comments
Culture-based methodology: BacT/ALERT 3D Automated Microbial Detection System (bioMérieux, Durham, NC)	Detects CO_2 production by bacteria; FDA approved for quality control; Semi-closed system; Detects 5-10 CFU/mL (12-26 hr incubation);4 mL required
Culture-based methodology: (Pall eBDS, Pall Corporation, East Hills, NY)	Measures O_2 consumption by bacteria; FDA approved for quality control; Completely closed system; Requires 5-6 mL (concentrated to 2-3 mL)
DNA/RNA-based amplification and non-amplification, Chemiluminescence systems	Highly sensitive and specific; Requires highly conserved target by all bacteria or multiple primers and large inoculum; In experimental use only
Tests detecting changes in metabolic parameters or physical elements (glucose concentration, pH, platelet swirling)	Low sensitivity and specificity; Platelet concentration of the sample can affect results; Can be used at point of issue; Validation and QC difficult
Flow or static cytometry: (Scansystem, Hemosystem, Marseilles, France [laser-based, solid-phase cytometry])	Recently approved in Europe; Rapid (30 hr incubation and 90 min test time); Acceptable sensitivity and specificity; Requires reagent antibody to highly conserved common antigen or multiple reagent antibodies; 3 mL required
Bacterial cell wall component detection systems: (Platelet PGD test, Verax Biomedical, Worcester, MA)	Rapid (20 minutes); Lateral flow format; Sensitivity (10^3 to 10^4) in preliminary trial; 0.5 mL required; In experimental use only
Dielectrophoretic method: (Cell Analysis, Slough, United Kingdom)	Recently approved in Europe; Rapid (30 min); Sensitivity (10^3 to 10^5) in preliminary trial; 1 mL required
Gram stain	Requires a high level of contamination; Low sensitivity at lower concentrations; Can be used at point of issue; Validation and QC difficult
Endotoxin detection	Requires a high level of contamination; Low sensitivity at lower concentrations

Adapted from Reference 22.

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Strategies for the Mitigation of Contaminated Blood Products

As previously stated, detection strategies show variable sensitivity and specificity. Measuring abnormal glucose concentrations, low pH, microscopic examination of gram-stained specimens, and platelet swirling characteristics have been less useful due to low sensitivity and specificity. However, these methods have the advantage of being able to be used at the time and point of transfusion, are less expensive and use equipment commonly available.

Automated culture-based systems used for years in the hospital setting for detection of bacteremia in blood cultures obtained from patients were implemented by many of the nation's blood collection systems. Principally, they detect CO_2 generation or O_2 consumption by bacteria. Some of the limitations of culture-based systems are relatively insensitive at low levels of bacterial contamination causing false negative results, long incubation times for slow-growing bacteria, false positive results, high cost and the need for capital investment.[24-26] Holme and colleagues have recently shown that modifications to the Pall eBDS system have attempted to minimize these limitations.[29] While feasible for apheresis-derived platelets (ADP), culture based methods are not considered feasible for each whole blood-derived platelet (WBP) unit at the time of collection because of the high cost. Thus, those centers and services that used ADP could comply more easily and effectively with the new standard than those who used WBP, and converting entire systems from ADP to WBP was in-and-of-itself costly and met with resistance due to standard of care, cost, and availability concerns.

Apheresis Derived (ADP) Versus Whole Blood Derived Platelets (WBP)

Even before the implementation of Standard 5.1.5.1, the use of ADP had increased (52% to 99% of total transfused products per Ness and colleagues from 1987-1998) likely in part due to concern by some authorities about bacterial contamination.[8] Indeed, Ness and colleagues concluded that the rate of septic transfusion reactions due to WBP was 5.39 times higher than ADP (95% CI, 1.89, 12.9). Dykstra and colleagues found that the rate of bacterial contamination in ADP and WBP was identical (P=1.0); however, when platelet concentrates were pooled, the risk increased by 5 fold.[7]

Despite the apparent advantages of using ADP, maintaining adequate inventories and simultaneously providing adequate bacterial contamination testing is still a challenge due to the time it takes for the culture. Many experts have considered the effect and possibility of extending the expiration date to 7 days. In order to have a licensed 7 day ADP, clinical tests of the platelets, storage and medium will be required as will demonstration of bacteria detection and an acceptable rate of "residual risk." In order to allow the use of WBP with cost effective and optimal bacterial detection performance, 2 alternatives can be considered, but both are in clinical development and thus are not available. These include: 1) a 5 or 7 day "pooled and stored" WBP where a culture-based system could be used as a single test on a pre-storage pooled product, and 2) the approval of a effective test that could be used at the point and time of transfusion and which would be rapid enough for most clinical situations.

Residual Risk in "Tested" Components

Despite the strategies described above, bacterial contamination continues to be observed, although markedly reduced, and fatal consequences have been reported. As there was no standardized or required system in place to determine the true incidence of the morbidity and mortality caused by septic platelet units prior to the implementation of AABB Standard 5.1.5.1, it is impossible to determine with accuracy the effect of the standard in terms of percent improvement or reduction in adverse events. Some relevant data are available however.

From March 1, 2004 through December 31, 2004, approximately 350,000 units from 87,000 voluntary donors at 36 regional centers were cultured by the American Red Cross. Two hundred nineteen were initially positive, 67 were confirmed on re-sampling for an overall confirmed positive rate of 0.019% or 1:5,234 as compared to published reports of 1:2,000 to 3,000. Initially, 4 to 5 mL from each unit was transferred through a sterile docking device at least 24 hours after collection and used to inoculate BacT/ALERT BPA aerobic culture bottles. Confirmation of a positive blood culture bottle was performed by taking a new sample from product, inoculating a new BacT/ALERT aerobic culture bottle and if positive, performing bacterial isolation and identification. Eighty percent of the confirmed positive cases were gram-positive bacteria, mainly *Staphylococcus* (46.3%) and *Streptococcus* (26.9%) species. Serratia was the most commonly isolated gram-negative bacteria (n=4). Seventy-two percent of gram-negative organisms were identified within the first 12 hours of inoculation (personal communication; ARC). No patient transfused with an unconfirmed positive product had a septic transfusion reaction.

Three fatal cases and 2 non-fatal cases of transfusion-associated sepsis in platelet recipients have occurred since the standard was adopted. The first 2 cases were reported in MMWR.[27] The first case was that of a 74-year-old man who received 1 pool of 5 platelet concentrates. The pooled unit was tested by a pH method and found to be acceptable. After a hypotensive reaction, *S. aureus* was cultured from both the patient's blood and the platelet bag and by pulsed-field gel electrophoresis (PFGE) were identical. The second case was a 79-year-old man who was transfused a single platelet pheresis unit. The unit was tested by an automated culture system using a standard method. One hour after transfusion the patient had shortness of breath, chills, and fever. *S. lugdenensis* was cultured from both the patient's blood and the platelet bag and by PFGE were identical. The final case of fatality [presented to the Advisory Committee on Blood Safety (1/25/2005)] was a premature infant who received 2 doses of a single platelet pheresis. The unit was tested by a manual culture. The patient had symptoms consistent with sepsis. The platelet unit was then recultured and found to be growing *Serratia marcescens*. The patient's cultures were negative, but the cultures were taken after antibiotic therapy was initiated. One of the non-fatal cases was a BacT/ALERT failure of an apheresis platelet unit.[16]

Using numbers that are estimates only, and recognizing the limitations therein, a residual risk figure may be on the order of 3 to 6 fatal cases per year following the administration of approximately 2 million platelet doses per year (*The reader is asked to note that the true number of transfused platelet doses per year in the United States has not been established with certainty. While as many as 9 million units are given, the proportion of ADP vs. WBP is not known, nor is the number of WBP pooled into a dose*). Therefore, an incidence figure of approximately 1 fatality per approximately 500,000 tested doses may be posited. This is

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likely to be grossly inaccurate due to the lack of validated data, suboptimal test methods for WBP, and reporting and assumptions used. If one uses the figures given earlier in this report of 100 to 150 deaths annually (pre-standard implementation) and a residual as high as 6, then the improvement has been about 95%. Again, this number is a gross estimate, which will likely be revised with the collection of additional data. Though the "improvement rate" seems excellent, a residual risk of fatality incidence of 1:500,000 may be judged unacceptable by some, and thus other means of improving upon this complication may be warranted.

Pathogen Reduction (Inactivation)

Pathogen reduction is the term given to a number of technologies that prevent pathogens from replicating and thus prevent them from causing disease following transfusion. Methods under investigation (some are in use in Europe) use a variety of compounds including methylene blue, riboflavin and solvent-detergent treatment. In addition, a number of photodynamic processes use psoralen-based chemicals followed by ultraviolet light to inactivate bacteria and viruses by preventing replication and transcription of nucleic acids. This latter method has been extensively tested for bacterial reduction in platelet products. Gram-positive and gram-negative bacteria have been shown in three preclinical trials to be sensitive to pathogen inactivation (reviewed in reference 28). The main disadvantage of pathogen inactivation is that no method is equally effective for all organisms and these methods may be especially ineffective for spore-forming organisms.[28] The advantage is that this is a proactive method for bacterial reduction and has the potential to be as effective for known pathogens as it is for emerging pathogens.

Ongoing Issues

Bacterial contamination of blood products was, and may continue to be, a serious health risk to transfusion recipients. While we believe substantial improvement has been made, though difficult to accurately quantify, some level of residual risk appears to exist. Systems to help quantify this residual risk need to be implemented and/or strengthened. In addition, there is some evidence to suggest that the implementation of Standard 5.1.5.1 has caused a significant reduction in platelet availability, delay in their release to hospital transfusion services, and/or a declination in WBP use which may have added to the overall cost of platelet provision and transfusion. In order to address these issues, rapid and cost-effective tests need to be developed and approved for use at the time and point of transfusion. Alternatively, and with the use of a validated bacterial detection test, prestorage pooling may be "allowed" and thus lead to a state of equipoise between ADP and WBP safety and therefore use. An effective method or methods for bacterial detection and limitation will likely allow the extension of either ADP or pooled and stored WBP to 7 or perhaps even 8 days, thus likely improving the logistical and availability issues currently surrounding this valuable human resource. Finally, the adoption of pathogen reduction technologies in Europe and their approval in the United States may abrogate any residual or evolving risk.

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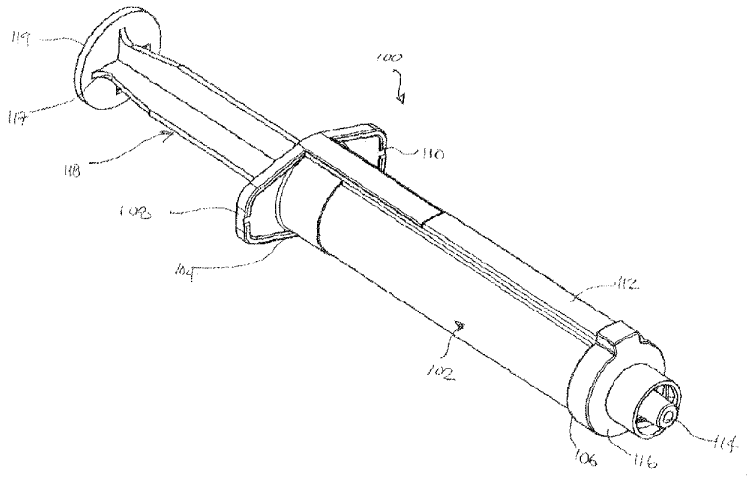
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(54) Title: DEVICE WITH INTEGRATED ALLERGY TESTING



(57) Abstract: The disclosure provides an allergy detection system for use during catheterization. The allergy detection system is incorporated into specialized syringes, connectors for use with standard syringes, or can be an independent test module designed for the sole purpose of allergy detection. The detection system features a test strip, such as an immunochromatographic test strip, and a structure to couple the system to a connector, syringe, or a housing, to form an independent test module. The detection system, by way of test strips, is used to detect potential allergic reactions.

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INTERNATIONAL APPLICATION FOR DEVICE WITH INTEGRATED ALLERGY TESTING

Related applications

[0001] This application claims the full Paris Convention priority to and benefit of U.S. Provisional Application Serial No. 61/564,593, filed on November 29, 2011, the contents of which are hereby incorporated by this reference, as if fully set forth herein in their entirety.

Field of the disclosure

[0002] The present disclosure generally relates to a medical testing device. More particularly, the present disclosure pertains to a device having an integrated allergy testing system.

Background of the disclosure

[0003] During surgical procedures and other medical procedures, it is often necessary to determine if a patient has any allergies that may be aggravated during the procedure. Testing for allergies can be a long process. Often, an immediate answer is needed during the procedure.

[0004] Extensive use of certain compounds in home and health care products (oral care products, contact lens care products, dressings, ointments, soaps, cosmetics) is causing a larger population to become pre-sensitized to such particular agents. When a pre-sensitized person comes in contact with such an agent, there is a high probability that person could develop much stronger symptoms as severe as anaphylactic shock with cardiac arrest. Currently known tests for such allergies cannot be performed at the patient bedside as they are time consuming, and involve numerous steps and equipment.

[0005] It is therefore desirable to provide a device for integrating allergy testing into a medical device.

Summary of the disclosure

[0006] The disclosure provides an allergy detection system for use during catheterization. The allergy detection system is incorporated into specialized syringes, connectors for use with standard syringes, or can be an independent test module designed for the sole purpose of allergy detection. The detection system features a test strip, such as an immunochromatographic test strip, and a structure to couple the system to a connector, syringe, or a housing, to form an independent test module. The detection system, by way of test strips, is used to detect potential allergic reactions.

[0007] In embodiments, the present disclosure provides a device for testing the presence or absence of a substance in blood, comprising: a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device; a first chamber for receiving the withdrawn blood; a second chamber configured for holding a test strip; a test strip that is held within the second chamber; a wall or panel that separates the first chamber from the second chamber; at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber; wherein the second chamber comprises a window for viewing the test strip, wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and, wherein the window is configured to allow visual detection of the visible signal.

[0008] Also provided is the above device, that comprises a syringe and wherein the first chamber is defined by the housing of the syringe. Also provided is the above device, that does not comprises a syringe. Also provided is the above device, that is capable of being coupled to a syringe and to a needle, wherein the device has a hub that is capable of coupling to the hub of the syringe, and wherein the device has a coupler that is capable of coupling to a needle. Moreover, what is provided is the above device, wherein the substance is an antibody. Furthermore, what is contemplated is the above device, wherein the substance is an antibody of the class IgG, IgA, or IgE. Additionally,

what is embraced is the above device, wherein the substance is an antibody that specifically binds to an antimicrobial agent, e.g., antiseptic or antibiotic.

[0009] In embodiments, what is provided is the above device that is capable of: testing for the presence or absence of a first substance in the blood; and, testing for the presence or absence of a second substance in the blood; wherein the test strip is capable of separately providing a first visual signal for the first substance and a second visual signal for the second substance. Also, what is provided is the above device, wherein the first substance is an IgE antibody that specifically binds latex and the second substance is an IgE antibody that specifically binds an antiseptic. What is further embraced is the above device, wherein the second chamber comprises a flexible dome, and wherein the flexible dome is capable of flexing radially outward; wherein in use the flexible dome flexes radially outwards and creates a partial vacuum that is capable of drawing blood out of the first chamber and into the second chamber; wherein a sliding latch is operably linked with the flexible dome; wherein in use the sliding latch is capable of being slid over the dome to compress the flexible dome radially downwards and increase the pressure within the second chamber; and wherein in use the sliding latch is capable of being slid away from the dome to release the dome and allow the dome to flex radially outwards thereby creating a partial vacuum in the second chamber. Alternatively, the first substance can be an antibody of the IgG, IgA, IgM, or IgD class. Alternatively, the second substance can be an antibody of the IgG, IgA, IgM, or IgD class.

[0010] In yet another aspect, what is provided is the above device, further comprising an end-cap, wherein the end-cap is configured for contacting and stabilizing the test strip, and configured for contacting and stabilizing the proximal portion of a needle that is coupled to said device. Also provided is the above device, wherein the second chamber comprises a proximal end and a distal end, and wherein one or both of the proximal end and distal ends comprises an opening for installing the test strip from the second chamber. In yet another aspect, what is provided is the above device, wherein the second chamber comprises a proximal end and a distal end, and wherein one or both of the proximal end and distal ends comprises an opening for installing the test

strip from the second chamber, further comprising one or more end caps that capable of capping one or both of the proximal end and the distal end.

[0011] What is further embraced, is the above device further comprising a needle, wherein the needle is reversibly coupled to the coupler. Also contemplated is the above device that does not comprise a needle.

[0012] In yet another embodiment, what is contemplated is a device for testing the presence or absence of IgE in blood, comprising: a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device; a first chamber for receiving the withdrawn blood;a second chamber configured for holding a test strip; a test strip that is held within the second chamber; a wall or panel that separates the first chamber from the second chamber; at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber; wherein the second chamber comprises a window for viewing the test strip; wherein the test strip is capable of producing a visible signal that indicates the presence or absence, in the withdrawn blood, of an antibody of the IgE class that specifically binds to an antiseptic or an antibiotic; and, wherein the window is configured to allow visual detection of the visible signal. Also provided is the above device, wherein the test strip is an immunochromatographic test strip.

[0013] In a process embodiment, what is provided is a process for allergy detection during catheterization, comprising: the step of drawing blood from a subject into the first chamber of a device that comprises: (a) a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device; (b) a first chamber for receiving the withdrawn blood; (c) a second chamber configured for holding a test strip; (d) a test strip that is held within the second chamber; (e) a wall or panel that separates the first chamber from the second chamber; (f) at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber; (g) wherein the second chamber comprises a window for viewing the test strip, (h) wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and, (i) wherein the window is configured to allow

visual detection of the visible signal; the step of allowing at least some of the drawn blood to enter the second chamber of the device; wherein a needle is coupled to the device; and, wherein in use, at least some of the withdrawn blood enters the needle and then enters the first chamber, then enters the second chamber, and then contacts the test strip.

[0014] In yet another process embodiment, what is provided is the above process, further comprising a reaction that is mediated by the test strip, wherein the reaction produces a visual signal that indicates presence or absence of a substance that mediates an allergy. Also provided is the above process, wherein the drawing blood into the first chamber is urged by one or more of: (a) Blood pressure of the subject; (b) Vacuum produced by a syringe plunger of the device; (c) Vacuum produced by a flexible dome of the device; and (d) Capillary action of the test strip of the device. In yet another process embodiment, the disclosure provides the above process wherein the test strip is configured for detecting an antibody that specifically binds an antimicrobial agent, e.g., antiseptic or antibiotic; wherein in use the test strip provides a visual signal that the blood does not contain detectable antibodies that specifically bind to the specific antimicrobial agent, e.g., antiseptic or antibiotic; followed by the step of inserting a catheter into the subject, wherein the catheter is impregnated or coated with the antimicrobial agent, e.g., antiseptic or antibiotic.

[0015] Also provided is the above process, wherein the test strip is configured for detecting an antibody that specifically binds an antimicrobial agent, e.g., antiseptic or antibiotic; wherein in use the test strip provides a visual signal that the blood does contain detectable antibodies that specifically bind to the specific antiseptic or antibiotic; followed by the step of making a decision on whether or not to insert a catheter that is impregnated or coated with the antiseptic or antibiotic; and, wherein the decision is to refrain from inserting the catheter in the subject, followed by the step of inserting a catheter into the subject, wherein the catheter is not impregnated or coated with the antiseptic or antibiotic.

[0016] In a system embodiment, the disclosure provides a system comprising, in combination, a medical instrument that is capable of holding blood, and a medical device that comprises: (a) a coupler or hub that is capable of coupling with a needle,

wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device; (b) a first chamber for receiving the withdrawn blood; (c) a second chamber configured for holding a test strip;(d) a test strip that is held within the second chamber; (e) a wall or panel that separates the first chamber from the second chamber;

[0017] (f) at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber;(g) wherein the second chamber comprises a window for viewing the test strip, (h) wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and, (i) wherein the window is configured to allow visual detection of the visible signal. What is also embraced, is the above system, wherein the combination is a reversible combination or a permanent combination. Furthermore, what is provided is the above system, wherein the combination is a reversible combination, wherein the device and the medical instrument are held in combination by one or more of a clip, snap, lock, or tab. Also disclosed, is the above system, wherein the combination is a permanent combination, wherein the device and the medical instrument are held in combination by one or more of an adhesive or integral molding. In yet another system embodiment, what is provided is the above system, wherein the medical instrument comprises one or more of a syringe, trocar, catheter, introducer, sheath, hub, pump, or valve.

[0018] The foregoing needs are met, to a great extent, by the present disclosure, wherein in some embodiments a device with an integrated allergy testing system that is capable of overcoming the disadvantages described herein at least to some extent is provided.

[0019] In accordance with an embodiment of the present disclosure an allergy testing device for testing a sample includes a housing having a proximal end and a distal end. The housing can also include an outer wall defining an inner chamber extending through at least a portion of the housing. The device can also include a needle extending from a distal end of the housing. Additionally, the device can include an immunochromatographic test strip configured to indicate whether a predetermined antibody is present in the sample. The test strip can be positioned in the housing.

[0020] In accordance with another embodiment of the present disclosure, a syringe with an integrated allergy testing system includes a syringe housing having an outer wall defining an inner chamber extending through at least a portion of the syringe housing and the syringe housing having a proximal end and a distal end. The syringe can also include a needle extending from a distal end of the housing. Additionally a syringe plunger can be movably disposed within the inner chamber of the syringe housing. The syringe can also include an immunochromatographic test component configured to indicate whether a predetermined antibody is present in a sample, where the sample can be aspirated into the syringe, and wherein the test component is positioned in the syringe housing.

[0021] In accordance with another embodiment of the present disclosure, an attachment for a medical device having an integrated allergy testing system can include a housing having a proximal end and a distal end, wherein the proximal end is configured to couple to a medical device and the distal end is configured to receive a needle. The attachment can also include an immunochromatographic test component configured to indicate whether a predetermined antibody is present in a sample, wherein the test component is positioned in the housing. The sample can be aspirated into the housing. Additionally, the attachment can include a window disposed in the housing such that the test component is viewable.

[0022] There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof, herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

[0023] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

[0024] As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present disclosure. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present disclosure.

[0025] Components for the methods and devices of the disclosure are available, for example, from any major medical device company, for example, Medtronic of Minneapolis, MN; Advanced Cardiovascular Systems in Santa Clara, CA; Baxter International of Deerfield, IL; Abbott Laboratories at Abbott Park, IL, Edwards Lifesciences, Irvine, CA, and Boston Scientific of Natick, MA. Components of the present disclosure can be made, without limitation, by molding, blow molding, slush molding, injection molding, rotational molding, compression molding, extrusion, thermoforming, stamping, calendaring, and so on (Brazel, CS; Rosen, SL (2012) Fundamental Principles of Polymeric Materials. Wiley, Hoboken, NJ).

Brief descriptions of the drawings

[0026] FIG. 1 illustrates a test strip in accordance with an embodiment of the invention.

[0027] FIGS. 2 and 3 illustrate a perspective view of an independent allergy testing module in accordance with an embodiment of the invention.

[0028] FIGS. 4 and 5 illustrate a sectional view of the independent allergy testing module illustrated in FIGS. 2 and 3 in accordance with an embodiment of the invention.

[0029] FIG. 6 illustrates an exploded view of the independent allergy testing module illustrated in FIGS. 2-5 in accordance with an embodiment of the invention.

[0030] FIG. 7 illustrates a syringe with integrated allergy testing in accordance with an embodiment of the invention.

[0031] FIG. 8 illustrates a sectional view of the syringe with integrated allergy testing illustrated in FIG. 7 in accordance with an embodiment of the invention.

[0032] FIG. 9 illustrates an exploded view of the syringe with integrated allergy testing illustrated in FIGS. 7 and 8 in accordance with an embodiment of the invention

[0033] FIG. 10 illustrates a connector with integrated allergy testing in accordance with an embodiment of the invention.

[0034] FIG. 11 illustrates a sectional view of the connector with integrated allergy testing illustrated in FIG. 10 in accordance with an embodiment of the invention.

[0035] FIG. 12 illustrates an exploded view of the connector with integrated allergy testing illustrated in FIGS. 10 and 11 in accordance with an embodiment of the invention.

[0036] FIG. 13 (A, B) illustrates the cap that is a part of the module embodiment, and structures in the vicinity of the cap.

Detailed description

[0037] The present disclosure provides in some embodiments, an allergy detection system for integration into medical devices. For instance, in accordance with embodiments of this invention, the allergy detection system can be incorporated into a specialized syringe, a connector for use with a standard syringe, or an independent test module, designed for the sole purpose of allergy detection. The detection system can include, without limitation, an immunochromatographic membrane and structure to couple it to a connector or syringe or a housing to form an independent test module. The detection system can be used to detect any potential allergies that can be identified using immunochromatography.

[0038] In embodiments, what is provided is a device and related methods for point of care testing. For example, where a needle is introduced for use in the Seldinger technique, the needle can be used in conjunction with device and method of the present disclosure for detecting antibodies and predicting adverse allergic reactions. The *Seldinger* technique, includes the initial step of inserting a needle into a patient's blood vessel, where the Seldinger technique concludes with replacing the needle with a catheter or other medical device. The end-result is that the catheter or other medical device is situated in a subject's blood vessel or other body cavity. The *Seldinger* technique, and variations thereof, and devices used to perform this technique, are described in Seldinger (1953) Acta Radiologica 39:368-376; U.S. Pat. No. 7,722,567 issued to Tal, 7,972,307 issued to Kraus, et al, and 7,938,806 issued to Fisher, et al, which are incorporated by reference. Following testing by device and method of the present disclosure, and where the test gives a negative result (indicating that the subject is not allergic), the clinician can proceed with the *Seldinger* technique, and replace the needle with a catheter that contains the antigenic drug, antigenic antiseptic,

antigenic adhesive, or antigenic latex. Alternatively, if the test gives a positive result and indicates that the subject is likely to be allergic to the antigenic drug, antigenic antimicrobial agent, antigenic antiseptic, antigenic adhesive, or antigenic latex, then the clinician refrains from using the medical device. Where the test gives a positive result, the clinician can use an alternative medical device that does not contain the offending drug, antiseptic, adhesive, or latex, and the like.

[0039] In this way, the device and procedure of the present disclosure is used at the point of care, and is integrated into the procedure for using any medical device of interest, and where the device and procedure of the present disclosure can give the clinician a yes/no answer. The device of the present disclosure can be a physical part of a device used for the medical procedure of interest, for example, the device can be connected to a syringe that is used in the *Seldinger* technique or other procedure. This connection can be by way of a luer lock, Storz lock, or other coupler. Alternatively, the device of the present procedure can be integrated into a syringe, that is, permanently molded into the syringe, that is used in the *Seldinger* technique or other procedure.

[0040] In exclusionary embodiments, the present disclosure includes only test-strip devices that are integrated into a syringe. In another exclusionary embodiment, the present disclosure excludes test-strip devices that are not integrated into a syringe. In exclusionary embodiments, the present disclosure includes only test-strip devices that are integrated into a needle hub, trocar, dilator, syringe, syringe barrel, introducer, and the like. In another exclusionary embodiment, the present disclosure excludes test-strip devices that are not integrated into a needle hub, that are not integrated into a trocar, that are not integrated into a dilator, that are not integrated into a syringe or syringe barrel, that are not integrated into an introducer, and the like.

Immune disorders arising from exposure to medical devices and pharmaceuticals

[0041] In embodiments, the present disclosure provides a device and related methods, for detecting antibodies against components of medical devices or components of pharmaceuticals, and for quantitating or for predicting allergic reactions in a subject to be exposed to the medical device or the pharmaceutical. What can be quantitated is, for example, antibodies of one or more of the classes IgG, IgA, IgM, IgD, or IgE, that are present in a subject's bloodstream or in any biological fluid. The device and related methods are configured for quantifying or for predicting anaphylactic-type reactions or

bronchospasm (Layton et al (1989) Clin. Exp. Allergy. 19:307-314; Terazawa et al(1998) Anesthesiology. 89:1298-1300), allergic contact dermatitis, irritant contact dermatitis, photoallergic contact dermatitis, or immediate type contact reactions (Kutzscher (2012) Clin. J. Oncol. Nurs. 16:E48-55; Krasteva (1999) Eur. J. Dermatol. 9:144-159), arising from exposure to an antimicrobial agent or an antiseptic, e.g., a biguanide antiseptic.

Allergic reactions against and antibodies to antimicrobial agents, and to other components of medical devices

[0042] Device and methods of the present disclosure can detect antibodies, present in a subject's blood, serum, or other biological fluid, where the antibodies specifically bind to an antimicrobial agent, such as an antiseptic or antibiotic (Torres et al (2009) 19:67-68), antibiotics such as rifampicin (Feng et al (2011) Eur. J. Dermatol. 21:696-699), adhesives on catheters (Meikle et al (2012) Can. J. Anaesth. 59:815-816), thimerosol or other preservatives in medical devices (Ancona et al (1990) Dermatol. Clin. 8:95-105). Allergic reactions to latex, and antibodies against latex, have been described (Patriarca et al (2002) J. Investig. Allergol. Clin. Immunol. 12:169-176; Unsel et al (2012) Int. Arch. Allergy Immunol. 158:281-287). Allergic reactions (analphylaxis) can occur in response to medical devices impregnated with one or more antiseptics (Darouiche and Raad (1999) New Engl. J. Med. 1762 (1 page)). Antibodies of the classes IgG and IgA are associated with drug-induced eruptions (pemphigus folicaeus) (Feng et al (2011) Eur. J. Dermatol. 21:696-699). Antibodies of the classes IgG and IgE are associated with allergic reactions to antiseptics (Layton et al (1987) Mol. Immunol. 24:133-141). Antibodies of the IgE class have been identified that are responsible for hypersensitivity to various beta-lactam antibiotics (Gunez et al (2012) J. Investig. Allergol. Clin. Immunol. 22:41-47). IgE antibodies have also been identified that specifically react against latex (Galindo et al (2011) J. Investig. Allergol. Clin. Immunol. 21:459-465).

[0043] The term "antimicrobial" encompasses, but is not limited to, antiseptics and antibiotics.

Detecting antibodies and other molecules that can provoke adverse events

[0044] Antibodies in blood or in other biological fluids can be detected, for example, by way of reagents in a test strip. The reagents can be covalently or non-covalently attached to the surface of a test strip, the reagents can be adsorbed to a test strip, the

reagents can be absorbed to a test strip, the reagents can be covalently or non-covalently bound to interior of test strip, such as porous interior or fibrous interior, or any combination of the above. Reagents, test strips, substrates, for immune assays, including color reactions, and the like, are provided, for example, from US 7,544,324 issued to Tung et al, US 7,438,852 issued to Tung et al, US 7,989,217 issued to Yee et al, 7,910,381 of Ford et al, each of which is individually incorporated herein by reference, each in its entirety. The present disclosure encompasses detection of antibodies, such as IgG, IgA, IgM, IgD, or IgE, detecting B cells that express IgE or other classes of antibodies, by way of test strip technology. Several antibody classes can be simultaneously expressed in the body, and that recognize the same antigen. Accordingly, the present disclosure provides a test strip that can detect antibodies two or more of the classes IgG, IgA, IgM, IgA, IgD, or IgE. In one embodiment, the test strip detects two different classes, and provides two different colors. In another embodiment, the test strip detects two different classes, and provides the same color for both of the respective color reactions, but at different locations in the test strip. In yet another embodiment, the test strip detects a plurality of different antibody classes (or detects a plurality of different specific antibodies that bind to respective different antigens, where all of these specific antibodies are in one particular class). Combinations of the previous embodiments are also provided, e.g., detecting IgG that binds to an antibiotic, and detecting IgE that binds to latex, or detecting an antibody that binds to an antimicrobial and an antibody that binds to a pathogen. Color reaction can be provided by a label that comprises a metal, a colloidal particle such as colloidal gold, a dye particle, or results from a reaction catalyzed by peroxidase or alkaline phosphatase (see US 7,262019 issued to Kovalenko, US 5,200,312 issued to Oprandy, US 5,637,468 issued to Mason, and US 6,503,726 issued to Anne, which are each incorporated herein in their entirety). Where a gold labeled anti-IgE antibody is used, for example, a test sample (e.g., blood) reacts with the gold labeled anti-IgE antibody, forming a complex. The complex travels across a membrane where immobilized allergens capture the complex, resulting in a colored line (see US 7,629,127 issued to Hubscher, which is incorporated herein by reference).

[0045] The following provides a non-limiting example. For detection of anti-antiseptic antibodies, blood can be deposited at a sample receiving area located at a first end of

the test strip. Flow of solvent from the first end of the test strip towards the opposite end of the test strip draws any antibodies towards the test strip, and draws the antibodies over a region of the test strip that contains conjugates of gold-antiseptic. When the antibodies migrate over the area that contains gold-antiseptic, the result is an insoluble complex that forms a visually detectable line. Conjugates of gold-antiseptic that are not trapped as part of this insoluble complex continue to migrate on the test strip, and do not contribute to the visual signal of the line. As an alternative to using a conjugate of gold-antiseptic, what can be used is a conjugate of gold with an antibody that specifically binds to anti-antiseptic antibodies (anti-idiotype antibodies). The above narrative applies to anti-antiseptic antibodies, but also to embodiments where the antigen is an antibiotic, a pharmaceutical, a drug, latex, an adhesive, and the like.

[0046] In a non-limiting embodiment, what is provided is a device that encompasses an immunoassay with all reagents embedded on a test strip that performs without the use of instruments. Total IgE in a biological fluid is bound by anti-human IgE immobilized on test strips in the IgE reactive field of the test strip. Visualization of captured IgE is indicated by colloidal gold labeled anti-human IgE. Excess labeled antibodies are captured by antibodies in the control field. A control line appears in the control field and determines when enough of the biological fluid has been collected. The presence of IgE in the sample is visualized by the appearance of a dark-colored line, e.g., a red line, in the reactive field and the control field. Absence of a line in the control field, regardless of the presence of line in the reactive field, indicates an invalid assay result. The area on the support identifying the reactive field and control field are on the back surface of the support in two colors. A sample with IgE in the normal reference range lacks a line in the reactive field but has a line in the control field. The presence of lines in the reactive and control fields indicates a sample with elevated total IgE levels. The device provides a qualitative/semi-quantitative measure of total IgE in the biological fluid when the intensity of color on the test strip is visually observed. The skilled artisan can divide or classify the different intensities of signal as negative or as positive, and the skilled artisan can prepare a standard operating procedure (SOP) that sets forth these different intensities. What is also provided is the above embodiment, but where it applies to other antibody classes, e.g., IgG, IgA, IgM, or IgD.

[0047] In a non-limiting embodiment, what is provided is a device that comprises a series of capillary beds (elements), for example, made of cellulose. The first element (a sample pad) acts as a sponge and can hold an excessive amount of biological fluid. Then, the fluid migrates to the second element (conjugate pad). The second element is manufactured with a conjugate, a dried format of particles in a soluble matrix that contains reagents that promote the desired chemical reaction between the target molecule (antigen) and its binding partner (antibody) that has been immobilized on the surface of the particle. At the time that the sample fluid dissolves the soluble matrix, it also dissolves the particles and the sample and conjugate mix while flowing through the porous structure. In this way, the analyte binds to the particles while migrating further through the third capillary bed. This material has one or more regions or stripes where a third molecule has been immobilized. By the time the sample-conjugate mix has migrated to these stripes, analyte has been bound on the particle and the third capture molecule binds the complex. When additional fluid passes the stripes, particles accumulate and the stripe-area changes color. In embodiments, there can be two stripes: one (the control) that captures any particle and demonstrates that reaction is in working order, the second contains a specific capture molecule and only captures those particles on which an analyte molecule has been immobilized.

Duration of detection

[0048] In embodiments, what is provided is a device that is capable of detecting an antibody responsible for an allergic reaction, for example, to an antibiotic or antiseptic,
(1) During a blood draw that is dedicated to this detection;

(2) Only during a blood draw that is dedicated to this detection, with no capability during subsequent procedures, e.g., during insertion of a catheter or other medical instrument. This is an exclusionary embodiment;

(3) During a period of time when a catheter or other medical instrument is indwelling in a subject, that is, when a catheter or other medical instrument is operably linked to a subject. This period of time can be, e.g., at least ten minutes, at least one hour, at least one day, at least one week, at least one month, and the like;

(4) Only during a period of time when a catheter or other medical instrument is indwelling in a subject, but not capable of detecting the antibody during a blood draw

that is solely dedicated to the detection of the antibody. This is an exclusionary embodiment.

Antibodies and other reagents

[0049] "Specifically" or "selectively" binds, when referring to a ligand/receptor, nucleic acid/complementary nucleic acid, antibody/antigen, or other binding pair (e.g., a cytokine to a cytokine receptor) indicates a binding reaction which is determinative of the presence of the protein in a heterogeneous population of proteins and other biologics. Thus, under designated conditions, a specified ligand binds to a particular receptor and does not bind in a significant amount to other proteins present in the sample. Specific binding can also mean, e.g., that the binding compound, nucleic acid ligand, antibody, or binding composition derived from the antigen-binding site of an antibody, of the contemplated method binds to its target with an affinity that is often at least 25% greater, more often at least 50% greater, most often at least 100% (2-fold) greater, conventionally at least ten times greater, more normally at least 20-times greater, more typically at least 100-times greater, and most typically at least 1000-fold than the affinity with any other binding compound (see, e.g., US 2012/0121643 of Dubensky, which is incorporated by reference).

[0050] In a typical embodiment an antibody will have an affinity that is greater than about 10^9 liters/mol, as determined, e.g., by Scatchard analysis (Munsen, et al. (1980) Analyt. Biochem. 107:220-239). It is recognized by the skilled artisan that some binding compounds can specifically bind to more than one target, e.g., an antibody specifically binds to its antigen, binds to lectins by way of the antibody's oligosaccharide, and also binds to an Fc receptor by way of the antibody's Fc region.

[0051] In embodiments, the disclosure provides test strip that is capable of detecting antibodies in blood, where the antibodies specifically bind to a pathogen. Anti-pathogen antibodies have been characterized. Reagents and kits are available for detecting antibodies that specifically bind to viruses (e.g., HIV, HCV,HBV), fungi, and bacteria (see, e.g., Novack et al (2006) J. Clin. Microbiol. 44:2909-2913; Hennessey et al (2009) J. Urban Health. 86:93-105; Thurman et al (2009) Clin. Infect. Dis. 48:1244-1249; Alexander et al (1996) J. Clin. Microbiol. 34:1180-1183).

[0052] "Sample" refers to a sample from a human, animal, placebo, or research sample, e.g., a cell, tissue, organ, fluid, gas, aerosol, slurry, colloid, or coagulated material. The "sample" may be tested in vivo, e.g., without removal from the human or animal, or it may be tested in vitro. The sample may be tested after processing, e.g., by histological methods. "Sample" also refers, e.g., to a cell comprising a fluid or tissue sample or a cell separated from a fluid or tissue sample. "Sample" may also refer to a cell, tissue, organ, or fluid that is freshly taken from a human or animal, or to a cell, tissue, organ, or fluid that is processed or stored.

[0053] A composition that is "labeled" is detectable, either directly or indirectly, by spectroscopic, photochemical, biochemical, immunochemical, isotopic, or chemical methods. For example, useful labels include ^{32}P, ^{33}P, ^{35}S, ^{14}C, ^{3}H, ^{125}I, stable isotopes, epitope tags fluorescent dyes, electron-dense reagents, substrates, or enzymes, e.g., as used in enzyme-linked immunoassays, or fluorettes (see, e.g., Rozinov and Nolan (1998) Chem. Biol. 5:713-728).

Detailed descriptions of the figures

[0054] The invention will now be described with reference to the drawing figures, in which like reference numerals refer to like parts throughout. As illustrated in FIG. 1, the allergy detection system can include an immunochromatographic membrane 2 (PVDF or nitrocellulose material) in strip or cassette format that can detect elevated levels of an allergen by employing a highly sensitive detecting antibody and a carrier-protein conjugated hapten. The antibody is labeled with a signal generator (e.g., colloidal gold), which is placed in the dry state at a predetermined site on the membrane. Using this novel approach the clinician (catheter inserters) would be able to determine if a patient is at risk of developing an allergic reaction before potentially introducing an allergen into a patient's system. The system also provides ease of use to the hospital staff as it does not require any additional step, equipment or time other than what is needed for standard procedures.

[0055] FIGS. 2 and 3 illustrate an independent testing module in accordance with an embodiment of this invention. FIG. 2 illustrates the independent testing module 10 in its inactive state and FIG. 3 illustrates the independent testing module 10 in its active state. The independent testing module 10 includes a housing 12 having a proximal end 14 and a distal end 16. A needle 18 can extend from the distal end 16 of the housing 12.

The needle 18 can include a sharpened distal end 20 and a proximal end 22 that extends into the housing 12. The needle 18 can be generally configured as a hypodermic-type needle with a bore 24 extending through its length. The testing module 10 can also include a viewing window 26, through which test strip 28 can be observed. The test strip 28 is disposed within the housing 12 behind the window 26, such that the operator can view any changes in the strip 28 during use. The testing module 10 can also include a slide 30 and a vacuum button 32 (as illustrated in FIGS. 4-6). In the inactive state illustrated in FIG. 2, the slide 30 is positioned toward the distal end of the testing module 10. When the needle 18 is inserted into the patient and testing is required the slide 30 can be moved from its distal, forward position to a proximal position. Slot 34, positioned on a side 36 of housing 12 in FIGS. 2 and 3, is configured to lock the slide 30 into place after it has been activated into the proximal position.

[0056] The button can comprise an elastic material, for example, silicone, latex, or polyurethane. In one non-limiting embodiment, button is thinner at the peak of the button's dome, and is thicker at the base of the dome.

[0057] FIGS. 4 and 5 illustrate a sectional view of the independent testing module 10 illustrated in FIGS. 2 and 3. FIG. 4 is a sectional view of the independent testing module 10 in the inactive position, as illustrated in FIG. 2, and FIG. 5 is a sectional view of the independent testing module 10 in the active position, as illustrated in FIG. 3. The housing 12 can define an inner space 38 near the proximal end 14 of the testing module 10. The test strip 28 can be disposed in this inner space 38. In addition, an absorbent pad 40 can be integrated into the bottom of the test strip 28 in this inner space 38. The test strip 28 can include a proximal end 42 and a distal end 44. Cap 46 is positioned on top of the junction between the proximal end of the needle 22 and the distal end 44 of the test strip 28.

[0058] The following concerns non-limiting embodiments of cap (46). The cap holds or positions the test strip. The cap holds or positions the proximal end of the needle. Also, the cap creates or defines small vacuum pathways from the vacuum button to the proximal end of the needle. In a preferred embodiment, the cap (46), is not removable.

[0059] In a non-limiting embodiment of the present disclosure, the absorbent pad is an integrated part of the test strip. In another non-limiting embodiment, the absorbent pad

is separate from, and does not occupy the same space as, the test strip. The absorbent pad increases the total volume of sample that enters the test strip. The absorbent pad can block the migration of blood cells, and thereby provide a clean field for development and detection (by clinician's eyes) of the color reaction. In addition, or alternatively, the absorbent pad can draw the biological fluid by way of capillary attraction, resulting in wetting of a broad area of the test strip. In another embodiment, the device comprises only a test strip and does not contain any absorbent pad. In one embodiment that does not contain an absorbent pad, the test strip does not disperse fluid by way of capillary attraction, and the biological fluid is sufficiently dispersed without capillary attraction. In another embodiment, the test strip is sufficiently thick (or thin but sufficiently opaque) that it blocks passage of red blood cells to the viewable area where the color reaction takes place. In yet another embodiment, the test strip has capillary attraction and is also sufficiently thick (or thin but sufficiently opaque) to block passage of red blood cells, and to prevent the red blood cells from residing in the viewable area where the color reaction takes place). Absorbent pad can comprise cellulose, polyvinylidene fluoride (PVDF), nitrocellulose, and the like. Filter material suitable as a matrix for test strips, and for serving as a reaction area for color reagents, and optionally for blocking red blood cells, and optionally for serving as a capillary attractant for attracting and dispersing a biological fluid, are available (EMD Millipore, Darmstadt, Germany; Millipore, Billerica, MA; Membrane Solutions, Plano, TX). US 4,855,240 of Rosenstein, US 4,703,017 of Campbell, and US 4,376,110 of David et al, disclose absorbent materials, capillary materials, test strips, labels, and immunoassays, are incorporated herein by reference in their entirety.

[0060] FIGS. 4 and 5 also illustrate a vacuum button 32 of the independent testing module 10. In the inactivated position illustrated in FIG. 4, the vacuum button 32 is depressed by slide 30. This keeps the vacuum button 32 depressed until the needle 18 is inserted and ready to extract blood. As illustrated in FIG. 5, once the device is in position, the slide 30 is retracted to the active position, releasing vacuum button 32, thus creating a vacuum and allowing blood to flow into the bore 24 of the needle 18. Locking the slide 30 in the active position prevents depression of the vacuum button 32, when the needle 18 is inserted into a vein of the patient, in turn preventing air from potentially being pushed into the access point or blood being squirted from the device

after it has been used. The blood aspirated into the testing module 10 is absorbed from the bottom end of the testing strip 28. The absorbent pad 40 can absorb the plasma sample after the completion of the signal detection reaction. The absorbent pad 40 can also include a porous backing and an absorbent dispersed, adsorbed, or coated into the pores of the porous backing. A color signal can appear within approximately 10 minutes within the viewing window 26, but could take less time or more time depending on the detecting antibodies contained in the test strip.

[0061] FIG. 6 illustrates an exploded view of the independent testing module 10 as shown in FIGS. 2-5. As shown in FIG. 6, the testing module includes the housing 12 and a needle 18 coupled to a distal end 16 of the housing 12. The housing 12 also defines the inner space 38 near the proximal end 14 of the testing module 10. The test strip 28 can be disposed in this inner space 38. In addition, an absorbent pad 40 can be integrated into the test strip 28 in this inner space 38. The test strip 28 can include a proximal end 42 and a distal end 44. Cap 46 is positioned on top of the junction between the proximal end of the needle 22 and the distal end 44 of the absorbent pad 40. FIG. 6 also illustrates the slide 30 and the vacuum button 32 which work together to release the vacuum for the independent testing module such that it can aspirate the blood sample. The slide 30 and vacuum button 32 also prevent the vacuum button from being re-depressed to prevent pushing any air into the entry site or allowing any blood to spurt out after use. The vacuum button 32 sits within an opening 48 defined by the housing 12. The slide 30 can lock into position via the slot 34, also illustrated in FIGS. 2 and 3. As illustrated, tab 31 interacts with a notch 31' in the architecture of slot 34 in order to lock the slide 30 into place. However, any suitable means of locking the slide into place can be used. Locking the slide 30 in the active position prevents depression of the vacuum button 32, when the needle 18 is inserted into a vein of the patient, in turn preventing air from potentially being pushed into the access point or blood being squirted from the device after it has been used. Cap 46 is also shown and is placed over the junction between the testing strip 28 and the proximal end 22 of the needle 18.

[0062] FIG. 7 illustrates a syringe with integrated allergy testing, in accordance with another embodiment of the integrated allergy testing system. As shown in FIG. 7, the syringe 100 includes a housing 102 having a proximal end 104 and a distal end 106. The proximal end 104 of the housing 102 can include flanges 108, 110 which can serve

as finger rests during use of the syringe 100. The housing 102 can include a window 112 positioned such that test strip positioned below the window is visible to a user of the syringe 100. The test strip resides within its own lumen or channel, such that only the distal end of the test strip is exposed to the blood that is aspirated within the syringe housing 102. A needle hub 114 can be positioned at the distal end 106 of the housing 102 and can be configured to couple to a hypodermic-type needle for aspirating blood into a lumen of the syringe 100. A syringe housing cap 116 can be coupled to the distal end 106 to hold the test strip in the housing 102. The syringe 100 can also include a plunger 118 extending into the lumen of the housing 102 for creating negative pressure to aspirate blood into the lumen of the syringe. The plunger 118 can include a thumb rest 119 positioned at a proximal end 117 of the plunger 118.

[0063] In embodiments, where test strip resides in its own lumen or channel, blood or other biological sample enters channel through a hole, slit, passage, or crevice, that is about 5% the distal-to-proximal length of the channel, about 10% the distal-to-proximal length of the channel, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 95%, about 100%, or longer, than the distal-to-proximal length of the channel. Where the slit or crevice is about 100% the distal-to-proximal length of the channel, the result is that blood entering the syringe, or entering a corresponding structure in the module (10), contacts that entire test strip essentially simultaneously.

[0064] Regarding the orientation of the channel with respect to the hole, slit, passage, or crevice, the hole, slit, or crevice, can start at a point corresponding to the distal-most portion of the channel, and then migrate proximally. Alternatively, the hole, slit, or crevice, can start at a point corresponding to the proximal-most portion of the channel, and then migrate distally. In yet another alternative, the hole, slit, passage, or crevice, can be situated entirely between the distal-most and proximal-most portions of the channel. For example, the hole or passage can be situated near the half-way point of the channel, where blood entering the hole migrates both in the proximal and in the distal directions.

[0065] In embodiments where the hole, slit, passage, or crevice, is about 5% the distal-to-proximal length of the channel, it may be the case that only about 5% of the

test strip is wetted by the blood or other biological sample. Alternatively, in embodiments where the hole, silt, passage, or crevice, is about 5% the distal-to-proximal length of the channel, it may be the case that greater than about 5% of the test strip is wetted by the blood or other biological sample, where this greater than amount results from migration of the biological sample through the test strip. Migration can by via diffusion, capillary force, or by a combination of diffusion and capillary force. The above narrative also applies to configurations where the hole, slit, passage, or crevice, is less than 90%, less than 80%, less than 70%, less than 60%, less than 50%, less than 40%, less than 30%, less than 20%, less than 10%, less than 5%, of the length of the distal-to-proximal length of the channel.

[0066] FIG. 8 illustrates a sectional view of the syringe illustrated in FIG. 7. As shown in FIG. 8, the syringe 100 includes the housing 102 defining a lumen 120, extending therethrough. The plunger 118 is shown extending into the lumen 120 of the housing 102. Additionally, FIG. 8 illustrates test strip 122 positioned within the housing 102 beneath window 112. The syringe housing cap 116 holds the test strip 122 in place beneath the window 112 for observation by the practitioner. Alternately, the test strip 122 can take the form of a cassette or any other appropriate form for positioning within the syringe 100. In addition, an absorbent pad 124 can be integrated into the test strip 122. The absorbent pad 124 can absorb the plasma sample after the completion of the signal detection reaction. The absorbent pad 124 can also include a porous backing and an absorbent dispersed, adsorbed, or coated into the pores of the porous backing. A color signal can appear within approximately 10 minutes within the viewing window 112, but could take less time or more time depending on the antibodies contained in the test strip.

[0067] FIG. 9 illustrates an exploded view of the syringe illustrated in FIGS. 7 and 8. FIG. 9 shows the housing 102 having a window 112 for the test strip 122. The syringe housing cap 116 can be used to hold the test strip in place, such that it does not move during testing. The plunger 118 can be configured to slide within the lumen 120 of the housing 112.

[0068] FIG. 10 illustrates a connector design for the integrated testing system in accordance with an embodiment of the invention. The connector 200, includes a housing 201, having a proximal end 202 and a distal end 204, and can be configured for

placement between a syringe body and a needle for the syringe. The connector 200 can be connected to the syringe body in a variety of different ways such as frictional hold, tabs, or any other suitable coupling. As illustrated in FIG. 10, the connector 200 can be coupled to the syringe via luer threads 206 positioned at the proximal end 202 of the connector 200. The connector 200 can also include a coupling 208 for coupling the connector 200 to a needle. The needle can take the form of a hypodermic-type needle or any other needle suitable for aspirating blood through the connector 200. The connector also includes a window 210 through which test strip (not shown) can be visualized.

[0069] FIG. 11 illustrates a sectional view of the embodiment shown in FIG. 10 and FIG. 12 illustrates an exploded view of the embodiment illustrated in FIGS. 10 and 11. FIGS. 11 and 12 illustrate the test strip 214 disposed within the connector housing 201. As illustrated, the test strip 214 is spirally wound within the connector housing 201. The test strip 214 can be viewed through window 210 in the housing 201. Blood can be aspirated into a lumen 212 defined by housing 201, when testing is required. In addition, an absorbent pad 216 can be positioned beneath the test strip 214. The absorbent pad 216 integrated into the test strip 228 can absorb the plasma sample after the completion of the signal detection reaction. The absorbent pad 216 can also include a porous backing and an absorbent dispersed, adsorbed, or coated into the pores of the porous backing. A color signal can appear within approximately 10 minutes within the viewing window 210, but could take less time or more time depending on the antibodies contained in the blood sample.

[0070] Alternately test strip, for example, an immunochromatographic test strip, can be incorporated into a number of different medical devices. One such example is an test strip incorporated into a "hemo-hopper," such as a blood reservoir in a medical tray or kit. The blood aspirated during access to the vessel would be disposed into the hemo-hopper. The sample could then be absorbed into the test strip. In addition, an absorbent pad can be positioned beneath the test strip. The absorbent pad can absorb the plasma sample after the completion of the signal detection reaction. The absorbent pad can also include a porous backing and an absorbent dispersed, adsorbed, or coated into the pores of the porous backing. A color signal can appear within

approximately 10 minutes, but could take less time or more time depending on the antibodies contained in the blood sample.

[0071] FIG. 13 (A, B) illustrates the end-cap that is a part of the module embodiment, and structures in the vicinity of the cap. The end-cap (346) is in contact with needle (318). The end-cap (346) defines part of cavity (348) where the vacuum button (32) can fit. A non-limiting embodiment of vacuum button (32) is shown in FIGS. 4-6. FIG. 13(A) shows cap without test strip, and FIG. 13 (B) shows cap with test strip.

[0072] While the method and apparatus have been described in terms of what are presently considered to be the most practical and preferred embodiments, it is to be understood that the disclosure need not be limited to the disclosed embodiments. It is intended to cover various modifications and similar arrangements included within the spirit and scope of the claims, the scope of which should be accorded the broadest interpretation so as to encompass all such modifications and similar structures. The present disclosure includes any and all embodiments of the following claims.

[0073] It should also be understood that a variety of changes may be made without departing from the essence of the invention. Such changes are also implicitly included in the description. They still fall within the scope of this invention. It should be understood that this disclosure is intended to yield a patent covering numerous aspects of the invention both independently and as an overall system and in both method and apparatus modes.

[0074] Further, each of the various elements of the invention and claims may also be achieved in a variety of manners. This disclosure should be understood to encompass each such variation, be it a variation of an embodiment of any apparatus embodiment, a method or process embodiment, or even merely a variation of any element of these.

[0075] Particularly, it should be understood that as the disclosure relates to elements of the invention, the words for each element may be expressed by equivalent apparatus terms or method terms -- even if only the function or result is the same.

[0076] Such equivalent, broader, or even more generic terms should be considered to be encompassed in the description of each element or action. Such terms can be

substituted where desired to make explicit the implicitly broad coverage to which this invention is entitled.

[0077] It should be understood that all actions may be expressed as a means for taking that action or as an element which causes that action.

[0078] Similarly, each physical element disclosed should be understood to encompass a disclosure of the action which that physical element facilitates.

[0079] Any patents, publications, or other references mentioned in this application for patent are hereby incorporated by reference.

[0080] Finally, all references listed in the Information Disclosure Statement or other information statement filed with the application are hereby appended and hereby incorporated by reference; however, as to each of the above, to the extent that such information or statements incorporated by reference might be considered inconsistent with the patenting of this/these invention(s), such statements are expressly not to be considered as made by the applicant.

[0081] In this regard it should be understood that for practical reasons and so as to avoid adding potentially hundreds of claims, the applicant has presented claims with initial dependencies only.

[0082] Support should be understood to exist to the degree required under new matter laws -- including but not limited to United States Patent Law 35 USC §132 or other such laws -- to permit the addition of any of the various dependencies or other elements presented under one independent claim or concept as dependencies or elements under any other independent claim or concept.

[0083] To the extent that insubstantial substitutes are made, to the extent that the applicant did not in fact draft any claim so as to literally encompass any particular embodiment, and to the extent otherwise applicable, the applicant should not be understood to have in any way intended to or actually relinquished such coverage as the applicant simply may not have been able to anticipate all eventualities; one skilled in the art, should not be reasonably expected to have drafted a claim that would have literally encompassed such alternative embodiments.

[0084] Further, the use of the transitional phrase "comprising" is used to maintain the "open-end" claims herein, according to traditional claim interpretation. Thus, unless the context requires otherwise, it should be understood that the term "compromise" or variations such as "comprises" or "comprising", are intended to imply the inclusion of a stated element or step or group of elements or steps but not the exclusion of any other element or step or group of elements or steps.

[0085] Such terms should be interpreted in their most expansive forms so as to afford the applicant the broadest coverage legally permissible.

[0086] The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, because numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to falling within the scope of the invention.

What is claimed is:

Claim 1. A device for testing the presence or absence of a substance in blood, comprising:

a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device;

a first chamber for receiving the withdrawn blood;

a second chamber configured for holding a test strip;

a test strip that is held within the second chamber;

a wall or panel that separates the first chamber from the second chamber;

at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber;

wherein the second chamber comprises a window for viewing the test strip,

wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and,

wherein the window is configured to allow visual detection of the visible signal.

Claim 2. The device of claim 1, that comprises a syringe and wherein the first chamber is defined by the housing or barrel of the syringe.

Claim 3. The device of claim 1 that is capable of being coupled to a syringe and to a needle, wherein the device has a hub that is capable of coupling to the hub of the syringe, and wherein the device has a coupler that is capable of coupling to a hub of a needle.

Claim 4. The device of claim 1, wherein the substance is an antibody that specifically binds to an antimicrobial agent.

Claim 5. The device of claim 1, wherein the substance is an antibody of the class IgG, IgA, IgM, or IgE.

Claim 6. The device of claim 1, wherein the second chamber comprises a flexible dome, and

wherein the flexible dome is capable of flexing radially outward;

wherein in use the flexible dome flexes radially outwards and creates a partial vacuum that is capable of drawing blood out of the first chamber and into the second chamber;

wherein a sliding latch is operably linked with the flexible dome;

wherein in use the sliding latch is capable of being slid over the dome to compress the flexible dome radially downwards and increase the pressure within the second chamber; and

wherein in use the sliding latch is capable of being slid away from the dome to release the dome and allow the dome to flex radially outwards thereby creating a partial vacuum in the second chamber.

Claim 7. The device of claim 1, further comprising an end-cap, wherein the end-cap is configured for contacting and stabilizing the test strip, and configured for contacting and stabilizing the proximal portion of a needle that is coupled to said device.

Claim 8. The device of claim 1, further comprising a needle, wherein the needle is reversibly coupled to the coupler.

Claim 9. The device of claim 1 that does not comprise a needle.

Claim 10. The device of claim 1, wherein the test strip is an immunochromatographic test strip.

Claim 11. A device for testing the presence or absence of an antibody in blood, wherein the antibody specifically binds to an antimicrobial agent, comprising:

a coupler that is capable of coupling with a hub of a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device;

a first chamber for receiving the withdrawn blood;

a second chamber configured for holding a test strip;

a test strip that is held within the second chamber;

a wall or panel that separates the first chamber from the second chamber;

at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber;

wherein the second chamber comprises a window for viewing the test strip;

wherein the test strip is capable of producing a visible signal that indicates the presence or absence, in the withdrawn blood, of the antibody that specifically binds to the antimicrobial agent; and,

wherein the window is configured to allow visual detection of the visible signal.

Claim 12. A process for allergy detection during catheterization, comprising:

the step of drawing blood from a subject into the first chamber of a device that comprises:

(a) a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device;

(b) a first chamber for receiving the withdrawn blood;

(c) a second chamber configured for holding a test strip;

(d) a test strip that is held within the second chamber;

(e) a wall or panel that separates the first chamber from the second chamber;

(f) at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber;

(g) wherein the second chamber comprises a window for viewing the test strip,

(h) wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and,

(i) wherein the window is configured to allow visual detection of the visible signal;

the step of allowing at least some of the drawn blood to enter the second chamber of the device;

wherein a needle is coupled to the device; and,

wherein in use, at least some of the withdrawn blood enters the needle and then enters the first chamber, then enters the second chamber, and then contacts the test strip.

Claim 13. The process of claim 12, further comprising a reaction that is mediated by the test strip, wherein the reaction produces a visual signal that indicates presence or absence of a substance that mediates an allergy.

Claim 14. The process of claim 12, wherein the drawing blood into the first chamber is urged by one or more of: (a) Blood pressure of the subject; (b) Vacuum produced by a syringe plunger of the device; (c) Vacuum produced by a flexible dome of the device; and (d) Capillary action of the test strip of the device.

Claim 15. The process of claim 12, wherein the test strip is configured for detecting an antibody that specifically binds an antimicrobial agent;

wherein in use the test strip provides a visual signal that the blood does not contain detectable antibodies that specifically bind to the specific antimicrobial agent;

followed by the step of inserting a catheter into the subject, wherein the catheter is impregnated or coated with the antimicrobial agent.

Claim 16. The process of claim 12, wherein the test strip is configured for detecting an antibody that specifically binds an antimicrobial agent;

wherein in use the test strip provides a visual signal that the blood does contain detectable antibodies that specifically bind to the specific antimicrobial agent;

followed by the step of making a decision on whether or not to insert a catheter that is impregnated or coated with the antimicrobial agent; and,

wherein the decision is to refrain from inserting the catheter in the subject,

followed by the step of inserting a catheter into the subject, wherein the catheter is not impregnated or coated with the antimicrobial agent.

Claim 17. A system comprising, in combination, a medical instrument that is capable of holding blood, and a medical device that comprises:

(a) a coupler or hub that is capable of coupling with a needle, wherein the needle is for withdrawing blood from a subject and for introducing the withdrawn blood into the device;

(b) a first chamber for receiving the withdrawn blood;

(c) a second chamber configured for holding a test strip;

(d) a test strip that is held within the second chamber;

(e) a wall or panel that separates the first chamber from the second chamber;

(f) at least one aperture in the wall or panel configuring for allowing blood to pass from the first chamber to the second chamber;

(g) wherein the second chamber comprises a window for viewing the test strip,

(h) wherein the test strip is capable of producing a visible signal that indicates the presence or absence of the substance in the withdrawn blood; and,

(i) wherein the window is configured to allow visual detection of the visible signal.

Claim 18. The system of claim 17, wherein the combination is a reversible combination or a permanent combination.

Claim 19. The system of claim 17, wherein the combination is a reversible combination, wherein the device and the medical instrument are held in combination by one or more of a clip, snap, lock, or tab.

Claim 20. The system of claim 17, wherein the medical instrument comprises one or more of a syringe, trocar, catheter, introducer, sheath, hub, pump, or valve.

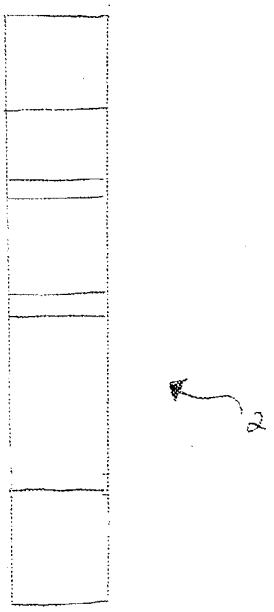


FIG. 1

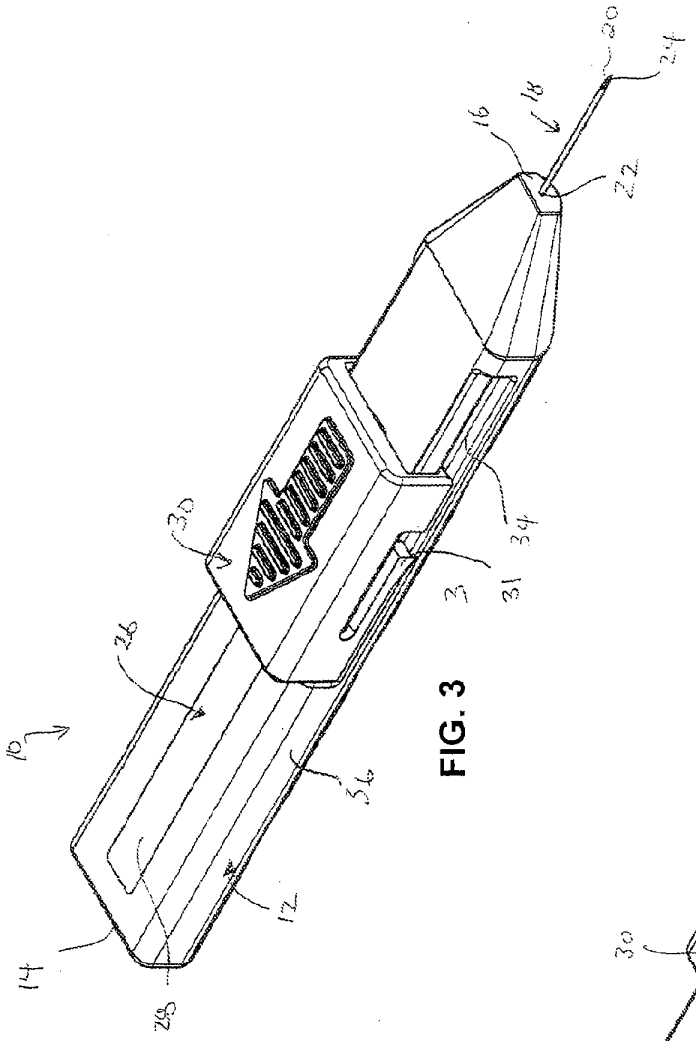

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FIG. 3

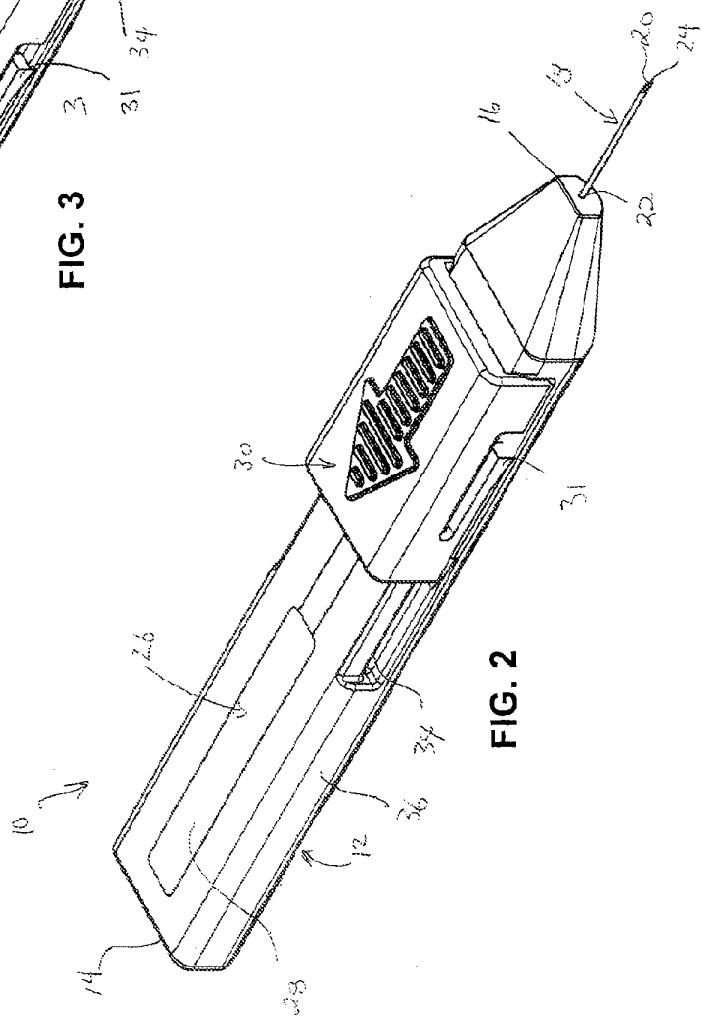

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FIG. 2

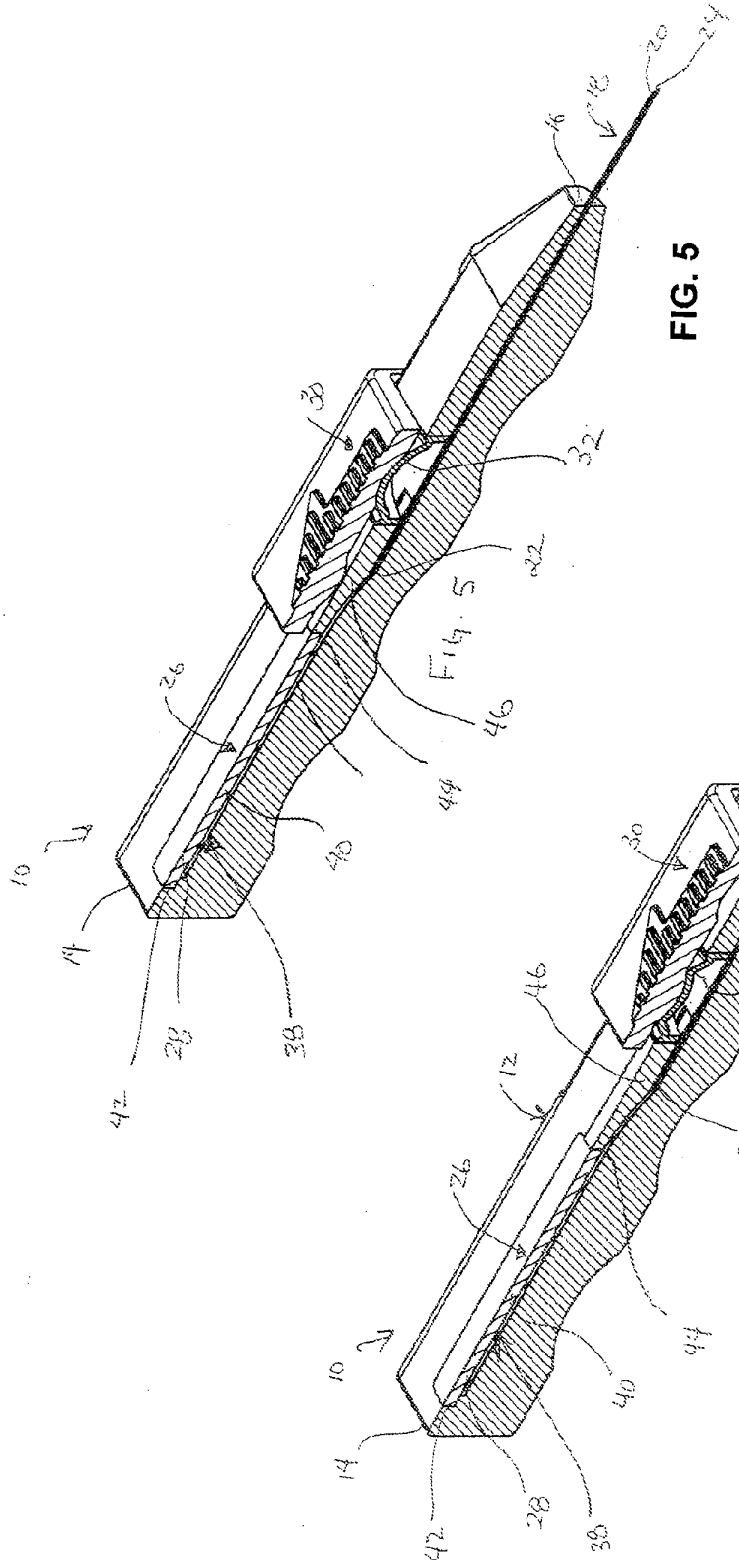

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FIG. 5

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FIG. 4

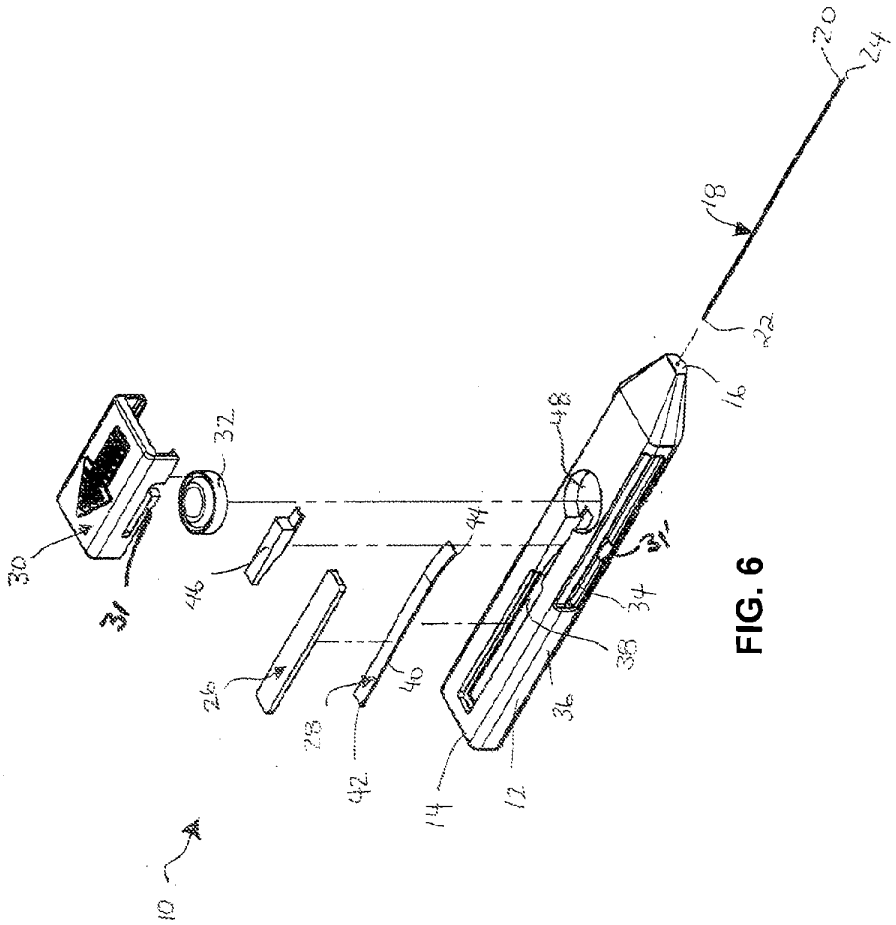


FIG. 6

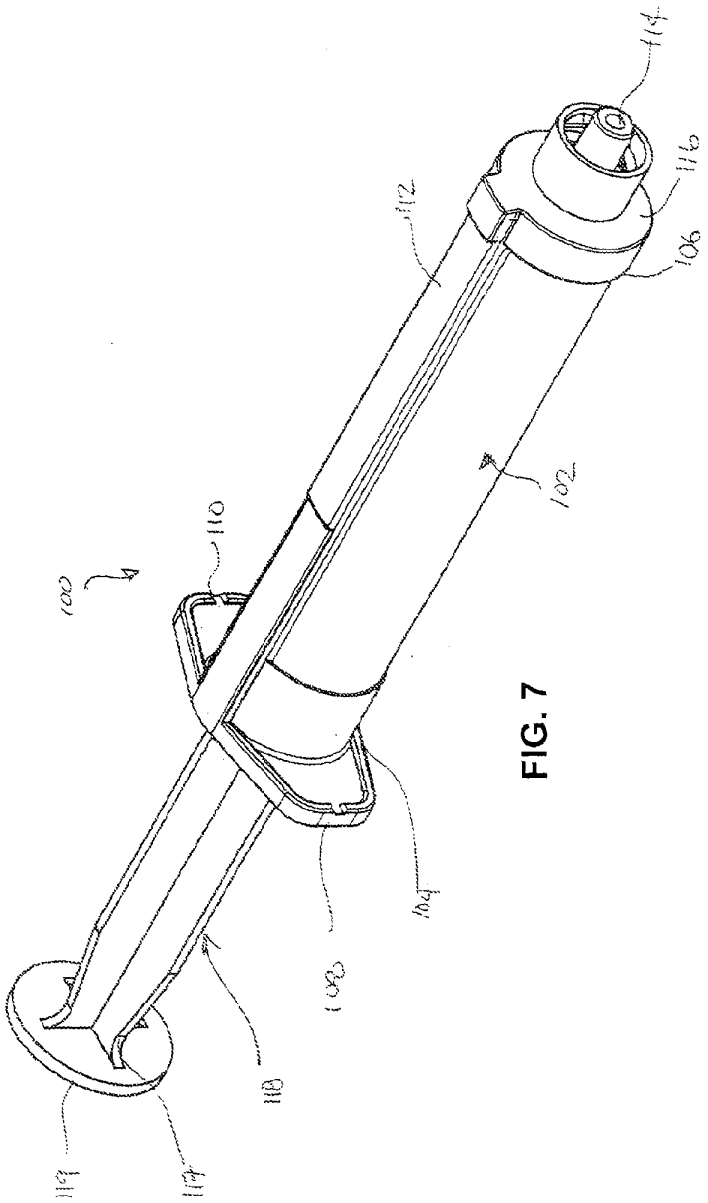


FIG. 7

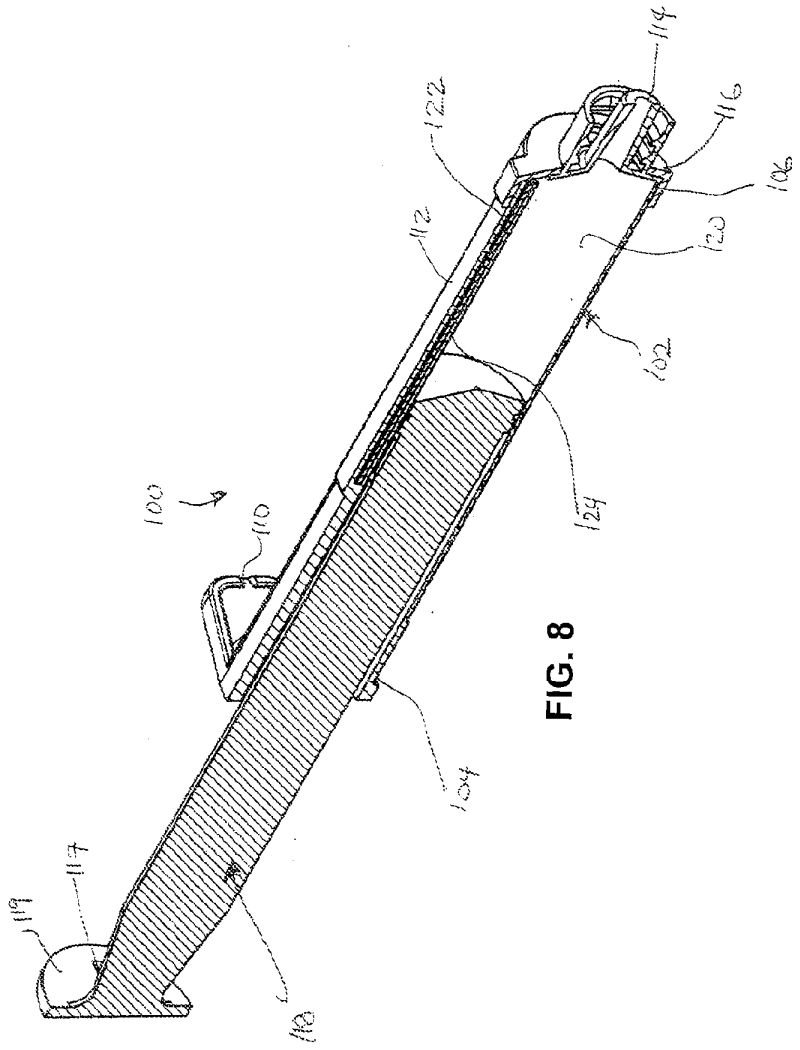


FIG. 8

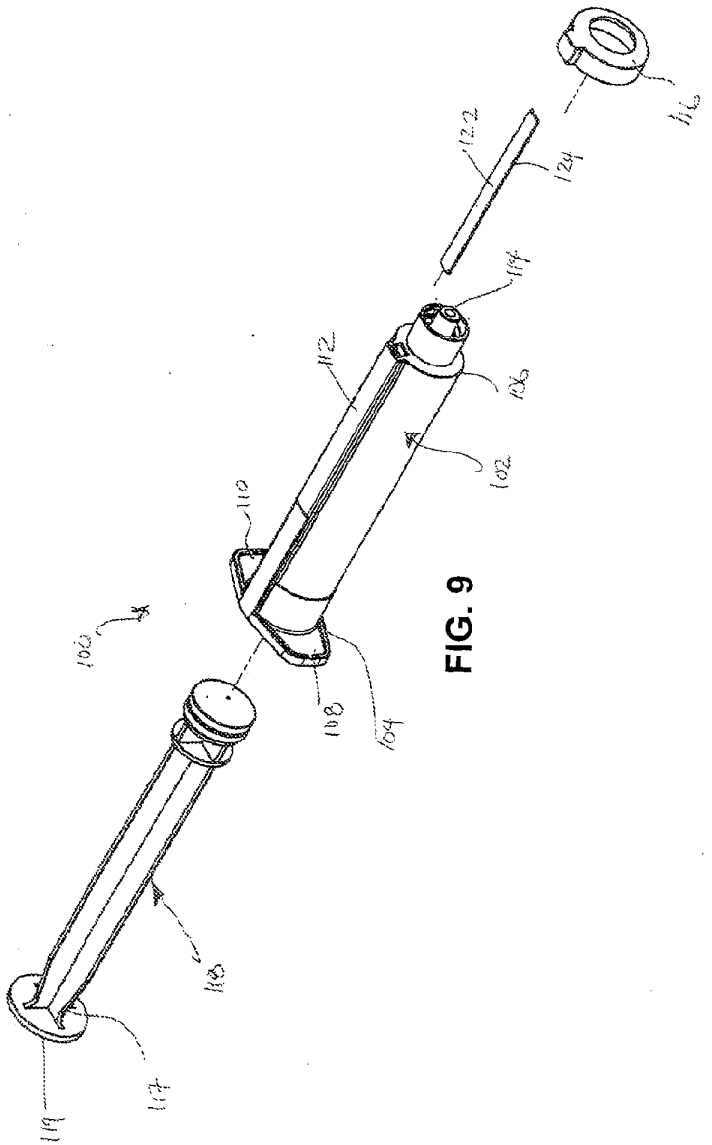


FIG. 9

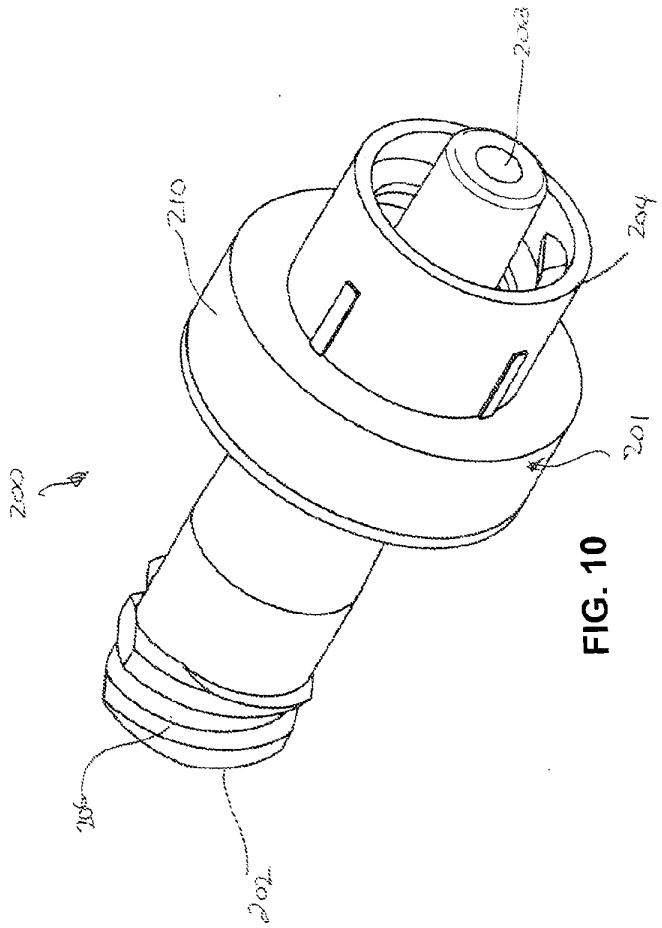


FIG. 10

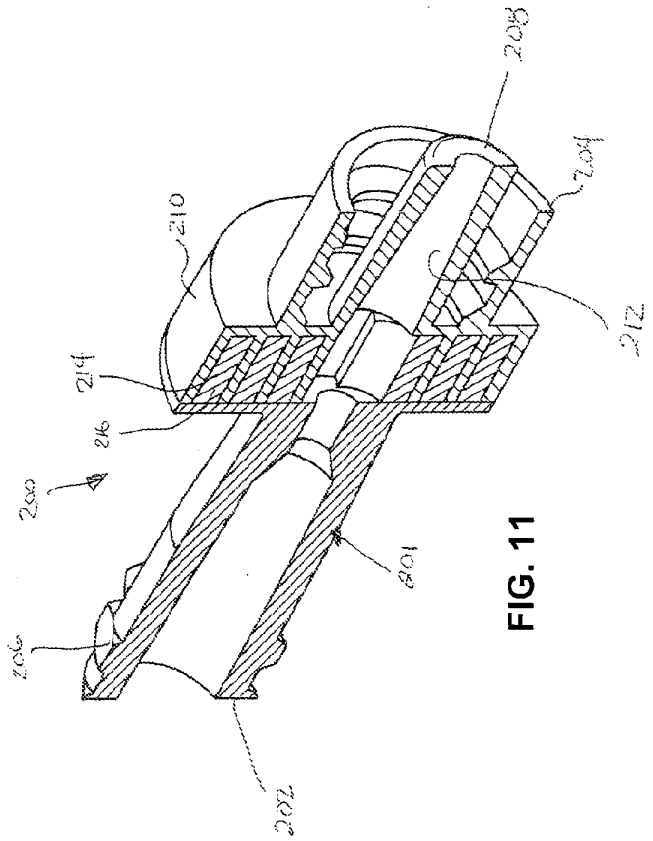


FIG. 11

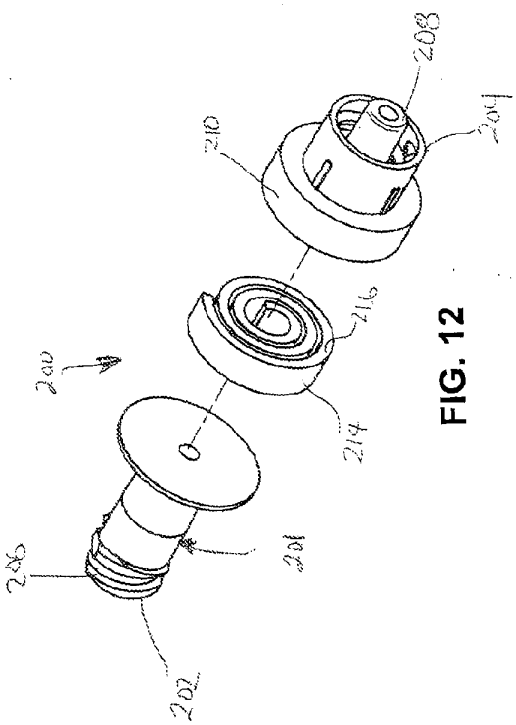
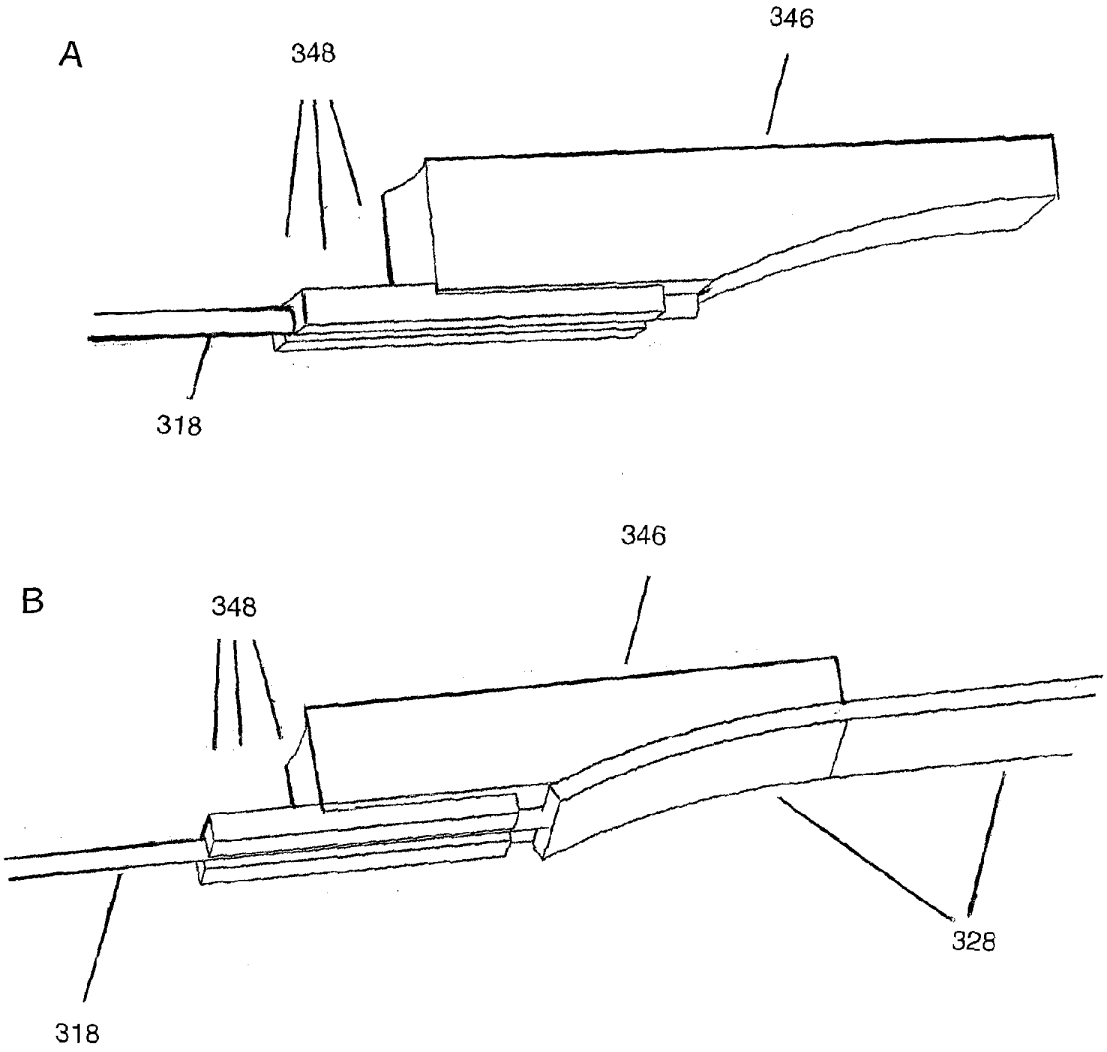


FIG. 12

Fig. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/067095

A. CLASSIFICATION OF SUBJECT MATTER

G01N 33/50(2006.01)i, G01N 33/52(2006.01)i, G01N 33/53(2006.01)i

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)

G01N 33/50; C25C 3/02; A61B 5/151; G01N 17/00; B32B 38/04; A61B 5/00

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: test strip, coupling, needle, chamber, window

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0112125 A1 (TAMIR, NILI) 30 April 2009 See paragraph [0100]; claims 1 and 5-6; figure 5.	1-20
A	US 2003-0109777 A1 (KLOEPFER, HANS G. et al.) 12 June 2003 See paragraph [0107]; claim 1; figures 1 and 5.	1-20
A	US 2003-0150745 A1 (TEODORCZYK, MARIA et al.) 14 August 2003 See claims 1, 8 and 13; figure 3.	1-20
A	US 2007-0161926 A1 (IMAMURA, TAKESHI et al.) 12 July 2007 See paragraph [0032]; claim 1; figure 2A.	1-20
A	US 2011-0046453 (KEIL, MICHAEL) 24 February 2011 See paragraphs [0017] and [0019]; claims 14-16; figures 1 and 7.	1-20

☐ 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
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 FEBRUARY 2013 (28.02.2013)	**04 MARCH 2013 (04.03.2013)**
Name and mailing address of the ISA/KR Facsimile No. 82-42-472-7140	Authorized officer LEE, Dong Yun Telephone No. 82-42-481-8734

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2012/067095

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/067095

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		WO 2011-020598 A2	24.02.2011
		WO 2011-020598 A3	14.04.2011

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(30) Priority Data:
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61/234,773 18 August 2009 (18.08.2009) US

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(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, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (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, 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: BLOOD COAGULATION INDUCING POLYMER HYDROGEL

(57) Abstract: The present application is drawn to a synthetic, polymer hydrogel-based material, which is able to actively induce the body's natural hemostatic coagulation process in blood or acellular plasma. The present invention provides the development of a primary amine containing polymer hydrogel capable of inducing blood coagulation and delivering therapeutics for hemostatic or wound care applications, and a method of forming such a primary amine containing polymer hydrogel capable of inducing the blood coagulation process. The primary amine containing polymer hydrogel is able to achieve the same end result as biological-based hemostatics, without the innate risk of disease transmission or immunological response, and at a fraction of the price. Furthermore, due to its inherent hydrogel-based design the material has the capability of arresting blood loss while simultaneously delivering therapeutics in a controlled manner, potentially revolutionizing the way in which wounds are treated.

WO 2010/062734 A1

BLOOD COAGULATION INDUCING POLYMER HYDROGEL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. provisional applications Serial Nos. 61/110,698, filed November 3, 2008 and 61/234,773, filed August 18, 2009, which are incorporated in their entireties by reference herein.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] This invention was made with government support under CTS0640778 awarded by the National Science Foundation. The U.S. Government has certain rights in this invention.

TECHNICAL FIELD

[0003] The present invention relates to a polymer material capable of actively inducing the blood coagulation cascade while simultaneously delivering therapeutics in a controlled manner for application in the wound care field.

BACKGROUND

[0004] Technology capable of effectively controlling traumatic hemorrhaging does not exist. As a result, millions of people around the world are dying every year. Over 3,000,000 worldwide, 156,000 in the U.S. alone, die from trauma related injuries each year. Half will die before they reach the hospital, and 80% will die within 24 hours of hospital admission. Uncontrolled hemorrhaging, or blood loss, accounts for almost half of these deaths. Moreover, on the battlefield an astounding 85% of military mortalities are due to blood loss, a statistic that has remained mostly unchanged since the Vietnam War. Army medics, emergency medical technicians (E.M.T.) personnel, and other various emergency responders need a product capable of providing rapid and effective hemostasis until they can get their patients to the operating room. Once at the operating room, hemostatic products are still crucial to surgeons who must control bleeding to maintain the stability of their patient.

[0005] Current products are either exorbitantly expensive, ineffective, and/or have adverse side effects. There is a clear need for a hemostatic product which is inexpensive,

effective, with little to no adverse side effects and medics, emergency responders, and surgeons are all looking for a solution. Furthermore, there is currently no existing product or material on the market with the capability of providing rapid hemostasis along with simultaneous drug delivery. A product which could effectively stop blood loss while simultaneously delivering potentially life-saving therapeutics such as adrenaline or insulin in a regulated manner would have a multitude of applications from the battlefield to the operating room.

[0006] Death may occur in minutes after a traumatic injury due to blood loss. The body has natural mechanisms to control hemorrhaging yet these processes may be insufficient in cases of excessive hemorrhaging, defective due to medical conditions such as hemophilia, or compromised due to adverse effects of medication like Coumadin. The natural hemostatic response is not adequate to control major hemorrhaging due to traumatic injury, which is the main reason why such injuries, if gone untreated, are typically fatal. Administration of biologically derived blood products to augment the native hemostatic response and to maintain adequate oxygen delivery to the brain and vital organs, carries significant risks including disease transmission, infection, pulmonary dysfunction, and immune response. Furthermore, many people have deficiencies within their hemostatic response i.e. hemophilia, which prevent them from adequately stopping blood loss. Millions of people around the world suffer from bleeding disorders, and are unable to clot blood effetively. Current treatments are typically limited to clotting factor (Factor VIII, Factor II) replacement therapies, which are typically painful and exorbitantly expensive. There is a clear need for an inexpensive, painless alternative to current treatments. Whether the injury overwhelms the body's clotting response or the native response is deficient or compromised, an inexpensive, synthetic material which has the ability to induce clotting effectively, while simultaneously delivering therapeutics would undoubtedly revolutionize the way in which wounds are treated.

[0007] The field of hemostatic agents and materials has expanded dramatically within the last decade. This considerable expansion and evolution of the field, throughout the last decade has also been accompanied by tremendous diversification resulting in a multitude of hemostatic products now available on the market, each with their own advantages and disadvantages. The hemostatic products currently available on the market today are either biological-based or synthetic-based. Biological-based hemostatics are comprised of animal or "animal derived" substrates which are able to initiate, amplify, and/or assist the natural

coagulation response. Although they have excellent hemostatic effects and work via the promotion of the body's natural responses, they are incredibly expensive (up to $500 per application) and carry risks of disease infection and severe immunological response. Synthetic hemostatic agents are typically less expensive and immune inert yet often fail to effectively induce the coagulation cascade. Such synthetic agents are mainly designed to be mere physical obstructions to impede blood flow while providing a scaffold for the coagulation process to occur. A purely synthetic, polymer-based hydrogel material capable of effectively inducing the body's natural coagulation response has enormous potential within the field. Such a material is unique to the market in that it could be used to effectively stop bleeding while simultaneously delivering necessary therapeutics to a wound site.

SUMMARY OF THE INVENTION

[0008] The inventors of the present application have developed a purely synthetic, polymer hydrogel-based material, which is able to actively induce the body's natural hemostatic coagulation process in blood or acellular plasma. There is currently no polymer hydrogel-based, synthetic hemostatic agent with the capability of inducing the formation of a natural hemostatic matrix in the absence of platelets or blood cells. Since the material is able to induce the formation of a natural hemostatic plug in the absence of platelets or cells, it has enormous potential as a hemostatic agent in surgery, to treat trauma victims, and especially for patients with platelet disorders. The material is able to achieve the same end result as biological-based hemostatics, without the innate risk of disease transmission or immunological response, and at a fraction of the price. Furthermore, due to its inherent hydrogel-based design the material has the capability of arresting blood loss while simultaneously delivering therapeutics in a controlled manner, potentially revolutionizing the way in which wounds are treated.

[0009] The blood coagulation cascade may be activated via two distinct routes, the tissue factor pathway and the intrinsic pathway, also known as the contact activation pathway. Both pathways eventually result in the activation of a common pathway, which leads to the formation of a fibrin-based hemostatic clot Our research has shown that a material is able to induce the formation of fibrin via the tissue pathway factor Specifically, a positively charged polymer network with adequate mechanical rigidity is capable of efficiently and effectively inducing the activation of FVII, which in turn leads to the activation of the common pathway and subsequent fibrin formation. Furthermore, the material is able to induce the activation of

FVII irrespective of calcium or platelets which are typically vital cofactors of the process.

[0010] In one aspect, the present invention provides a cross-linked primary amine containing polymer hydrogel capable of inducing blood coagulation, and subsequent fibrin clot formation, while simultaneously delivering therapeutics in a controlled or regulated manner for wound care applications.

[0011] In another aspect the present invention is able to induce coagulation in Factor XII, XI, IX, VIII, and V deficient blood plasma.

[0012] In another aspect the present invention is capable of inducing the activation of FVII irrespective of calcium and platelets.

[0013] In another aspect, the present invention provides a method of forming the specific type of cross-linked primary amine containing polymer hydrogel in order to effectively induce blood coagulation: (a) adding either a primary amine containing monomer or primary amine containing polymer with a pKa greater than 7.4 thereby being positively charged within a plasma or blood environment (pH 7.4); (b) addition of additional monomers different from the initial primary amine containing monomer; (c) forming a polymer matrix by initiating polymerization of monomer units into polymer strand; (d) cross-linking the polymer strands to produce a polymeric mesh network.

[0014] In other aspects, the present invention provides various uses for a polymer hydrogel capable of inducing blood coagulation and delivering therapeutics in a controlled manner, in the health care field.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **Figure 1: Coagulate complex formed by optimal hydrogel after immersion in citrated plasma.** Typical coagulate complex (fibrin-hydrogel complex) formed after rotating the optimal hydrogel in human plasma (4 % w/v sodium citrate) for 18 hours.

[0016] **Figure 2: Characterization images (H&E, IHC, ESEM) of coagulate complex formed by optimal hydrogel after immersion in citrated plasma.** (**A**) H&E stained micrograph image of coagulate complex. Polymer hydrogel appears as lighter, smoother material on right side of the micrograph while fibrin appears as the darker, rougher material on the left side of them micrograph. (**B**) IHC stained micrograph image of coagulate complex. (**C**) ESEM surface image of the coagulate complex.

[0017] **Figure 3: Optimization experiment.** Experiment aimed to investigate the dependence of fibrin formation on various compositional factors including total monomer

concentration (acrylamide + APM + BIS), positive electrostatic charge (APM), and cross-linker ratio (acrylamide:APM:BIS). Acrylamide concentration is located on the horizontal axis while APM concentration is on the vertical axis. BIS concentration is also indicated on the horizontal axis and is kept constant for each respective acrylamide concentration. The amount of fibrin formation induced by each composition was visually scored from 0 (no fibrin formation) to 10 (substantial fibrin formation). All samples were run in triplicate.

[0018] Figure 4. Factor deficient and factor inhibited plasma experiment. Optimal hydrogel composition tested in various factor deficient and factor inhibited plasmas. The resulting fibrin formation was visually scored from 0 (no fibrin formation) to 10 (substantial fibrin formation) and graphed accordingly. All samples were run in triplicate.

[0019] Figure 5: Kinetic biological mechanism experiments. Factor VIIa concentration (**A**), calcium concentration (**B**) , and TFPI activity (**C**) was measured in human plasma containing various hydrogel compositions at 30, 90, and 180 minutes (left axis: bar graph). The amount of fibrin formation was also rated for each composition at each time point (right axis: line graph). Data is representative of an average and corresponding standard deviation (error bar) of three (n=3) separate sample trials. Asterisk (*) indicates duplicate sample point.

[0020] Figure 6: Dynamic mechanical analysis. Dynamic mechanical analysis of three compositions used in the kinetic biological mechanism experiments (FVIIa, calcium, TFPI) ranging from high APM, low acrylamide and BIS content (composition A) to low APM, high acrylamide and BIS content (composition F). Spectra for sample compositions C and F are shifted vertically to avoid overlapping of data.

[0021] Figure 7: Fresh sheep blood experiment. 250 mg of our hydrogel material (**A**) compared to a control (**B**). Clotting time of blood with material was dramatically decreased (~45 seconds) compared to control (~10 minutes).

[0022] Figure 8: Prototype images. (**A**) Computer generated graphic of prototype used in animal experiment. (**B**) Actual prototype used in animal trial.

[0023] Figure 9: Animal trial. (**A**) Image of lung at time of incision, before hydrogel was applied. (**B**) Image of the incision site after the hydrogel prototype bandage was applied for approximately 2 minutes.

[0024] Figure 10: Stained lung section of incision site. Micrograph of hematoxylin and eosin (H&E) stained section of incision site after hydrogel material was applied for two minutes.

DETAILED DESCRIPTION OF THE INVENTION

[0025] A reference to an element by the indefinite article "a" or "an" does not exclude the possibility that more than one of the element is present. Rather, the article "a" or "an" is intended to mean one or more (or at least one) unless the text expressly indicates otherwise. The terms "first," "second," and so on, when referring to an element, are not intended to suggest a location or ordering of the elements. Rather, the terms are used as labels to facilitate discussion and distinguish elements from one another.

[0026] The foregoing description and examples have been set forth merely to illustrate the invention and are not intended to be limiting. Each of the disclosed aspects and embodiments of the present invention may be considered individually or in combination with other aspects, embodiments, and variations of the invention. Modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art and such modifications are within the scope of the present invention.

[0027] The present invention provides the development of a primary amine containing polymer hydrogel capable of inducing blood coagulation and delivering therapeutics for hemostatic or wound care applications. Various therapeutics intended to be delivered include but are not limited to ester or amide based anesthetics such as Novocain or Lidocain, antibiotics such as erythromycin or bacitracin, vasoconstrictors such as adrenaline, and pain relievers or anti-inflammatory medicines such as topricin, acetaminophen, or ibuprofen. The hydrogel may be designed in order to deliver the drugs in various ways including based on a swelling change, a change in pH, or via the introduction of a magnetic or electric field.

[0028] The present invention provides the development of a primary amine containing polymer hydrogel capable of inducing blood coagulation and delivering other hemostatic agents for hemostatic or wound care applications, including biological-based hemostatic agents and non biological-based hemostatic agents.

[0029] Biological-based hemostatics contain, incorporate, or are derived from biological substrates, i.e. proteins, or cells. They can further be subdivided into the type of biological substrates incorporated into the system including collagen, thrombin, fibrin, albumin, and/or platelets.

[0030] Collagen is the main protein of connective tissue in mammals, including the skin, bones, ligaments, and tendons making up about 30% of the total protein in the body. In addition to providing structural integrity for the animal body, including all organs, collagen also activates the contact activation pathway of the coagulation cascade. Due to collagen's

ability to induce coagulation, along with the fact that is it naturally occurring, makes it an ideal choice for a hemostatic agent. Collagen is typically incorporated into the products via gelatin or microfibrillar form. Gelatin is an irreversibly hydrolyzed form of collagen and may be prepared as a powder, sponge, sheet, film or foam. Gelatin products are typically pliable, easy to handle, and relatively inert. When placed in soft tissue gelatin products typically absorb in 4 to 6 weeks, yet when applied to bleeding nasal, rectal or vaginal mucosa, will liquefy in approximately 2 to 5 days. The product Gelfoam (Pfizer, New York, NY), first introduced in 1945, is produced from purified pork skin gelatin granules. The foam swells up to 45 times its original dry weight and 200% of its initial volume.

[0031] Microfibrillar collagen is the predominant form used in modern hemostatic products. The collagen network acts as a framework which aggregates clotting factors, platelets, along with various coagulative and adhesive proteins to facilitate clot formation. Furthermore, the collagen fibrils are able to efficiently activate the contact activation coagulation pathway. The product is typically formed into various products including powder (shredded fibrils), sheets, and sponges. Market examples include Ultrafoam and Avitene (Davol Inc., Cranston, RI), Instat (Johnson & Johnson, Langhorne, PA), Helistat and Helitene (Integra LifeSciences, Plainsboro, NJ), Collatape/CollaCote/CollaPlug (Integra Lifesciences Corporation, Plainsboro, NJ), Collastat and Collatene (Xemax, Napa, CA).

[0032] Collagen-based hemostatic products are easily removable, cause little aggravation to the wound site, and can be very effective hemostats (especially relative to cellulose or gelatin hemostats). Disadvantages of collagen products include their prohibitive high price (around $150 per dressing), poor biodegradability, inherent risk of antigenicity, low solubility (difficult to make concentrated solutions), and handling difficulties since the products will irreversibly adhere to any hydrated surface.

[0033] Thrombin is the central activating enzyme of the common coagulation pathway. Thrombin circulates within the blood in its precursor, or zymogen form, prothrombin. Prothrombin is specifically cleaved to produce the enzyme thrombin. The main role of thrombin in the coagulation pathway is to convert fibrinogen into fibrin, which in turn is covalently cross-linked to produce a hemostatic plug. Thrombin-based products are typically sold in liquid or powder form and include Thrombostat (ParkeDavis, Ann Arbor, MI), Thrombin-JMI (King Pharmaceuticals, Briston, TN), and Quixil (Omrix Biopharmaceuticals Ltd, Tel Hashomer, Israel). There are also several combination products which include Evicel

(Johnson & Johnson, Langhorne, PA) which is a combination of thrombin and fibrin used mainly as a tissue sealant, along with FloSeal (Baxter Healthcare Corporation, Westlake Village, CA) and SurgiFlow which are both hybrid products composed of bovine or porcine gelatin and thrombin.

[0034] Thrombin-based products take advantage of the natural physiologic coagulation response by augmenting, amplifying, and assisting the process. Advantages of these products include low risk of foreign body or inflammatory reactions, firm attachment to wound bed, and its excellent hemostatic effect, specifically with patients that have platelet dysfunctions. Another advantage of thrombin is the versatility that the product may be applied, in powder or liquid (spray on) form. Disadvantages of these products include their often prohibitive high price ($75-$300 per application), difficulty of use including the inconvenience of premixing preparation, along with the risk of intravenous introduction which may result in intravascular clotting.

[0035] Fibrin is a fibrillar protein which is polymerized and cross-linked to form a mesh network, typically at the site of an injury after the induction of the coagulation cascade. The mesh network, incorporative of other various proteins and platelets, forms a hemostatic plug to prevent continuous or further blood loss. Fibrin is activated from its inert zymogen, fibrinogen, by thrombin. Fibrin is in turn polymerized and covalently cross-linked by another coagulation factor, known as Factor XIIIa. Due to its natural mechanical hemostatic role fibrin has been commercially used to control blood flow since the early 1900s. Most fibrin glues or fibrin sealants are derived from human and bovine proteins. The product is typically sold in the form of a dual syringe. The first syringe compartment contains the matrix and matrix stabilizing components including fibrinogen, factor XIII, fibronectin, and fibrinolysis inhibitors. The second syringe compartment contains the activating agent, typically thrombin and calcium chloride. At the time of application, the contents of both syringes are ejected, combining to activate fibrin matrix formation which typically takes a matter of seconds to set and approximately 5 to 10 days to degrade or absorb into the body. Various fibrin sealants on the market include Tiseel (Baxter HealthCare Corporation, Westlake Village, CA), FibRx (CryoLife Inc., Kennesaw, GA), Crosseel (Johnson & Johnson, Langhorne, PA), Hemaseel (Haemacure Corporation, Montreal, Quebec), Beriplast P (Aventis Behring, King of Prussia, PA), and Bolheal (Kaketsuken, Kumamoto, Japan).

[0036] Fibrin-based hemostatics or tissue sealants are fast-acting, composed of native coagulative factors, are biodegradable, do not promote inflammation or tissue necrosis, have diverse applications, and are particularly useful in patients with coagulation deficiencies such as hemophilia or von Willebrand's disease. Major disadvantages of fibrin-based hemostatics include their often prohibitive price ($100- $300/mL), their fragile nature, and difficulty of handling and application.

[0037] Other prominent biological-based hemostatic products include those composed of covalently cross-linked protein networks such as BioGlue (Cryolife, Kennewsaw, GA), along with products which incorporate platelets such as Costasis, marketed as Vitagel (Orthovita, Malvern, PA). BioGlue is comprised of bovine serum albumin, and various other proteins, cross-linked with glutaraldehyde to form a rigid, insoluble matrix. The reaction occurs spontaneously upon the introduction of glutaraldehyde to the protein mixture, and requires no external factors such as coagulation factors. Disadvantages of the product include the high price ($300-$425/5 ml application), mediocre hemostatic effect, necessity of a dry environment for application, the toxic effects associated with tissue exposure to glutaraldehyde, and risk of immune reactions associated with glutaraldehyde-based products.

[0038] Costasis is a combination product combining bovine collagen and the patient's own platelets. The collagen within the product promotes the initiation of the contact activation pathway of the coagulation cascade. The presence of platelets in such a product improves overall clot strength and supplies various growth factors which facilitate tissue regeneration. Disadvantages include high price ($100- $150/mL) and difficultly of application.

[0039] Non biological-based, or synthetic, hemostatic agents are defined as any products which do not incorporate biological materials, or more specifically animal derived components. Synthetic hemostatics are typically cheaper, easier to use, and easier to apply relative to their biological counterparts. Furthermore, synthetic hemostatics have no innate antigenicity, rarely induce immune responses or inflammatory reactions, and are inherently free of disease vectors." The main classes of synthetic hemostatics include cyanoacrylates, polysaccharides (e.g. oxidized cellulose, N-acetyl glucosamine), synthetic polymers, and mineral/metal based.

[0040] Cyanoacrylates are liquids that rapidly polymerize. These products create a tight seal between tissues, obstructing blood flow. Cyanoacrylates are categorized upon their

length. Shorter chain cyanoacrylates (ethyl cyanoacrylates) are typically quicker to absorb yet more toxic relative to intermediate (butyl cyanoacrylates) or longer chain cyanoacrylates (octyl cyanoacrylates). Due to their inherent high toxicity few hemostatic products composed of short chain cyanoacrylates have reached the market. There is however some research supporting the efficacy of Krazy Glue (ethyl-2-cyanoacrylate, Elmer's, Columbus, OH) for cutaneous wound closure. Cohera Medical Corporation is currently in the process of developing a butyl cyanoacrylate (isobutyl-2-cyanoacrylate), marketed as TissuGlu (Cohera Medical Inc., Pittsburgh, PA). Furthermore, there are currently several octyl acrylate-based hemostatic products that are FDA-approved for skin closure which include Dermabond (Ethicon, Somerville, NJ) and Band-Aid Liquid Bandage (Johnson & Johnson, Langhore, PA).

[0041] Cyanoacrylates are typically nonreactive, do not promote infection, are rapidly curing, and are only moderately expensive. Disadvantages of cyanoacrylates and cyanoacrylate-based hemostatics include difficulty of application due to their highly adhesive nature, and risk of tissue neurotoxicity, fibrosis and inflammatory reactions.

[0042] The two main polysaccharides used as hemostatics today are oxidized cellulose and poly-N-acetyl glucosamine. The hemostatic effects of certain polysaccharides, specifically oxidized cellulose and N-acetyl glucosamine, have been known since the early twentieth century. Oxidized cellulose is derived from plant fiber, which is in turn oxidized in the presence of nitrogen dioxide to form cellulosic acid. Oxidized cellulose activates the coagulation cascade (contact activation pathway) and accelerates thrombin generation within the body. Furthermore, the polysaccharide meshwork serves as a physical framework for coagulation to occur, with moderate absorbent properties. Oxidized cellulose products on the market today include Oxycel (Becton Dickinson, Franklin Lakes, NJ), Celox (Medtrade Products Ltd., Crewe, England), Surgicel (Ethicon Incorporation), and BloodStop (LifeScience PLUS, Inc., Santa Clara, CA).

[0043] Cellulose-based hemostatics are relatively easy to handle, fully absorbable and biodegradable (over 1 to 6 weeks), relatively inexpensive, and have antibacterial properties. The major drawback of these products is the risk of foreign body reactions. Furthermore, these products have only moderate coagulation-inducing capability and therefore are reserved as an adjunct to the natural response rather than a synthetic replacement.

[0044] Poly-N-acetyl glucosamine, also known as chitin or chitosan, is a complex polysaccharide produced by fermenting microalgal cultures. The hemostatic effects of poly-N-acetyl glucosamine are believed to be a result of the attraction and binding of circulating blood cells. The positive charges on the polymer attract the negatively charged erythrocytes, to help seal the clot. Poly-N-acetyl glucosamine also has vasospasm effects. Poly-N-acetyl glucosamine products include HemCon (HemCon Inc., Portland, OR), TraumaDex (Medafor, Minneapolis, MN), SyvekPatch (Marine Polymer Technologies Inc., Danvers, MA), Clo-Sur P.A.D. (Scion Cardio-Vascular, Miami, FL), and Chito-Seal (Abbott Vascular Devices, Redwood, City, CA).1

[0045] Advantages of poly-N-acetyl glucosamine dressings include their ease of application, robustness, and lack of toxicity. Disadvantages include the high cost ($100 per unit), and variability of efficacy between batches.

[0046] Most polymer-based hemostatics are designed to provide a mechanical tissue sealant. The majority of products on the market today are composed of polyethylene glycol (PEG) which are applied and polymerized at the wound site. The polymer is typically cross-linked with itself or with a primer to yield a robust framework stopping blow flow and sealing tissue. Most PEG products undergo biodegradation in approximately 30 days. PEG products include Coseal (Baxter Healthcare Corporation, Westlake Village, CA) and AdvaSeal-S (Genzyme Corporation, Cambridge, MA). PEG-based hemostatics or tissue sealants are typically non inflammatory, do not induce immune response, and are biodegradable. Drawbacks include difficulty of application and high price ($400/application).

[0047] Pro QR Powder (Biolife, Sarasota, FL) is another polymer-based hemostatic on the market today. Pro QR is a combination product of a hydrophilic polymer and a potassium iron oxyacid salt. The polymer is absorptive of blood flow, promoting the formation of a natural blood clot while the potassium salt component releases iron which complexes with proteins and activates hemostatic channels. The product is inexpensive, nontoxic, easily stored, flexible, stops bleeding rapidly, and is available over the counter. The main drawback of the product is its awkward application.

[0048] The final class of non-biological, or synthetic, hemostatics includes those which incorporate metal salts or minerals such as zinc, iron, silver nitrate, or aluminum chloride. Although this class of hemostatics are typically easy to use, cost-effective, and provide adequate hemostatic effects their toxic side effects limit their appeal.

[0049] Zinc paste was first used to fix tissue after surgery in the early 1940s. Zinc paste solutions have impressive hemostatic abilities but are rarely used do to their harmful side effects including pain and toxicity of the site. Monsel's solution is a 20% ferric subsulfate solution, which is believed to occlude vessels via protein precipitation. Monsel's solution is easy to obtain, cost-effective, and resistant to bacterial contamination. Major disadvantages include its caustic and toxic nature which may promote melanocyte activity, increased erythema, dermal fibrosis, and reepithelialization. Silver nitrate is typically used as a 10% solution and coagulates blood through protein precipitation. Silver nitrate is cost-effective, easy to use, and has potent antibacterial properties. Disadvantages include its severe tissue toxicity, risk of permanent skin discoloration, and the painful burning sensation experienced upon application. Aluminum chloride has modest hemostatic properties and is prepared in concentrations of 20% to 40% in water, alcohol, ether, or glycerol. Its mechanism of action is thought to be caused by the hydrolysis of the salt, resulting in the generation of hydrogen chloride which causes vasoconstriction, and can assist in the activation of the extrinsic coagulation pathway. Aluminum chloride is cost effective, easy to use, and may be stored at room temperature. Side effects of its use include painful paresthesias, tissue irritation, and reepithelialization. Aluminum chloride solutions are marketed as Drysol and Xerac AC (person-Covey, Dallas, TX).I

[0050] A small subclass of hemostatics is based upon various mixtures of minerals. Zeolite is a granular mixture of silicon, aluminum, sodium, and magnesium derived from lava rock. When coming into contact with blood the mixture absorbs water, concentrating platelets and coagulation factors within the wound, accelerating the clotting process. QuikClot (Z-Medica, Wallingford, CT) and WoundStat (TraumaCure, Bethesda, MD) are two main products based upon a zeolite mixture. Zeolite is inexpensive, easy to manufacture, clots fairly quickly, robust under various conditions, and is fairly immunological inert. The main drawback of the formulation is the risk of thermal injury associated with use.

[0051] A hydrogel is generically defined as an insoluble, cross-linked network of polymer chains which swells in an aqueous environment. A hydrogel may be chemically cross-linked through covalent bonds or physically cross-linked through entanglements or non-covalent interactions. Due to their unique properties hydrogels have been used in various pharmaceutical and biomedical applications. Since it is possible to create hydrogel constructs with specific degradative and swelling characteristics their potential for tissue engineering

and artificial implantation is immense. Furthermore, because hydrogels can be engineered with "smart" swelling behavior based on time, pH, ionic concentration, electrical, or magnetic stimuli they have been used with incredible success as drug delivery systems.

[0052] A cationic, acrylamide-based hydrogel has been developed which exhibits unique and potent coagulation-inducing effects upon the interaction with blood or acellular plasma. The hydrogel is composed of acrylamide, N-(3-Aminopropy)methacrylamide hydrochloride, and cross-linked with N-N'- methylenebisacrylamide. Upon interaction with acellular plasma the hydrogel initiates the coagulation cascade which results in the formation of a natural, fibrin-based hemostatic matrix (Figure 1). The stained microscopic images clearly show two distinct materials; the polymer hydrogel, which appears smooth and glassy on the right side of each image and a fibrin layer, which surrounds the polymer hydrogel located on the left side of each image.

[0053] In one aspect, the present invention provides a specific method of forming such a primary amine containing polymer hydrogel capable of inducing the blood coagulation process. In one embodiment, the primary amine monomer may be a strong base (wherein its ability to exhibit a positive charge is largely pH independent). In another embodiment, the primary amine monomer may be a weak base (wherein its ability to exhibit a positive charge is largely pH dependent). In yet another embodiment, the primary amine monomer is a weak base with a pKa above 7.4 and is able to exhibit a strong positive charge at the pH of blood and plasma (~7.4).

[0054] The method involves mixing at least one monomer with a primary amine group, along with desired other monomers, different from the initial primary amine containing monomer in a solvent, specifically an aqueous solvent. The polymer hydrogel is formed by polymerizing the monomers and cross-linking either after or during the polymerization process. Preferably, the polymer hydrogel is cross-linked in such a way so as to ensure the creation of pockets within the hydrogel which are incredibly dense with primary amine functionality. These dense pockets of positive electrostatic charge are able to induce coagulation through a Factor VII dependent mechanism. Without being bound to any specific theory, it is believed that that hydrogel acts as a catalyst activating and enhancing the functioning of Factor VII along with the Factor VII-tissue factor complex. Research has shown that this phenomenon is dependent on positive electrostatic charge and the mechanical rigidity of the hydrogel formed. That is to say, the primary amine monomer, within the hydrogel, should be positively charged at the pH of blood and/or plasma, 7.4. Therefore, if

the monomer is a weak base it preferably has a pKa of at least 7.4, more preferably at least 8, and even more preferably, at least 8.5, to ensure the predominant majority of the monomers are hydrogenated bearing a positive charge. Furthermore, as stated previously the amine monomer containing polymer strand must be sufficiently cross-linked to create an appropriately rigid material.

[0055] In certain embodiments, the monomer units are capable of exhibiting an electrostatic charge in an aqueous solution. In particular the primary amine containing monomer is able to exhibit a positive electrostatic in a salt buffered, aqueous environment of pH 7.4 (blood/plasma). In some cases, the contributing monomer units may be acidic or basic, which under the appropriate pH conditions, exhibit a negative or positive electrostatic charge, respectively. The acid/base monomer units may have varying levels of acidity/basicity, which will determine the extent to which the monomer units will be present in the anionic/cationic form at the pH level of the aqueous solution. With respect to acidic monomer units, the monomer unit may be a strong acid (in which its ability to exhibit a negative charge is largely pH independent) or a weak acid (in which its ability to exhibit a negative charge is pH dependent respect to basic monomer units), the monomer unit may be a strong base (in which its ability to exhibit a positive charge is largely pH independent) or a weak base (in which its ability to exhibit a positive charge is pH dependent).

[0056] In certain embodiments, the monomer units used are able to exhibit marked morphological or structural changes based on certain stimuli such as pH, electric field, magnetic field, or temperature for regulated drug delivery applications. In some cases the contributing monomer units may be basic, which under the appropriate pH conditions, exhibit a positive electrostatic charge. The base monomer units may have varying levels of basicity, which will determine the extent to which the monomer units will be present in the cationic form at the pH level of the aqueous solution. The monomer unit may be a strong base (in which its ability to exhibit a positive charge is largely pH independent) or a weak base (in which its ability to exhibit a positive charge is pH dependent).

[0057] In some cases the contributing monomers may be electrically sensitive, that is, the monomer is able to exhibit a structural phase change upon introduction to an electrical field. Examples of such monomers include vinyl alcohol, diallyldimethylammonium chloride, and acrylic acid.

[0058] In some cases the contributing monomers may able to exhibit a marked morphological or structural change based upon temperature. An example of such a

temperature sensitive monomer is N-isopropylacrylamide. The monomer may be used to produce a temperature-sensitive hydrogel for regulated release or rather for a hydrogel capable of inducing coagulation in a temperature dependent manner.

[0059] Examples of primary amine containing monomers include but are not limited to allylamine, N-3-aminopropyl methacrylamide (APM), and N-2-aminoethyl methacrylamide (AEMA). Examples of monomer units that are strong bases include those having ammonium groups, such as 3-acrylamidopropyl trimethylammonium chloride (AMPTAC). The monomer units may also be neutral monomers exhibiting no electrostatic charge in the solution. Examples of such monomers include acrylamide (Am), N-tertbutylacrylamide (NTBAAm), N-isopropylacrylamide (NIPAAm), and N,N'-dimethylacrylamide (DMAAm).

[0060] Polymerization of the monomer units can be achieved using any of various techniques known in the art, including chemical processes (e.g., using free-radical initiators and/or catalysts), photochemical processes (e.g., exposure to UV-irradiation), or electrochemical processes. Likewise, cross-linking can be achieved using any of various techniques known in the art, including the addition of a cross-linking agent to the solution. In some cases, polymerization may be effected by the addition of ammonium persulfate (APS) as the polymerization initiator and N,N,N',N'-tetramethylethylenediamene (TEMED) as the catalyst. In some cases, the cross-linking agent is a difunctional monomer, N,N'-methylenebisacrylamide (BIS), epichlorohydrin (EPI), genipin, glutaraldehyde, or ethylene glycol diglycidyl ether (EDGE). Biodegradable cross-linkers such as ethylene glycol dimethacrylate and ethylene glycol diacrylate may also be used as the cross-linking agent. The biodegradable polymers are capable of undergoing hydrolytic cleavage in vivo. Polymerization and cross-linking may take place simultaneously or sequentially in any order. As such, the polymerization initiator, catalyst, and/or cross-linking agent may be added to the solution simultaneously or sequentially in any order.

[0061] Upon polymerization (and cross-linking, in some cases) of the monomer units, a polymer matrix is formed. The amount of cross-linker used (ratio of cross-linker monomer:total remaining functional monomers) determines the mesh size of the gel network. If a polymer hydrogel composed of a primary amine containing monomer is cross-linked appropriately the material, is capable of inducing the blood coagulation pathway, in a factor VII-tissue factor dependent manner. The ability of the polymer hydrogel to induce coagulation is dependent mainly on mechanical rigidity, i.e. cross-link density, and the primary amine functionality on the main chain polymer backbone. It should be noted that

experiments were conducted using the non-cross-linked amine containing polymers, and they were unable to induce coagulation.

[0062] In certain embodiments, the polymer hydrogel is able to induce clotting in platelet deficient plasma. In other embodiments, the polymer hydrogel is able to induce clotting in Factor XII, XI, Factor IX, or Factor VIII-deficient plasma.

[0063] In a specific aspect the invention details the production of a multi-component material consisting of two different compositions of polymeric hydrogels – one for use in any internal hemostatic application, and one for use in any external hemostatic application.

[0064] In another aspect, an embodiment of the present invention provides a polymeric material comprising a cross-linked polymer matrix having a cavity, highly dense in primary amine functionality capable of inducing the blood coagulation pathway. This polymeric hydrogel may be synthesized using any of various techniques, including those described above.

[0065] The cavity may have a geometry (including its size and shape) which is capable of aiding in the activation process. Geometry of the cavity, along with density of electrostatic functional groups within the cavity, is determined, in part, by the amount of cross-linker used in the process.

[0066] The created polymeric hydrogel, depending on the specific concentration of primary amine monomers and corresponding cross-link density may have varying degrees of inducing the blood coagulation cascade, as shown in Figure 6 herein. In a specific embodiment, the optimum concentration for the APM, acrylamide, BIS hydrogel is between 1.5-2 M of APM and 1.5-2 M of acrylamide cross-linked at between 5:1 and 7:1 (acrylamide:BIS). In another specific embodiment (blood optimization) the optimum composition is approximately 2.73 M of APM, .27 M of acrylamide, and .056 M BIS.

[0067] The ability of the hydrogel to initiate blood coagulation in the absence of cells offers a potentially substantial advantage over other hemostatic approaches. In particular these polymers may offer treatment alternatives for patients experiencing platelet-related disorders for which there are no accepted treatment methods available. Another desirable characteristic of the materials, depicted in Figure 1 herein, is their ability to swell in plasma. In practice this would allow the polymers to apply pressure (tamponade) at the site of action, which also aids in reducing blood loss. Furthermore, because of this characteristic swelling in plasma, the hydrogel may be designed in order to administer therapeutics in a controlled and regulated manner.

EXAMPLES

[0068] In one experiment, a randomized copolymer composed of acrylamide and APM, initiated with a 7.5% weight percent solution of TEMED (20 μL/1 mL) and a 15% weight percent solution of APS (20 μL/1 mL), and cross-linked with BIS, was produced. Figure 3 depicts an optimization chart where 156 different polymer compositions, each cross-linked at three different ratios, were tested in citrated human plasma, and rated accordingly their ability to produce a clot. As shown the optimal concentration for inducing coagulation lies between 1.5-2 M of acrylamide and 1.5-2 M of APM, each at its highest cross-link density (maximal amount soluble). The primary amine-containing hydrogel is able to induce the blood coagulation cascade resulting in the formation of a fibrin clot. Figure 1 depicts the ability of the material to induce a fibrin based clot in human plasma (4% sodium citrate). The hydrogel shown is composed of 1.5 M acrylamide 1.5 M APM and cross-linked with .3 M BIS (acrylamide:BIS ratio = 5:1).

[0069] Figure 2 shows micrographs of the coagulate complex (fibrin-hydrogel complex) after hematoxlyin and eosin (H&E) staining, immunohistochemical (IHC) staining, along with an image of the complex obtained using an environmental scanning electron microscope.

[0070] Figure 4 shows the ability of the optimized hydrogel (1.5 M acrylamide, 1.5 M APM< and .3 M BIS) to induce fibrin formation in a variety of factor deficient and factor inhibited plasmas.

[0071] Figure 5 shows the ability of the optimized hydrogel to induce the activation of FVII (5C).

[0072] Figure 6 shows that the optimized hydrogel is not in fact a homogenous network but rather is made up of several mechanically distinct regions.

[0073] Experimentation in human and sheep blood produced an optimum composition consisting of .27 M of acrylamide and 2.73 M of APM and .056 M (acrylamide:BIS ratio= 5:1). [Composition 2]

[0074] The effectiveness of the primary amine-containing hydrogel in hemostatic clot formation was assessed. Blood was drawn from a live adult sheep and added immediately to a vial containing a small amount of the primary amine-containing hydrogel (Figure 7A) and an empty vial (Figure 7B), used as a control. The material was able to induce the formation of a robust clot within seconds of blood contact, compared to the control which took

approximately 10 minutes. Furthermore, the mechanical integrity of the clot produced was dramatically superior to that of the control.

[0075] The primary amine-containing hydrogel was also effective in inducing hemostatic clot formation in vivo. A primary amine-containing hydrogel, consisting of 0.27 M acrylamide, 2.73 M N-3-aminopropyl methacrylamide (APM), and 0.054 M N-N'-methylene bisacrylamide (BIS), placed on a 4x4 inch gauze bandage (a prototype of the presently claimed invention, shown in Figure 8), was administered to inhibit bleeding from an incision introduced into a live sheep lung. The hydrogel was able to successfully stop bleeding from the induced lung incision in approximately 2 minutes. Figure 9 shows an image of the site immediately after the surgeon made the incision (Figure 9A) along with an image of the incision site after the hydrogel based prototype was applied for 2 minutes (Figure 9B). Initial post operative analysis showed that the material was able to induce fibrin formation at the incision causing a natural suturing process, and thus sealing the tissue preventing blood loss. Hematoxylin and eosin stained sections of the incision site confirmed that the material was able to induce the rapid formation of a natural, fibrous-based hemostatic suture, as shown in Figure 10.

INDUSTRIAL APPLICABILITY

[0076] The polymer hydrogel created of the present invention may have various uses. Such uses include a bandage for trauma related injuries or a surgical gauze for use in the operating rooms. In terms of the bandage the hydrogel would be incorporated into a filtered bandage, similar to that of a Band-Aid®, which would then be applied to the wound in order to prevent blood loss and deliver necessary therapeutics. In terms of the surgical gauze the hydrogel would be incorporated into a filtered gauze-like material for use by surgeons to control blood loss during surgery.

[0077] Notably, the bandage application of the hydrogel is novel in the sense that there is no other synthetic polymer, hydrogel material capable of inducing blood clotting while simultaneously delivering therapeutics. Furthermore, the hydrogel functions in Factor VIII and Factor IX deficient plasma, a functionality which should revolutionize wound care for people suffering from hemophilia.

CLAIMS

We claim:

1. A cross-linked polymer, comprising cross-links between at least two monomer backbones, wherein at least one monomer comprises a primary, secondary, tertiary or quaternary amine with a pKa of at least 7.4, and capable of displaying a positive electrostatic charge at the pH of blood or plasma (7.4), and wherein the polymer is capable of activating the blood coagulation cascade by inducing fibrin formation.

2. The polymer of claim 1, wherein said at least one monomer is selected from the group consisting of N-3-aminopropyl methacrylamide, allylamine, and a primary-amine containing monomer capable of displaying a positive electrostatic charge at the pH of blood or plasma (7.4).

3. The polymer of claim 1, wherein at least one of the monomer backbones is acrylamide, or a derivative thereof.

4. A hydrogel comprising the polymer of claim 1, wherein the monomer backbones are cross-linked with cross-linkers selected from the group consisting of N-N'-methylene bisacrylamide, N-N'-bisacrylylcystamine, bisacrylyl piperazine, ethylene glycol diglycidyl ether, epichlorohydrin, N-N'-diallyltartardiamide, ethylene glycol dimethacrylate and ethylene glycol diacrylate.

5. The hydrogel of claim 4, wherein the primary amine is allylamine and the cross-linker is either ethylene glycol diglycidyl ether or epichlorohydrin.

6. The hydrogel of claim 4, therein the monomer backbones are cross-linked with cross-linkers selected from the group consisting of ethylene glycol dimethacrylate and ethylene glycol diacrylate.

7. The polymer of claim 1, wherein the primary amine containing monomer is N-3-aminopropyl methacrylamide (APM), the co-monomer is acrylamide, and the cross-linker is N-N'-methylene bisacrylamide (BIS).

8. The hydrogel of claim 4, wherein said hydrogel consists of 1.5 M acrylamide, 1.5 M N-3-aminopropyl methacrylamide (APM), and 0.3 M N-N'-methylene bisacrylamide (BIS).

9. The polymer of claim 7, wherein said hydrogel consists of 0.27 M acrylamide, 2.73 M N-3-aminopropyl methacrylamide (APM), and 0.054 M N-N'-methylene bisacrylamide (BIS).

10. The hydrogel of claim 4, wherein said hydrogel consists of 1.5 M acrylamide, 1.5 M N-3-aminopropyl methacrylamide (APM), and 0.3 M N-N'-methylene bisacrylamide (BIS).

11. The hydrogel of claim 4, further comprising one or more pharmaceutical active ingredients selected from the group consisting of Novocain, Lidocain, erythromycin, bacitracin, adrenaline, topricin, acetaminophen, ibuprofen, and a hemostatic agent.

12. A method of forming the hydrogel of claim 4, comprising:

adding the monomer backbone comprising a primary amine to the aqueous solution, wherein the first monomer unit exhibits an electrostatic positive charge in the aqueous solution at pH of 7.4 (pH of blood or plasma);

adding a second monomer backbone to the aqueous solution, wherein the second monomer backbone is different from the first monomer unit;

forming the cross-linked polymer using a cross-linking agent, wherein the step of forming polymer comprises polymerizing the monomer backbone.

13. The method of claim 12, wherein the second monomer backbone is neutral or exhibits an electrostatic charge opposite to that of the first monomer backbone.

14. The method of claim 12, wherein the first monomer backbone is added before the second monomer backbone is added.

15. The method of claim 12, wherein the second monomer backbone is added before the first monomer backbone.

16. The method of claim 12, wherein the first and second monomer backbone are added simultaneously to the aqueous solution.

17. A kit for inducing hemostatic clot formation, comprising the polymeric hydrogel of claim 4.

18. A kit for inducing hemostatic clot formation, comprising the polymeric hydrogel of claim 5.

19. A kit for inducing hemostatic clot formation, comprising the polymeric hydrogel of claim 6.

20. A kit for inducing hemostatic clot formation, comprising the polymeric hydrogel of claim 8.

21. A kit for inducing hemostatic clot formation, comprising the polymeric hydrogel of claim 10.

22. A method of treating trauma-induced hemorrhage, comprising administering the hydrogel of any of Claims 4-6, 8, 10 and 11 to a subject in need thereof.

23. A method of treating internal hemorrhaging, comprising administering the hydrogel of any of Claims 4-6, 8, 10 and 11 to a subject in need thereof.

24. A method of treating hemorrhaging during surgical operations, comprising administering the hydrogel of any of Claims 4-6, 8, 10 and 11 to a subject in need thereof.

25. The method of any one of Claims 22-24, wherein said hydrogel is administered on a material selected from the group consisting of a bandage, gauze, tape and adhesive wound dressing.

FIG. 1

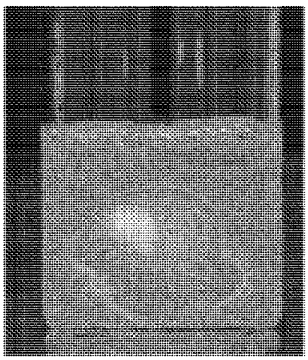
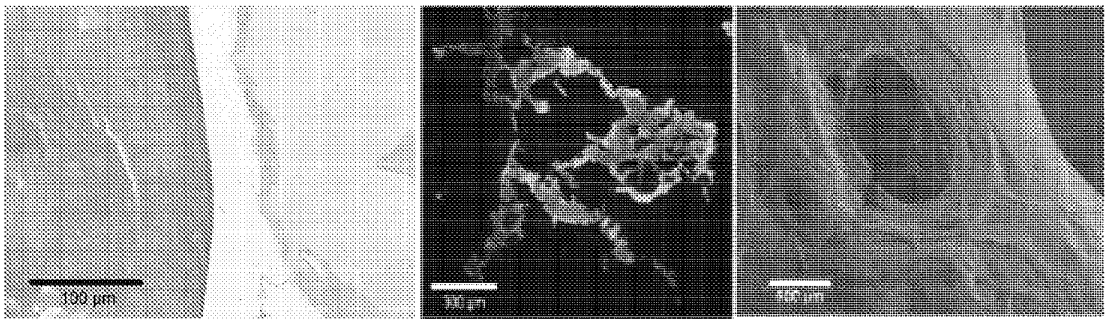


FIG. 2



a b c

FIG. 3

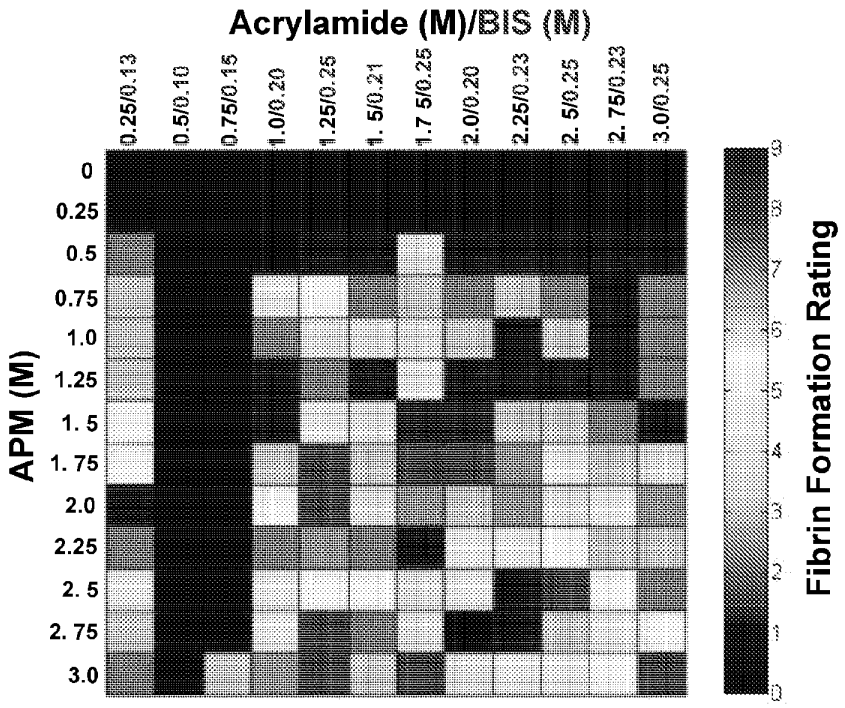

Acrylamide (M)/BIS (M)
0.25/0.13
0.5/0.10
0.75/0.15
1.0/0.20
1.25/0.25
1. 5/0.21
1.7 5/0.25
2.0/0.20
2.25/0.23
2. 5/0.25
2. 75/0.23
3.0/0.25
APM (M)
0
0.25
0.5
0.75
1.0
1.25
1. 5
1. 75
2.0
2.25
2. 5
2. 75
3.0
Fibrin Formation Rating

FIG. 4

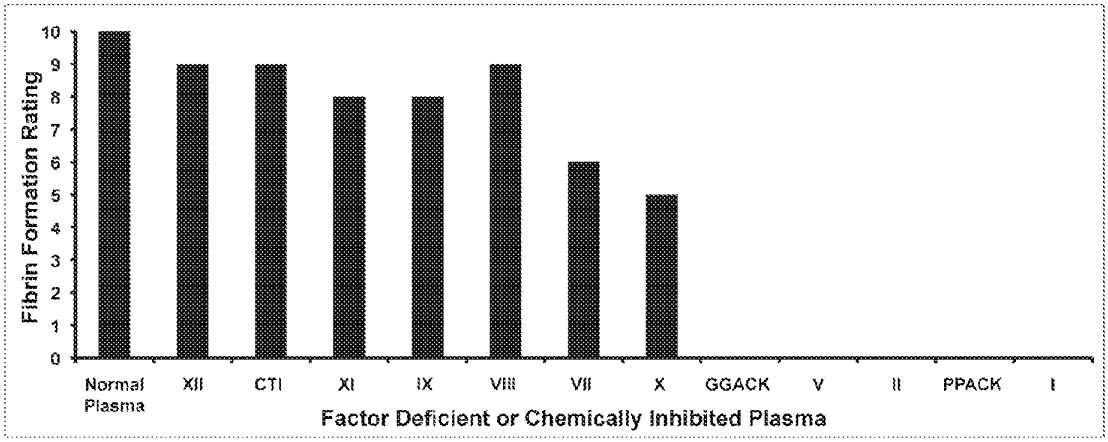

Fibrin Formation Rating
10
9
8
7
6
5
4
3
2
1
0
Normal Plasma
XII
CTI
XI
IX
VIII
VII
X
GGACK
V
II
PPACK
I
Factor Deficient or Chemically Inhibited Plasma

FIG. 5

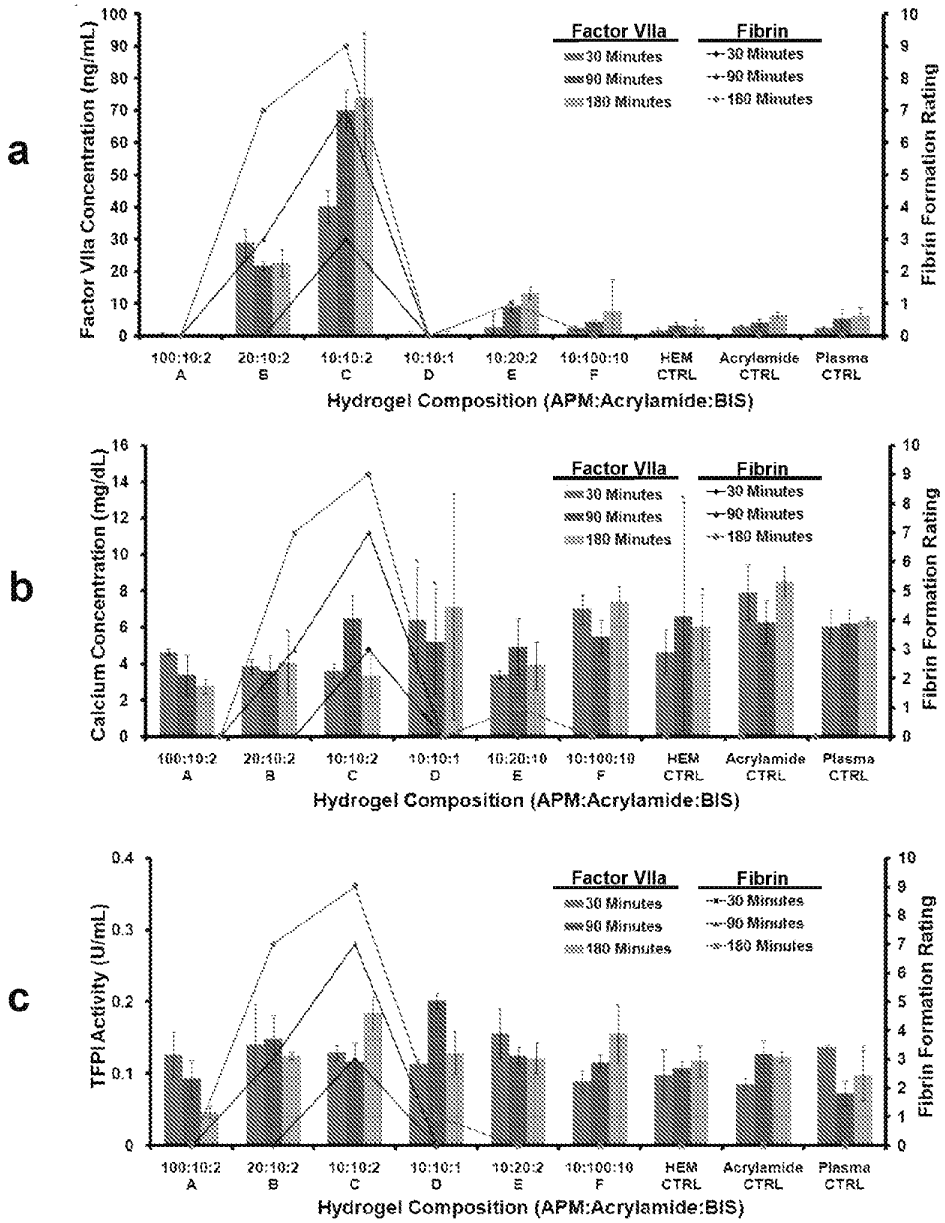

a
Factor VIIa Concentration (ng/mL)
Fibrin Formation Rating
Factor VIIa
30 Minutes
90 Minutes
180 Minutes
Fibrin
30 Minutes
90 Minutes
180 Minutes
100:10:2 A
20:10:2 B
10:10:2 C
10:10:1 D
10:20:2 E
10:100:10 F
HEM CTRL
Acrylamide CTRL
Plasma CTRL
Hydrogel Composition (APM:Acrylamide:BIS)
b
Calcium Concentration (mg/dL)
Fibrin Formation Rating
Factor VIIa
30 Minutes
90 Minutes
180 Minutes
Fibrin
30 Minutes
90 Minutes
180 Minutes
100:10:2 A
20:10:2 B
10:10:2 C
10:10:1 D
10:20:10 E
10:100:10 F
HEM CTRL
Acrylamide CTRL
Plasma CTRL
Hydrogel Composition (APM:Acrylamide:BIS)
c
TFPI Activity (U/mL)
Fibrin Formation Rating
Factor VIIa
30 Minutes
90 Minutes
180 Minutes
Fibrin
30 Minutes
90 Minutes
180 Minutes
100:10:2 A
20:10:2 B
10:10:2 C
10:10:1 D
10:20:2 E
10:100:10 F
HEM CTRL
Acrylamide CTRL
Plasma CTRL
Hydrogel Composition (APM:Acrylamide:BIS)

FIG. 6

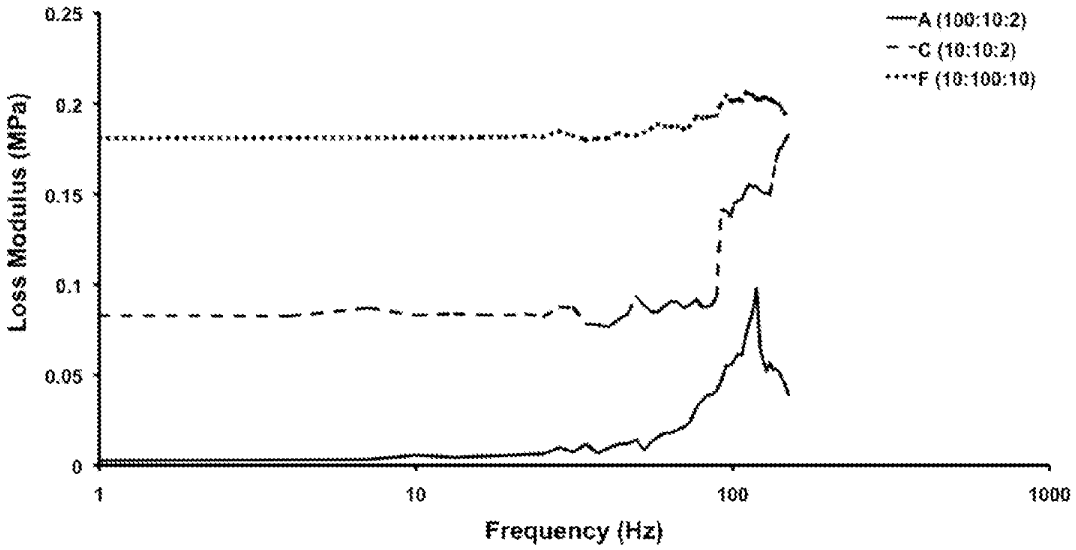

A (100:10:2)
C (10:10:2)
F (10:100:10)
Loss Modulus (MPa)
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
Frequency (Hz)

FIG. 7

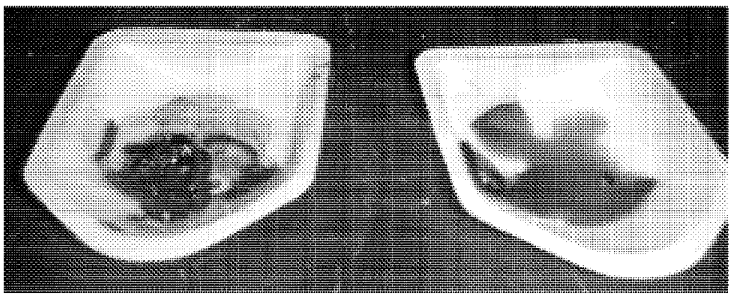
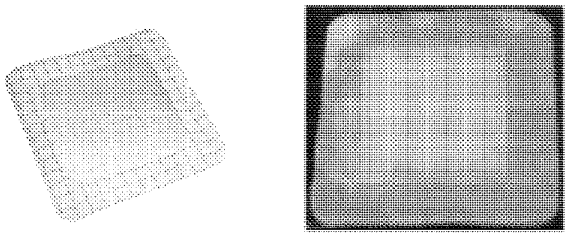
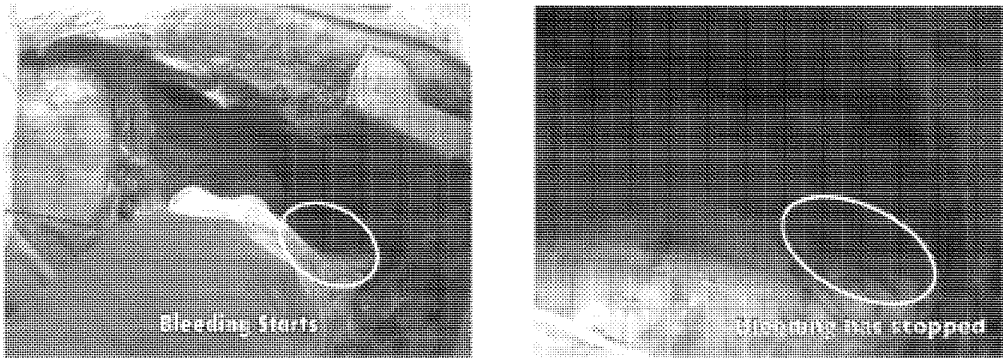

A
B

FIG. 8



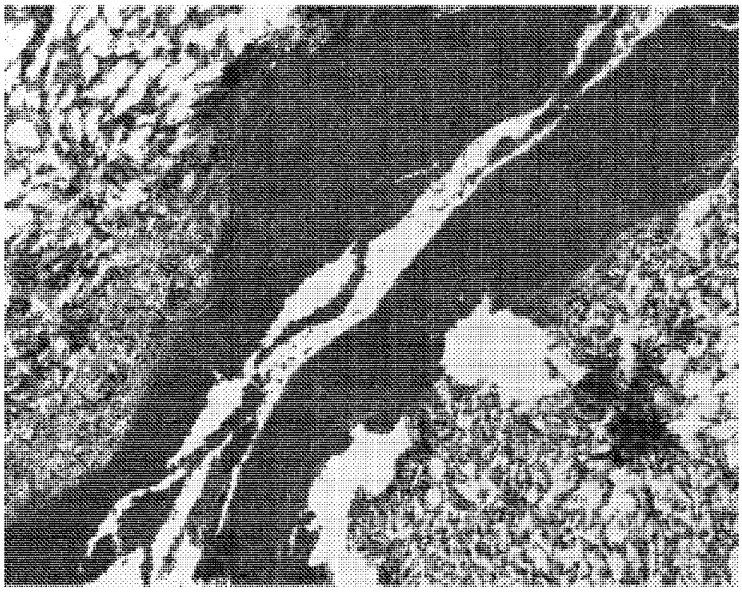
A B

FIG. 9



A B

FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/063049

A. CLASSIFICATION OF SUBJECT MATTER

A61F 13/02(2006.01)i, A61L 15/44(2006.01)i, A61P 7/04(2006.01)i

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)
A61F 13/02; A61K 31/785; A61K 9/14; A61K 9/16; A61K 9/50; B01D 21/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models
(Chinese Patents and application for patent)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: coagulation, polymer, crosslink, hydrogel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007-0237742 A1 (GARRET FIGULY et al.) 11 October 2007 See whole pages.	1-21
A	US 2003-0215519 A1 (ALEXANDER SCHWARZ et al.) 20 November 2003 See whole pages.	1-21
A	US 5648100 A1 (BOSCHETTI; EGISTO et al.) 15 July 1997 See whole pages.	1-21
A	US 4994192 A1 (CORIN; ALAN F. et al.) 19 February 1991 See whole pages.	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
"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 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
31 MARCH 2010 (31.03.2010)	**01 APRIL 2010 (01.04.2010)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
LEE, Dong Won
Telephone No. 82-42-481-5549

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/063049

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.: 22-25
because they relate to subject matter not required to be searched by this Authority, namely:
Claims 22-25 pertain to methods for treatment of the human body by therapy, and thus relate to a subject matter which this International Searching Authority is not required, under Article 17(2)(a)(i) of the PCT and Rule 39.1(iv) of the Regulations under the PCT, to search.

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:

1. ☐ As all required addtional 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 an additional fee, this Authority did not invite payment of any additional fee.

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.:

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/US2009/063049

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007-0237742 A1	11.10.2007	None	
US 2003-0215519 A1	20.11.2003	AU 2003-239374 A1	11.11.2003
		WO 03-094930 A1	20.11.2003
US 5648100 A1	15.07.1997	CA 2110290 C	05.02.2002
		EP 0588875 A1	30.03.1994
		EP 0588875 A4	03.08.1994
		EP 0588875 B1	09.04.1997
		JP 03-509858 B2	09.01.2004
		KR 10-1994-0700869 A	22.04.1994
		US 5635215 A1	03.06.1997
		WO 92-21327 A1	10.12.1992
US 4994192 A1	19.02.1991	EP 0438192 A1	24.07.1991
		JP 06-249849 A	09.09.1994
		KR 10-1991-0014707 A	31.08.1991

Bibliographic data: DE2541494 (A1) — 1977-03-31

Hypodermic needle blood taking device - has valves at needle end and at attachable evacuated chamber connection

Inventor(s): GUERRA LUIS A DR ± (A.,DR. GUERRA,LUIS)

Applicant(s): GUERRA LUIS A ± (GUERRA,LUIS A.,DR)

Classification: **- international:** ***A61B5/15; A61M39/02; A61M5/34;*** (IPC1-7): A61B5/14

- cooperative: **A61B5/15003 (EP); A61B5/150221 (EP); A61B5/150351 (EP); A61B5/150389 (EP); A61B5/150496 (EP); A61B5/150732 (EP); A61B5/150992 (EP); A61B5/154 (EP); A61M39/02 (EP);** A61M2005/341 (EP); A61M2005/342 (EP); A61M5/346 (EP)

Application number: DE19752541494 19750917

Priority number(s): DE19752541494 19750917 ; FR19750025934 19750821 ; GB19750034265 19750818

Also published as: FR2321262 (A1) GB1506449 (A)

Abstract of DE2541494 (A1)

The blood-taking device is of the type where a hypodermic needle is inserted into a blood vessela nd one or more evacuated containers in successions are connected to the needle for collecting blood samples. The device has two valves. The first valve closes the proximal end of the needle section when a container is not connected to it and the second valve makes it possible to control the difference of pressure utilized for drawing blood from a subject. The second valve can be closed rapidly in the event it is discovered that the needle lies in tissue exterior to a blood vessel rather than in a blood vessel itself, thereby preventing extravasation and haematoma.

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Notice

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DESCRIPTION DE2541494A1

[0001]

13 blood collection device

[0002]

17 The invention relates to a blood sampling device for draining blood from a blood vessel.

[0003]

21 It is routine in modern hospitals to draw blood samples from patients by sequentially inserting one or more evacuated test tubes into a holder having a double-tipped cannula; one pointed end of the kanttle pierces the patient's vein and the other pointed end pierces the stopper of the evacuated test tube, thereby allowing blood to flow from the vein into the evacuated tube.

[0004]

28 However, vacuum tube holders are relatively expensive and therefore not disposable; they are also bulky devices subject to contamination (see U.S. Patent 3,520,292).

30 Unless dual-tipped cannulas are already installed in the holders, they must be attached to the holders by a user.

32 However, handling these double-tipped cannulas is dangerous because the user could prick their fingers or infect the cannula.

34 In addition, double-ended needles do not readily permit the injection of soluble drugs into the vein. In medical practice, however, it is sometimes desirable to inject drugs after the blood has been drawn through the cannula in order to save the patient the pain of re-inserting a vein. Another disadvantage of using double-pointed cannulas is that when the tube is withdrawn,

some blood from the vein will flow back through the cannula to its inner end and soil the surrounding area. Of particular note when vacuum tubes are used with double-pointed cannulas is the risk that if the outer tip is not in a vein but in tissue, puncture of the inner tip of the cannula through the tube will result in blood leaking from the vein and a hematoma is coming. Then the user must pull out the cannula as quickly as possible. Even then, the user cannot grasp the situation quickly enough to avoid damage because the full pressure differential is applied to the outer tip of the cannula when the stopper of the evacuated tube is punctured.

[0005]

48 The conventional device has a holder surrounding the proximal end of the double-pointed cannula to receive the plugged end of the evacuated tube.

50 The diameter of the holder part is so large that the cannula penetrates the skin at a relatively acute angle, which increases the risk that the cannula will also puncture the other wall of the blood vessel, so that the tip of the cannula will then be in the tissue rather than in the blood vessel comes to rest. Even without an evacuated reservoir attached to the proximal end of the cannula, blood can clot at the tip, making the device inoperable if another sample is to be taken.

[0006]

58 The invention seeks to provide an improved blood sampling device that avoids the above deficiencies.

60 With the device according to the invention, it should be possible to take a plurality of blood samples with a single puncture of a cannula in a blood vessel without the risk of blood clotting in the space between the successive blood withdrawals. Furthermore, the angle at which the cannula penetrates the patient's skin should be determined by the device itself.

[0007]

67 In order to achieve this, the invention provides a blood sampling device as described in the characterizing part of the first claim.

[0008]

72 The device according to the invention has two valves.

73 The first valve closes the proximal end of the needle part when no container is connected; the second valve makes it possible to control the pressure difference used to aspirate blood from the patient.

76 The second valve can be quickly closed if it is discovered that the needle is not in a blood vessel but outside of it in the tissue. In this way, leakage of blood into the environment and a flamatoma are avoided.

[0009]

82 The device according to the invention consists of two composable parts; the first part comprises a cannula and a holder, the second part comprises an evacuated container closed with a stopper through which an axially slidable and rotatable tube passes.

85 The first and second parts, hereinafter referred to as the holder part and the container part, can be firmly joined together to form a continuous channel for blood to flow through the cannula, holder part and tube into the container. In the holder part is arranged the first valve, which is usually closed, so that when the tube and the container part are not connected to the holder part, the blood trapped in the holder part does not come into contact with air and thus possible infection is avoided. A second valve is mounted in the reservoir portion to allow control of the pressure differential acting across the distal tip of the cannula and to shut off negative pressure from the tip if the cannula is improperly seated in a blood vessel from which blood is being drawn to avoid the risk of a hematoma. The second valve is operated by rotating the container around the tube.

[0010]

98 The distal end of the tube can be inserted into the proximal end of the holder member so that a continuous channel is formed.

100 In one embodiment the distal end of the tube is provided with a protruding flange which opens the first valve when the container part and the holder part are connected to each other. In a second embodiment, the distal end of the tube itself opens the first valve and the container part can be detached from the holder part only when the second valve is closed.

[0011]

107 The invention thus has the advantage, among other things, that the negative pressure at the tip of a cannula is shut off by a valve if the cannula is not correctly positioned in a blood vessel.

109 The invention also eliminates the need for a holder and double-pointed needles by providing a novel vacuum container stopper and hypodermic applicator.

[0012]

114 The hypodermic applicator allows both the injection of soluble drugs into a blood vessel and the collection of blood samples without splashing back blood.

[0013]

119 Assembling the cannula containing part with the container part automatically opens the valve in the holder part so that a continuous and unobstructed channel is formed from the tip of the cannula to the proximal end of the tube which opens into the container.

122 Controlling the negative pressure applied to a vein can prevent the vein from collapsing.

[0014]

126 Further details and advantages of the invention result from the following description of exemplary embodiments with reference to the accompanying drawings.

128 1 shows a side view of a device according to the invention, in which the part containing the cannula is separated from the container part; Figure 2 shows a side elevation of the device according to the invention, in which the two parts are ready for assembly; Figure 3 is a side elevation showing the two parts of the device connected together and showing the valve in the container part closed; Figure 4 is a side elevation similar to Figure 3 but with the valve in the container part open; Figure 5 is a sectional view taken along line 5-5 of Figure 4; Figure 6 is a sectional view taken along line 6-6 of Figure 4; Figure 7 is a side perspective view of a second embodiment of the invention; Figure 8 is a partially sectioned view of the two parts of the second embodiment of the invention separated; Figure 9 is a view similar to Figure 8 but showing the two parts combined; Figure 10 shows the same two parts of the second embodiment but with the container advanced so that the second valve is open; Figure 11 is a view taken along line 11-11 of Figure 10; Figure 12 is a view taken along line 12-12 of Figure 10; and FIG. 13 is a sectional view taken along line 13-13 of FIG.

[0015]

144 The blood sampling device according to the invention consists of two parts that can be joined together, a holder part and a container part, which are shown separately from one another in FIG.

147 A cannula 23 has a tip 24 for piercing a blood vessel through a patient's skin.

148 The proximal end 25 (FIG. 2) of the cannula 23 is fastened in a holder part 22 through which a channel 26 runs. A flexible walled plug 27 sits in the end 28 of the channel. A flexible wall of the ben lies across an opening 29 so that the plug 27 simultaneously seals the opening 29 and the end 28 of the channel.

[0016]

155 The holder part 22 has a projection 30 which serves to hold the holder part at a certain distance from the patient's skin, thereby adjusting the angle at which the cannula 23 penetrates the skin and the manipulation of the holder part and the cannula is facilitated.

[0017]

161 A container 12 is closed with a stopper 10 having a flange 11 seated on the open end of the container 12 .

163 The plug 10 is penetrated by an axial passage in which is inserted a tube 14 which fits tightly

enough in the plug 10 to prevent air from entering between the tube 14 and the axial passage in the plug 10, yet is loose enough That they can move or rotate in the plug 10 in the axial direction.

[0018]

170 The tube 14 is closed at its proximal end, preferably with a disc cemented or otherwise secured onto the end of the tube 14 after the tube 14 is inserted into the stopper 10.

172 The washer 15 performs the dual function of sealing the end of the tube 14 and at the same time limiting the axial movement of the tube 14 away from the container 12.

174 The tube 14 also has a rigidly attached or molded stop 18 at a location such that the movement of the tube 14 axially toward the container 12 is limited.

[0019]

179 The tube 14 is provided with a side opening 16 located a small distance from the sealed tube end.

181 As shown in Figure 2, the opening 16 lies within the passage through the stopper 10 so that the container 12 is protected against ingress of air during evacuation. In a convenient embodiment, the axial passage through the plug 10 is threaded from its outer part to just short of where the orifice 16 comes to rest when the disc 15 is brought into contact with the plug 10. In this case, of course, the tube 14 must also be equipped with a suitable thread.

[0020]

189 Figure 2 shows the container part of the device being assembled with the holder part.

190 The connection is made by inserting the distal end 19 of the tube 14 into a socket 29. The tube end and socket are shaped to fit flush and prevent air from entering between them. A flange 20 is attached to the tube end 19 which bears against the flexible wall 29' of the plug 27 when the two parts are joined together. When the tube end 19 is pushed into the receptacle 29, the flange 20 pushes aside the top of the stopper 27 so that a continuous channel is established between the tip of the cannula 23 and the interior of the tube 14. This can be seen in Figure 3 where the top wall of the flexible plug 27 is depressed by the flange 20. The appearance of the holder portion of the device after insertion of the tube end 19 into the socket 29 is shown in the sectional views of Figs.

[0021]

202 When a blood sample is to be taken, the container 12 is gently rotated in the direction indicated by the arrow in FIG.

204 The axial movement of the container 12 towards the stop 18 results from the fact that the tube 14 is provided with a thread 13 which engages with a threaded part 13' of the stopper 10.

[0022]

209 It should be noted that the plug 10 has an unthreaded portion at its proximal end which ensures a tight seal when the opening 16 is within the plug 10.

[0023]

214 If blood does not flow through opening 16 into container 12 substantially immediately, the container 12 is rotated in the opposite direction to bring opening 16 back into stopper 10, thereby avoiding the full pressure differential being applied to the tissue in where the cannula must lie.

218 This avoids extravasation of blood and the resulting hematoma.

219 The cannula can then be pulled out and properly inserted again so that its tip comes to rest in a blood vessel.

[0024]

224 Then the container 12 is turned again according to FIG. 4 in order to start again with the blood collection.

226 If blood flows through the opening 16, the container 12 is rotated further until the stopper 10 hits the stop 18 on the holder part 22. The container then remains in this position until the desired amount of blood has been aspirated or until the container is filled.

[0025]

232 A second embodiment of the invention is shown in FIGS.

233 Again the device consists of two parts, a holder part, generally designated 221, containing the cannula, and a container part, generally designated 351. The container part 351 has a container 121 which is closed with a stopper 101 in which a through hole is made. A tube 141 having a threaded portion 131 is mounted in the bore of plug 101 . The tube 141 has two parts 141a and 141b which form an angle with each other. A passage 161a through tube 141 is closed at its end by a conical portion 151 which fits into a corresponding portion 151a of the bore in plug 101. A lateral opening 161 is provided in the channel 161a near the conical part 151 . The threaded portion 131 of the tube 141 terminates short of the side opening 161 so that when the container 121 is in a position such that the conical portion 151 is snugly received in section 151a, the opening 161 passes through the cylindrical portion of the stopper 101 is tightly closed.

[0026]

247 To assemble the holder portion and container portion of the device, end 191 of tube 141 is

inserted into a receptacle 291 in holder portion 221, lugs 301a slide into grooves 301b in holder portion 221, and rotation of container portion 351 establishes a bayonet fitting between lugs 301a and 301a grooves 301b.

251 In addition, the receptacle 29a has a spherical portion 311b which mates with a corresponding spherical portion 311a on the tube 141 to provide a tight seal between the holder portion and the container portion.

[0027]

257 When the tube end 191 is inserted into the socket 291 and the bayonet fitting is made, the pointed tube end 191 pushes down the top of a flexible plug 271 which is preferably hollow.

259 In doing so, the pointed end of the tube itself serves as a means to push the upper part 271' of the plug 271 aside. This displacement creates an uninterrupted line between the channel 161a in the container part and the cannula 23. The hollow plug 271 closes the end of the socket 291 and acts as a valve upon insertion of the tube end 191 due to the depressed top plug wall 271'. A portion 401 of the tube end is preferably received in a snug fit in receptacle 29a so that a seal is formed between these portions.

[0028]

268 When the container 121 is rotated in the direction indicated by an arrow in Fig. 10, it moves distally as shown in Fig. 10 and communicates the side opening 161 with the container interior; so that a connection is made from the cannula 23 to the container.

271 If the container is evacuated before the two parts are joined, then blood will flow through the cannula and through the associated channels into the container 121 after the side opening 161 enters the conical portion of the bore in the stopper 101. The range of movement of the container in a distal direction - the threads on the tube 141 are right-hand in this case - is restricted by the contact between the plug 101 and the rear part 321 of the border of the holder part 221.

[0029]

280 Conveniently, the plug 271 carries a ridge 271a which nests in a groove 271b in the retainer portion 221 to help hold the plug 271 in place.

[0030]

285 The manner in which the lugs 301a are fixed in the grooves 301b can be clearly seen from FIGS.

287 The path by which liquid enters the container 121 from the cannula is clear from FIGS. 10 and 12.

[0031]

292 Once the container is filled, the tip 191 of the tube 141 is removed from the channel, i. pulled out of the socket 29a and the flexible wall of the plug 27a springs back so that it blocks a channel 261 in the holder part 221.

295 This process can be repeated any number of times, each time using a new container to collect a sample.

[0032]

300 The distance between the border 321 of the holder part 221 and the outer surface 38a of the plug 101 is chosen so that the container part cannot lift off the corner 361 until the conical part 151 seals tightly in the bore portion 151a, and this sealing engagement is achieved by Turning the container 351 produced with simultaneous displacement of the same in the proximal direction.

305 The dashed curve shows how the distance at which the tip 371 of the plug 101 clears the corner 361 is determined.

307 The purpose of this arrangement is to ensure that the container is properly sealed before container portion 351 is removed from holder portion 221.

[0033]

312 The container portion can then be handled separately without risk of contamination of its contents.

[0034]

317 It should be noted that the seal between the tube end portion 401 and the receptacle 291 prevents air ingress when unlocking the bayonet fitting if unlocking is attempted when the container portion 351 at the side opening 161 is only partially closed.

[0035]

323 If desired, a soluble drug can be injected without causing pain to the patient by drawing the drug into an ordinary syringe fitted with a thin gauge needle and piercing the stopper 271 through an opening 28a with the needle tip of the syringe.

326 The drug is then injected into the channel 26a and from there goes to the cannula 23, to its tip 24 and finally into the patient's blood vessel, provided that the passageway serving as receptacle 291 remains sealed.

329 A new reservoir portion can be attached to the holder portion 221 that remains in place to aspirate more blood, or the cannula 23 can be withdrawn from the blood vessel and then discarded.

332 The filled part of the container is sent to an appropriate biochemical laboratory, where the valve of the side opening 161 is first opened, after which the plug 101 can be easily removed, the tests can be carried out and the whole unit can then be destroyed.

[0036]

338 Since receptacle 291 is blocked each time a container is removed, blood cannot continue to ooze out of channel 261, nor is it drawn back into the blood vessel.

[0037]

343 The object of the invention is thus fulfilled.

344 Modifications are possible with respect to the exemplary embodiments described.

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CLAIMS DE2541494A1

1.

13 L n 8 p r u c h e 9 Blood extraction device for draining blood from a blood vessel, characterized in that it consists of a holder part (22, 221) and a container part (351), that the holder part has a cannula (23) with a pointed distal end (24) and a proximal end (25) and is traversed by a channel (26, 261), in whose distal end the proximal end (25) of the cannula is received in a sealed manner and which communicates with an opening (29, 291) of the holder part and that a first valve (27, 271) is seated in the proximal end of the duct (26, 261) to close the duct, normally blocking communication between the opening (29, 291) and the duct, that further the container part has an evacuatable container (12, 121), the opening of which is closed by a stopper (10, 101), and that a tube (14, 141) is provided, the proximal end of which passes through the stopper (10, 101). and is connected at its distal end to the opening (29, 291) in the holder part in such a way that a sealing connection can be established between the tube and the holder part at this opening, and that at the distal end of the tube an actuating element (20, 191) is provided which opens the first valve (27, 271) thereby connecting the orifice (29, 291) to the channel (26, 261) when the tube (14, 141) is attached to the holder part (22, 221) with the plug (10,101) being attached to the container (12,121) so that it is movable with the container relative to the tube but is sufficiently tight in the container opening to prevent air ingress between the two prevent sharing.

2.

33 Device according to Claim 1, characterized in that the first valve consists of a flexible plug (27, 271) which fits into the proximal end (28, 281) of the channel (26, 261) and closes this end (28, 281). and which extends across the opening (29, 291) and completely seals this opening when the tube (14, 141) is not connected to the holder part (22, 221).

3.

40 Apparatus according to claim 2 characterized in that the actuator on the tube (14) is a flange (20) projecting from the distal end of the tube and positioned to engage that portion (29) of the hollow flexible plug (27) blocking the opening (29), pushing aside and thereby establishing communication with the channel (26) so that blood can flow through the holder part (22) into the tube (14).

4.

48 Apparatus according to any one of the preceding paragraphs characterized in that the opening (29, 291) is shaped as a socket and the distal end of the tube (14, 141) is receivable in the socket-shaped opening with a snug fit.

5.

54 Device according to one of the preceding claims, characterized in that the holder part is provided with a projection (30) which can be placed on the surface into which the cannula (2#) is to be inserted and thus defines the angle under which the cannula is inserted into the surface, and also maintains the holder portion at a distance from the surface and provides a means for more conveniently retaining the holder portion.

6.

62 Device according to any one of the preceding claims, characterized in that the plug (10, 101) is traversed by an axial channel in which the tube (14, 141) fits tightly enough to permit a flow of fluid between the tube and the channel wall preventing, and that the tube (14, 141) is closed at its proximal end and has an opening (16, 161) in its side wall near the proximal end, and that the container (12, 121) relative to this proximal end of the tube is axially movable sufficiently so that in a first position the opening (16, 161) is within the container and communicates between the tube and the container and in a second position within the channel in the stopper (10, 101) and thus the container is sealed against the ingress of air or liquid from the tube into the container, the opening (16, 161) in the side wall of the tube constituting a second valve.

7.

74 Device according to claim 6, characterized in that the distal end of the channel in the stopper (10, 101) and the proximal end of the tube are externally provided with mating threads (13, 13'; 131, 131') so that through Rotating the container around the tube gradually establishes a connection between the tube and the container or the connection can be broken.

8.

81 Device according to claim 6 or 7, characterized in that the tube (14) is provided on both sides of the stopper (10) with protruding parts (18, 15) serving as stops to limit the relative axial freedom of movement of the container and the stopper to limit the tube.

9.

87 A device according to any one of claims 6 to 8, characterized in that the proximal end of the tube and the proximal end of the channel in the stopper are shaped to match each other so that a seal is formed between the two parts when the tube is inserted into the channel.

10.

93 Apparatus according to claim 9, characterized in that the mating parts (151, 151a) of the tube and duct are conically shaped.

11.

98 Apparatus according to any one of the preceding claims characterized in that the first valve is a hollow plug (27, 271) through which a hypodermic needle can be inserted to inject fluid into a patient once the patient's skin has been punctured for blood collection .

12.

104 Device according to one of claims 6 to 11, characterized in that the axial range of movement of the container (121) relative to the tube (141) in the proximal direction is determined by the contact of the proximal end (151) of the tube with the stopper (101) and in the distal Direction is limited by the contact of the plug (101) with the holder part (221).

13.

111 Device according to Claim 12, characterized in that the distance between the holder part (221) and the stopper (101) is selected in such a way that the container part (351) can only be removed from the holder part (221) if the container has reached the am position furthest from the holder part, which position corresponds to the limit of movement of the container in the proximal direction, thereby ensuring that the second valve (161) is closed.

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Ansprüche

1. Blutentnahmevorrichtung zum Abzapfen von Blut aus einem Blutgefäß, dadurch gekennzeichnet, daß sie aus einem Halterteil (22, 221) und einem Behälterteil (351) besteht, daß der Halterteil eine Kanüle (23) mit einem zugespitzten distalen Ende (24) und einem proximalen Ende (25) aufweist und von einem Kanal (26, 261) durchzogen ist, in dessen distalem Ende das proximale Ende (25) der Kanüle dichtend aufgenommen ist und der mit einer Öffnung (29, 291) des Halterteils in Verbindung steht, und daß ein erstes Ventil (27, 271) in dem proximalen Ende des Kanals (26, 261) sitzt, um den Kanal zu schließen, das normalerweise die Verbindung zwischen der Öffnung (29, 291) und dem Kanal sperrt, daß ferner der Behälterteil einen evakuierbaren Behälter (12, 121) aufweist, dessen Öffnung durch einen Stöpsel (10, 101) verschlossen ist, und daß eine Röhre (14, 141) vorgesehen ist, die mit ihrem proximalen Ende durch den Stöpsel (10, 101) tritt und an ihrem distalen Ende derart mit der Öffnung (29, 291) in dem Halterteil verbunden ist, daß an dieser Öffnung eine abdichtende Verbindung zwischen der Röhre und dem Halterteil herstellbar ist, und daß an dem distalen Ende der Röhre ein Betätigungselement (20, 191) vorgesehen ist, das das erste Ventil (27, 271) öffnet und dabei die Öffnung (29, 291) mit dem Kanal (26, 261) verbindet, wenn die Röhre (14, 141) an den Halterteil (22, 221) angeschlossen wird, wobei der Stöpsel (10, 101) derart an dem Behälter (12, 121) angebracht ist, daß er mit dem Behälter relativ zur Röhre bewegbar ist, aber fest genug in der Behälteröffnung sitzt, um ein Eindringen von Luft zwischen den beiden Teilen zu verhindern.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das erste Ventil aus einem flexiblen Stopfen (27, 271) besteht, der in dem proximalen Ende (28, 281) des Kanals (26, 261) sitzt und dieses Ende (28, 281) verschließt und der sich quer über die Öffnung (29, 291) erstreckt und die-

se Öffnung vollständig abdichtet, wenn die Röhre (14, 141) nicht mit dem Halterteil (22, 221) verbunden ist.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß das Betätigungselement an der Röhre (14) ein Flansch (20) ist, der vom distalen Ende der Röhre absteht und eine solche Lage hat, daß er denjenigen Teil (29) des hohlen flexiblen Stopfens (27), der die Öffnung (29) versperrt, beiseitedrückt und dadurch eine Verbindung mit dem Kanal (26) herstellt, so daß Blut durch den Halterteil (22) in die Röhre (14) fließen kann.

4. Vorrichtung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die Öffnung (29, 291) als Muffe geformt ist und das distale Ende der Röhre (14, 141) im Paßsitz in der muffenförmigen Öffnung aufnehmbar ist.

5. Vorrichtung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß der Halterteil mit einem Vorsprung (30) versehen ist, der an der Oberfläche, in die die Kanüle (23) eingeführt werden soll, aufsetzbar ist und damit den Winkel festlegt, unter dem die Kanüle in die Oberfläche eingeführt wird, und zudem den Halterteil in einem Abstand von der Oberfläche hält und ein Mittel zum bequemeren Festhalten des Halterteils darstellt.

6. Vorrichtung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß der Stöpsel (10, 101) von einem axialen Kanal durchzogen ist, in dem die Röhre (14, 141) fest genug sitzt, um einen Fluß von Fluid zwischen der Röhre und der Kanalwand zu verhindern, und daß die Röhre (14, 141) an ihrem proximalen Ende verschlossen ist und in ihrer Seitenwand nahe dem proximalen Ende eine Öffnung (16, 161) hat, und daß der Behälter (12, 121) relativ zu diesem proximalen Ende der Röhre in Achsrichtung weit genug bewegbar ist, so daß die Öffnung (16, 161) in einer

ersten Stellung sich in dem Behälter befindet und eine Verbindung zwischen der Röhre und dem Behälter herstellt und in einer zweiten Stellung innerhalb des Kanals in dem Stöpsel (10, 101) liegt und damit der Behälter gegen das Eindringen von Luft oder Flüssigkeit aus der Röhre in den Behälter abgedichtet ist, wobei die Öffnung (16, 161) in der Seitenwand der Röhre ein zweites Ventil darstellt.

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß das distale Ende des Kanals im Stöpsel (10, 101) und das proximale Ende der Röhre auf der Außenseite mit zusammenpassenden Gewinden (13, 13'; 131, 131') versehen sind, so daß durch Drehen des Behälters um die Röhre allmählich eine Verbindung zwischen der Röhre und dem Behälter herstellbar ist bzw. die Verbindung unterbrechbar ist.

8. Vorrichtung nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß die Röhre (14) zu beiden Seiten des Stöpsels (10) mit vorstehenden Teilen (18, 15) versehen ist, die als Anschläge dienen, um den axialen Bewegungsspielraum des Behälters und des Stöpsels relativ zur Röhre zu begrenzen.

9. Vorrichtung nach einem der Ansprüche 6 bis 8, dadurch gekennzeichnet, daß das proximale Ende der Röhre und das proximale Ende des Kanals im Stöpsel zueinander passend geformt sind, so daß beim Einsetzen der Röhre in den Kanal eine Abdichtung zwischen beiden Teilen zustandekommt.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, daß die zusammenpassenden Teile (151, 151a) von Röhre und Kanal konisch geformt sind.

11. Vorrichtung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß das erste Ventil ein hohler Stopfen (27, 271) ist, durch den eine Injektionsnadel eingeführt werden kann, um Fluid einem Patienten zu injizieren,

wenn die Haut des Patienten zur Blutentnahme bereits einmal durchstochen ist.

12. Vorrichtung nach einem der Ansprüche 6 bis 11, dadurch gekennzeichnet, daß der axiale Bewegungsspielraum des Behälters (121) relativ zur Röhre (141) in proximaler Richtung durch den Kontakt des proximalen Endes (151) der Röhre mit dem Stöpsel (101) und in distaler Richtung durch den Kontakt des Stöpsels (101) mit dem Halterteil (221) begrenzt ist.

13. Vorrichtung nach Anspruch 12, dadurch gekennzeichnet, daß der Abstand zwischen dem Halterteil (221) und dem Stöpsel (101) so gewählt ist, daß ein Wegnehmen des Behälterteils (351) vom Halterteil (221) nur dann möglich ist, wenn der Behälter die am weitesten von dem Halterteil entfernte Lage einnimmt, wobei diese Lage der Bewegungsgrenze des Behälters in proximaler Richtung entspricht, wodurch sichergestellt ist, daß das zweite Ventil (161) geschlossen ist.

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Blutentnahmevorrichtung

Die Erfindung betrifft eine Blutentnahmevorrichtung zum Abzapfen von Blut aus einem Blutgefäß.

In modernen Krankenhäusern gehört es zur Routine, von Patienten Blutproben zu entnehmen, indem man eine oder mehrere evakuierte Teströhren nacheinander in einen Halter einsetzt, der eine Kanüle mit zwei Spitzen hat; das eine zugespitzte Ende der Kanüle sticht in die Vene des Patienten ein und das andere spitze Ende durchsticht den Stöpsel der evakuierten Teströhre, um auf diese Weise Blut aus der Vene in die evakuierte Röhre fließen zu lassen.

Halter für Vakuumröhren sind jedoch verhältnismäßig teuer und daher keine Wegwerfartikel; außerdem sind sie unhandliche Geräte, die einer Verunreinigung ausgesetzt sind (siehe US-PS 3 520 292). Wenn in den Haltern nicht bereits Kanülen mit zwei Spitzen eingebaut sind, müssen sie von einem Benützer an den Haltern angebracht werden. Die Handhabung dieser Kanülen mit zwei Spitzen ist jedoch gefährlich, weil der Benützer sich in die Finger stechen oder die Kanüle infizieren kann. Außerdem erlauben doppelseitig zugespitzte Kanülen nicht ohne weiteres die Injektion von löslichen Arzneimitteln in die Vene. In der medizinischen Praxis ist es jedoch manchmal erwünscht, nach der Blutentnahme durch die Kanüle Arzneimittel zu injizieren,

weil man so dem Patienten den Schmerz beim nochmaligen Einstechen in eine Vene erspart. Ein weiterer Nachteil in der Verwendung doppelt zugespitzter Kanülen ist, daß beim Herausziehen der Röhre etwas Blut aus der Vene durch die Kanüle zu deren innerem Ende zurückfließt und die Umgebung beschmutzt. Besonders beachtlich ist bei der Verwendung von Vakuumröhren zusammen mit doppelt zugespitzten Kanülen die Gefahr, daß, wenn die äußere Spitze nicht in einer Vene sondern im Gewebe liegt, es beim Durchstechen der inneren Spitze der Kanüle durch die Röhre zu einem Blutaustritt aus der Vene und einem Hämatom kommt. Dann muß der Benützer die Kanüle so rasch wie möglich herausziehen. Selbst dann kann der Benützer die Situation nicht schnell genug erfassen, um Schaden zu vermeiden, weil der volle Druckunterschied an die äußere Spitze der Kanüle angelegt wird, wenn der Stöpsel der evakuierten Röhre durchstochen wird.

Das herkömmliche Gerät hat einen Halter, der das proximale Ende der doppelt zugespitzten Kanüle umgibt, um das zugestöpselte Ende der evakuierten Röhre aufzunehmen. Der Durchmesser des Halterteils ist so groß, daß die Kanüle in die Haut unter einem verhältnismäßig spitzen Winkel eindringt, was die Gefahr erhöht, daß die Kanüle auch noch die andere Wand des Blutgefäßes durchsticht, so daß die Spitze der Kanüle dann im Gewebe statt im Blutgefäß zu liegen kommt. Auch wenn auf dem proximalen Ende der Kanüle kein evakuierter Behälter angebracht ist, kann es an der Spitze zu einer Blutgerinnung kommen, wodurch die Funktion des Gerätes gestört ist, wenn eine weitere Probe entnommen werden soll.

Die Erfindung will eine verbesserte Blutentnahmevorrichtung schaffen, die die obigen Mängel vermeidet. Mit der erfindungsgemäßen Vorrichtung sollen mit einem einzigen Einstich einer Kanüle in ein Blutgefäß mehrere Blutproben entnommen werden können, ohne daß die Gefahr einer Blutgerinnung in dem Zwischenraum zwischen den aufeinanderfolgenden Blutentnahmen besteht. Ferner soll der Winkel, unter dem die Kanüle in die

Haut des Patienten eindringt, durch das Gerät selbst festgelegt sein.

Um dies zu erreichen, sieht die Erfindung eine Blutentnahmevorrichtung vor, wie sie im kennzeichnenden Teil des ersten Anspruchs beschrieben ist.

Die erfindungsgemäße Vorrichtung hat zwei Ventile. Das erste Ventil schließt das proximale Ende des Nadelteils, wenn kein Behälter angeschlossen ist; das zweite Ventil macht es möglich, den Druckunterschied, der zum Absaugen von Blut aus dem Patienten genützt wird, zu steuern. Das zweite Ventil kann rasch geschlossen werden, falls man entdeckt, daß die Nadel nicht in einem Blutgefäß sondern außerhalb desselben im Gewebe liegt. Auf diese Weise wird ein Blutaustritt in die Umgebung und ein Hämatom vermieden.

Die erfindungsgemäße Vorrichtung besteht aus zwei zusammensetzbaren Teilen; der erste Teil umfaßt eine Kanüle und einen Halter, der zweite Teil umfaßt einen evakuierten Behälter, der mit einem Stöpsel geschlossen ist, durch den eine axial verschiebbare und drehbare Röhre tritt. Der erste und zweite Teil, die nachstehend als der Halterteil und der Behälterteil bezeichnet werden, können fest miteinander vereinigt werden, so daß ein durchgehender Kanal für das fließende Blut durch die Kanüle, den Halterteil und die Röhre in den Behälter gebildet ist. In dem Halterteil ist das erste Ventil angeordnet, das gewöhnlich geschlossen ist, so daß, wenn die Röhre und der Behälterteil nicht mit dem Halterteil verbunden sind, das in dem Halterteil eingeschlossene Blut nicht mit Luft in Berührung kommt und somit eine mögliche Infizierung vermieden ist. In dem Behälterteil ist ein zweites Ventil angebracht, das die Steuerung der Druckdifferenz, die an der distalen Spitze der Kanüle wirksam wird, ermöglicht und den Unterdruck von der Spitze absperren kann, falls die Kanüle nicht ordnungsgemäß in einem Blutgefäß liegt, aus dem Blut entnommen werden soll, um so die Gefahr eines Hämatoms auszuschließen. Das zweite Ven-

til wird durch Drehung des Behälters um die Röhre betätigt. Das distale Ende der Röhre kann in das proximale Ende des Halterteils eingesetzt werden, so daß ein durchgehender Kanal gebildet wird. In einer Ausführungsform ist das distale Ende der Röhre mit einem vorstehenden Flansch versehen, der das erste Ventil öffnet, wenn der Behälterteil und der Halterteil miteinander verbunden werden. In einer zweiten Ausführungsform öffnet das distale Ende der Röhre selbst das erste Ventil und der Behälterteil kann von dem Halterteil nur dann abgenommen werden, wenn das zweite Ventil geschlossen ist.

Die Erfindung hat also u.a. den Vorteil, daß der Unterdruck an der Spitze einer Kanüle von einem Ventil abgesperrt wird, falls die Kanüle nicht richtig in einem Blutgefäß liegt. Die Erfindung macht außerdem durch einen neuartigen Stöpsel für einen Vakuumbehälter und einen neuartigen hypodermischen Applikator einen Halter und doppelt zugesptitze Kanülen überflüssig. Der hypodermische Applikator erlaubt sowohl die Injizierung löslicher Arzneimittel in ein Blutgefäß als auch das Entnehmen von Blutproben, ohne ein Verspritzen von rückschießendem Blut. Durch das Zusammensetzen des die Kanüle enthaltenden Teils mit dem Behälterteil wird automatisch das Ventil in dem Halterteil geöffnet, so daß ein durchgehender und unbehinderter Kanal von der Kanülenspitze bis zum proximalen Ende der Röhre, das in den Behälter mündet, gebildet ist. Durch die Steuerung des an eine Vene angelegten Unterdruckes kann ein Kollaps der Vene vermieden werden.

Weitere Einzelheiten und Vorzüge der Erfindung ergeben sich aus der nachfolgenden Beschreibung von Ausführungsbeispielen anhand der beigefügten Zeichnungen. Darin zeigen:

Fig.1 eine Seitenansicht einer erfindungsgemäßen Vorrichtung, in der der die Kanüle enthaltende Teil von dem Behälterteil getrennt ist;

Fig.2 einen Seitenriß der erfindungsgemäßen Vorrichtung, in dem die beiden Teile in der Lage zum Zusammensetzen sind;

Fig.3 einen Seitenriß, der die zwei Teile der Vorrichtung miteinander verbunden zeigt und in dem das Ventil im Behälterteil geschlossen dargestellt ist;

Fig.4 einen der Fig.3 ähnlichen Seitenriß, bei dem jedoch das Ventil im Behälterteil offen ist;

Fig.5 eine Schnittansicht nach der Linie 5-5 der Fig.4;

Fig.6 eine Schnittansicht nach der Linie 6-6 der Fig.4;

Fig.7 eine perspektivische Seitenansicht einer zweiten Ausführungsform der Erfindung;

Fig.8 eine teilweise geschnittene Ansicht der beiden Teile der zweiten Ausführungsform der Erfindung im getrennten Zustand;

Fig.9 eine der Fig.8 ähnliche Ansicht, in der jedoch die beiden Teile vereinigt sind;

Fig.10 die gleichen beiden Teile der zweiten Ausführungsform, wobei jedoch der Behälter vorgeschoben ist, so daß das zweite Ventil offen ist;

Fig.11 eine Ansicht nach der Linie 11-11 der Fig.10;

Fig.12 eine Ansicht nach der Linie 12-12 der Fig.10; und

Fig.13 eine Schnittansicht nach der Linie 13-13 der Fig.9.

Die erfindungsgemäße Blutentnahmevorrichtung besteht aus zwei zusammenfügbaren Teilen, einem Halterteil und einem Behälterteil, die in Fig.1 getrennt voneinander dargestellt sind. Eine Kanüle 23 hat eine Spitze 24 zum Einstechen in ein Blutgefäß durch die Haut eines Patienten. Das proximale Ende 25 (Fig.2) der Kanüle 23 ist in einem Halterteil 22 befestigt, der von einem Kanal 26 durchzogen ist. Ein Stopfen 27 mit flexiblen Wänden sitzt im Ende 28 des Kanals. Eine flexible Wand desselben liegt quer über einer Öffnung 29, so daß der Stopfen 27 zugleich die Öffnung 29 und das Ende 28 des Kanals abdichtet. Der Halterteil 22 hat einen Vorsprung 30, der dazu dient, den Halterteil in einem bestimmten Abstand von der Haut des Patien-

ten zu halten, wodurch der Winkel eingestellt wird, unter dem die Kanüle 23 in die Haut eindringt, und die Handhabung des Halterteils und der Kanüle erleichtert wird.

Ein Behälter 12 ist mit einem Stöpsel 10 verschlossen, der einen auf dem offenen Ende des Behälters 12 aufsitzenden Flansch 11 hat. Der Stöpsel 10 ist von einem axialen Kanal durchzogen, in dem eine Röhre 14 steckt, die fest genug in dem Stöpsel 10 sitzt, um ein Eindringen von Luft zwischen die Röhre 14 und den axialen Kanal im Stöpsel 10 zu verhindern, aber andererseits doch so locker, daß sie sich im Stöpsel 10 in Achsrichtung verschieben oder drehen kann.

Die Röhre 14 ist an ihrem proximalen Ende verschlossen, vorzugsweise mit einer Scheibe, die auf dem Ende der Röhre 14 festgekittet oder sonstwie befestigt wird, nachdem die Röhre 14 in den Stöpsel 10 eingeführt ist. Die Scheibe 15 erfüllt eine doppelte Aufgabe, nämlich das Ende der Röhre 14 abzudichten und zugleich den axialen Bewegungsspielraum der Röhre 14 von dem Behälter 12 weg zu begrenzen. Die Röhre 14 hat auch noch einen starr angebrachten oder angeformten Anschlag 18 an einer solchen Stelle, daß der Bewegungsspielraum der Röhre 14 in axialer Richtung zum Behälter 12 hin begrenzt wird.

Die Röhre 14 ist mit einer seitlichen Öffnung 16 versehen, die in einem kleinen Abstand von dem abgedichteten Röhrenende angeordnet ist. Wie in Fig.2 gezeigt, liegt die Öffnung 16 innerhalb des den Stöpsel 10 durchziehenden Kanals, so daß der Behälter 12 gegen ein Eindringen von Luft beim Evakuieren geschützt ist. In einer zweckmäßigen Ausführungsform ist der axiale Kanal durch den Stöpsel 10 von seinem äußeren Teil bis kurz vor die Stelle, wo die Öffnung 16 zu liegen kommt, wenn die Scheibe 15 mit dem Stöpsel 10 in Kontakt gebracht ist, mit einem Gewinde versehen. Selbstverständlich ist in diesem Fall auch die Röhre 14 mit einem passenden Gewinde auszustatten.

Fig.2 zeigt den Behälterteil der Vorrichtung gerade beim Zu-

sammenfügen mit dem Halterteil. Die Verbindung wird in der Weise hergestellt, daß das distale Ende 19 der Röhre 14 in eine Aufnahme 29 eingesetzt wird, Das Röhrenende und die Aufnahme sind so geformt, daß sie bündig zusammenpassen und keine Luft zwischen ihnen eindringen kann. An dem Röhrenende 19 ist ein Flansch 20 angebracht, der sich gegen die flexible Wand 29' des Stopfens 27 anlegt, wenn die beiden Teile miteinander vereinigt sind. Wenn das Röhrenende 19 in die Aufnahme 29 eingeschoben wird, drückt der Flansch 20 den oberen Teil des Stopfens 27 beiseite, so daß ein durchgehender Kanal zwischen der Spitze der Kanüle 23 und dem Inneren der Röhre 14 hergestellt wird. Dies ist in Fig.3 zu sehen, in der die obere Wand des flexiblen Stopfens 27 von dem Flansch 20 niedergedrückt ist. Das Aussehen des Halterteils der Vorrichtung nach dem Einführen des Röhrenendes 19 in die Aufnahme 29 ist in den Schnittansichten der Fig.5 und 6 gezeigt.

Wenn eine Blutprobe entnommen werden soll, wird der Behälter 12 vorsichtig in der durch den Pfeil in Fig.4 angegebenen Richtung gedreht, bis die Öffnung 16 eben von dem proximalen Ende des Stöpsels 10 freikommt. Die axiale Bewegung des Behälters 12 in Richtung zum Anschlag 18 ergibt sich aus der Tatsache, daß die Röhre 14 mit einem Gewinde 13 versehen ist, das mit einem Gewindeteil 13' des Stöpsels 10 im Eingriff ist. Zu beachten ist, daß der Stöpsel 10 an seinem proximalen Ende einen gewindefreien Teil hat, wodurch eine feste Abdichtung sichergestellt ist, wenn sich die Öffnung 16 innerhalb des Stöpsels 10 befindet.

Wenn nicht praktisch sofort Blut durch die Öffnung 16 in den Behälter 12 fließt, wird der Behälter 12 in der entgegengesetzten Richtung gedreht, um die Öffnung 16 wieder in den Stöpsel 10 zurückzubringen, wodurch man vermeidet, daß die volle Druckdifferenz auf das Gewebe einwirkt, in dem die Kanüle liegen muß. Auf diese Weise werden eine Extravasation von Blut und das dabei entstehende Hämatom vermieden. Die Kanüle kann dann herausgezogen und noch einmal richtig eingestochen wer-

den, so daß ihre Spitze in einem Blutgefäß zu liegen kommt. Dann wird der Behälter 12 wieder gemäß Fig.4 gedreht, um noch einmal mit der Blutentnahme zu beginnen. Falls Blut durch die Öffnung 16 fließt, wird der Behälter 12 weitergedreht, bis der Stöpsel 10 auf den Anschlag 18 am Halterteil 22 trifft. In dieser Lage bleibt dann der Behälter, bis die gewünschte Blutmenge abgesaugt ist oder bis der Behälter gefüllt ist.

In den Fig.7-12 ist eine zweite Ausführungsform der Erfindung dargestellt. Wieder besteht die Vorrichtung aus zwei Teilen, einem die Kanüle enthaltenden Halterteil, der insgesamt mit 221 bezeichnet ist, und einem insgesamt mit 351 bezeichneten Behälterteil. Der Behälterteil 351 weist einen Behälter 121 auf, der mit einem Stöpsel 101 verschlossen ist, in dem eine durchgehende Bohrung angebracht ist. Eine Röhre 141, die einen Gewindeteil 131 hat, ist in der Bohrung des Stöpsels 101 angebracht. Die Röhre 141 hat zwei Teile 141a und 141b, die miteinander einen Winkel bilden. Ein die Röhre 141 durchziehender Kanal 161a ist an seinem Ende mit einem konischen Teil 151 verschlossen, das in einen entsprechenden Abschnitt 151a der Bohrung im Stöpsel 101 paßt. In dem Kanal 161a ist nahe dem konischen Teil 151 eine seitliche Öffnung 161 vorgesehen. Der Gewindeteil 131 der Röhre 141 hört kurz vor der seitlichen Öffnung 161 auf, so daß, wenn der Behälter 121 eine solche Lage hat, daß das konische Teil 151 im Paßsitz im Abschnitt 151a aufgenommen ist, die Öffnung 161 durch den zylindrischen Teil des Stöpsels 101 dichtend verschlossen ist.

Um den Halterteil und den Behälterteil der Vorrichtung zusammenzufügen, wird das Ende 191 der Röhre 141 in eine Aufnahme 291 im Halterteil 221 eingeführt. Nasen 301a schieben sich in Nuten 301b im Halterteil 221 und eine Drehung des Behälterteils 351 stellt einen Bajonettverschluß zwischen den Nasen 301a und Nuten 301b her. Außerdem hat die Aufnahme 29a einen kugeligen Teil 311b, der mit einem entsprechenden kugeligen Teil 311a an der Röhre 141 zusammenpaßt, so daß eine feste Abdich-

tung zwischen dem Halterteil und dem Behälterteil zustande kommt.

Wenn das Röhrenende 191 in die Aufnahme 291 eingeschoben und der Bajonettverschluß hergestellt ist, drückt das zugespitzte Röhrenende 191 den oberen Teil eines flexiblen Stopfens 271 nach unten, der vorzugsweise hohl ist. Dabei dient das zugespitzte Röhrenende selbst als ein Mittel, um den oberen Teil 271' des Stopfens 271 beiseite zu schieben. Durch diese Verlagerung entsteht eine ununterbrochene Leitung zwischen dem Kanal 161a im Behälterteil und der Kanüle 23. Der hohle Stopfen 271 schließt das Ende der Aufnahme 291 und wirkt beim Einführen des Röhrenendes 191 als Ventil infolge der herabgedrückten oberen Stopfenwand 271'. Ein Teil 401 des Röhrenendes ist vorzugsweise im Paßsitz in der Aufnahme 29a aufgenommen, so daß zwischen diesen Teilen eine Abdichtung hergestellt ist.

Wenn der Behälter 121 in der durch einen Pfeil in Fig.10 angedeuteten Richtung gedreht wird, bewegt er sich gemäß Fig.10 in distaler Richtung und verbindet die seitliche Öffnung 161 mit dem Behälterinnenraum; damit ist eine Verbindung von der Kanüle 23 zum Behälter hergestellt. Falls der Behälter vor dem Vereinigen der beiden Teile evakuiert ist, fließt dann Blut durch die Kanüle und durch die verbundenen Kanäle in den Behälter 121, nachdem die seitliche Öffnung 161 in den konischen Abschnitt der Bohrung im Stöpsel 101 gelangt ist. Der Bewegungsspielraum des Behälters in distaler Richtung - das Gewinde an der Röhre 141 ist in diesem Fall rechtsgängig - wird durch den Kontakt zwischen dem Stöpsel 101 und dem hinteren Teil 321 der Begrenzung des Halterteils 221 eingeschränkt.

Zweckmäßigerweise trägt der Stopfen 271 einen Wulst 271a, der sich in eine Nut 271b im Halterteil 221 einbettet, um dazu beizutragen, daß der Stopfen 271 in seiner Lage gehalten wird.

Auf welche Weise die Nasen 301a sich in den Nuten 301b festsetzen, ist deutlich aus den Fig.11 und 12 ersichtlich. Der

Weg, auf dem Flüssigkeit von der Kanüle in den Behälter 121 gelangt, wird aus den Fig.10 und 12 deutlich.

Sobald der Behälter gefüllt ist, wird die Spitze 191 der Röhre 141 von dem Kanal, d.i. aus der Aufnahme 29a herausgezogen und die flexible Wand des Stopfens 27a schnellt zurück, so daß sie einen Kanal 261 im Halterteil 221 versperrt. Dieser Vorgang kann beliebig oft wiederholt werden, wobei man jedesmal einen neuen Behälter zum Entnehmen einer Probe verwendet.

Der Abstand zwischen der Begrenzung 321 des Halterteils 221 und der Außenfläche 38a des Stöpsels 101 ist so gewählt, daß der Behälterteil von der Ecke 361 nicht abheben kann, bevor nicht das konische Teil 151 fest in dem Bohrungsabschnitt 151a abdichtet, und diese dichtende Anlage wird durch Drehen des Behälters 351 mit gleichzeitiger Verschiebung desselben in proximaler Richtung hergestellt. Die gestrichelte Kurve zeigt, wie der Abstand, bei dem die Spitze 371 des Stöpsels 101 von der Ecke 361 freikommt, bestimmt wird. Zweck dieser Anordnung ist es, sicherzustellen, daß der Behälter gut abgedichtet ist, bevor der Behälterteil 351 vom Halterteil 221 weggenommen wird. Der Behälterteil kann dann getrennt gehandhabt werden, ohne daß die Gefahr einer Verunreinigung seines Inhalts besteht.

Zu beachten ist, daß die Abdichtung zwischen dem Röhrenendenteil 401 und der Aufnahme 291 ein Eindringen von Luft beim Entriegeln des Bajonettverschlusses verhindert, falls ein Entriegeln versucht wird, wenn der Behälterteil 351 an der seitlichen Öffnung 161 nur teilweise verschlossen ist.

Nach Wunsch kann ein lösliches Arzneimittel ohne Schmerzen für den Patienten injiziert werden, indem man das Arzneimittel in eine übliche Spritze aufzieht, an der eine dünnkalibrige Nadel angesetzt ist, und den Stopfen 271 durch eine Öffnung 28a hindurch mit der Nadelspitze der Spritze durchsticht. Das Arzneimittel wird dann in den Kanal 26a eingespritzt und geht

von dort zur Kanüle 23, zu deren Spitze 24 und schließlich in das Blutgefäß des Patienten, vorausgesetzt, daß der als Aufnahme 291 dienende Durchgang abgedichtet bleibt. An den am Ort bleibenden Halterteil 221 kann ein neuer Behälterteil angesetzt werden, um mehr Blut abzusaugen, oder es kann auch die Kanüle 23 aus dem Blutgefäß herausgezogen und dann weggeworfen werden. Der gefüllte Behälterteil wird an ein entsprechendes biochemisches Labor geschickt, wo das Ventil der seitlichen Öffnung 161 zuerst geöffnet wird, worauf der Stöpsel 101 ohne weiteres entfernt, die Untersuchungen vorgenommen und die ganze Einheit dann vernichtet werden kann.

Da die Aufnahme 291 jedesmal versperrt wird, wenn ein Behälter weggenommen wird, kann Blut weder weiter aus dem Kanal 261 aussickern, noch wird es in das Blutgefäß zurückgesaugt.

Die der Erfindung gestellt Aufgabe ist somit erfüllt. Gegenüber den beschriebenen Ausführungsbeispielen sind Abänderungen möglich.

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FIG. 1

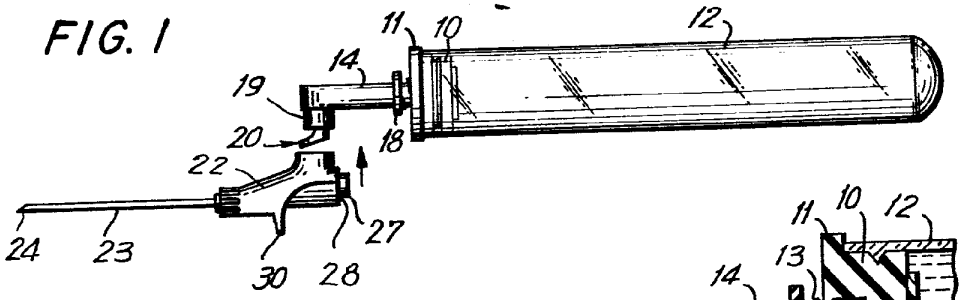


FIG. 2

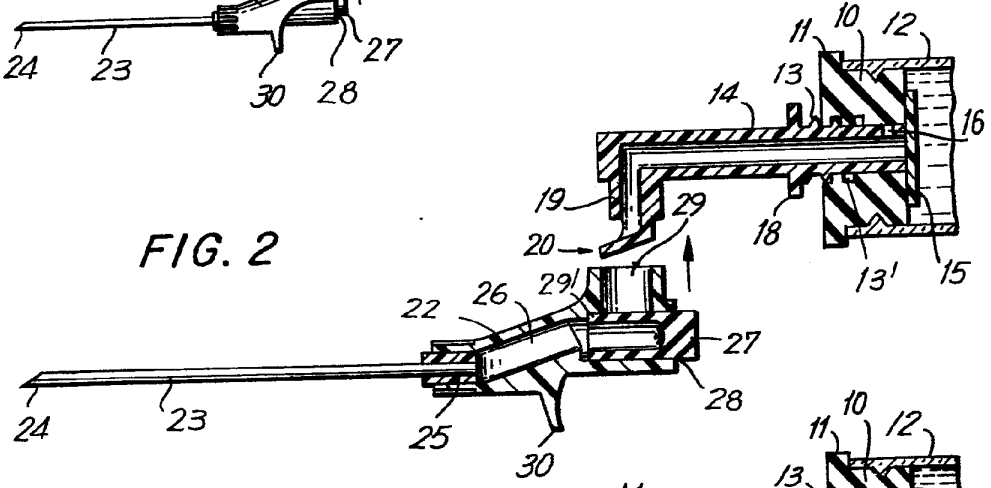


FIG. 3

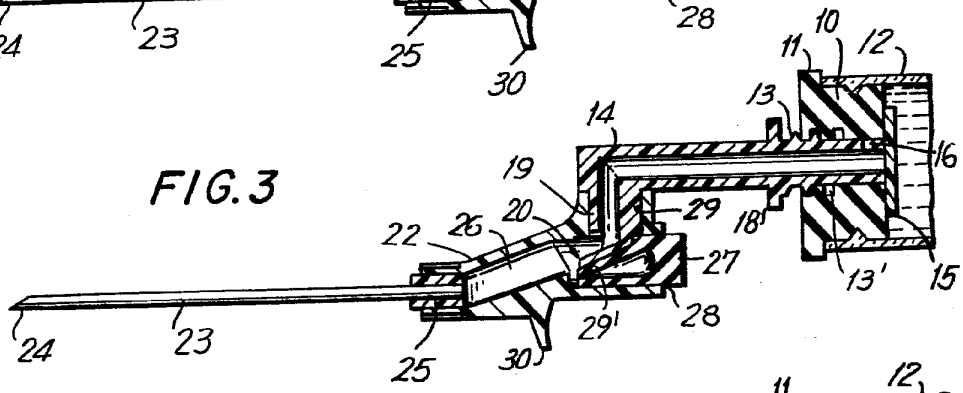


FIG. 4

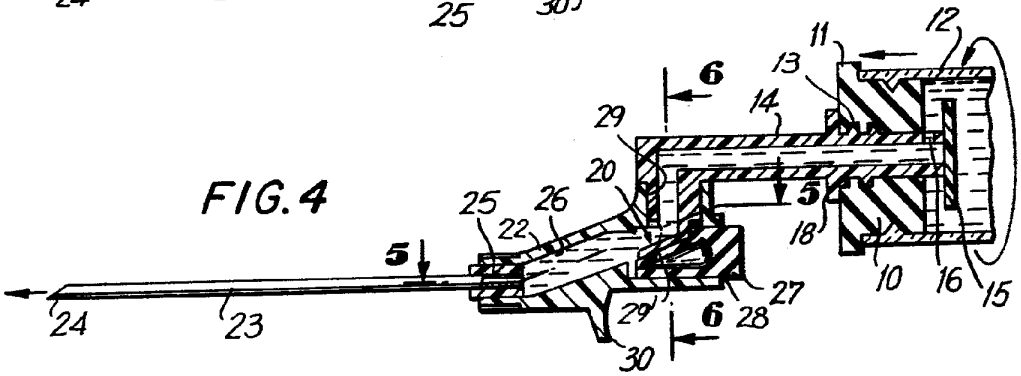


FIG. 5

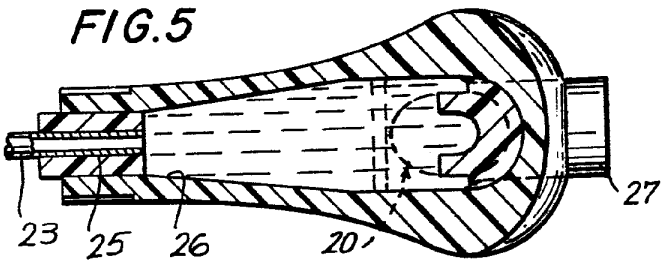
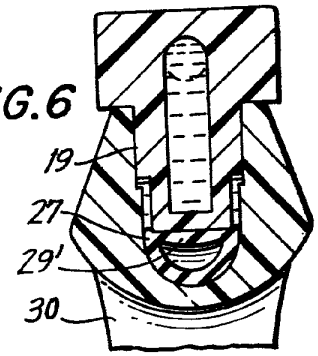


FIG. 6



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FIG. 7

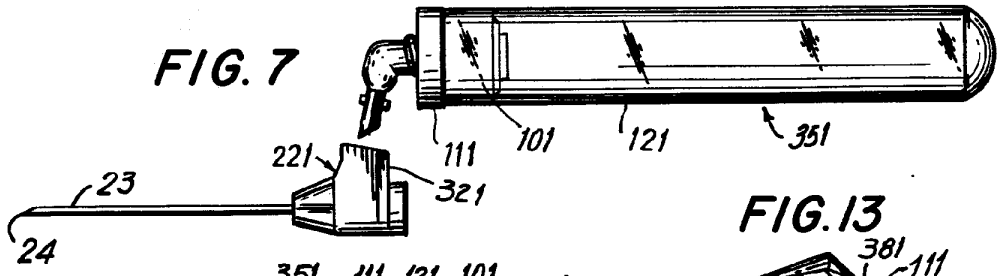


FIG. 13

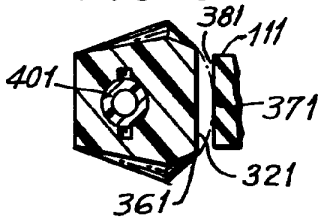


FIG. 8

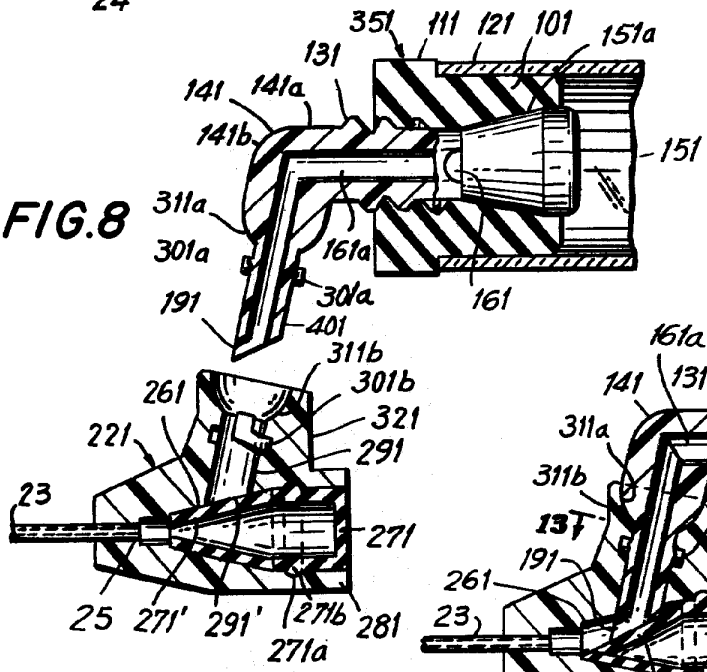


FIG. 9

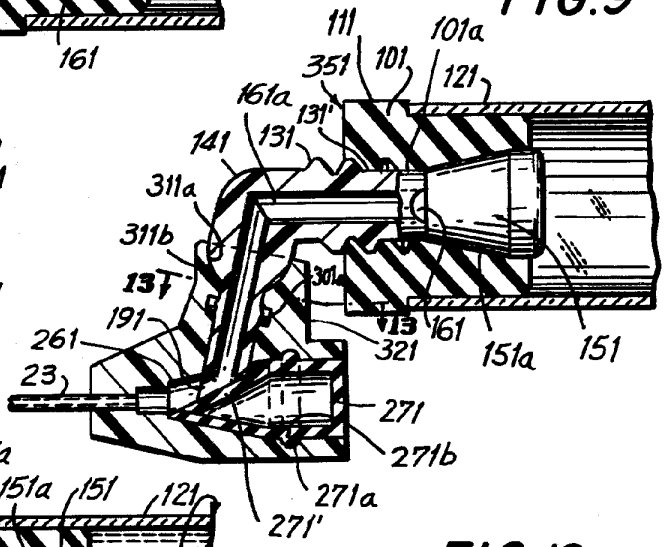


FIG. 10

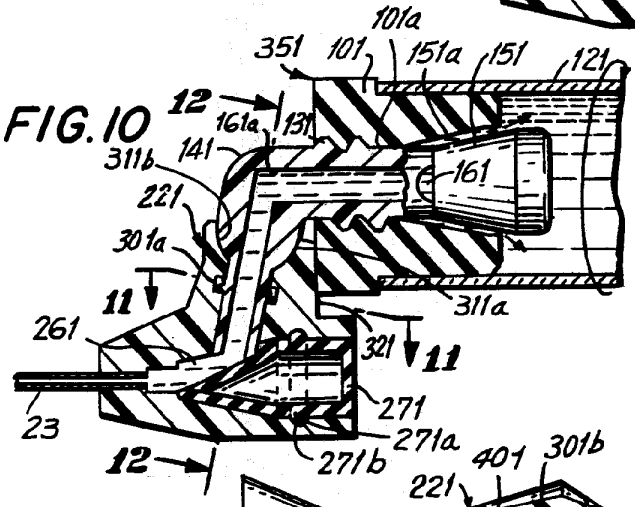


FIG. 12

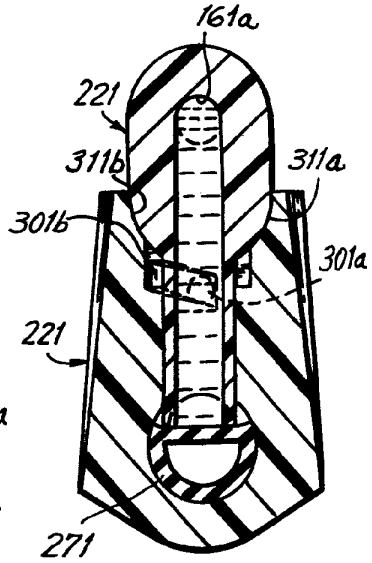
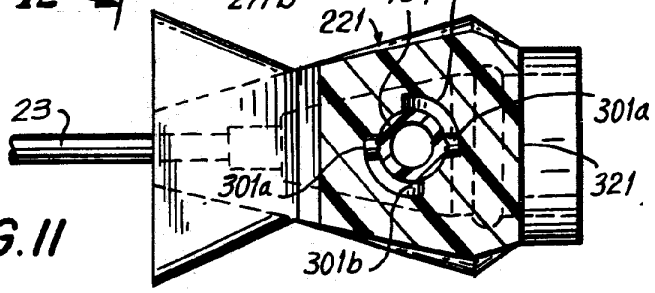


FIG. 11



Espacenet

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Compartmental body fluid collection tube.

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Abstract of EP0448795 (A2)

A compartmented body fluid specimen collection tube (10) is provided which allows the user to select a size compartment (14,16) depending upon the quantity of specimen required. Thus, the tube of the invention may be of the standard size which is much easier for the user to handle than very small tubes when taking a blood sample, but a selected size compartment (14,16) is available. The manufacturer of the tube itself may use a single moid for making tubes accommodating differing required specimen quantities, and, thereafter the vendor may select either size compartment (14,16) for imparting a vacuum and the other processing required into a final product. The invention allows the use of a single standard size laboratory equipment array for processing collected specimens of varying quantities, as well as a single standard stopper (28). Finally, reduced vacuum application or "partial draw" tubes are avoided, thus eliminating the problem of unpredictable specimen draw response because of varying atmospheric pressures at different locations of use.

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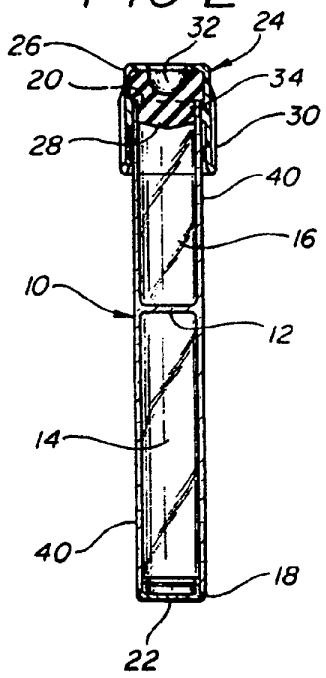
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(54) Compartmental body fluid collection tube.

(57) A compartmented body fluid specimen collection tube is provided which allows the user to select a size compartment depending upon the quantity of specimen required. Thus, the tube of the invention may be of the standard size which is much easier for the user to handle than very small tubes when taking a blood sample, but a selected size compartment is available. The manufacturer of the tube itself may use a single mold for making tubes accommodating differing required specimen quantities, and, thereafter the vendor may select either size compartment for imparting a vacuum and the other processing required into a final product. The invention allows the use of a single standard size laboratory equipment array for processing collected specimens of varying quantities, as well as a single standard stopper. Finally, reduced vacuum application or "partial draw" tubes are avoided, thus eliminating the problem of unpredictable specimen draw response because of varying atmospheric pressures at different locations of use.

FIG-2



EP 0 448 795 A2

BACKGROUND AND STATEMENT OF THE INVENTION

This invention relates to body fluid collection tubes for collecting a body fluid specimen from a patient for subsequent examination in a laboratory. More particularly, this invention relates to a blood collection tube for taking such specimens in which the tube has imparted thereto an internal vacuum with the vacuum being utilized for drawing the blood specimen from the vein of a patient.

Attempts have been made to overcome the problem of proliferation of a number of tubes for taking a plurality of specimens from a single venous entry into a patient. For example, Japanese Patent Application No. 62-51238, filed March 6, 1987 teaches a device in which a tube is divided axially into two chambers for taking two blood specimens simultaneously. However, there is no recognition for arranging different size compartments for taking different separate specimens of different size to accommodate subsequent laboratory testing of those specimens.

Other prior art arrangements, such as that taught in U.S. Patent 3,894,951, for example, provide for compartmentalized blood collection tubes in which the compartments have fluid connections for subsequent separation of a single blood sample into separate components.

In taking such specimens, differing quantities or volumes of specimens are required for certain applications. For this reason, larger and smaller tubes are manufactured for this purpose. As an alternative to making larger and smaller tubes, so-called "partial draw" tubes are provided in which the vacuum imparted to the tube is varied in order to accommodate differing quantities of specimen as required. All of these variations increase the cost of collecting blood specimens, and when it is understood that literally billions of such tubes are used and discarded after a single use each year the costs become substantial for medical applications.

This invention overcomes this problem by using a conventionally sized tube of, for example, 6cc in volume and incorporates an integral divider substantially centrally of the length of the tube to provide two compartments of differing size. Such compartments may be, for example, 2cc and 3cc. Thus, the manufacturer, rather than having to use two separate molds and two separate production lines, may manufacture a single tube having a selection of a 2cc and a 3cc compartment or chamber. Thereafter, the user or vendor may utilize or select one of the sizes of compartment and impart a vacuum thereto and place a stopper in the open end of the compartment size selected. The remaining compartment or chamber not being utilized for this particular series of tubes has a plug for closing the open end of the non-utilized chamber or compartment.

Conventional blood collection tubes have only one chamber, and volume in those conventional tubes is varied by using either larger or smaller diameter tubes, taller or shorter length tubes or varying the degree of vacuum imparted. As will be understood by practitioners-in-the-art, larger and smaller diameter tubes require specific dimensioned stoppers for accommodating those various sizes. Moreover, taller and shorter tubes require different packaging to accommodate tube length. If an accommodation is made to utilizing only a single size tube and imparting a partial vacuum for subsequent use in which only a small quantity of specimen is required in relatively large tubes, there is inconsistent draw over different areas of use because of differing atmospheric pressure gradients.

Finally, the users of tubes of different length and diameter must have varying size equipment, such as centrifuges, tube racks and like supporting arrangements to accommodate the varying sizes of tubes being utilized for collecting differing quantities of body fluid specimens for different applications.

With this invention, by contrast, a single size tube, as noted above is utilized. For this reason, the user, in the sometimes tense environment of taking a blood specimen from an individual, has a relatively large tube for handling during the collection activity Nevertheless the tube has a smaller compartment; for accommodating the actual size specimen required. Moreover, because only a single size tube relative to diameter is being utilized with the invention here, a single stopper size is required rather than a plurality of stopper sizes of differing diameters to accommodate differing diametered tubes. This reduces manufacturing requirements as well as storage requirements for such a variety of stopper sizes.

Moreover, because of the large size tubes having small compartmentalized areas, no "partial draw" vacuum applications are required. This eliminates the problem of inconsistency depending upon the atmospheric pressure gradients over many areas of use of such tubes. Finally, because of the uniformity of size of the tube, the hospital or clinical laboratory only needs to have one size equipment necessary for handling the tubes of a standard size.

A further feature of the invention may be the use of both compartments of a single tube by the phlebotomist. That is, the vendor or manufacturer of the tubes may, for example, impart vacuum to both a 3cc and a 2cc compartment or chamber in a single tube and place stoppers for sealing and

maintaining the vacuum. Thereafter, the phlebotomist, in requiring two separate blood sample volumes for different tests subsequently can first draw blood into one chamber followed by inversion of the tube and collection of blood into the second chamber. Two blood samples would then be contained in a single tube for subsequent examination in the clinical laboratory, and with only one venous entry.

Other objects and advantages of this invention will be apparent from the following description, the accompanying drawings and the appended claims.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is longitudinal sectional view of the compartmentalized blood collection tube of the invention;

Fig. 2 is a longitudinal sectional view of one embodiment of the invention wherein a vacuum has been imparted to the smaller chamber or compartment of the tube of the invention and showing the sealing stopper arrangement for such a tube, together with a plug for the unused chamber;

Fig. 3 is a longitudinal sectional view of the tube of the invention reversed in its application from that shown in Fig. 2;

Fig. 4 is an enlarged partial cross-sectional view of one open end of the tube of the invention showing the mating configuration of a sealing plug applied to the open end for closing off the non-utilized chamber or compartment of the tube of the invention;

Fig. 5 is a longitudinal sectional view of a blood sample tube holder for taking a blood sample from a vein of a patient with the tube of the invention inserted therein; and

Fig. 6 is a longitudinal sectional view of a tube similar to that shown in Fig. 1, but both chambers being closed with a stopper closure for use in evacuating two chambers for collecting two specimens sequentially.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings in which like reference characters refer to like parts throughout the several views thereof, Fig. 1 illustrates the invention in the form of a conventionally sized blood collection tube compartmentalized in its formation to provide two chambers or compartments of differing size to accommodate differing blood sample requirements.

In Fig. 1, the device 10 is an elongated tube with walls 40 and having open ends 18, 20 at each end thereof. As can be seen in Fig. 1, tube 10 is divided by a wall 12 into compartments or chambers 14 and 16. Also, as will be seen in Fig. 1, chamber 14 is larger than chamber 16. For example, in a 6cc tube, chamber 14 may be, for example, 3cc in volume while chamber 16 may be 2cc in volume.

It will be understood that the volume amounts may be varied as use requirements dictate. Tube 10 may be comprised of a thermoplastic resin material, for example, formed in a mold to provide wall 12 integrally joined to wall 40 of tube 10.

Referring now to Fig. 2, tube 10 is shown in a prepared form for use by a vendor. In this case, the smaller dimensioned chamber 16 has had, for example, a vacuum applied thereto with a subsequent insertion of a stopper assembly 24 for maintaining the vacuum in chamber 16. The assembly 24 includes a rubber stopper for closing the open end, 20 of the tube, assembly 10. That is, the outer surface of lower portion of stopper 28 seals against the internal surface of walls 40 of the upper end of tube 10. The assembly 24 includes a plastic cap 26 connected to and surrounding elastomer stopper 28. This serves to accommodate removal of stopper 28 in a simple fashion, when required, to obtain access to the collected sample in chamber 16.

Stopper 28 includes a well 32 formed in the top surface thereof which has the purpose of reducing the vertical extent of stopper 28 in the center portion thereof to provide a diaphragm 34 of vertically smaller dimension through stopper 28 for receiving a needle such as needle 52 and the point 54 thereof, as shown in Fig. 5. The plastic portion 26 of stopper 24 assembly includes outer ridges 34 to provide an easier grip of the assembly 24 for removal thereof from the evacuated chamber 16, when required.

Referring to Fig. 4, the open end 18 of chamber 14, which in this case is not being utilized for fluid collection includes a plug 22 for stabilizing the open end 18 of the tube assembly 10 for subsequent use of the tube or for storing the tube prior to use.

In Fig. 4, an enlarged view of the open end 18 or 20 is shown to accommodate the snap-fit arrangement of plug 22 in the open end 18 or 20 of chamber 14 or 16, as the case may be, when they are not being utilized in a particular tube 10 assembly. That is, the lower end of wall 40 may include an annular indentation 36 for receiving in snap-fit engagement an annular abutment, 38 on plug 22.

Referring now to Fig. 3, a tube 10 is shown reversed from the Fig. 2 showing for accommodating use of the 3cc and/or larger compartment 14 as desired by the user. In this case, stopper assembly 24 closes the open end 18 rather than 20, while the open end 20 is closed with a plug 22. It will be understood by practitioners-in-the-art that both compartments or chambers 14, 16 may be utilized in a single tube 10 by imparting a vacuum to both chambers and using a stopper closure assembly

24 for closing both open ends 18 and 20. In such cases, a plug 22 is not utilized.

Such an arrangement is shown in Fig. 6 wherein a tube 60 similar to tube 10 is shown with chambers 64, 66 divided by wall 62. Tube 60 includes two open ends 68 and 70. In this case, a stopper assembly 24 is applied to both open ends after application of vacuum to chambers 64, 68, respectively. As discussed above, in such an application, the user collects two different volumes of specimen from a patient as required for subsequent testing purposes.

In use, the assembly 10 of the invention is inserted into a blood collection needle holder such as 42 shown in Fig. 5. Holders 42, for example, include at the closed end thereof a hub 46 with internal screw threads 48 for accommodating the screw threads of a needle holder hub 50. Thus, a plurality of needle holder hubs 50 may be, sequentially, screwed into hub 46 of needle holder 42 for repeated use. The needle 52 includes a sharpened end 56 which is inserted into the vein of a patient for collecting a blood Specimen.

Subsequent to insertion of the needle 56 into the vein of a patient, the laboratory technician, doctor or nurse inserts the tube assembly 10 into the blood collection holder 42 at the open end 43 thereof. In doing so, the technician holds onto the holder 42 utilizing the flange 44. Subsequently, the tube 10 is moved forward toward the closed end of the holder 42 until such time as the negative pressure needle point 54 passes through stopper 28. When this happens, access to the vacuum in chamber 16 takes place and the vacuum draws blood from the patient's vein through the needle 52 into chamber 16.

As will be understood by practitioners-in-the-art, the smaller chamber 16 may be, for example, of a volume of 2ccs which is all that is required for certain subsequent examinations of the specimen in the lab. A tube such as tube 60 shown in Fig. 6 may be used in holder 42 instead of tube 10. With such an arrangement, the double-ended needle assembly would include a sealing valve sleeve well known in the art so that the tube 60 may be pulled off needle point 54, and reversed for inserting the needle point 54 into the subsequent stopper 28 without blood loss, for collecting a second blood sample in chamber 66, for example.

Alternatively, the technician may use a standard size blood collection container and collect a subsequent larger blood sample, as required from the single insertion of point 56 of needle 52 in the patient's vein all as will be understood by the practitioner-in-the-art.

The blood collection tube of the invention may be comprised, preferably, from a clear molded thermoplastic material such as polyethylene, for example, or glass. Other materials which may be used, as will be appreciated by practitioners-in-the-art include various other thermoplastics such as polypropylene, polyethylene terephthalate, and polyvinyl chloride.

The evacuated chambers utilized for collection in the device of the invention here may have incorporated therein materials for reaction with the specimen being collected for providing a proper response to the collected specimen for subsequent examination in the clinical laboratory. The stopper may be comprised of an elastomer appropriate for providing the sealing required to maintain the imparted vacuum in the chamber selected for subsequent use by the laboratory technician. The plastic cover portion 26 of stopper assembly 24 may be comprised of polyethylene or other thermoplastic which may be molded into the proper shape for the assembly of the invention.

Whereas, as discussed above, specific embodiments of associated stoppers and caps have been shown, it should be understood that it is within the purview of this invention to provide other forms of closures for blood collection tubes of the kind discussed herein.

It will be understood that the invention here is most appropriate for medical applications because of the substantial reduced cost in accommodating a variety of different requirements for a body fluid specimen collection, and for reducing the number of molds required for providing an assembly which is nevertheless, much easier to handle than the miniaturized collection tubes presently being utilized for small volume specimen collection. Moreover, the arrangement herein eliminates the need for the application of "partial draw" tubes and the inconsistency apparent with the use of such partial draw tubes.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

Claims

1. A blood collection tube; comprising
   (a) a tube body;
   (b) said tube body comprised of walls formed as a cylinder to define a tube body chamber;
   (c) said tube body chamber having a first open end at one end of said tube body chamber and a second open end at the end of said tube body chamber opposite said first open end;

(d) a divider wall positioned between said first and second open ends;
(e) said divider wall dividing said tube body chamber into a first and a second compartment; and
(f) said divider wall being formed integrally as one piece with said cylindrical tube body walls.

2. The blood collection tube of Claim 1, further comprising
(a) said first and second compartments being of different volume capacity.

3. The blood collection tube of Claim 1 further comprising
(a) a stopper closing one of said first and second open ends; and
(b) a plug closing the other of said open ends not closed by said stopper.

4. The blood collection tube of Claim 3, further comprising
(a) said compartment with the open end closed by said stopper being evacuated.

5. The blood collection tube of Claim 3, further comprising said stopper being comprised of
(a) a first elastomeric portion inserted into said open end in sealing engagement therewith;
(b) a plastic portion fitted over and surrounding said elastomeric portion;
(c) said plastic portion encompassing said tubular walls adjacent said open end into which said stopper is inserted;
(d) the top of said plastic portion having an opening adjacent the axis thereof for providing needle access to said elastomeric portion; and
(e) cooperating abutment means on said elastomeric portion and said plastic portion for holding said elastomeric portion and said plastic portion together.

6. The blood collection tube of Claim 3, further comprising
(a) said tube walls and said divider wall are comprised of a material selected from the group consisting of polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride and glass.

7. A blood collection tube; comprising
(a) a tube body;
(b) said tube body comprised of walls formed as a cylinder to define a tube body chamber;
(c) said tube body chamber having a first open end at one end of said tube body chamber and a second open end at the end of said tube body chamber opposite said first open end;
(d) a divider wall positioned between said first and second open ends;
(e) said divider wall dividing said tube body chamber into a first and a second compartment;
(f) said divider wall being formed integrally as one piece with said cylindrical tube body walls;
(g) said first and second compartments being of different volume capacity;
(h) a first stopper closing said first open end; and
(i) a second stopper closing said second open end.

8. The blood collection tube of Claim 7, further comprising
(a) both said first and said second compartments being evacuated.

9. The blood collection tube of Claim 7, further comprising each of said first and second stoppers comprised of
(a) a first elastomeric portion inserted into said open end in sealing engagement therewith;
(b) a plastic portion fitted over and surrounding said elastomeric portion;
(c) said plastic portion encompassing said tubular walls adjacent said open end into which said stopper is inserted;
(d) the top of said plastic portion having an opening adjacent the axis thereof for providing needle access to said elastomeric portion; and
(e) cooperating abutment means on said elastomeric portion and said plastic portion for holding said elastomeric portion and said plastic portion together.

10. The blood collection tube of Claim 7, further comprising
(a) said tube walls and said divider wall are comprised of a material selected from the group consisting of polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride and glass..

FIG-1

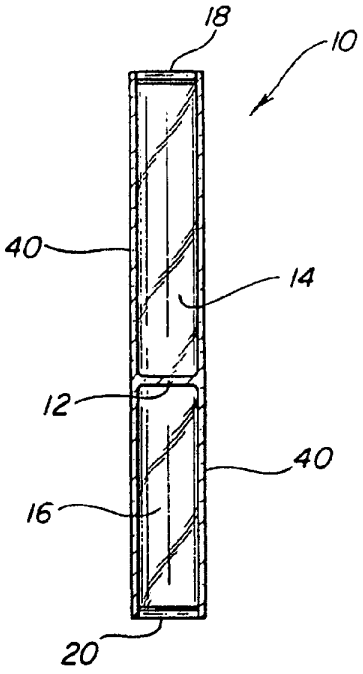


FIG-2

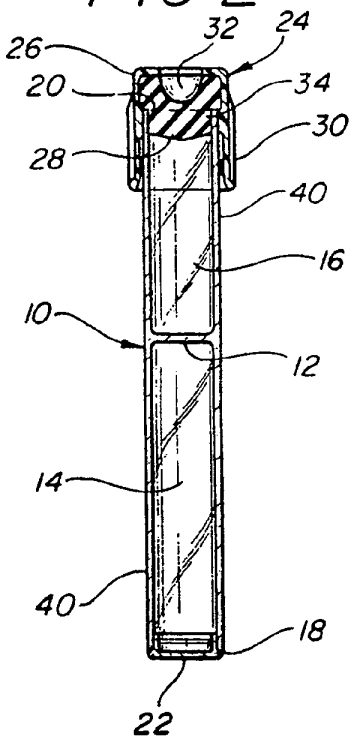


FIG-3

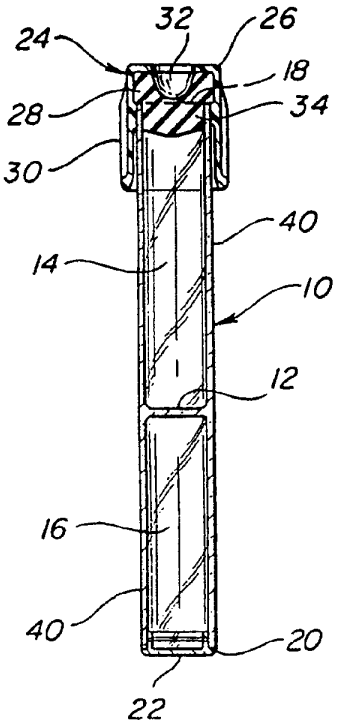


FIG-4

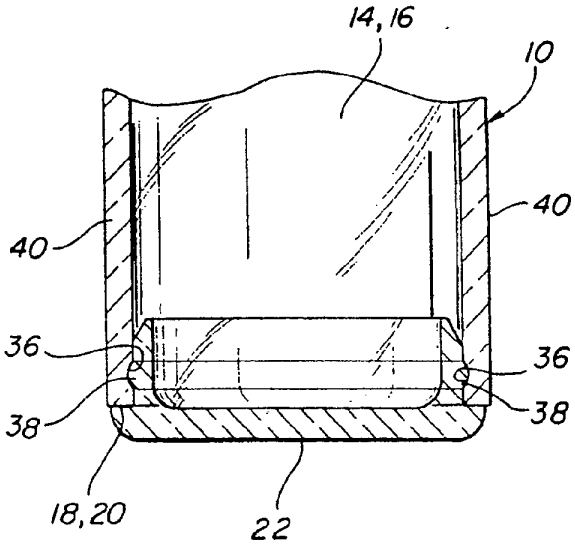


FIG-5

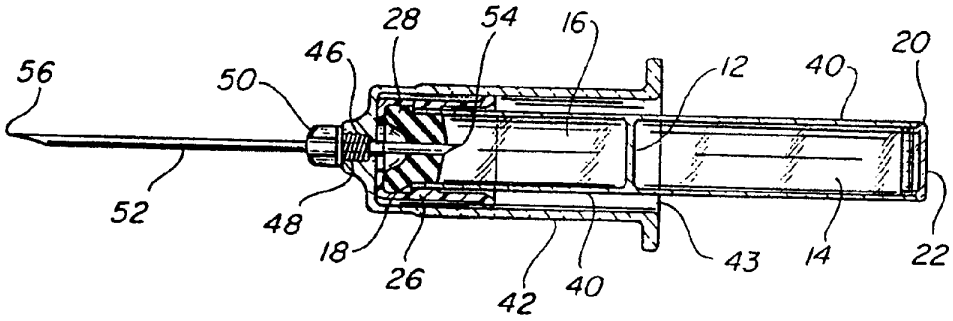
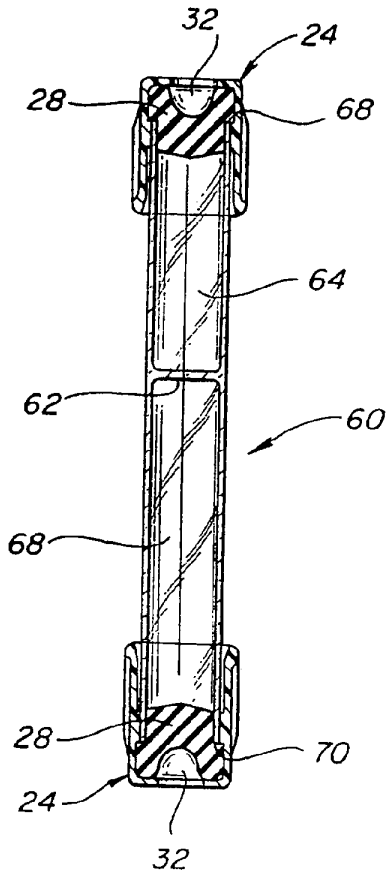

28
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FIG-6


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Espacenet

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Compartmental body fluid collection tube.

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Abstract of EP0448795 (A2)

A compartmented body fluid specimen collection tube (10) is provided which allows the user to select a size compartment (14,16) depending upon the quantity of specimen required. Thus, the tube of the invention may be of the standard size which is much easier for the user to handle than very small tubes when taking a blood sample, but a selected size compartment (14,16) is available. The manufacturer of the tube itself may use a single moid for making tubes accommodating differing required specimen quantities, and, thereafter the vendor may select either size compartment (14,16) for imparting a vacuum and the other processing required into a final product. The invention allows the use of a single standard size laboratory equipment array for processing collected specimens of varying quantities, as well as a single standard stopper (28). Finally, reduced vacuum application or "partial draw" tubes are avoided, thus eliminating the problem of unpredictable specimen draw response because of varying atmospheric pressures at different locations of use.

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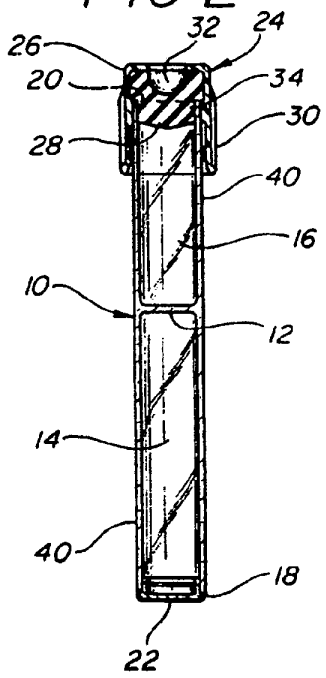
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(54) Compartmental body fluid collection tube.

(57) A compartmented body fluid specimen collection tube is provided which allows the user to select a size compartment depending upon the quantity of specimen required. Thus, the tube of the invention may be of the standard size which is much easier for the user to handle than very small tubes when taking a blood sample, but a selected size compartment is available. The manufacturer of the tube itself may use a single mold for making tubes accommodating differing required specimen quantities, and, thereafter the vendor may select either size compartment for imparting a vacuum and the other processing required into a final product. The invention allows the use of a single standard size laboratory equipment array for processing collected specimens of varying quantities, as well as a single standard stopper. Finally, reduced vacuum application or "partial draw" tubes are avoided, thus eliminating the problem of unpredictable specimen draw response because of varying atmospheric pressures at different locations of use.

FIG-2



EP 0 448 795 A2

BACKGROUND AND STATEMENT OF THE INVENTION

This invention relates to body fluid collection tubes for collecting a body fluid specimen from a patient for subsequent examination in a laboratory. More particularly, this invention relates to a blood collection tube for taking such specimens in which the tube has imparted thereto an internal vacuum with the vacuum being utilized for drawing the blood specimen from the vein of a patient.

Attempts have been made to overcome the problem of proliferation of a number of tubes for taking a plurality of specimens from a single venous entry into a patient. For example, Japanese Patent Application No. 62-51238, filed March 6, 1987 teaches a device in which a tube is divided axially into two chambers for taking two blood specimens simultaneously. However, there is no recognition for arranging different size compartments for taking different separate specimens of different size to accommodate subsequent laboratory testing of those specimens.

Other prior art arrangements, such as that taught in U.S. Patent 3,894,951, for example, provide for compartmentalized blood collection tubes in which the compartments have fluid connections for subsequent separation of a single blood sample into separate components.

In taking such specimens, differing quantities or volumes of specimens are required for certain applications. For this reason, larger and smaller tubes are manufactured for this purpose. As an alternative to making larger and smaller tubes, so-called "partial draw" tubes are provided in which the vacuum imparted to the tube is varied in order to accommodate differing quantities of specimen as required. All of these variations increase the cost of collecting blood specimens, and when it is understood that literally billions of such tubes are used and discarded after a single use each year the costs become substantial for medical applications.

This invention overcomes this problem by using a conventionally sized tube of, for example, 6cc in volume and incorporates an integral divider substantially centrally of the length of the tube to provide two compartments of differing size. Such compartments may be, for example, 2cc and 3cc. Thus, the manufacturer, rather than having to use two separate molds and two separate production lines, may manufacture a single tube having a selection of a 2cc and a 3cc compartment or chamber. Thereafter, the user or vendor may utilize or select one of the sizes of compartment and impart a vacuum thereto and place a stopper in the open end of the compartment size selected. The remaining compartment or chamber not being utilized for this particular series of tubes has a plug for closing the open end of the non-utilized chamber or compartment.

Conventional blood collection tubes have only one chamber, and volume in those conventional tubes is varied by using either larger or smaller diameter tubes, taller or shorter length tubes or varying the degree of vacuum imparted. As will be understood by practitioners-in-the-art, larger and smaller diameter tubes require specific dimensioned stoppers for accommodating those various sizes. Moreover, taller and shorter tubes require different packaging to accommodate tube length. If an accommodation is made to utilizing only a single size tube and imparting a partial vacuum for subsequent use in which only a small quantity of specimen is required in relatively large tubes, there is inconsistent draw over different areas of use because of differing atmospheric pressure gradients.

Finally, the users of tubes of different length and diameter must have varying size equipment, such as centrifuges, tube racks and like supporting arrangements to accommodate the varying sizes of tubes being utilized for collecting differing quantities of body fluid specimens for different applications.

With this invention, by contrast, a single size tube, as noted above is utilized. For this reason, the user, in the sometimes tense environment of taking a blood specimen from an individual, has a relatively large tube for handling during the collection activity Nevertheless the tube has a smaller compartment; for accommodating the actual size specimen required. Moreover, because only a single size tube relative to diameter is being utilized with the invention here, a single stopper size is required rather than a plurality of stopper sizes of differing diameters to accommodate differing diametered tubes. This reduces manufacturing requirements as well as storage requirements for such a variety of stopper sizes.

Moreover, because of the large size tubes having small compartmentalized areas, no "partial draw" vacuum applications are required. This eliminates the problem of inconsistency depending upon the atmospheric pressure gradients over many areas of use of such tubes. Finally, because of the uniformity of size of the tube, the hospital or clinical laboratory only needs to have one size equipment necessary for handling the tubes of a standard size.

A further feature of the invention may be the use of both compartments of a single tube by the phlebotomist. That is, the vendor or manufacturer of the tubes may, for example, impart vacuum to both a 3cc and a 2cc compartment or chamber in a single tube and place stoppers for sealing and

maintaining the vacuum. Thereafter, the phlebotomist, in requiring two separate blood sample volumes for different tests subsequently can first draw blood into one chamber followed by inversion of the tube and collection of blood into the second chamber. Two blood samples would then be contained in a single tube for subsequent examination in the clinical laboratory, and with only one venous entry.

Other objects and advantages of this invention will be apparent from the following description, the accompanying drawings and the appended claims.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is longitudinal sectional view of the compartmentalized blood collection tube of the invention;

Fig. 2 is a longitudinal sectional view of one embodiment of the invention wherein a vacuum has been imparted to the smaller chamber or compartment of the tube of the invention and showing the sealing stopper arrangement for such a tube, together with a plug for the unused chamber;

Fig. 3 is a longitudinal sectional view of the tube of the invention reversed in its application from that shown in Fig. 2;

Fig. 4 is an enlarged partial cross-sectional view of one open end of the tube of the invention showing the mating configuration of a sealing plug applied to the open end for closing off the non-utilized chamber or compartment of the tube of the invention;

Fig. 5 is a longitudinal sectional view of a blood sample tube holder for taking a blood sample from a vein of a patient with the tube of the invention inserted therein; and

Fig. 6 is a longitudinal sectional view of a tube similar to that shown in Fig. 1, but both chambers being closed with a stopper closure for use in evacuating two chambers for collecting two specimens sequentially.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings in which like reference characters refer to like parts throughout the several views thereof, Fig. 1 illustrates the invention in the form of a conventionally sized blood collection tube compartmentalized in its formation to provide two chambers or compartments of differing size to accommodate differing blood sample requirements.

In Fig. 1, the device 10 is an elongated tube with walls 40 and having open ends 18, 20 at each end thereof. As can be seen in Fig. 1, tube 10 is divided by a wall 12 into compartments or chambers 14 and 16. Also, as will be seen in Fig. 1, chamber 14 is larger than chamber 16. For example, in a 6cc tube, chamber 14 may be, for example, 3cc in volume while chamber 16 may be 2cc in volume.

It will be understood that the volume amounts may be varied as use requirements dictate. Tube 10 may be comprised of a thermoplastic resin material, for example, formed in a mold to provide wall 12 integrally joined to wall 40 of tube 10.

Referring now to Fig. 2, tube 10 is shown in a prepared form for use by a vendor. In this case, the smaller dimensioned chamber 16 has had, for example, a vacuum applied thereto with a subsequent insertion of a stopper assembly 24 for maintaining the vacuum in chamber 16. The assembly 24 includes a rubber stopper for closing the open end, 20 of the tube, assembly 10. That is, the outer surface of lower portion of stopper 28 seals against the internal surface of walls 40 of the upper end of tube 10. The assembly 24 includes a plastic cap 26 connected to and surrounding elastomer stopper 28. This serves to accommodate removal of stopper 28 in a simple fashion, when required, to obtain access to the collected sample in chamber 16.

Stopper 28 includes a well 32 formed in the top surface thereof which has the purpose of reducing the vertical extent of stopper 28 in the center portion thereof to provide a diaphragm 34 of vertically smaller dimension through stopper 28 for receiving a needle such as needle 52 and the point 54 thereof, as shown in Fig. 5. The plastic portion 26 of stopper 24 assembly includes outer ridges 34 to provide an easier grip of the assembly 24 for removal thereof from the evacuated chamber 16, when required.

Referring to Fig. 4, the open end 18 of chamber 14, which in this case is not being utilized for fluid collection includes a plug 22 for stabilizing the open end 18 of the tube assembly 10 for subsequent use of the tube or for storing the tube prior to use.

In Fig. 4, an enlarged view of the open end 18 or 20 is shown to accommodate the snap-fit arrangement of plug 22 in the open end 18 or 20 of chamber 14 or 16, as the case may be, when they are not being utilized in a particular tube 10 assembly. That is, the lower end of wall 40 may include an annular indentation 36 for receiving in snap-fit engagement an annular abutment, 38 on plug 22.

Referring now to Fig. 3, a tube 10 is shown reversed from the Fig. 2 showing for accommodating use of the 3cc and/or larger compartment 14 as desired by the user. In this case, stopper assembly 24 closes the open end 18 rather than 20, while the open end 20 is closed with a plug 22. It will be understood by practitioners-in-the-art that both compartments or chambers 14, 16 may be utilized in a single tube 10 by imparting a vacuum to both chambers and using a stopper closure assembly

24 for closing both open ends 18 and 20. In such cases, a plug 22 is not utilized.

Such an arrangement is shown in Fig. 6 wherein a tube 60 similar to tube 10 is shown with chambers 64, 66 divided by wall 62. Tube 60 includes two open ends 68 and 70. In this case, a stopper assembly 24 is applied to both open ends after application of vacuum to chambers 64, 68, respectively. As discussed above, in such an application, the user collects two different volumes of specimen from a patient as required for subsequent testing purposes.

In use, the assembly 10 of the invention is inserted into a blood collection needle holder such as 42 shown in Fig. 5. Holders 42, for example, include at the closed end thereof a hub 46 with internal screw threads 48 for accommodating the screw threads of a needle holder hub 50. Thus, a plurality of needle holder hubs 50 may be, sequentially, screwed into hub 46 of needle holder 42 for repeated use. The needle 52 includes a sharpened end 56 which is inserted into the vein of a patient for collecting a blood Specimen.

Subsequent to insertion of the needle 56 into the vein of a patient, the laboratory technician, doctor or nurse inserts the tube assembly 10 into the blood collection holder 42 at the open end 43 thereof. In doing so, the technician holds onto the holder 42 utilizing the flange 44. Subsequently, the tube 10 is moved forward toward the closed end of the holder 42 until such time as the negative pressure needle point 54 passes through stopper 28. When this happens, access to the vacuum in chamber 16 takes place and the vacuum draws blood from the patient's vein through the needle 52 into chamber 16.

As will be understood by practitioners-in-the-art, the smaller chamber 16 may be, for example, of a volume of 2ccs which is all that is required for certain subsequent examinations of the specimen in the lab. A tube such as tube 60 shown in Fig. 6 may be used in holder 42 instead of tube 10. With such an arrangement, the double-ended needle assembly would include a sealing valve sleeve well known in the art so that the tube 60 may be pulled off needle point 54, and reversed for inserting the needle point 54 into the subsequent stopper 28 without blood loss, for collecting a second blood sample in chamber 66, for example.

Alternatively, the technician may use a standard size blood collection container and collect a subsequent larger blood sample, as required from the single insertion of point 56 of needle 52 in the patient's vein all as will be understood by the practitioner-in-the-art.

The blood collection tube of the invention may be comprised, preferably, from a clear molded thermoplastic material such as polyethylene, for example, or glass. Other materials which may be used, as will be appreciated by practitioners-in-the-art include various other thermoplastics such as polypropylene, polyethylene terephthalate, and polyvinyl chloride.

The evacuated chambers utilized for collection in the device of the invention here may have incorporated therein materials for reaction with the specimen being collected for providing a proper response to the collected specimen for subsequent examination in the clinical laboratory. The stopper may be comprised of an elastomer appropriate for providing the sealing required to maintain the imparted vacuum in the chamber selected for subsequent use by the laboratory technician. The plastic cover portion 26 of stopper assembly 24 may be comprised of polyethylene or other thermoplastic which may be molded into the proper shape for the assembly of the invention.

Whereas, as discussed above, specific embodiments of associated stoppers and caps have been shown, it should be understood that it is within the purview of this invention to provide other forms of closures for blood collection tubes of the kind discussed herein.

It will be understood that the invention here is most appropriate for medical applications because of the substantial reduced cost in accommodating a variety of different requirements for a body fluid specimen collection, and for reducing the number of molds required for providing an assembly which is nevertheless, much easier to handle than the miniaturized collection tubes presently being utilized for small volume specimen collection. Moreover, the arrangement herein eliminates the need for the application of "partial draw" tubes and the inconsistency apparent with the use of such partial draw tubes.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

Claims

1. A blood collection tube; comprising
   (a) a tube body;
   (b) said tube body comprised of walls formed as a cylinder to define a tube body chamber;
   (c) said tube body chamber having a first open end at one end of said tube body chamber and a second open end at the end of said tube body chamber opposite said first open end;

(d) a divider wall positioned between said first and second open ends;
(e) said divider wall dividing said tube body chamber into a first and a second compartment; and
(f) said divider wall being formed integrally as one piece with said cylindrical tube body walls.

2. The blood collection tube of Claim 1, further comprising
(a) said first and second compartments being of different volume capacity.

3. The blood collection tube of Claim 1 further comprising
(a) a stopper closing one of said first and second open ends; and
(b) a plug closing the other of said open ends not closed by said stopper.

4. The blood collection tube of Claim 3, further comprising
(a) said compartment with the open end closed by said stopper being evacuated.

5. The blood collection tube of Claim 3, further comprising said stopper being comprised of
(a) a first elastomeric portion inserted into said open end in sealing engagement therewith;
(b) a plastic portion fitted over and surrounding said elastomeric portion;
(c) said plastic portion encompassing said tubular walls adjacent said open end into which said stopper is inserted;
(d) the top of said plastic portion having an opening adjacent the axis thereof for providing needle access to said elastomeric portion; and
(e) cooperating abutment means on said elastomeric portion and said plastic portion for holding said elastomeric portion and said plastic portion together.

6. The blood collection tube of Claim 3, further comprising
(a) said tube walls and said divider wall are comprised of a material selected from the group consisting of polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride and glass.

7. A blood collection tube; comprising
(a) a tube body;
(b) said tube body comprised of walls formed as a cylinder to define a tube body chamber;
(c) said tube body chamber having a first open end at one end of said tube body chamber and a second open end at the end of said tube body chamber opposite said first open end;
(d) a divider wall positioned between said first and second open ends;
(e) said divider wall dividing said tube body chamber into a first and a second compartment;
(f) said divider wall being formed integrally as one piece with said cylindrical tube body walls;
(g) said first and second compartments being of different volume capacity;
(h) a first stopper closing said first open end; and
(i) a second stopper closing said second open end.

8. The blood collection tube of Claim 7, further comprising
(a) both said first and said second compartments being evacuated.

9. The blood collection tube of Claim 7, further comprising each of said first and second stoppers comprised of
(a) a first elastomeric portion inserted into said open end in sealing engagement therewith;
(b) a plastic portion fitted over and surrounding said elastomeric portion;
(c) said plastic portion encompassing said tubular walls adjacent said open end into which said stopper is inserted;
(d) the top of said plastic portion having an opening adjacent the axis thereof for providing needle access to said elastomeric portion; and
(e) cooperating abutment means on said elastomeric portion and said plastic portion for holding said elastomeric portion and said plastic portion together.

10. The blood collection tube of Claim 7, further comprising
(a) said tube walls and said divider wall are comprised of a material selected from the group consisting of polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride and glass..

FIG-1

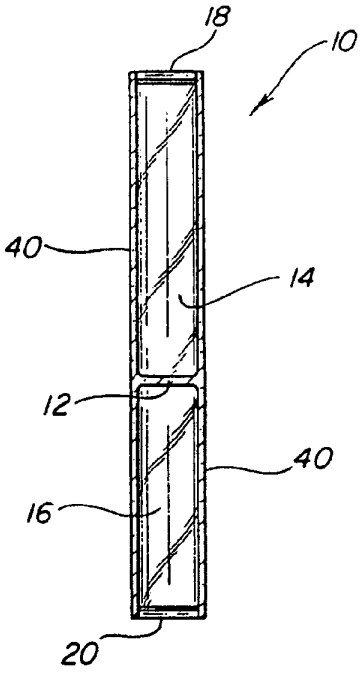


FIG-2

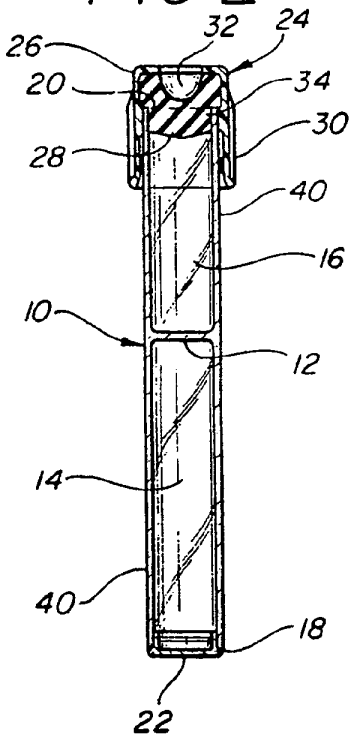


FIG-3

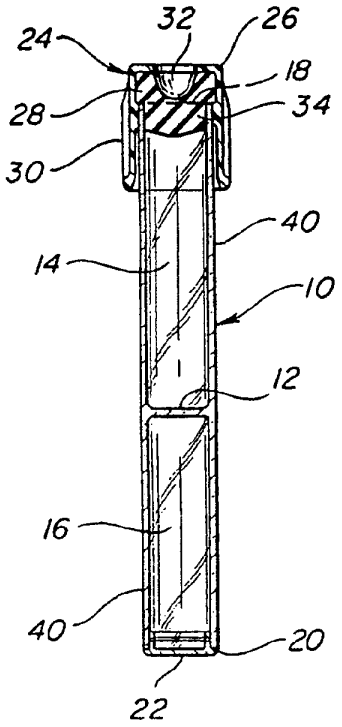


FIG-4

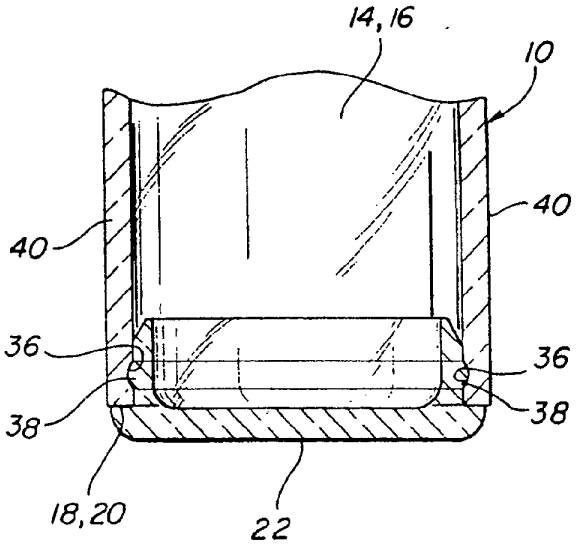


FIG-5

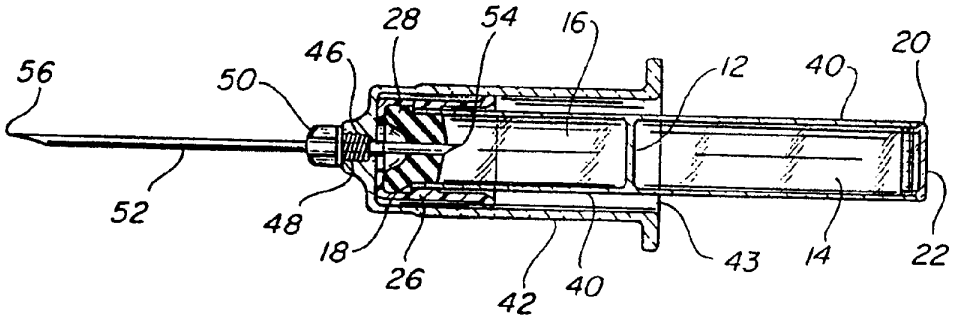
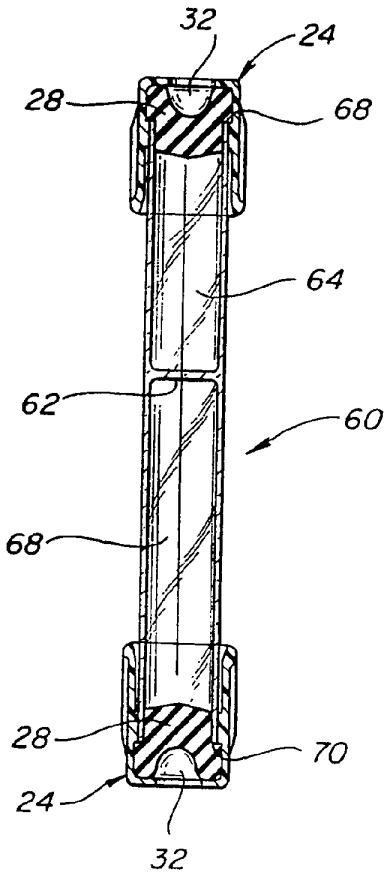

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FIG-6


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European Patent Office
Office européen des brevets

European Patent Office
80298 MUNICH
GERMANY

Questions about this communication ?
Contact Customer Services at www.epo.org/contact

Thum, Bernhard
Wuesthoff & Wuesthoff
Patentanwälte PartG mbB
Schweigerstraße 2
81541 München
ALLEMAGNE

Date
09.12.20

Reference	Application No./Patent No.
EPA-150 670	20197213.0 - 1132
Applicant/Proprietor	
Kurin, Inc.	

Communication

The extended European search report is enclosed.

The extended European search report includes, pursuant to Rule 62 EPC, the European search report (R. 61 EPC) or the partial European search report/ declaration of no search (R. 63 EPC) and the European search opinion.

Copies of documents cited in the European search report are attached.

☑ 0 additional set(s) of copies of such documents is (are) enclosed as well.

The following have been approved:

☐ Abstract ☐ Title

☑ The Abstract was modified and the definitive text is attached to this communication.

The following figure(s) will be published together with the abstract: 30B

Refund of search fee
If applicable under Article 9 Rules relating to fees, a separate communication from the Receiving Section on the refund of the search fee will be sent later.

Should you wish to further prosecute this application in the examination phase, your attention is drawn to the provisions of Rule 70a EPC. An invitation to respond to the extended European search report will be issued once the date of publication of the European search report has been mentioned in the European Patent Bulletin (R. 69(1), R. 70(2) EPC).

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Europäisches Patentamt
European Patent Office
Office européen des brevets

European Patent Office
10958 BERLIN
GERMANY
Tel: +49 30 2590 10
Fax: +49 30 2590 1840

Application No.: 20 197 213.0

The application and the invention to which it relates seem to meet the requirements of the EPC. Upon presence of a valid request for examination and consideration by the examining division, a communication under Rule 71(3) EPC may be issued.

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 19 7213

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2014/039348 A1 (BULLINGTON GREGORY J [US] ET AL) 6 February 2014 (2014-02-06) * the whole document *	1-7	INV. A61B5/15 A61B5/153 A61B5/154 A61B5/157
A	US 2014/107564 A1 (BULLINGTON GREGORY J [US] ET AL) 17 April 2014 (2014-04-17) * the whole document *	1-7	
A	US 4 813 433 A (DOWNEY JOHN M [US]) 21 March 1989 (1989-03-21) * the whole document *	1-7	
A	US 2013/317391 A1 (BULLINGTON GREGORY J [US] ET AL) 28 November 2013 (2013-11-28) * abstract * * paragraph [0048] - paragraph [0075]; figures 2-12 *	1-7	
A	WO 2013/181352 A1 (MAGNOLIA MEDICAL TECHNOLOGIES INC [US]; BULLINGTON GREGORY J [US]; PAT) 5 December 2013 (2013-12-05) * abstract * * paragraph [1090]; figures 11,12 *	1-7	TECHNICAL FIELDS SEARCHED (IPC) A61B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	19 November 2020	Nielsen, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

1

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 19 7213

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-11-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014039348 A1	06-02-2014	US 2014039348 A1	06-02-2014
		US 2016113560 A1	28-04-2016
		WO 2014022275 A1	06-02-2014
US 2014107564 A1	17-04-2014	EP 2906269 A1	19-08-2015
		EP 3318295 A1	09-05-2018
		US 2014107564 A1	17-04-2014
		US 2015367069 A1	24-12-2015
		US 2018177943 A1	28-06-2018
		US 2019151536 A1	23-05-2019
		WO 2014058945 A1	17-04-2014
US 4813433 A	21-03-1989	NONE	
US 2013317391 A1	28-11-2013	US 2013317391 A1	28-11-2013
		US 2015099996 A1	09-04-2015
		US 2015351678 A1	10-12-2015
		US 2018092584 A1	05-04-2018
		US 2019209066 A1	11-07-2019
WO 2013181352 A1	05-12-2013	AU 2013267448 A1	18-12-2014
		AU 2017216493 A1	07-09-2017
		AU 2019204941 A1	25-07-2019
		AU 2020213415 A1	27-08-2020
		CA 2875118 A1	05-12-2013
		CN 104902817 A	09-09-2015
		CN 107736901 A	27-02-2018
		EP 2854643 A1	08-04-2015
		EP 3173021 A1	31-05-2017
		EP 3549522 A1	09-10-2019
		JP 6242386 B2	06-12-2017
		JP 6695314 B2	20-05-2020
		JP 2015519145 A	09-07-2015
		JP 2018034009 A	08-03-2018
		JP 2020121167 A	13-08-2020
		US 2014155781 A1	05-06-2014
		US 2015351679 A1	10-12-2015
		US 2018116577 A1	03-05-2018
		US 2020359951 A1	19-11-2020
		WO 2013181352 A1	05-12-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
KURIN3PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2017/068569	27 December 2017 (27-12-2017)	27 December 2016 (27-12-2016)
Applicant		
KURIN, INC		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 30B
      [ ] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [X] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

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

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2017/068569	27.12.2017	27.12.2016

International Patent Classification (IPC) or both national classification and IPC
INV. A61B5/15 A61B5/153 A61B5/154 A61B5/157

Applicant
KURIN, INC

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office Gitschiner Str. 103 D-10958 Berlin Tel. +49 30 25901 - 0 Fax: +49 30 25901 - 840	see form PCT/ISA/210	Nielsen, Michael Telephone No. +49 30 25901-0

Form PCT/ISA/237 (Cover Sheet) (January 2015)

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-20
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-20
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

In light of the documents cited in the international search report, it is considered that the invention as claimed in the independent claims meets the criteria mentioned in Article 33 (1) PCT, i.e. it appears to be novel, to involve an inventive step and to be industrially applicable.

Prior art: Blood drawing devices capable of isolating a pre-sample in order to minimize the risk of contamination of the main sample. Well known concept, see any of the documents cited in the search report.

Problem: As in the prior art to minimize the risk of contamination of blood drawn from a patient.

Solution: The pre-sample chamber (sequestration chamber) having **the specific vent** as defined in the independent claims 1, 8 and 15.

None of the cited documents hint to said specific solution in order to solve said problem. Contribution to the art.

Claims 2-7, 9-14 and 16 to 20 are dependent on one or more independent claims whose subject-matter is considered as being new and inventive, as discussed above, and as such said dependent claims also meet the requirements of the PCT with respect to novelty and inventive step.

Re Item VII

Certain defects in the international application

1). The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT.

2). The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

3). Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art (see search report) is not mentioned in the description, nor are these documents identified therein.

4). Upon entering the regional phase via the European Patent Office, the requirements of Rule 43(2) EPC should be observed.

Information on Search Strategy - Pilot phase (see OJ 2015, A86)
The type of information contained in this sheet may change during the pilot for improving the usefulness of this new service.

Application Number
PCT/US2017/068569

TITLE: BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE AND METHOD

APPLICANT: KURIN, INC

IPC CLASSIFICATION: A61B5/15, A61B5/153, A61B5/154, A61B5/157

EXAMINER: Nielsen, Michael

CONSULTED DATABASES: WPI

CLASSIFICATION SYMBOLS DEFINING EXTENT OF THE SEARCH:

IPC:

CPC: A61B5/15003, A61B5/150213, A61B5/150251, A61B5/150389, A61B5/150488, A61B5/150992, A61B5/153, A61B5/150274, A61B5/1535, A61B5/1545, A61B5/157

FI/F-TERMS:

KEYWORDS OR OTHER ELEMENTS FEATURING THE INVENTION:

EPO FORM P04A42

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/068569

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/15 A61B5/153 A61B5/154 A61B5/157
ADD.

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)
A61B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/039348 A1 (BULLINGTON GREGORY J [US] ET AL) 6 February 2014 (2014-02-06) the whole document	1-20
A	US 2014/107564 A1 (BULLINGTON GREGORY J [US] ET AL) 17 April 2014 (2014-04-17) the whole document	1-20
A	US 4 813 433 A (DOWNEY JOHN M [US]) 21 March 1989 (1989-03-21) the whole document	1-20
A	US 2013/317391 A1 (BULLINGTON GREGORY J [US] ET AL) 28 November 2013 (2013-11-28) abstract paragraph [0048] - paragraph [0075]; figures 2-12	1-20

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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

"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
29 March 2018	25/04/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nielsen, Michael

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/068569

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/181352 A1 (MAGNOLIA MEDICAL TECHNOLOGIES INC [US]; BULLINGTON GREGORY J [US]; PAT) 5 December 2013 (2013-12-05) abstract paragraph [1090]; figures 11,12	1-20

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/068569

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014039348 A1	06-02-2014	US 2014039348 A1	06-02-2014
		US 2016113560 A1	28-04-2016
		WO 2014022275 A1	06-02-2014
US 2014107564 A1	17-04-2014	EP 2906269 A1	19-08-2015
		US 2014107564 A1	17-04-2014
		US 2015367069 A1	24-12-2015
		WO 2014058945 A1	17-04-2014
US 4813433 A	21-03-1989	NONE	
US 2013317391 A1	28-11-2013	US 2013317391 A1	28-11-2013
		US 2015099996 A1	09-04-2015
		US 2015351678 A1	10-12-2015
WO 2013181352 A1	05-12-2013	AU 2013267448 A1	18-12-2014
		AU 2017216493 A1	07-09-2017
		CA 2875118 A1	05-12-2013
		CN 104902817 A	09-09-2015
		CN 107736901 A	27-02-2018
		EP 2854643 A1	08-04-2015
		EP 3173021 A1	31-05-2017
		JP 6242386 B2	06-12-2017
		JP 2015519145 A	09-07-2015
		JP 2018034009 A	08-03-2018
		US 2014155781 A1	05-06-2014
		US 2015351679 A1	10-12-2015
		WO 2013181352 A1	05-12-2013

Form PCT/ISA/210 (patent family annex) (April 2005)

Europäisches Patentamt
European Patent Office
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European Patent Office
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Fax: +49 30 2590 1840

Thum, Bernhard
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Formalities Officer
Name: Golze, Doreen
Tel: +49 30 25901 - 704
or call
+31 (0)70 340 45 00

Application No.	Ref.	Date
17 840 467.9 - 1132	EPA-147 134	22.04.2020
Applicant: Kurin, Inc.		

Communication under Rule 71(3) EPC

1. Intention to grant

You are informed that the examining division intends to grant a European patent on the basis of the above application, with the text and drawings and the related bibliographic data as indicated below.

A copy of the relevant documents is enclosed.

1.1 In the text for the Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Description, Pages

1, 2, 4-44	as published	
3, 3a	filed in electronic form on	16-12-2019

Claims, Numbers

1-14	filed in electronic form on	16-12-2019

Drawings, Sheets

1/69-69/69	as published

With the following amendments to the above-mentioned documents proposed by the division

Description, Pages 1, 20, 23, 27, 40

Comments

Registered letter
EPO Form 2004C 12.17CXP

DESCRIPTION
Page 1: Deletion of irrelevant and/or superfluous information (Rule 48(1)(c) EPC, Guidelines F-II, 7.4)
Pages 20, 23, 27, 40: Insertion of SI/metric units (Rule 49(10) EPC)
CLAIMS
Page 1: Deletion of irrelevant and/or superfluous information (Rule 48(1)(c) EPC, Guidelines F-II, 7.4)

1.2 Bibliographic data

The title of the invention in the three official languages of the European Patent Office, the international patent classification, the designated contracting states, the registered name(s) of the applicant(s) and the other bibliographic data are shown on **EPO Form 2056** (enclosed).

2. Invitation

You are invited, **within a non-extendable period of four months** of notification of this communication,

2.1 to EITHER approve the text communicated above and verify the bibliographic data (Rule 71(5) EPC)

(1) by filing a translation of the claim(s) in the other two official languages of the EPO

		Fee code	EUR
(2a)	by paying the fee for grant including the fee for publication:	**007**	960.00
	minus any amount already paid (Rule 71a(5) EPC):		0.00
		Total amount:	960.00
(3)	by paying additional claims fees under Rule 71(4) EPC; number of claims fees payable: 0	**016**	0.00
	minus any amount already paid (Rule 71a(5) EPC):		0.00
		Total amount:	0.00

Important: If the translations of the claims and fees have already been filed and paid respectively in reply to a previous communication under Rule 71(3) EPC, e.g. in the case of resumption of examination after approval (see Guidelines C-V, 6), **agreement as to the text to be granted** (Rule 71a(1) EPC) must be expressed within the same time limit (e.g. by approving the text and verifying the bibliographic data, by confirming that grant proceedings can go ahead with the documents on file and/or by stating which translations of the claims already on file are to be used).

Note 1: See "Notes concerning fee payments" below.
Note 2: Any overpaid "minus" amounts will be refunded when the decision to grant (EPO Form 2006A) has been issued.
Note 3: For the calculation of the grant fee under Article 2(2), No. 7, RFees (old fee structure), the number of pages is determined on the basis of a clean copy of the application documents, in which text deleted as a result of any amendments by the examining division is not shown. Such clean copy is made available via on-line file inspection only.

2.2 OR, in the case of disapproval, to request reasoned amendments or corrections to the text communicated above or keep to the latest text submitted by you (Rule 71(6) EPC).

In this case the translations of the claims and fee payments mentioned under point 2.1 above are NOT due.

The terms "amendment(s)" and "correction(s)" refer only to amendments or corrections of the application documents and not of other documents (e.g. bibliographic data, the designation of the inventor, etc.).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the examining division requesting that you correct this deficiency (Rule 137(4) EPC).

2.3 Bibliographic data

Where you request a change or correction of bibliographic data in response to the Rule 71(3) communication, this will **not** cause the sending of a further communication under Rule 71(3) EPC. You will still have to pay the fees and file translations in reply to the Rule 71(3) communication in the case of 2.1 above, unless you also file a reasoned request for amendments or corrections in response to the Rule 71(3) communication (see case 2.2 above).

3. Loss of rights

If neither of the two possible actions above (see points 2.1 or 2.2) is performed in due time, the European patent application will be deemed to be withdrawn (Rule 71(7) EPC).

4. Further procedure

4.1 In the case of point 2.1 above

4.1.1 The decision to grant the European patent will be issued, and the **mention of the grant** of the patent will be published in the European Patent Bulletin, if the requirements concerning the translation of the claims and the payment of all fees are fulfilled and there is agreement as to the text to be granted (Rule 71a(1) EPC).

Note on payment of the renewal fee:
If a renewal fee becomes due before the next possible date for publication of the mention of the grant of the European patent, publication will be effected only after the renewal fee and any additional fee have been paid (Rule 71a(4) EPC).

Under Article 86(2) EPC, the obligation to pay renewal fees to the European Patent Office terminates with the payment of the renewal fee due in respect of the year in which the mention of the grant of the European patent is published.

Note on payment of the designation fee(s):
If the designation fee(s) become(s) due after the communication under Rule 71(3) EPC, the mention of the grant of the European patent will not be published until these fees have been paid (Rule 71a(3) EPC).

4.1.2 After publication, the **European patent specification** can be downloaded free of charge from the EPO publication server https://data.epo.org/publication-server.

4.1.3 Filing of translations in the contracting states

As regards translation requirements prescribed by the contracting states under Article 65(1) EPC, please consult the website of the European Patent Office
www.epo.org →Law & practice →Legal texts, National law relating to the EPC
www.epo.org →Law & practice →All Legal texts →London Agreement

In the case of a valid extension or validation

As regards translation requirements prescribed by the extension or validation states, please consult the website of the European Patent Office

www.epo.org →Law & practice →Legal texts, National law relating to the EPC

Failure to supply a prescribed translation in a contracting state, or in an extension or validation state may result in the patent being deemed to be void *ab initio* in the state concerned (Art. 65(3) EPC).

4.2 In the case of 2.2 above

If the present communication under Rule 71(3) EPC is based on an auxiliary request and, within the time limit, you maintain the main request or a higher ranking request which is not allowable, the application will be refused (Art. 97(2) EPC).

If the examining division gives its consent to the requested amendments or corrections, it will issue a new communication under Rule 71(3) EPC; otherwise, it shall resume the examination proceedings (Rule 71(6) EPC).

5. Filing of a divisional application

Any divisional application relating to this European patent application must be filed directly with the European Patent Office in Munich, The Hague or Berlin and will be in the language of the proceedings for the present application, or if the latter was not in an official language of the EPO, the divisional application may be filed in the language of the present application as filed (see Article 76(1) and Rule 36(2) EPC). Any such divisional application must be filed while the present application is still pending (Rule 36(1) EPC; Guidelines A-IV, 1.1.1).

6. Notes concerning fee payments

6.1 Making payments

For payments made via deposit account, please note that as from 1 December 2017 debit orders will only be carried out if filed in an electronically processable format (xml), using an accepted means of filing as laid down in the Arrangements for deposit accounts (ADA), published in the Supplementary publication in the Official Journal.

All relevant information related to the modes of payment of fees to the EPO can be retrieved from the EPO website at "**Making Payments**".

6.2 Information concerning fee amounts

Procedural fees are usually adjusted every two years, on even years, with effect from 1 April. Therefore, before making a payment, parties should verify the amounts actually due on the date of payment using the applicable version of the Schedule of fees and expenses, published as a Supplement to the Official Journal of the EPO, available on the EPO website (**www.epo.org**) at **www.epo.org/schedule-of-fees**. The "Schedule of fees" table allows the viewing, downloading and searching of individual fee amounts, both current and previous.

6.3 Note to users of the automatic debiting procedure

The fee for grant, including the fee for publication, and any additional claims fees due under Rule 71(4) EPC will be debited automatically on the date of filing of the translations of the claims, or on the last day of the period of this communication. However, if the designation fee(s) become(s) due as set out in Rule 71a(3) EPC and/or a renewal fee becomes due as set out in Rule 71a(4) EPC, these should be paid separately by another permitted way of payment in order not to delay the publication of the mention of the grant. The same applies in these circumstances to the payment of extension and validation fees. The same applies in these circumstances to the payment of extension and validation fees.

Note: If a waiver is expressed in response to a Rule 71(3) communication (see OJ EPO 2015, A52), the fee for grant, including the fee for publication/printing, and any additional claims fees will not be debited automatically. These fees must be paid separately by another means of payment allowed under the Rules relating to Fees.

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Enclosures: Text intended for grant

EPO Form 2056

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Annex to EPO Form 2004, Communication pursuant to Rule 71(3) EPC

Bibliographical data of European patent application No. 17 840 467.9

For the intended grant of the European patent, the bibliographical data are set out below, for information:

Title of invention:	- BLUTPROBENOPTIMIERUNGSSYSTEM SOWIE VORRICHTUNG ZUR SEQUESTRIERUNG VON BLUTKONTAMINANTEN - BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE - SYSTÈME D'OPTIMISATION D'ÉCHANTILLON DE SANG ET DISPOSITIF DE SÉQUESTRATION DE CONTAMINANT DU SANG
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Extension States* for which fees have been paid:	
Validation States* for which fees have been paid:	
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*)	If the time limit for the payment of designation fees according to Rule 39(1) EPC has not yet expired and the applicant has not withdrawn any designation, **all Contracting States/Extension States/Validation States** are currently still deemed to be designated. See also Rule 71a(3) EPC and, if applicable, the above Note to users of the automatic debiting procedure.
**)	If two or more applicants have designated different Contracting States, this is indicated here.

~~BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE AND METHOD~~

BACKGROUND

[0001] Bacteraemia is the presence of microorganisms in the blood. Sepsis, on the other hand, is bacteraemia in the presence of clinical symptoms and signs such as fever, tachycardia, tachypnea and hypotension. Bacteraemia and sepsis are associated with a high mortality and an increased incidence and duration of hospital stay and associated costs. Many bacteraemias, sepsis, fungaemias and other pathogens actually occur within a hospital or other healthcare settings with catheters and venipunctures being a source of contamination as potential carriers of these pathogens.

[0002] Blood cultures are the standard test used to detect microbial pathogens related to bacteraemia and sepsis in a patient's blood. The term blood culture refers to a single venipuncture, either from a peripheral site or central or arterial line, with the blood inoculated into one or more blood culture bottles or containers. One bottle is considered a blood culture where two or more are considered a set. Multiple sets may be obtained from multiple venipunctures and are associated with different sites on the patient.

[0003] These methods allow for microbial identification and susceptibility testing to be performed, which is a critical component to managing sepsis, however the lack of rapid results and decreased sensitivity for fastidious pathogens has led to the development of improved systems and adjunctive molecular or proteomic testing.

[0004] Collection of blood samples for conducting blood cultures is a critical component of modern patient care and can either positively affect the patient outcome by providing an accurate diagnosis, or can adversely affect the outcome by prolonging unnecessary antimicrobial therapy, the length of hospital stays, and increasing costs.

[0005] One outcome of collection of blood cultures is contamination. Blood culture contamination can lead to a false positive culture result and/or significant increase in healthcare related costs. Sources of blood culture contamination include improper skin antisepsis, improper collection tube disinfection, and contamination of the initial blood draw which may then skew results.

[0006] Blood culture collection kits generally consist of a "butterfly" set, infusion set, or other type of venipuncture device as offered by companies like BD, Smiths, B. Braun and others, and aerobic and anaerobic blood culture bottles. Various different bottles are also available depending on the test requirements. These bottles are specifically designed to optimize recovery of both aerobic and anaerobic organisms. In conventional kits, a bottle used is known generally as a "Vacutainer," which is a blood collection tube formed of a sterile glass or plastic tube with a closure that is evacuated to create a vacuum inside the tube to facilitate the draw of a predetermined volume of liquid such as blood.

[0007] False positive blood cultures are typically a result of poor sampling techniques. They cause the use of antibiotics when not needed, increasing hospital costs and patient anxiety. Blood cultures are drawn from a needlestick into the skin, and then a Vacutainer is attached to capture a sample of blood. Contamination may occur from improper or incomplete disinfection of the skin area in and around the puncture site. It may also occur from the coring of the skin by the needle during insertion, with the cored skin cells and any associated contamination being pulled into the sample.

[0008] Blood flow through a hypodermic needle is laminar, and as such, a velocity gradient can be developed over the flow tube as a pressure drop is applied to the hypodermic needle. Either forceful aspiration of blood, or using a very small hypodermic needle, can cause lysis and a release of potassium from the red blood cells, thereby rendering the blood samples abnormal.

[0009] In other instances, some patients have delicate veins that can collapse under a pressure drop or vacuum, particularly as applied by a syringe's plunger that is drawn too quickly for the patient's condition. Since such condition is impossible to know beforehand, such vein collapses are a risk and very difficult to control.

[0010] Various strategies have been implemented to decrease blood culture contamination rates, e.g. training staff with regard to aseptic collection technique, feedback with regard to contamination rates and implementation of blood culture collection kits. Although skin antisepsis can reduce the burden of contamination, 20% or more of skin organisms are located deep within the dermis and are unaffected by

antisepsis. Changing needles before bottle inoculation is not advisable as it increases the risk to acquire needle stick injuries without decreasing contamination rates.

[0011] Some conventional systems and techniques for reducing blood culture contamination include discarding the initial aliquot of blood taken from central venous catheters, venipunctures, and other vascular access systems. However, these systems require the user to mechanically manipulate an intravascular device, or require a complex series of steps that are difficult to ensure being followed.

US 2014/039348 A1 discloses a device including a pre-sample reservoir, an actuator mechanism and a diverter. The pre-sample reservoir can be fluidically coupled to a delivery member to receive and isolate a predetermined volume of bodily-fluid withdrawn from a patient. US 2014/107564 A1 discloses an apparatus including a cannula assembly, a housing, a fluid reservoir, a flow control mechanism and an actuator. US 4 813 433 A discloses a syringe for withdrawing fluids which consists of one-handed operated syringe. The syringe comprises a double compartmented housing, a piston disposed in one of said compartments, a piston rod connected to said piston controlling the movement of said piston in a barrel, and vent means. US 2013/317391 A1 discloses an apparatus including a housing, a flow control mechanism and an actuator. At least a portion of the flow control mechanism is movably disposed within the housing.

SUMMARY

[0012] This document presents systems and methods for reducing blood culture contamination, lysing of cells, and vein collapse. In some implementations, a system and method can eliminate user variability in disinfection, and also eliminate the risk of skin cells getting into the blood culture sample. The systems and methods disclosed herein do not require a change in existing clinical processes, other than to potentially indicate when a vacutainer or other blood collection device (i.e., syringe) should be attached for drawing contaminant-free blood samples.

[0013] In some implementations of the systems and methods disclosed herein the withdrawal of blood is accomplished passively by use of the patient's own blood pressure, thereby reducing the risk of vein collapse and eliminating any additional user steps over current practice. The systems and methods can be applied to accommodate

short-path direct stick or butterfly venipuncture systems. They can also be used with samples drawn through a catheter.

[0014] In one aspect, a blood sequestration device is presented. The blood sequestration device includes an inlet port and an outlet port. The blood sequestration device further includes a sequestration chamber connected with the inlet port, the sequestration chamber having a vent comprising an air permeable blood barrier. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port and a distal end connected with the outlet port.

[0015] In another aspect, a blood sequestration device connected with a blood sampling pathway is described. The blood sampling pathway has a patient needle and a sample collection device. The blood sequestration device includes an inlet port connected

with the patient needle, and a sequestration chamber connected with the inlet port, the sequestration chamber having a vent comprising an air permeable blood barrier. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port, and an outlet port connected with a distal end of the sampling channel and with the sample collection device.

[0016] In yet another aspect, a blood sequestration device connected with a blood sampling system is described. The blood sampling system includes a patient needle for accessing a blood sample from a patient, and a sample needle that is sealed and adapted for receiving an evacuated blood collection tube. The blood sequestration device includes an inlet port connected with the patient needle to receive the blood sample from the patient. The blood sequestration device further includes a sequestration chamber connected with the inlet port and having a vent comprising an air permeable blood barrier, the sequestration chamber for receiving and sequestering a first portion of the blood sample prior to the sample needle being unsealed by the evacuated blood collection tube. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port, the sampling channel for conveying a subsequent portion of the blood sample once the sample needle is unsealed by the evacuated blood collection tube. The blood sequestration device further includes an outlet port connected with a distal end of the sampling channel for conveying the subsequent portion of the blood sample to the sample needle.

[0017] In yet another aspect, a blood sample optimization system is disclosed and described. The blood sample optimization system includes a blood sampling system for accessing and acquiring one or more samples of a patient's blood, and a blood sequestration device for receiving and sequestering a first portion of the one or more samples of the patient's blood which might be contaminated by a venipuncture process and which could result in a false positive identification of a pathogen in the patient's blood.

[0018] The blood sampling system includes a patient needle configured for a venipuncture of a patient to access a sample of blood of a patient, a blood sampling pathway connected with the patient needle for conveying the sample of blood, and a sample needle configured for receiving an evacuated blood collection container to collect and contain a subsequent portion of the sample of blood.

[0019] In yet another aspect, a blood sequestration device is disclosed and described. In some implementations, the blood sequestration device can include an inlet port, an outlet port connected with the inlet port, and a sequestration chamber connected with the inlet port. The sequestration chamber can have a vent comprising an air permeable blood barrier.

[0020] The blood sequestration device, in one aspect can include an inlet port, an outlet port, a sequestration chamber connected with the inlet port via a junction, the sequestration chamber having a vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further includes a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber, and a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port. In certain related aspects, the sequestration chamber, the sampling channel and the junction are sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0021] In another aspect, the sampling channel and the junction is sized and configured such that a first portion of blood flows into and fills the sequestration chamber to displace air therein through the vent, and such that a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0022] The blood sequestration and sampling system sequestration device, in certain aspects can include a blood sampling pathway having a patient needle on a proximal end and a sample collection device on a distal end; and a blood sequestration device attached on the blood sampling pathway between the proximal end and distal end of the blood sampling pathway. The blood sequestration device in one aspect can include an inlet port coupled with the blood sampling pathway toward the patient needle, an outlet port coupled with the blood sampling pathway toward the sample collection device, a sequestration chamber connected with the inlet port via a junction, which chamber has a

vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further including a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port. In a certain related aspect, the sequestration chamber, the sampling channel and the junction can be sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0023] The blood sequestration device is connected along the blood sampling pathway between the patient needle and the sample needle, and includes an inlet port for receiving the sample of blood. The blood sequestration device further includes a sequestration chamber connected with the inlet port for receiving a first amount of the sample of blood, the sequestration chamber having a vent comprising an air permeable blood barrier for sequestering at least a first portion of the first amount of the sample of blood. The blood sequestration device may further include a sampling channel having a proximal end connected with the inlet port, the sampling channel conveying a subsequent amount of the sample of blood to the evacuated blood collection container upon the sequestration chamber sequestering at least the first portion of the first amount of the sample of blood. The blood sequestration device further includes an outlet port connected with a distal end of the sampling channel, the outlet port for outputting the subsequent amount of the sample of blood.

[0024] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and other aspects will now be described in detail with reference to the following drawings.

[0026] FIG. 1 illustrates a blood sample optimization system.

[0027] FIG. 2 illustrates a blood sample optimization system in accordance with an alternative implementation.

[0028] FIG. 3 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0029] FIG. 4 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0030] FIG. 5 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0031] FIG. 6 illustrates a blood sample optimization system in accordance with an alternative implementation.

[0032] FIG. 7 is a flowchart of a method for optimizing a quality of a blood culture.

[0033] FIGS. 8A – 8E illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with some implementations.

[0034] FIG. 9 illustrates a pathway splitter for use in a blood sequestrations system.

[0035] FIGS. 10A – 10D illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with alternative implementations.

[0036] FIGS. 11A – 11E illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with other alternative implementations.

[0037] FIGS. 12A-12D illustrate a blood sample optimization system including a blood sequestration device in accordance with yet other alternative implementations.

[0038] FIGS. 13A-13D illustrate a blood sample optimization system 1300 in accordance with yet another alternative implementations.

[0039] FIGS. 14A-14E illustrate yet another implementation of a blood sampling system to sequester contaminates of an initial aliquot or sample to reduce false positives in blood cultures or tests performed on a patient's blood sample.

[0040] FIGS. 15A-15G illustrate a blood sequestration device and method of using the same, in accordance with yet another implementation.

[0041] FIGS. 16A-16D illustrate a blood sequestration device in accordance with yet another implementation.

[0042] FIGS. 17A – 17E illustrate a bottom member of a housing for a blood sequestration device.

[0043] FIGS. 18A – 18F illustrate a top member of a housing for a blood sequestration device.

[0044] FIGS. 19A and 19B illustrate a blood sequestration device having a top member mated with a bottom member.

[0045] FIG. 20 shows a blood sample optimization system including a blood sequestration device.

[0046] FIG. 21 illustrates a non-vented blood sequestration device using a wicking material chamber.

[0047] FIGS. 22A and 22B illustrate a material makeup of a filter for sequestering blood in a sequestration chamber of a blood sequestration device.

[0048] FIGS. 23A – 23E illustrate another implementation of a blood sequestration device that uses a vacuum force from a blood collection device.

[0049] FIGS. 24A – 24D illustrate another implementation of a blood optimization system and blood sequestration device.

[0050] FIGS. 25A – 25D illustrate another implementation of a blood optimization system and blood sequestration device.

[0051] FIGS. 26A – 26E illustrate another implementation of a blood optimization system and blood sequestration device.

[0052] FIGS. 27A – 27D illustrate another implementation of a blood optimization system and blood sequestration device.

[0053] FIGS. 28A – 28F illustrate another implementation of a blood optimization system and blood sequestration device.

[0054] FIGS. 29A – 29C illustrate another implementation of a blood optimization system and blood sequestration device.

[0055] FIGS. 30A – 30G illustrate another implementation of a blood optimization system and blood sequestration device.

[0056] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0057] This document describes blood sample optimization systems and methods for reducing or eliminating contaminates in collected blood samples, which in turn reduces or eliminates false positive readings in blood cultures or other testing of collected blood samples. In some implementations, a blood sample optimization system includes a patient needle for vascular access to a patient's bloodstream, a sample needle for providing a blood sample to a blood collection container, such as an evacuated blood collection container or tube like a Vacutainer™ or the like, or other sampling device, and a blood sequestration device located between the patient needle and the sample needle. The blood sequestration device includes a sequestration chamber for sequestering an initial, potentially contaminated aliquot of blood, and may further include a sampling channel that bypasses the sequestration chamber to convey likely uncontaminated blood between the patient needle and the sample needle after the initial aliquot of blood is sequestered in the sequestration chamber.

[0058] FIG. 1 illustrates a blood sample optimization system in accordance with some implementations. The system includes a patient needle 1 to puncture the skin of a patient to access the patient's vein and blood therein. The system further includes a sample needle (i.e., a resealably closed needle for use with Vacutainers™ or the like) 5, which may be contained within and initially sealed by a resealable boot 10, a Luer activated valve, or another collection interface or device. The resealable boot 10 can be

pushed aside or around the sample needle 5 by application of a Vacutainer™ bottle (not shown) for drawing the patient's blood. The system can further include a low volume chamber 30 that leads to the sample needle 5, but also includes an orifice or one or more channels 45 that lead to a sequestration chamber 55 formed by a housing 50.

[0059] The sequestration chamber 55 is a chamber, channel, pathway, lock, or other structure for receiving and holding a first aliquot of the patient's blood, which may be in a predetermined or measured amount, depending on a volume of the sequestration chamber 55. The first draw of blood typically contains or is more susceptible to containing organisms that cause bacteraemia and sepsis or other pathogens than subsequent blood draws. The sequestration chamber 55 can be a vessel encased in a solid housing, formed in or defined by the housing itself, or can be implemented as tubing or a lumen. The sequestration chamber 55, regardless how formed and implemented, may have a predetermined volume. In some implementations, the predetermined volume may be based on a volume of the patient needle, i.e. ranging from less than the volume of the patient needle to any volume up to or greater than 20 times or more of the volume of the patient needle. The predetermined volume of the sequestration chamber 55 may also be established to economize or minimize an amount of blood to be sequestered and disposed of.

[0060] The sequestration chamber 55 can be formed, contained or housed in a chamber housing 50, and can be made of plastic, rubber, steel, aluminum or other suitable material. For example, the sequestration chamber 55 could be formed of flexible tubing or other elastomeric materials. The sequestration chamber 55 further includes an air permeable blood barrier 20 that allows air to exit the sequestration chamber 55. As used herein the term "air permeable blood barrier" means an air permeable but substantially blood impermeable substance, material, or structure. Examples may include hydrophobic membranes and coatings, a hydrophilic membrane or coating combined with a hydrophobic membrane or coating, mesh, a filter, a mechanical valve, antimicrobial material, or any other means of allowing air to be displaced from the sequestration chamber 55 as it is filled with blood. In various exemplary embodiments, an air permeable blood barrier may be formed by one or more materials that allow air to pass through until contacted by a liquid, such material then becomes completely or partially sealed to prevent or inhibit the passage of air and/or liquid. In other words, prior to contact with liquid, the material forms a barrier that is air permeable. After contact with a

liquid, the material substantially or completely prevents the further passage of air and/or liquid.

[0061] The orifice or channel 45 can be any desired length, cross-sectional shape or size, and/or can be formed to depart from the low volume chamber 30 at any desired angle or orientation. The orifice or channel 45 may also include a one-way flap or valve 60 that maintains an initial aliquot of blood sample within the sequestration chamber 55. In some specific implementations, the orifice or channel 45 can include a "duck bill" or flapper valve 60, or the like, for one-way flow of blood from low volume chamber 30 to the sequestration chamber 55. The air permeable blood barrier 20 can also be constructed of a material that allows air to exit but then seals upon contact with blood, thereby not allowing external air to enter sequestration chamber 55. This sealing would eliminate the need for a valve.

[0062] Valve 60 can be any type of valve or closing mechanism. Chamber 30 is designed to hold virtually no residual blood, and can be designed to be adapted to hold or allow pass-through of a particular volume or rate of blood into sequestration chamber 55. Likewise, sequestration chamber 55 may also include any type of coating, such as an anti-microbial coating, or a coating that aids identification and/or diagnosis of components of the first, sequestered blood draw.

[0063] Housing 50 and 40 can be formed of any suitable material, including plastic, such as acrylonitrile butadiene styrene (ABS) or other thermoplastic or polymeric material, rubber, steel, or aluminum. The air permeable blood barrier 20 can include a color-providing substance, or other signaling mechanism, that is activated upon contact with blood from the initial blood draw, or when air displacement is stopped, or any combination of events with blood in the sequestration chamber 55. The air permeable barrier may also include an outer layer such as a hydrophobic membrane or cover that inhibits or prevents the inadvertent or premature sealing of the filter by an external fluid source, splash etc. Sequestration chamber 55 can also be translucent or clear to enable a user to visually confirm the chamber is filled.

[0064] FIG. 2 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown in FIG. 2, a sequestration chamber 55, or waste chamber, surrounds the patient needle 1, with an

open-ended cuff or housing connected with the waste chamber and encircling the sample needle housing base and housing. The patient needle 1 and sample needle 5 are connected together by a boot 56, which forms a continuous blood draw channel therethrough. The boot 56 includes a single orifice or channel leading from the blood draw channel into sequestration chamber 55. The device can include more than one single orifice or channel, in other implementations. Each orifice or channel can include a one-way valve, and can be sized and adapted for predetermined amount of blood flow.

[0065] The sequestration chamber 55 includes an air permeable blood barrier. The filter can further include a sensor or indicator to sense and/or indicate, respectively, when a predetermined volume of blood has been collected in the sequestration chamber 55. That indication will alert a user to attach an evacuated blood collection tube or bottle, such as a Vacutainer™ to the sample needle 5. The housing for the sequestration chamber 55 can be any size or shape, and can include any type of material to define an interior space or volume therein. The interior space is initially filled only with air, but can also be coated with an agent or substance, such as a decontaminate, solidifying agent, or the like. Once evacuated blood collection tube is attached to the sample needle 5, blood will flow automatically into the patient needle 1, through the blood draw channel and sample needle 5, and into the bottle. The sample needle 5 is covered by a resealable boot, coating or membrane that seals the sample needle when a blood collection bottle is not attached thereon or thereto.

[0066] FIG. 3 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown, a sample needle 5 is surrounded by a resealable boot or membrane, and is further connected with a patient needle 1. A blood flow channel is formed through the sample needle and the patient needle. The connection between the sample needle and patient needle includes a "T" or "Y" connector 102, which includes a channel, port or aperture leading out from the main blood flow channel to a sequestration chamber 104.

[0067] The T or Y connector 102 may include a flap or one-way valve, and have an opening that is sized and adapted for a predetermined rate of flow of blood. The sequestration chamber 104 can be formed from tubing, or be formed by a solid housing, and is initially filled with air. The sequestration chamber 104 will receive blood that flows out of a patient automatically, i.e. under pressure from the patient's own blood

pressure. The sequestration chamber 104 includes an air permeable blood barrier 106, preferably at the distal end of tubing that forms the sequestration chamber 104, and which is connected at the proximal end to the T or Y connector 102. The T or Y connector 102 can branch off at any desired angle for most efficient blood flow, and can be formed so as to minimize an interface between the aperture and channel and the main blood flow channel, so as to minimize or eliminate mixing of the initial aliquot of blood with main blood draw samples.

[0068] In some alternative implementations, the sample needle may be affixed to a tubing of any length, as shown in FIG. 4, connecting at its opposite end to the T or Y connector 102. The sequestration chamber 104 can be any shape or volume so long as it will contain a predetermined amount of blood sample in the initial aliquot. The T or Y connector 102 may also include an opening or channel that is parallel to the main blood flow channel. The air permeable blood barrier may further include an indicator 107 or other mechanism to indicate when a predetermined amount of blood has been collected in the sequestration chamber, or when air being expelled reaches a certain threshold, i.e. to zero. The tubing can also include a clip 109 that can be used to pinch off and prevent fluid flow therethrough.

[0069] Once the air permeable blood barrier and primary chamber are sealed the initial aliquot of blood is trapped in the sequestration chamber 104, an evacuated blood collection tube, such as a Vacutainer™ bottle may be attached to the sample needle 5 to obtain the sample. The blood collection tube can be removed, and the sample needle 5 will be resealed. Any number of follow-on blood collection tubes can then be attached for further blood draws or samples. Upon completion of all blood draws, the system can be discarded, with the initial aliquot of blood remaining trapped in the sequestration chamber 104.

[0070] FIG. 5 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown, a sample needle 5 is connected with a patient needle by tubing. A “T” or “Y” connector 120 is added along the tubing at any desired location, and includes an aperture, port or channel leading to a sequestration chamber 204, substantially as described above.

[0071] FIG. 6 illustrates a blood sample optimization system in accordance with some alternative implementations, in which a sequestration chamber 304, formed as a primary collection channel, receives an initial aliquot of blood, and is provided adjacent to the blood sampling channel. The sequestration chamber 304 can encircle the blood sampling channel, the patient needle 1, and/or the sample needle 5. The primary collection channel can include a T or Y connector 120, or other type of aperture or channel. The sequestration chamber 304 includes an air permeable blood barrier, which can also include an indicator of being contacted by a fluid such as blood, as described above.

[0072] In some implementations, either the patient needle 1 or the sample needle 5, or both, can be replaced by a Luer lock male or female connector. However, in various implementations, the connector at a sample needle end of the blood sample optimization system is initially sealed to permit the diversion of the initial aliquot of blood to the sequestration chamber, which is pressured at ambient air pressure and includes the air outlet of the air permeable blood barrier. In this way, the system passively and automatically uses a patient's own blood pressure to overcome the ambient air pressure of the sequestration chamber to push out air through the air permeable blood barrier and displace air in the sequestration chamber with blood.

[0073] FIG. 7 is a flowchart of an exemplary method for optimizing the quality of a blood culture. At 702, a clinician places a needle into a patient's vein. At 704, blood then flows into a sequestration chamber, pushing the air in the sequestration chamber out of the sequestration chamber through an air permeable blood barrier. In some implementations, the volume of the sequestration chamber is less than 0.1 to more than 5 cubic centimeters (cc's), or more. The sequestration chamber is sized and adapted to collect a first portion of a blood sample, which is more prone to contamination than secondary and other subsequent portion of the blood sample or subsequent draws. Since the sequestration chamber has an air-permeable blood barrier through which air can be displaced by blood pushed from the patient's vein, such blood will naturally and automatically flow into the sequestration chamber before it is drawn into or otherwise enters into a Vacutainer or other bottle for receiving and storing a blood sample.

[0074] When the sequestration chamber fills, the blood will gather at or otherwise make contact with the air permeable blood barrier, which will inhibit or prevent blood

from passing therethrough. At 706, when the blood comes into contact with the entire internal surface area of the air permeable blood barrier, the air permeable blood barrier is then closed and air no longer flows out or in. At 708, the clinician may be provided an indictor or can see the full chamber, to indicate the evacuated blood collection tube, such as a Vacutainer™ can be attached. The indicator can include visibility into the primary chamber to see whether it is full, the blood barrier changing color, for example, or other indicator. The fill time of the sequestration chamber may be substantially instantaneous, so such indicator, if present, may be only that the sequestration chamber is filled.

[0075] Prior to an evacuated blood collection tube being attached, communication between the needle, sampling channel, and the sequestration chamber is restricted by the sealing of the sequestration chamber blood barrier thereby not permitting air to reenter the system through the sequestration. Sealing the communication path could also be accomplished with a mechanical twist or other movement, a small orifice or tortuous pathway, eliminating the need for a separate valve or mechanical movement or operation by the clinician. At 710, once the evacuated blood collection tube is removed, the self-sealing membrane closes the sample needle, and at 712, additional subsequent evacuated blood collection tubes may be attached. Once samples have been taken, at 714 the device is removed from the patient and discarded.

[0076] FIGS. 8A – 8E illustrate an exemplary blood sample optimization system 800 for non-contaminated blood sampling, in accordance with some implementations. The blood sample optimization system 800 includes an inlet port 802 that can be connected to tubing, a patient needle (or both), or other vascular or venous access device, and a pathway splitter 804 having a first outlet to a sequestration chamber tubing 806 and a second outlet to sample collection tubing 808. One or both of the sequestration chamber tubing 806 and the sample collection tubing 808 can be formed of tubing. In some implementations, the sequestration chamber tubing 806 is sized so as to contain a particular volume of initial blood sample. The sample collection tubing 808 will receive a blood sample once the sequestration chamber tubing 806 is filled. The sample collection tubing 808 can be connected to a Vacutainer™ base or housing 810, or other blood sample collection device.

[0077] The blood sequestration system 800 further includes a blood sequestration device 812 which, as shown in more detail in FIGS. 8B – 8D, includes a housing 818 that

includes a sampling channel 820 defining a pathway for the non-contaminated sample collection tubing 808 or connected at either end to the non-contaminated sample collection tubing 808. The sampling channel 820 can be curved through the housing 818 so as to better affix and stabilize the housing 818 at a location along the non-contaminated sample collection tubing 808.

[0078] The blood sequestration device 812 further includes a sequestration chamber 822 connected with the sequestration chamber tubing 806 or other chamber. The sequestration chamber 822 terminates at an air permeable blood barrier 824. The air permeable blood barrier 824 can also include a coloring agent that turns a different color upon full contact with blood, as an indicator that the regular collection of blood samples (i.e. the non-contaminated blood samples) can be initiated. Other indicators may be used, such as a small light, a sound generation mechanism, or the like. In some implementations, the air permeable blood barrier is positioned at a right angle from the direction of sequestration chamber 822, but can be positioned at any distance or orientation in order to conserve space and materials used for the housing 818. The housing 818 and its contents can be formed of any rigid or semi-rigid material or set of materials.

[0079] FIG. 9 illustrates a pathway splitter 900 for use in a blood sequestrations system, such as those shown in FIGS. 8A – 8E, for example. The pathway splitter 900 includes an inlet port 902, a main line outlet port 904, and a sequestration channel outlet port 906. The inlet port 902 can be connected to main tubing that is in turn connected to a patient needle system, or directly to a patient needle. The main line outlet port 904 can be connected to main line tubing to a blood sampling system, such as a vacutainer base or housing, or directly to such blood sampling system. The sequestration channel outlet port 906 can be connected to sequestration tubing for receiving and sequestering a first sample of blood, up to a measured amount or predetermined threshold. Alternatively, the sequestration channel outlet port 906 can be connected to a sequestration chamber. The sequestration channel outlet port 906 is preferably 20-70 degrees angled from the main line outlet port 904, which in turn is preferably in-line with the inlet port 902. Once the predetermined amount of initial blood sample is sequestered in the sequestration tubing or chamber, in accordance with mechanisms and techniques described herein, follow-on blood samples will flow into the inlet port 902 and directly out the main line outlet port 904, without impedance.

[0080] FIGS. 10A – 10D illustrate a blood sequestration device 1000 in accordance with alternative implementations. The blood sequestration device 1000 includes an inlet port 1002, a main outlet port 1004, and a sequestration channel port 1006. The inlet port 1002 can be connected to a patient needle or related tubing. The main outlet port 1004 can be connected to a blood sample collection device such as a Vacutainer, associated tubing, or a Luer activated valve, or the like. The sequestration channel port 1006 splits off from the main outlet port 1004 to a sequestration chamber 1008. In some implementations, the sequestration chamber 1008 is formed as a helical channel within a housing or other container 1001.

[0081] The sequestration chamber 1008 is connected at the distal end to an air permeable blood barrier 1010, substantially as described above. Air in the sequestration chamber 1008 is displaced through the air permeable blood barrier 1010 by an initial aliquot of blood that is guided into the sequestration channel port 1006. Once the sequestration chamber 1008 is filled, further blood draws through the main outlet port 1004 can be accomplished, where these samples will be non-contaminated.

[0082] FIGS. 11A – 11E illustrate a blood sequestration device 1100 in accordance with other alternative implementations. The blood sequestration device 1100 includes an inlet port 1102, similar to the inlet ports described above, a main outlet port 1104, and a sequestration channel port 1106 that splits off from the main outlet port 1104 and inlet port 1102. The sequestration channel port is connected to a sequestration chamber 1108. In the implementation shown in FIGS. 11A – 11E, the blood sequestration device includes a base member 1101 having a channel therein, which functions as the sequestration chamber 1108. The channel can be formed as a tortuous path through the base member 1101, which is in turn shaped and formed to rest on a limb of a patient.

[0083] A portion of the sequestration chamber 1108 can protrude from the base member or near a top surface of the base member, just before exiting to an air permeable blood barrier 1110, to serve as a blood sequestration indicator 1109. The indicator 1109 can be formed of a clear material, or a material that changes color when in contact with blood.

[0084] In some implementations, the blood sequestration device 1100 can include a blood sampling device 1120 such as a normally closed needle, Vacutainer™ shield or other collection device. The blood sampling device 1120 can be manufactured and sold with the blood sequestration device 1100 for efficiency and convenience, so that a first aliquot of blood that may be contaminated by a patient needle insertion process can be sequestered. Thereafter, the blood sampling device 1120 can draw non-contaminated blood samples to reduce the risk of false positive testing and ensure a non-contaminated sample.

[0085] FIGS. 12A-12D illustrate a blood sample optimization system 1200 in accordance with yet other alternative implementations. The system 1200 includes a blood sequestration device 1202 for attaching to a blood sampling device 1204, such as a Vacutainer™ or other collection and sampling device. The blood sequestration device 1202 is configured and arranged to receive, prior to a Vacutainer™ container or vial being attached to a collection needle of the blood sampling device 1204, a first aliquot or amount of blood, and sequester that first aliquot or amount in a sequestration channel of the blood sequestration device 1202.

[0086] In some implementations, the blood sequestration device 1202 can include an inlet port 1212, a main outlet port, and a sequestration channel port. The inlet port 1212 can be connected to a patient needle or related tubing. The main outlet port 1214 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like. The sequestration channel port splits off from the main outlet port to a sequestration chamber 1218.

[0087] In some implementations, the sequestration chamber 1218 is formed as a channel within the body of a sequestration device 1202. The sequestration chamber 1218 can be a winding channel, such as a U-shaped channel, an S-shaped channel, a helical channel, or any other winding channel. The sequestration device 1202 can include a housing or other containing body, and one or more channels formed therein. As shown in FIGS. 12A and 12B, the sequestration device 1202 includes a main body 1206 and a cap 1208. The main body 1206 is formed with one or more cavities or channels, which are further formed with one or more arms 1210 that extend from the cap 1208, and which

abut the cavities or channels in the main body 1206 to form the primary collection port and main outlet port.

[0088] FIGS. 13A-13D illustrate a blood sample optimization system 1300 in accordance with yet other alternative implementations. The system 1300 includes a blood sequestration device 1302 for attaching to a blood sampling device 1304, such as a Vacutainer or other bodily fluid collection and sampling device. The blood sequestration device 1302 is configured and arranged to receive, prior to a Vacutainer container or vial being attached to a collection needle of the blood sampling device 1304, a first aliquot or amount of blood, and to sequester that first aliquot or amount of blood or other bodily fluid in a sequestration channel of the blood sequestration device 1302.

[0089] The blood sequestration device 1302 includes a housing 1301 having an inlet port 1314, a main outlet port 1312, and a sequestration channel port 1316. The inlet port 1314 can be connected to a patient needle or associated tubing. The main outlet port 1312 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like. The sequestration channel port 1316 splits off from the main inlet port 1314 to a sequestration chamber 1318.

[0090] In the implementation shown in FIGS. 13A-D, the sequestration chamber 1318 is formed as a cavity or chamber within housing 1301 or formed by walls that define housing 1301. The sequestration chamber 1318 can be a winding channel, such as a U-shaped channel, an S-shaped channel, a helical channel, or any other winding channel, that is defined by the cooperation and connection of housing 1301 with cap 1307 which cap 1307 can include a protrusion 1305 that provides one or more walls or directors for the winding channel in the sequestration chamber 1318. The protrusion 1305 from the cap 1307 can be straight or curved, and may have various channels, apertures or grooves embedded therein, and can extend from the cap 1307 any angle or orientation. When the cap 1307 is connected with the housing 1301 to complete the formation of the sequestration chamber 1318, the protrusion 1305 forms at least part of the winding channel to sequester a first aliquot or amount of blood or other bodily fluid in a sequestration channel formed in the sequestration chamber 1318 and by the winding channel.

[0091] The sequestration chamber 1318 includes an air permeable blood barrier 1310, substantially as described above. Air in the sequestration chamber 1318 is displaced through the air permeable blood barrier 1310 by an initial aliquot of blood that is provided into the sequestration chamber 1318 by the blood pressure of the patient. Once the sequestration chamber 1318 is filled and the air in the sequestration chamber 1318 displaced, the blood pressure of the patient will be insufficient to drive or provide further blood into the blood sequestration device 1302, and in particular the outlet port 1312, until a force such as a vacuum or other pressure, such as provided by the blood sample collection device like Vacutainer is provided to draw out a next aliquot or amount of blood or bodily fluid. Further blood draws through the main outlet port 1312 can be accomplished, where these samples will be non-contaminated since any contaminants would be sequestered in the sequestration chamber 1318 with the first aliquot of blood.

[0092] FIGS. 14A-14E illustrate yet another implementation of a blood sampling system 1400 to sequester contaminates of an initial aliquot or sample to reduce false positives in blood cultures or tests performed on a patient's blood sample. The blood sampling system 1400 includes a blood sequestration device 1401 that can be connected between a blood sample collection device 1403 and a patient needle (not shown). The blood sample collection device 1403 can be a Vacutainer or the like. The blood sequestration device 1401 includes an inlet port 1402 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1402 may also be connected with tubing or other conduit that is in turn connected with the patient needle.

[0093] The inlet port 1402 defines an opening into the blood sequestration device 1401, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately ≥ 0,1143 cm (0,045 inches), ≥ ~~0.045 inches,~~ but can have a diameter of between ≥ 0,0254 cm (0,01 inches) ≥ ~~0.01 inches~~ or less to ≥ 0,508 cm (0,2 inches) ≥ ~~0.2 inches~~ or more. The blood sequestration device 1401 further includes an outlet port 1404, which defines an opening out of the blood sequestration device 1401 and to the blood sample collection device 1403. The outlet port 1404 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device 1403. The outlet port 1404 can further include a connector device such as a threaded cap, a Luer connector (male or female), a

non threaded interference or glue joint fitting for attachment of various devices including but not limited to tubing, or the like.

[0094] The blood sequestration device 1401 further includes a sampling channel 1406 between the inlet port 1402 and the outlet port 1404, and which functions as a blood sample pathway once a first aliquot of blood has been sequestered. The sampling channel 1406 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 1406 has a substantially similar cross sectional area as the opening of the inlet port 1402. In other implementations, the sampling channel 1406 can gradually widen from the inlet port 1402 to the outlet port 1404.

[0095] The blood sequestration device 1401 further includes a sequestration chamber 1408 that is connected to and split off or diverted from the sampling channel 1406 at any point between the inlet port 1402 and the outlet port 1404, but preferably from a proximal end of the sampling channel 1406 near the inlet port 1402. The sequestration chamber 1408 is at first maintained at atmospheric pressure, and includes an air outlet 1412 at or near a distal end of the sequestration chamber 1408 opposite the diversion point from the sampling channel 1406. The air outlet 1412 includes an air permeable blood barrier 1412. As shown in FIG. 14B, the air permeable blood barrier 1412 can be overlaid with a protective cover 1416. The protective cover 1416 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1412 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1412 as the air is displaced from the sequestration chamber 1408 by blood being forced into the sequestration chamber 1408 by a patient's own blood pressure. In addition the protective cover 1416 can be constructed to inhibit or prevent accidental exposure of the air permeable blood barrier to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[0096] As shown in FIGS. 14C and 14D, the sampling channel 1406 can be cylindrical or frusto-conical in shape, going from a smaller diameter to a larger diameter, to minimize a potential to lyse red blood cells. Likewise, the sampling channel 1406 is formed with a minimal amount of or no sharp turns or edges, which can also lyse red blood cells. The sampling channel 1406 splits off to the sequestration chamber 1408 near the inlet port 1402 via a diversion pathway 1409. The diversion pathway 1409 can have

any cross-sectional shape or size, but is preferably similar to the cross-sectional shape of at least part of the inlet port 1402.

[0097] In some implementations, the sampling channel 1406 and the sequestration chamber 1408 are formed by grooves, channels, locks or other pathways formed in housing 1414. The housing 1414 can be made of plastic, metal or other rigid or semi-rigid material. The housing 1414 can have a bottom member that sealably mates with a top member. One or both of the bottom member and the top member can include the sampling channel 1406 and the sequestration chamber 1408, as well as the diversion pathway 1409, the inlet port 1402, and the outlet port 1404. In some other implementations, one or more of the diversion pathway 1409, the inlet port 1402, and/or the outlet port 1404 can be at least partially formed by a cap member that is connected to either end of the housing 1414. In some implementations, the top member and the bottom member, as well as the cap member(s), can be coupled together by laser welding, heat sealing, gluing, snapping, screwing, bolting, or the like. In other implementations, some or all of the interior surface of the diversion pathway 1409 and/or sequestration chamber 1408 can be coated or loaded with an agent or substance, such as a decontaminate, solidifying agent, or the like. For instance, a solidifying agent can be provided at the diversion pathway 1409 such that when the sequestration chamber 1408 is filled and the initial aliquot of blood backs up to the diversion pathway 1409, that last amount of sequestered blood could solidify, creating a barrier between the sequestration chamber 1408 and the sampling channel 1406.

[0098] FIGS. 15A-15G illustrate a blood sequestration device 1500. The blood sequestration device 1500 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like.

[0099] The blood sequestration device 1500 includes an inlet port 1502 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1502 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 1502 defines an opening into the blood sequestration device 1500, which opening may be the same cross sectional dimensions as tubing or other conduit connected with the

patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately 0,1143 cm (0,045 inches), ~~0.045 inches,~~ but can have a diameter of between 0,0254 cm (0,01 inches) ~~0.01 inches~~ or less to 0,508 cm (0,2 inches) ~~0.2 inches~~ or more.

[00100] The inlet port 1502 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 1502, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 1500 can be fabricated and sold with the patient needle as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 1500 at the time of blood draw or sampling.

[00101] The blood sequestration device 1500 further includes an outlet port 1504, which defines an opening out of the blood sequestration device 1500 and to the blood sample collection device. The outlet port 1504 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 1500 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 1500 at the time of blood draw or sampling.

[00102] The blood sequestration device 1500 further includes a sampling channel 1506 between the inlet port 1502 and the outlet port 1504, and which functions as a blood sample pathway once a first aliquot of blood has been sequestered. The sampling channel 1506 can be any sized, shaped or configured channel or conduit. In some implementations, the sampling channel 1506 has a substantially similar cross sectional area as the opening of the inlet port 1502. In other implementations, the sampling channel 1506 can gradually widen from the inlet port 1502 to the outlet port 1504.

[00103] The blood sequestration device 1500 further includes a sequestration chamber 1508 that is connected to and split off or diverted from the sampling channel 1506 at any point between the inlet port 1502 and the outlet port 1504, but preferably from a proximal end of the sampling channel 1506 near the inlet port 1502. In some

implementations, the diversion includes a Y-shaped junction. The sequestration chamber 1508 is preferably maintained at atmospheric pressure, and includes a vent 1510 at or near a distal end of the sequestration chamber 1508. The vent 1510 includes an air permeable blood barrier 1512. FIG. 15C illustrates the blood sequestration device 1500 with the sequestration chamber 1508 filled with a first aliquot or sample of blood from the patient.

[00104] The air permeable blood barrier 1512 can be covered with a protective cover 1516. The protective cover 1516 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1512 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1512 as the air is displaced from the sequestration chamber 1508 by blood being forced into the sequestration chamber 1508 by a patient's own blood pressure. The protective cover 1516 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00105] FIG. 15B is a perspective view of the blood sequestration device 1500 from the outlet port 1504 and top side of a housing 1501 of the blood sequestration device 1500 that includes the vent 1510, and illustrating an initial aliquot of blood filling sequestration chamber 1508 while the sampling channel 1506 is empty, before a sample collection device is activated. FIG. 15G is a perspective view of the blood sequestration device 1500 from the outlet port 1504 and bottom side of the housing 1501 of the blood sequestration device 1500, and illustrating the initial aliquot of blood filling sequestration chamber 1508 while the sampling channel 1506 is empty, before the sample collection device is activated. FIG. 15C is another perspective view of the blood sequestration device 1500 from the inlet port 1502 and top side of a housing 1501 of the blood sequestration device 1500 that includes the vent 1510, and illustrating blood now being drawn through sampling channel 1506 while the sequestered blood remains substantially in the sequestration chamber 1508.

[00106] FIG. 15D is a cross section of the blood sequestration device 1500 in accordance with some implementations, showing the housing 1501 that defines the sampling channel 1506 and the sequestration chamber 1508. FIGS. 15E and 15F

illustrate various form factors of a housing for a blood sequestration device, in accordance with one or more implementations described herein.

[00107] The sequestration chamber 1508 can have a larger cross-sectional area than the sampling channel 1506, and the cross-sectional area and length can be configured for a predetermined or specific volume of blood to be sequestered or locked. The sampling channel 1506 can be sized to be compatible with tubing for either or both of the patient needle tubing or the blood collection device tubing.

[00108] The housing 1501 can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated in FIG. 15D, the housing 1501 includes a top member 1520 and a bottom member 1522 that are mated together, one or both of which having grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc. The top member 1520 can be connected with the bottom member 1522 by any mating or connection mechanism, such as by laser welding, thermal bonding, ultrasonic welding, gluing, using screws, rivets, bolts, or the like, or by other mating mechanisms such as latches, grooves, tongues, pins, flanges, or the like.

[00109] In some implementations, such as shown in FIG. 15D, the top member 1520 can include the grooves, channels, locks, conduits or other pathways, while the bottom member 1522 can include a protrusion 1524 that is sized and adapted to fit into at least one of the grooves, channels, locks or other pathways of the top member 1520. The protrusion 1524 can provide a surface feature, such as a partial groove or channel, for instance, to complete the formation of either the sampling channel 1506 and/or the sequestration chamber 1508. In some implementations, the protrusion 1524 can be formed with one or more angled sides or surfaces for a tighter fit within the corresponding groove, channel, lock or other pathway. In yet other implementations, both the top member 1520 and the bottom member can include grooves, channels, locks or other pathways, as well as one or more protrusions 1524.

[00110] In some implementations, the sampling channel 1506 and the sequestration chamber 1508 are formed by grooves, channels, locks or other pathways formed in housing 1501. The housing 1501 can be made of any suitable material, including rubber, plastic, metal or other material. The housing 1501 can be formed of a clear or translucent

material, or of an opaque or non-translucent material. In other implementations, the housing 1501 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 1506 and/or the sequestration chamber 1508 is clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 1508 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 1506. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 1512 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00111] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will make its way into the inlet port 1502 blood sequestration device 1500 and flow into the sequestration chamber 1508 by following the path of least resistance, as the patient's own blood pressure overcomes the atmospheric pressure in the sequestration chamber 1508 to displace air therein through the air permeable blood barrier 1512. The patient's blood pressure will not be sufficient to overcome the air pressure that builds up in the sealed sampling channel 1506. Eventually, the sequestration chamber 1508, which has a predetermined volume, is filled with blood that displaces air through the air permeable blood barrier 1512. Once the blood hits the air permeable blood barrier, the blood interacts with the air permeable blood barrier 1512 material to completely or partially seal the vent 1510. A signal or indication may be provided that the practitioner can now utilize the Vacutainer capsule or other blood sample collection device to acquire a next amount of the patient's blood for sampling. The blood in the sequestration chamber 1508 is now effectively sequestered in the sequestration chamber.

[00112] Upon filling the blood sequestration pathway 1508 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 1506, possibly resulting in a small amount of blood moving past the diversion point to the sequestration chamber 1508 and into the sampling channel 1506, queuing up the uncontaminated blood to be drawn through the sampling channel 1506.

[00113] In some instances, as shown in FIG. 15H, an inlet port 1532 can include a male luer connector for connecting to a removable patient needle, and an outlet port 11534 can include a female luer connector for connecting with a syringe. This implementation of the inlet port and outlet port can be used with any device described herein, for avoiding a propensity of a Vacutainer-type device collapsing a patient's vein. In this implementation, a clinician can use the syringe in a modulated fashion to obtain a blood sample. In operation, the syringe is attached to the outlet port 1004, and the needle is attached to the inlet port 1002. A venipuncture is performed with the needle, and without the clinician pulling on the syringe. An initial aliquot of blood fills a sequestration chamber, and then the syringe can be used to draw a sample of blood through the collection channel, bypassing the sequestered blood in the sequestration chamber.

[00114] FIGS. 16-19 illustrate yet another implementation of a blood sequestration device. FIGS. 16A-16D illustrate a blood sequestration device 1600 that can be connected between a blood sample collection device, such as an evacuated blood collection container like a Vacutainer™ (not shown), and a patient needle (not shown) and/or associated tubing. FIG. 17 illustrates a bottom member of the blood sequestration device, and FIG. 18 illustrates a top member of the blood sequestration device, which top member and bottom member can be mated together to form an inlet port, and outlet port, a sequestration chamber and a sampling channel, as explained more fully below. FIGS. 19A and B show the top member and bottom member mated together. It should be understood that FIGS. 16-19 illustrate one exemplary manner of constructing a blood sequestration device as described herein, and other forms of construction are possible.

[00115] Referring to FIGS. 16A – D, the blood sequestration device 1600 includes an inlet port 1602 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1602 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 1602 defines an opening into the blood sequestration device 1600, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately ≥ 0,1143 cm (0,045 inches), ≥ ~~0.045 inches,~~ but can have a diameter of between ≥ 0,0254 cm (0,01 inches) ≥ ~~0.01 inches~~ or less to ≥ 0,508 cm (0,2 inches) ≥ ~~0.2 inches~~ or more.

[00116] The inlet port 1602 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 1602, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 1600 can be fabricated and sold with the patient needle and/or tubing as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 1600 at the time of blood draw or sampling.

[00117] The blood sequestration device 1600 further includes an outlet port 1604, which defines an opening out of the blood sequestration device 1600 and to the blood sample collection device. The outlet port 1604 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 1600 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 1600 at the time of blood draw or sampling.

[00118] The blood sequestration device 1600 further includes a sampling channel 1606 between the inlet port 1602 and the outlet port 1604, and a sequestration chamber 1608 that is connected to and split off or diverted from the sampling channel 1606 at any point between the inlet port 1602 and the outlet port 1604. The sampling channel 1606 functions as a blood sampling pathway once a first aliquot of blood has been sequestered in the sequestration chamber 1608. The sampling channel 1606 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 1606 has a substantially similar cross sectional area as the opening of the inlet port 1602. In other implementations, the sampling channel 1606 can gradually widen from the inlet port 1602 to the outlet port 1604. The sequestration chamber 1608 may have a larger cross section to form a big reservoir toward the sequestration channel path so that the blood will want to enter the reservoir first versus entering a smaller diameter on the sampling channel 1606, as is shown more fully in FIGS. 17 and 19.

[00119] In some exemplary implementations, the diversion between the sampling channel 1606 and the sequestration chamber 1608 is by diverter junction 1607. Diverter junction 1607 may be a substantially Y-shaped, T-shaped, or U-shaped. In some preferred exemplary implementations, and as shown in FIG. 17A – 17B, the diverter junction 1607 is configured such that the flow out of the inlet port 1602 is preferentially directed toward the sequestration chamber 1608. The sequestration chamber 1608 may also include or form a curve or ramp to direct the initial blood flow toward and into the sequestration chamber 1608.

[00120] The sequestration chamber 1608 is preferably maintained at atmospheric pressure, and includes a vent 1610 at or near a distal end of the sequestration chamber 1608. The vent 1610 may include an air permeable blood barrier 1612 as described above.

[00121] The blood sequestration device 1600 can include a housing 1601 that can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated in FIGS. 17A – 17E and FIGS. 18A – 18F, the housing 1601 includes a top member 1620 and a bottom member 1622 that are mated together. The blood sequestration device 1600 can also include a gasket or other sealing member (not shown) so that when the top member 1620 is mechanically attached with the bottom member 1622, the interface between the two is sealed by the gasket or sealing member. The FIGS. 17A – 17E illustrate a bottom member 1622 of a housing for a blood sequestration device 1600. The bottom member 1622 can include grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc., to form the sampling channel 1606, the sequestration chamber 1608, and diverter junction 1607.

[00122] The sequestration chamber 1608 may have a larger cross section than the sampling channel 1606 so that the blood will preferentially move into the sequestration chamber first versus entering a smaller diameter on the sampling channel 1606.

[00123] FIGS. 18A – 18F illustrate the top member 1620, which can be connected with the bottom member 1622 by any mating or connection mechanism, such as by laser welding, thermal bonding, gluing, using screws, rivets, bolts, or the like, or by other mating mechanisms such as latches, grooves, tongues, pins, flanges, or the like. The top

member 1620 can include some or all of the grooves, channels, locks, conduits or other pathways to form the sampling channel 1606, the sequestration chamber 1608, and the diverter junction 1607. In yet other implementations, both the top member 1620 and the bottom member 1622 can include the grooves, channels, locks or other pathways.

[00124] In some implementations, the sampling channel 1606 and the sequestration chamber 1608 are formed by grooves, channels, locks or other pathways formed in housing 1601. The housing 1601 can be made of rubber, plastic, metal or any other suitable material. The housing 1601 can be formed of a clear or translucent material, or of an opaque or non-translucent material. In other implementations, the housing 1601 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 1606 and/or the sequestration chamber 1608 may be clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 1608 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 1606. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 1612 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00125] As shown in FIGS. 18A – 18F, the air permeable blood barrier 1612 can be covered with, or surrounded by, a protective member 1616. The protective member 1616 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1612 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1612 as the air is displaced from the sequestration chamber 1608. In some implementations, the protective member 1616 includes a protrusion that extends up from a top surface of the top member 1620 and around the air permeable blood barrier 1612. The protective member 1616 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00126] In use, the blood sequestration device 1600 includes a sampling channel 1606 and a sequestration chamber 1608. Both pathways are initially air-filled at

atmospheric pressure, but the sampling channel 1606 is directed to an outlet port 1604 that will be initially sealed by a Vacutainer or other such sealed blood sampling device, and the sequestration chamber 1608 terminates at a vent 1610 to atmosphere that includes an air permeable blood barrier 1612.

[00127] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will pass through inlet port 1602 of blood sequestration device 1600. This initial volume of potentially contaminated blood will preferentially flow into the sequestration chamber 1608 by finding the path of least resistance. The patient's own blood pressure overcomes the atmospheric pressure in the vented sequestration chamber 1608 to displace air therein through the air permeable blood barrier 1612, but is not sufficient to overcome the air pressure that builds up in the sealed sampling channel 1606. In various exemplary embodiments, the sequestration chamber 1608 and sampling channel 1606 can be configured such that the force generated by the patient's blood pressure is sufficient to overcome any effect of gravity, regardless of the blood sequestration device's orientation.

[00128] Eventually, the sequestration chamber 1608 fills with blood that displaces air through the air permeable blood barrier 1612. Once the blood contacts the air permeable blood barrier, the blood interacts with the air permeable blood barrier 1612 material to completely or partially seal the vent 1610. A signal or indication may be provided that the practitioner can now utilize the Vacutainer or other blood sampling device.

[00129] Upon filling the blood sequestration pathway 1608 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 1606, possibly resulting in a small amount of blood moving past the diversion point into the sampling channel 1606, queuing up the uncontaminated blood to be drawn through the sampling channel 1606.

[00130] FIG. 19A is a side view, and FIG. 19B is a cross-sectional view, of the blood sequestration device 1600, illustrating the top member 1620 mated with the bottom member 1622.

[00131] FIG. 20 shows a blood sample optimization system 2000 that includes a patient needle 2002 for vascular access to a patient's bloodstream, a blood sample collection device 2004 to facilitate the collecting of one or more blood samples, and a conduit 2006 providing a fluid connection between the patient needle 2002 and the blood sample collection device 2004. In some implementations, the blood sample collection device 2004 includes a protective shield that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2002.

[00132] The blood sample optimization system 2000 further includes a blood sequestration device 2008, located at any point on the conduit 2006 between the patient needle 2002 and the blood sample collection device 2004 as described herein.

[00133] FIG. 21 illustrates a non-vented blood sequestration device 2100 using a wicking material chamber. The blood sequestration device 2100 includes a housing 2101 that has a sampling channel 2104 that is at least partially surrounded or abutted by a sequestration chamber 2102 that is filled with a wicking material. An initial aliquot of blood is drawn in from the patient needle into the sampling channel 2104 where it is immediately wicked into the wicking material of the sequestration chamber 2102. The wicking material and/or sequestration chamber 2102 is sized and adapted to receive and hold a predetermined amount of blood, such that follow-on or later blood draws pass by the wicking material and flow straight through the sampling channel 2104 to a sampling device such as a Vacutainer. The wicking material can include a substance such as a solidifier, a decontaminate, or other additive.

[00134] As described herein, an air permeable blood barrier may be created using a wide variety of different structures and materials. As shown in FIGS. 22A and B, an air permeable blood barrier 2202 of a blood sequestration device 2200 can include a polymer bead matrix 2204, in which at least some beads are treated to make them hydrophilic. The air permeable blood barrier 2202 further includes a self-sealing material 2206, such as carboxymethyl cellulose (CMC) or cellulose gum, or other sealing material. The air permeable blood barrier 2202 can further include voids 2208 that permit air flow before contact or during partial contact with a fluid such as blood. As shown in FIG. 22B,

contact with a fluid causes the self-sealing material 2206 to swell and close off the voids 2208, occluding air flow through the voids 2208 and creating a complete or partial seal.

[00135] FIGS. 23A and B illustrate yet another implementation of a blood sequestration device 2300, having an inlet port 2302 to connect with a patient needle, an outlet port 2304 to connect with a blood sample collection device, a sequestration chamber 2306, and a sampling channel 2308 that bypasses the sequestration chamber 2306 once the sequestration chamber is filled to an initial aliquot of potentially contaminated blood to be sequestered. The sequestration chamber 2306 includes a hydrophobic plug 2312 at a distal end of the sequestration chamber 2306 that is farthest from the inlet port 2302. A vacuum or other drawing force applied from the outlet port 2304, such as from a Vacutainer or the like, draws in blood into the inlet port 2302 and directly into the sequestration chamber 2306, where the initial aliquot of blood will contact the hydrophobic plug 2312 and cause the initial aliquot of blood to back up into the sequestration chamber 2306 and be sequestered there. A small amount of blood may make its way into the sampling channel 2308, which is initially closed off by valve 2308. Upon release of the valve 2308, and under further force of the vacuum or other force, follow-on amounts of blood will flow into inlet port 2302, bypass the sequestration chamber 2306, and flow into and through sampling channel 2308 toward the outlet port 2304 and to the collection device.

[00136] The sampling channel 2308 can have any suitable geometry and can be formed of plastic tubing or any other suitable material. Valve 2308 can be a clip or other enclosing device to pinch, shunt, bend or otherwise close off the sampling channel 2308 before the initial aliquot of blood is sequestered in the sequestration chamber 2306. For instance, valve 2308 can also be formed as a flap, door or closable window or barrier within the sampling channel 2308.

[00137] FIGS. 23C – 23E illustrate an alternative implementation of the blood sequestration device 2300', in which a sequestration chamber 2320 branches off from a main collection channel 2322 between an inlet port 2316 to connect with a patient needle and an outlet port 2318 to connect with a blood sample collection device, such as a Vacutainer, a syringe, or the like. The sequestration chamber 2320 includes an air-permeable, blood impermeable blood barrier 2324, such as a hydrophobic plug of material, or a filter formed of one or more layers, for example. A valve 2324 closes off

and opens the collection channel 2322, and the device 2300' can be used similarly as described above.

[00138] FIG. 24A – 24D illustrate a blood sample optimization system 2400 that includes a patient needle 2402 for vascular access to a patient's bloodstream, a blood sample collection device 2404 to facilitate the collecting of one or more blood samples for blood testing or blood cultures, and a conduit 2406 providing a fluid connection between the patient needle 2402 and the blood sample collection device 2404. In some implementations, the blood sample collection device 2404 includes a protective shield that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2402.

[00139] The blood sample optimization system 2400 further includes a blood sequestration device 2408, located at any point on the conduit 2406 between the patient needle 2402 and the blood sample collection device 2404. The location of the blood sequestration device 2408 can be based on a length of the conduit between the blood sequestration device 2408 and the patient needle 2402, and the associated volume that length provides.

[00140] The blood sequestration device 2408 includes an inlet port 2412 for being connected to the conduit 2406 toward the patient needle 2402, and an outlet port 2414 for being connected to the conduit 2406 toward the blood sample collection device 2404, and a housing 2416. The housing 2416 can be any shape, although it is shown in FIGS. 24A – D as being substantially cylindrical, and includes the inlet port 2412 and outlet port 2414, which can be located anywhere on the housing although shown as being located on opposite ends of the housing 2416.

[00141] The blood sequestration device 2408 further includes a blood sequestration chamber 2418 connected with the inlet port 2412. The blood sequestration chamber 2418 is defined by an inner chamber housing 2419 that is movable from a first position to receive and sequester a first aliquot of blood, to a second position to expose one or more apertures 2424 at a proximal end of the inner chamber housing 2419 to allow blood to bypass and/or flow around the inner chamber housing 2419 and through a blood sample channel 2422 defined by the outer surface of the inner chamber housing 2419 and the

inner surface of the housing 2416. The blood sequestration chamber 2418 includes an air permeable blood barrier 2420 at a distal end of the blood sequestration chamber 2418.

[00142] In operation, the inner chamber housing 2419 is in the first position toward the inlet port 2412, such that the one or more apertures 2424 are closed, and the blood sequestration chamber 2418 is in a direct path from the patient needle. Upon venipuncture of a patient, and drawing of blood by way of a syringe or Vacutainer, or other blood collection device 2404, the initial aliquot of blood flows into the blood sequestration chamber 2418. As the initial aliquot of blood flows into the blood sequestration chamber, it displaces air therein and eventually the blood contacts the blood barrier 2420, forcing the inner chamber housing to the second position. The inner chamber housing 2419 and/or housing 2416 can include a locking mechanism of one or more small tabs, grooves, detents, bumps, ridges, or the like, to maintain the inner chamber housing 2419 in the first position until the blood sequestration chamber 2418 is filled, providing force to overcome the locking mechanism to enable movement of the inner chamber housing 2419 to the second position. Once in the second position, the initial aliquot of blood is sequestered in the blood sequestration chamber 2418 and the one or more apertures 2424 are opened to create a pathway from the inlet port 2412 to the blood sampling channel 2422, bypassing and/or flowing around the blood sequestration chamber 2418.

[00143] As described above, the housing 2416 and/or inner chamber housing 2419 can be formed as cylindrical and concentric, but can be any shape, such as squared, rectangular, elliptical, oval, or other cross-sectional shape. The outer surface of the distal end of the inner chamber housing 2419 can have one or more outwardly projecting tangs 2421with gaps therebetween. The tangs 2421 contact the inner surface of the housing 2416 to help define the blood sampling channel 2422 therebetween, and to help stop the inner chamber housing 2419 in the second position. The gaps between the tangs 2421 enable blood to flow through the blood sampling channel 2422 and to the outlet port 2414. When the inner chamber housing 2419 is in the second position and the blood sequestration chamber 2418 is filled with the first aliquot of blood, further blood samples will automatically flow through the inlet port 2412, through the one or more apertures 2424, through the blood sampling channel 2422, through the gaps between the tangs 2421, and ultimately through the outlet port 2414 to be collected by a blood sampling device 2404.

[00144] FIGS. 25A – D show a blood optimization system 2500 and blood sequestration device 2502, formed substantially as described in FIGS. 15, 16, 17, 18 and 19, but being formed to inhibit a user or other object from touching or blocking an air venting mechanism from a blood sequestration chamber 2520. Air initially in the blood sequestration chamber 2520 is displaced by an initial aliquot of blood upon venipuncture, where a patient's blood pressure overcomes the ambient air pressure in the blood sequestration chamber 2520. The air venting mechanism includes an air permeable blood barrier 2506, such as a porous material or set of materials that allows air to escape but blocks blood from leaving the blood sequestration chamber 2520.

[00145] The air venting mechanism includes an inner wall 2516 that at least partially circumscribes or surrounds the air permeable blood barrier 2506, and an outer wall 2504 spaced apart from the inner wall 2516. The outer wall 2504 can have one or more air vents 2514 formed therein. The outer wall 2504 extends higher upward than the inner wall 2516, such that a lid 2510, such as a cap, plug, cover, etc., can be attached to the outer wall 2504 and be displaced by a small distance from the top of the inner wall 2516. A seal 2508 in the form of a silicone wafer, or other elastomeric material, fits within the outer wall 2504 to cover the air permeable blood barrier 2506 and abut the top of the inner wall 2516. The seal 2508 covers and seals the air permeable blood barrier 2506 and inhibits air from entering the blood sequestration chamber 2520 through the air permeable blood barrier 2506. A fulcrum 2512 on an underside of the lid 2510 allows the seal 2508 to flexibly disconnect from the top of the inner wall 2516 when pushed by air displaced from the blood sequestration chamber 2520, to allow air to vent from the air permeable blood barrier 2506 and through the one or more air vents 2514 in the outer wall 2504.

[00146] FIG. 26A – E illustrate a blood sample optimization system 2600 that includes a patient needle 2602 for vascular access to a patient's bloodstream, a blood sample collection device 2604 to facilitate the collecting of one or more blood samples for blood testing or blood cultures, and a conduit 2606 providing a fluid connection between the patient needle 2602 and the blood sample collection device 2604. The conduit 2606 can include flexible tubing. In preferred implementations, the blood sample collection device 2604 includes a protective shield 2605 that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the

collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2602.

[00147] The blood sample optimization system 2600 further includes a blood sequestration device 2608, located at any point on the conduit 2606 between the patient needle 2602 and the blood sample collection device 2604. The location of the blood sequestration device 2608 can be based on a length of the conduit between the blood sequestration device 2608 and the patient needle 2602, and the associated volume that length provides.

[00148] The blood sequestration device 2608 includes an inlet port 2612 for being connected to the conduit 2606 toward the patient needle 2602, and an outlet port 2614 for being connected to the conduit 2606 toward the blood sample collection device 2604. The blood sequestration device 2608 includes an outer housing 2616 and an inner housing 2617, both having a cylindrical form, and being connected concentrically. The outer housing 2616 includes an outer wall 2618 and an inner conduit 2620 that defines a blood sampling channel 2622 to convey blood through the conduit 2606 to the blood sampling device 2604. The inner housing 2617 fits snugly between the inner conduit 2620 and the outer wall 2618 of the outer housing, and is rotatable in relation to the outer housing 2616. The fit between the outer housing 2616 and the inner housing 2617 can be a friction fit that maintains the housings in a particular position. The inner housing 2617 defines a blood sequestration chamber 2624, preferably a helical or corkscrew channel around the outer surface of inner conduit 2620 of the outer housing 2616, and which terminates at an air vent 2628 having an air permeable blood barrier, as shown in FIG. 26E.

[00149] The blood sequestration chamber 2624 is connected with the blood sampling channel 2622 via diversion junction 2624 formed in the inner conduit 2620, when the blood sequestration device in a first state, illustrated in FIG. 26C. The protective shield 2606 on the collection needle 2604 provides a block for air or blood, enabling a diversion of an initial aliquot of blood into the blood sequestration chamber 2624 as the patient's blood pressure overcomes the ambient air pressure in the blood sequestration channel 2624 to displace air therefrom through air vent 2628.

[00150] When the inner housing 2617 is rotated relative to the outer housing 2616, or vice versa, to a second state, as illustrated in FIG. 26D, the blood sequestration chamber 2624 is shut off from diversion junction 2624, enabling a direct path from the patient needle through the conduit 2606 to the collection needle 2604, via blood sampling channel 2622. The outer housing 2616 and/or inner housing 2617 can include ridges or grooves formed within a portion of their surfaces, to facilitate relative rotation from the first state to the second state.

[00151] FIGS. 27A – D illustrate a blood optimization system 2700 and blood sequestration device 2702, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, and 25, but being formed to inhibit a user or other object from touching or blocking an air venting mechanism from a blood sequestration chamber 2720. Air initially in the blood sequestration chamber 2720 is displaced by an initial aliquot of blood upon venipuncture, where a patient's blood pressure overcomes the ambient air pressure in the blood sequestration chamber 2720. The air venting mechanism includes an air permeable blood barrier 2706, such as a porous material or set of materials that allows air to escape but blocks blood from leaving the blood sequestration chamber 2720.

[00152] The air venting mechanism includes an inner wall 2716 that at least partially circumscribes or surrounds the air permeable blood barrier 2706, and an outer wall 2704 spaced apart from the inner wall 2716. A cap 2722 is positioned on the air venting mechanism, preferably by having a lower cap wall 2728 that fits between the inner wall 2716 and the outer wall 2704 of the air venting mechanism, and frictionally abutting either the the inner wall 2716 or the outer wall 2704 or both. The cap 2722 further includes one or more vent holes 2724 or slits, apertures, openings, or the like, which extend through an upper surface of the cap 2722 around a downwardly extending plug 2726. The plug 2726 is sized and adapted to fit snugly within the space defined by inner wall 2716.

[00153] In a first position, as illustrated in FIG. 27C, the cap 2722 is extended from the air venting mechanism to allow air from the blood sequestration chamber 2720 to exit through the air permeable blood barrier 2706 and through the one or more vent holes 2724. Once the air from the blood sequestration chamber 2720 has been displaced, i.e., when the blood sequestration chamber 2720 is filled with the first aliquot of potentially tainted blood from the patient, then the cap 2722 can be pushed down on the air venting

mechanism in a second position as shown in FIG. 27D, so that the plug 2726 fits within the inner wall 2716 over the air permeable blood barrier 2706 to seal the air venting mechanism. In either the first position or the second position, the cap 2722 protects the air permeable blood barrier 2706 from outside air or from being touched by a user.

[00154] FIGS. 28A – F illustrate a blood optimization system 2800 and blood sequestration device 2802, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26, but utilizing a multi-layered filter, and in some implementations, a filter with trapped reactive material, for an air permeable blood barrier. As shown in FIGS. 28C and D, an air permeable blood barrier 2803 includes a first layer 2804 of an air permeable but blood impermeable material, and a second layer 2806 that includes a reactive material, such as a hydrophobic material, for repelling blood while still allowing air to pass through both layers. As shown in FIGS. 28E and F, the air permeable blood barrier 2803 can include any number of layers, such as a third layer 2808 formed of the same air permeable but blood impermeable material as first layer 2804, while a second layer 2806 includes trapped or embedded blood reactive material.

[00155] FIGS. 29A – C illustrate a blood optimization system 2900 and blood sequestration device 2902, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26, but in which a blood sequestration chamber 2904 is at least partially filled with a blood-absorptive material 2906. The blood-absorptive material 2906 can act as a wicking material to further draw in blood to be sequestered upon venipuncture of the patient, and prior to use of a blood drawing device such as a Vacutainer™ or a syringe, or the like.

[00156] FIGS. 30A – G illustrate a blood optimization system 3000 and blood sequestration device 3002, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26. The blood sequestration device 3000 includes an inlet port 3002 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 3002 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 3002 defines an opening into the blood sequestration device 3000, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the

opening can be circular with a diameter of approximately ~~0.045 inches,~~ 0,1143 cm (0,045 inches), but can have a diameter of between ~~0.01 inches~~ 0,0254 cm (0,01 inches) or less to ~~0.2 inches~~ 0,508 cm (0,2 inches) or more.

[00157] The inlet port 3002 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 3002, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 3000 can be fabricated and sold with the patient needle and/or tubing as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 3000 at the time of blood draw or sampling.

[00158] The blood sequestration device 3000 further includes an outlet port 3004, which defines an opening out of the blood sequestration device 3000 and to the blood sample collection device. The outlet port 3004 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 3000 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 3000 at the time of blood draw or sampling.

[00159] The blood sequestration device 3000 further includes a sampling channel 3006 between the inlet port 3002 and the outlet port 3004, and a sequestration chamber 3008 that is connected to and split off or diverted from the sampling channel 3006 at any point between the inlet port 3002 and the outlet port 3004. The sampling channel 3006 functions as a blood sampling pathway once a first aliquot of blood has been sequestered in the sequestration chamber 3008. The sampling channel 3006 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 3006 has a substantially similar cross sectional area as the opening of the inlet port 3002. In other implementations, the sampling channel 3006 can gradually widen from the inlet port 3002 to the outlet port 3004. The sequestration chamber 3008 may have a larger cross section to form a big reservoir toward the sequestration channel path so that the

blood will want to enter the reservoir first versus entering a smaller diameter on the sampling channel 3006.

[00160] In some exemplary implementations, the diversion between the sampling channel 3006 and the sequestration chamber 3008 is by diverter junction 3007. Diverter junction 3007 may be a substantially Y-shaped, T-shaped, or U-shaped. In some preferred exemplary implementations, and as shown in FIG. 17A – 17B, the diverter junction 3007 is configured such that the flow out of the inlet port 3002 is preferentially directed toward the sequestration chamber 3008. The sequestration chamber 3008 may also include or form a curve or ramp to direct the initial blood flow toward and into the sequestration chamber 3008.

[00161] The sequestration chamber 3008 is preferably maintained at atmospheric pressure, and includes a vent 3010 at or near a distal end of the sequestration chamber 3008. The vent 3010 may include an air permeable blood barrier 3012 as described above.

[00162] The blood sequestration device 3000 can include a housing 3001 that can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated FIG. 30F, the housing 3001 includes a top member 3020 and a bottom member 3022 that are mated together. The blood sequestration device 3000 can also include a gasket or other sealing member (not shown) so that when the top member 3020 is mechanically attached with the bottom member 3022, the interface between the two is sealed by the gasket or sealing member. The bottom member 3022 can include grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc., to form the sampling channel 3006, the sequestration chamber 3008, and diverter junction 3007.

[00163] The sequestration chamber 3008 may have a larger cross section than the sampling channel 3006 so that the blood will preferentially move into the sequestration chamber first versus entering a smaller diameter on the sampling channel 3006.

[00164] In some implementations, the sampling channel 3006 and the sequestration chamber 3008 are formed by grooves, channels, locks or other pathways formed in housing 3001. The housing 3001 can be made of rubber, plastic, metal or any other suitable material. The housing 3001 can be formed of a clear or translucent material, or

of an opaque or non-translucent material. In other implementations, the housing 3001 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 3006 and/or the sequestration chamber 3008 may be clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 3008 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 3006. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 3012 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00165] The air permeable blood barrier 3012 can be covered with, or surrounded by, a cap 3032. The cap 3032 can be sized and configured to inhibit a user from touching the air permeable blood barrier 3012 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 3012 as the air is displaced from the sequestration chamber 3008. The cap 3032 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00166] The air venting mechanism includes a wall 3030 that at least partially circumscribes or surrounds the air permeable blood barrier 3012. The wall 3030 can have one or more air vents formed therein. The cap 3032 covers wall 3030 and can be snapped, glued, or otherwise attached in place. A seal 3017 in the form of a silicone wafer, or other elastomeric material, fits within the wall 3030 to cover the air permeable blood barrier 3012 and abut the top of the wall 3030. The seal 3017 covers and seals the air permeable blood barrier 3012 and inhibits air from entering the blood sequestration chamber 3008 through the air permeable blood barrier 3012. A fulcrum 3012 on an underside of the cap 3032 allows the seal 3008 to flexibly disconnect from the top of the inner wall 3016 when pushed by air displaced from the blood sequestration chamber 3008, to allow air to vent from the air permeable blood barrier 3012 and through the one or more air vents in the wall 3030 and/or cap 3032.

[00167] In use, the blood sequestration device 3000 includes a sampling channel 3006 and a sequestration chamber 3008. Both pathways are initially air-filled at atmospheric pressure, but the sampling channel 3006 is directed to an outlet port 3004 that will be initially sealed by a Vacutainer or other such sealed blood sampling device, and the sequestration chamber 3008 terminates at a vent 3010 to atmosphere that includes an air permeable blood barrier 3012.

[00168] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will pass through inlet port 3002 of blood sequestration device 3000. This initial volume of potentially contaminated blood will preferentially flow into the sequestration chamber 3008 by finding the path of least resistance. The patient's own blood pressure overcomes the atmospheric pressure in the vented sequestration chamber 3008 to displace air therein through the air permeable blood barrier 3012, but is not sufficient to overcome the air pressure that builds up in the sealed sampling channel 3006. In various exemplary embodiments, the sequestration chamber 3008 and sampling channel 3006 can be configured such that the force generated by the patient's blood pressure is sufficient to overcome any effect of gravity, regardless of the blood sequestration device's orientation.

[00169] Eventually, the sequestration chamber 3008 fills with blood that displaces air through the air permeable blood barrier 3012. Once the blood contacts the air permeable blood barrier, the blood interacts with the air permeable blood barrier 3012 material to completely or partially seal the vent 3010. A signal or indication may be provided that the practitioner can now utilize the Vacutainer or other blood sampling device.

[00170] Upon filling the blood sequestration pathway 3008 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 3006, possibly resulting in a small amount of blood moving past the diversion point into the sampling channel 3006, queuing up the uncontaminated blood to be drawn through the sampling channel 3006.

[00171] In yet another aspect, the blood sequestration chamber and/or blood sampling channel, or other component, of any of the implementations described herein,

can provide a visually discernable warning or result in a component adapted for operative fluid communication with the flash chamber of an introducer for an intravenous catheter into a blood vessel of a patient. The device and method provides a visually discernable alert when blood from the patient communicates with a test component reactive to communicated blood plasma, to visually change. The reaction with the blood or the plasma occurs depending on one or a plurality of reagents positioned therein configured to test for blood contents, substances or threshold high or low levels thereof, to visually change in appearance upon a result.

[00172] In yet other aspects, the blood sequestration chamber and/or blood sampling channel can be sized and adapted to provide a particular volumetric flow of blood, either during the sequestration process and/or the sampling process.

[00173] Although a variety of embodiments have been described in detail above, other modifications are possible. Other embodiments may be within the scope of the following claims.

~~Amended~~ claims

1. A blood sequestration device (812, 1000, 1100, 1202, 1302, 1401, 1500, 1600, 2008, 2100, 2200, 2300, 2408, 2502, 2608, 2702, 2802, 2902, 3000) comprising;

an inlet port (802, 902, 1002, 1102, 1212, 1314, 1402, 1502, 1532, 1602, 2302, 2316, 2412, 2612, 3002);

an outlet port (904, 1004, 1104, 1214, 1312, 1404, 1504, 1534, 1604, 2304, 2318, 2414, 2614, 3004) ;

a sequestration chamber (55, 104, 204, 304, 822, 1008, 1108, 1218, 1318, 1408, 1508, 1608, 2102, 2306, 2320, 2418, 2520, 2624, 2720, 2904, 3008) connected with the inlet port via a junction, the sequestration chamber having a vent (1510, 1610, 2628, 3010) that includes an air permeable blood barrier (20, 106, 824, 1010, 1110, 1310, 1412, 1512, 1612, 2202, 2420, 2506, 2706, 2803, 3012), the vent being defined by an outer wall (2504, 2618, 2704) that at least partially circumscribes the air permeable blood barrier and includes one or more air vents (2514), the vent further including a cap (1208, 1307, 2722, 3032), that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and

a sampling channel (820, 1406, 1508, 1606, 2104, 2308, 2422, 2622, 3006) having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port;

the sequestration chamber, the sampling channel and the junction being sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

2. The blood sequestration device in accordance with claim 1, further comprising a housing (40, 50, 818, 1301, 1414, 1501, 1601, 2101, 2416, 2616, 3001) that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel.

3. The blood sequestration device in accordance with claim 1, wherein the vent further includes an inner wall (2516, 2716, 3016) within the outer wall and that contains the air permeable blood barrier.

4. The blood sequestration device in accordance with claim 1, wherein the one-way seal is positioned over the inner wall and within the outer wall of the vent.

5. The blood sequestration device in accordance with claim 4, wherein the cap includes an inner surface that faces the air permeable blood barrier, the inner surface of the cap including a fulcrum (2512, 3012) against which the seal can flexibly unseal from the air permeable blood barrier to allow air to escape the sequestration chamber.

6. The blood sequestration device in accordance with claim 1, wherein the air permeable blood barrier includes a sealing material that seals the vent upon contact with blood.

7. The blood sequestration device in accordance with claim 1, wherein the air permeable blood barrier includes a filter having a first layer and a second layer, the second layer of the filter having a hydrophobic material to repel blood.

8. A blood sequestration and sampling system (800, 1200, 1300, 1400, 2000, 2400, 2500, 2600, 2700, 2800, 2900, 3000) comprising;

a blood sampling pathway having a patient needle on a proximal end and a sample collection device on a distal end; and

a blood sequestration device in accordance with any of claims 1 to 7 attached on the blood sampling pathway between the proximal end and distal end of the blood sampling pathway, wherein the inlet port is coupled with the blood sampling pathway toward the patient needle;

the outlet port is coupled with the blood sampling pathway toward the sample collection device.

9. The blood sequestration system in accordance with claim 8, wherein the blood sequestration device further comprises a housing that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel.

10. The blood sequestration system in accordance with claim 8, wherein the vent of the blood sequestration device further includes an inner wall within the outer wall and that contains the air permeable blood barrier.

11. The blood sequestration system in accordance with claim 8, wherein the one-way seal of the vent is positioned over the inner wall and within the outer wall of the vent.

12. The blood sequestration system in accordance with claim 11, wherein the cap includes an inner surface that faces the air permeable blood barrier, the inner surface of the cap including a fulcrum against which the seal can flexibly unseal from the air permeable blood barrier to allow air to escape the sequestration chamber.

13. The blood sequestration system in accordance with claim 8, wherein the air permeable blood barrier of the blood sequestration device includes a sealing material that seals the vent upon contact with blood.

14. The blood sequestration system in accordance with claim 8, wherein the air permeable blood barrier of the blood sequestration device includes a filter having a first layer and a second layer, the second layer of the filter having a hydrophobic material to repel blood.

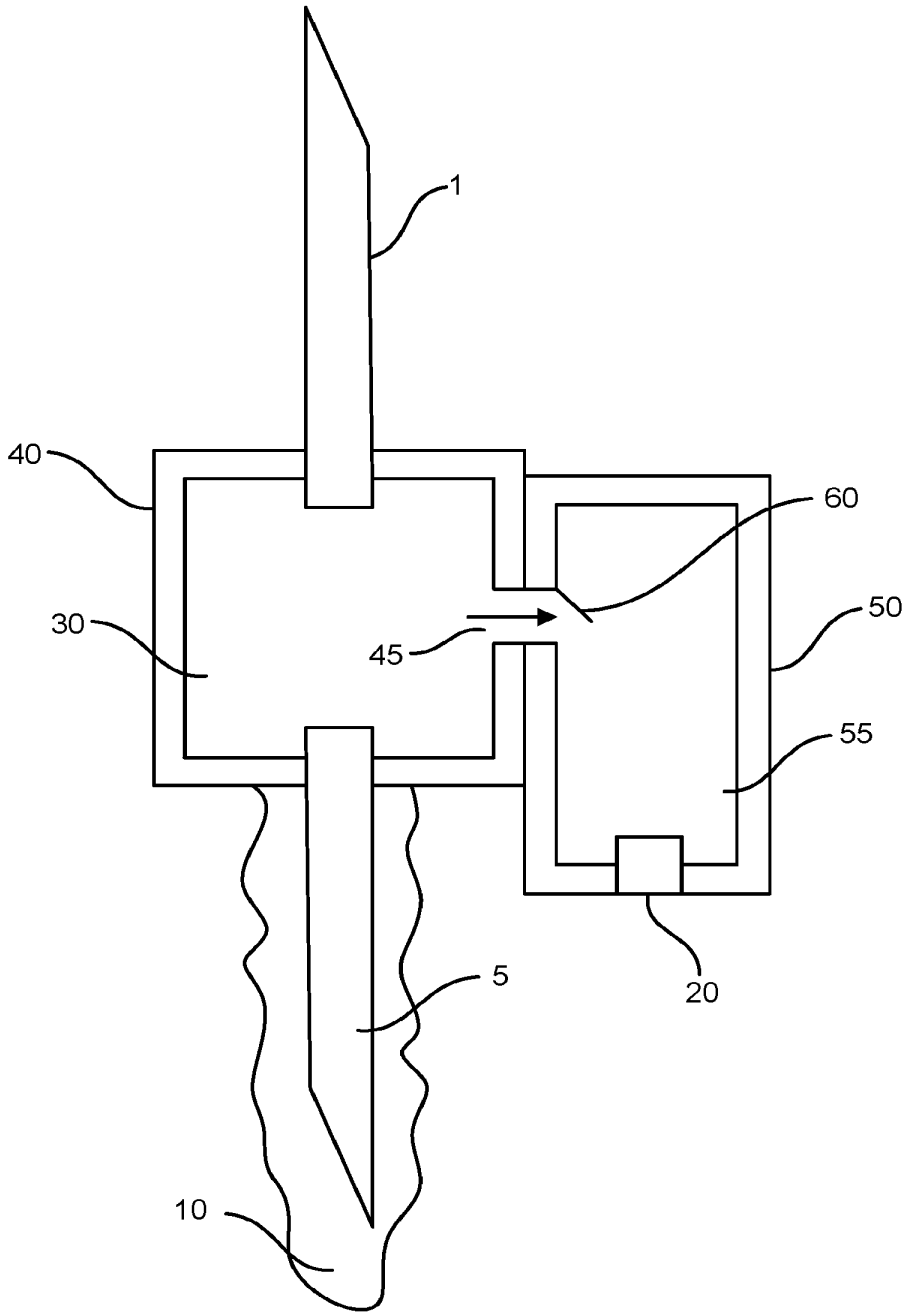


FIG. 1

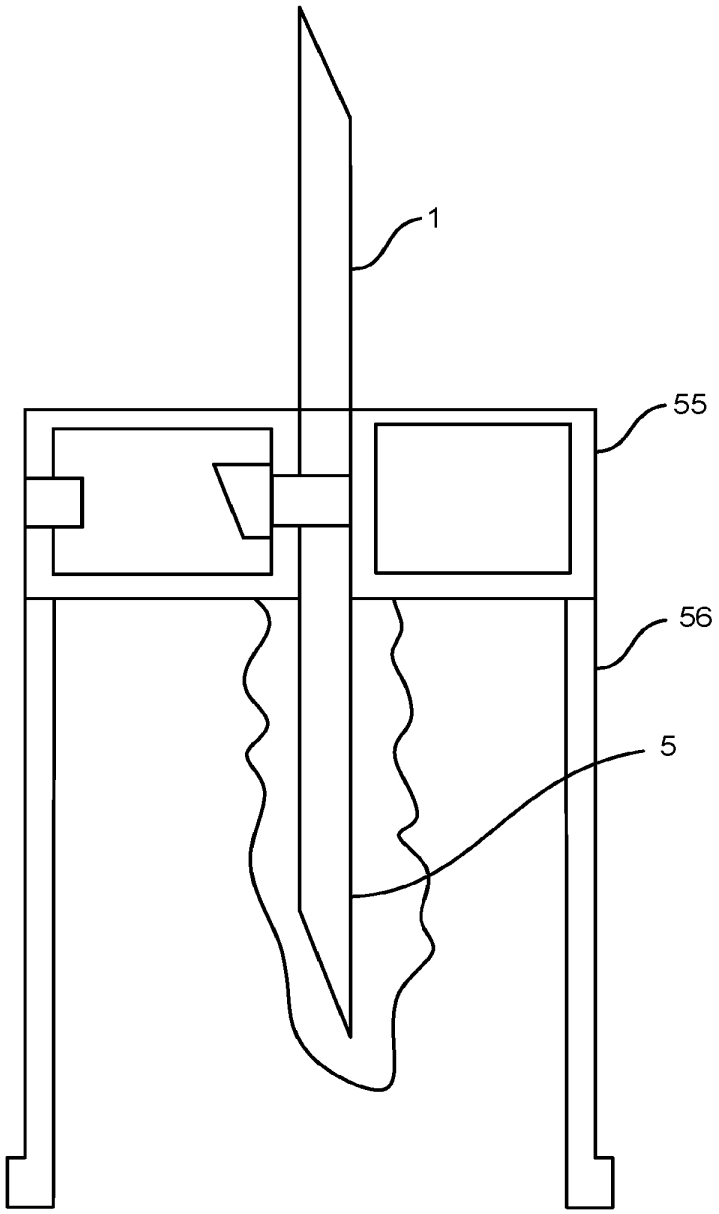


FIG. 2

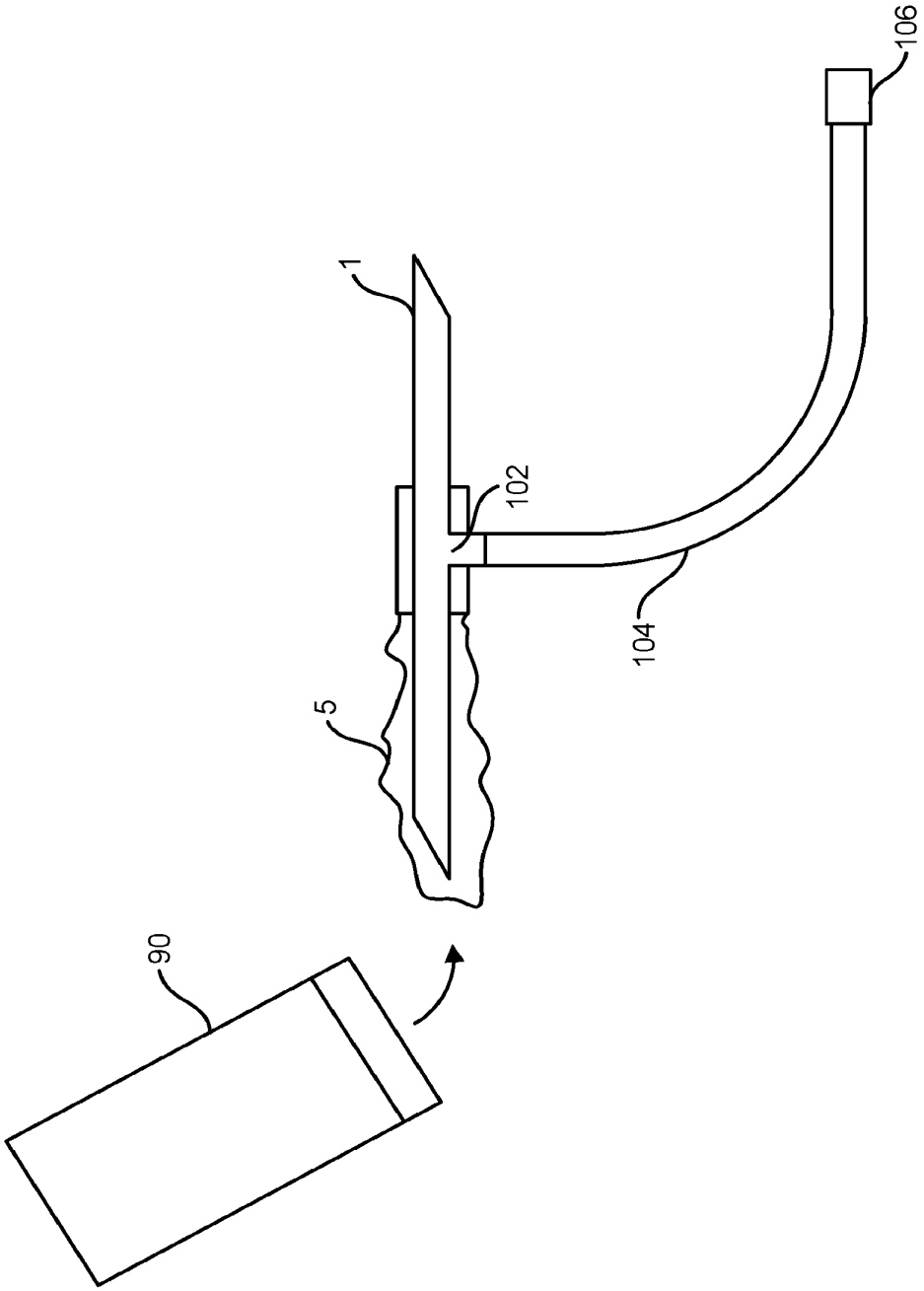


FIG. 3

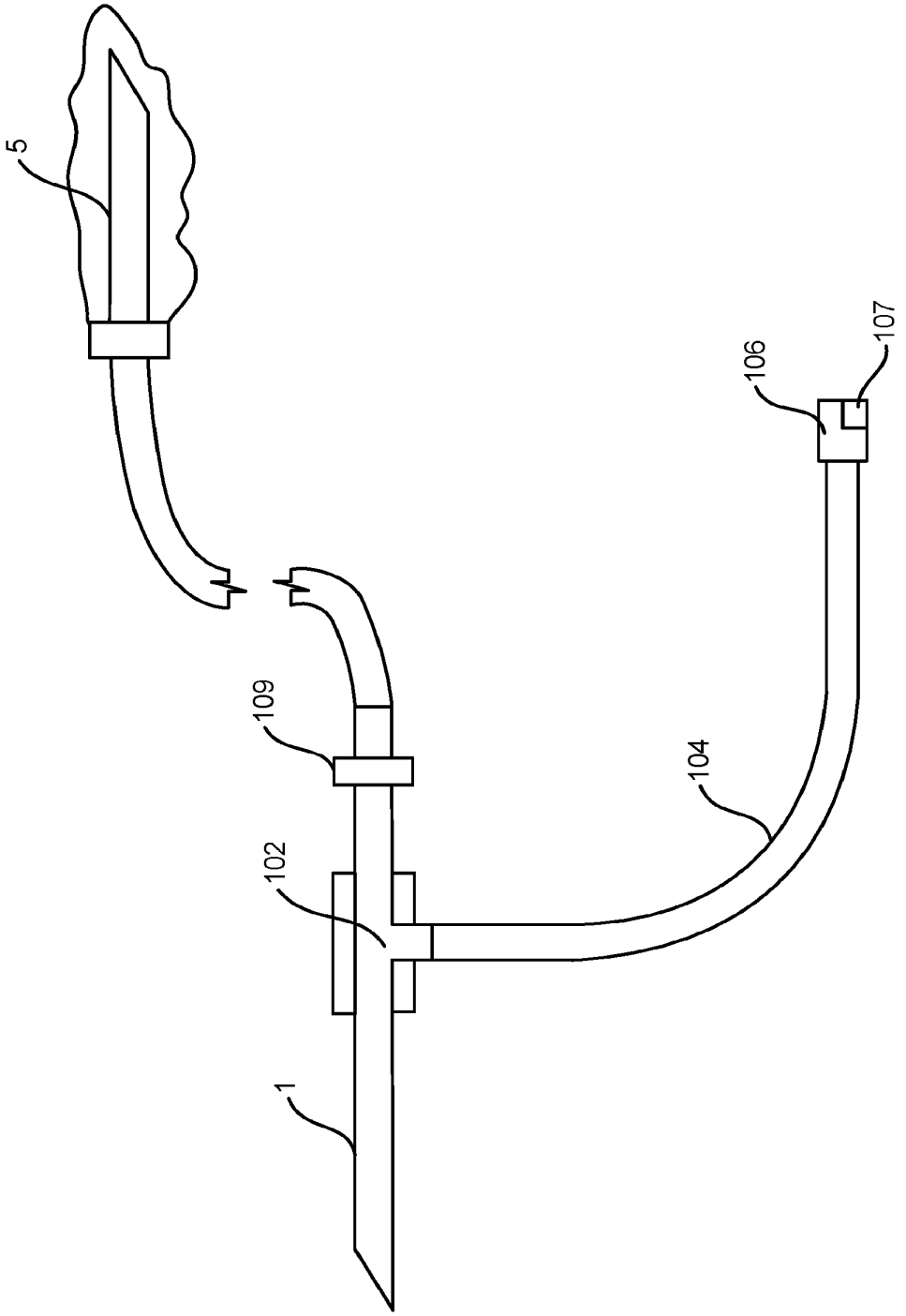


FIG. 4

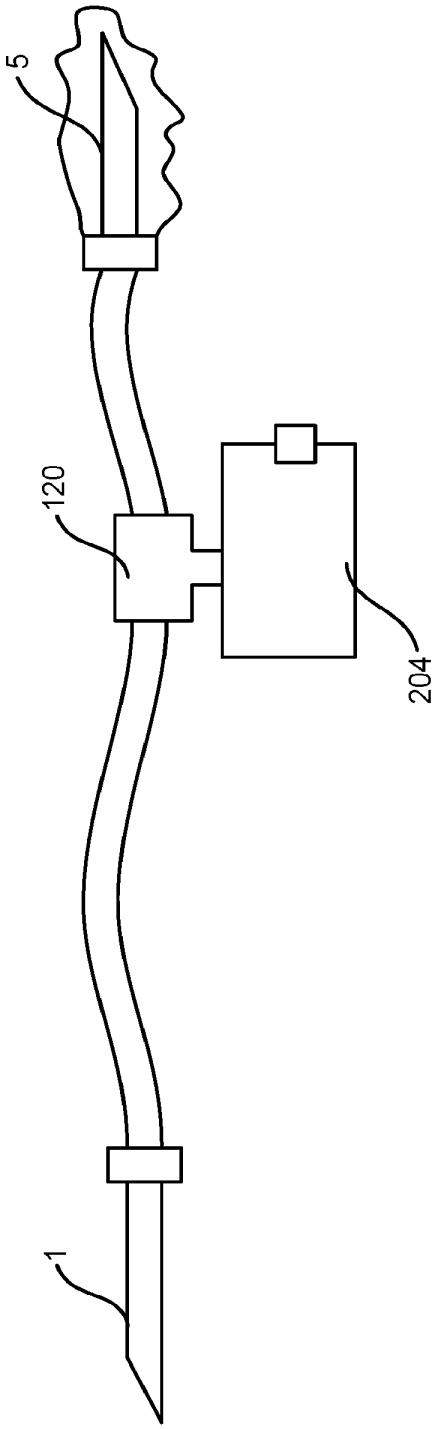


FIG. 5

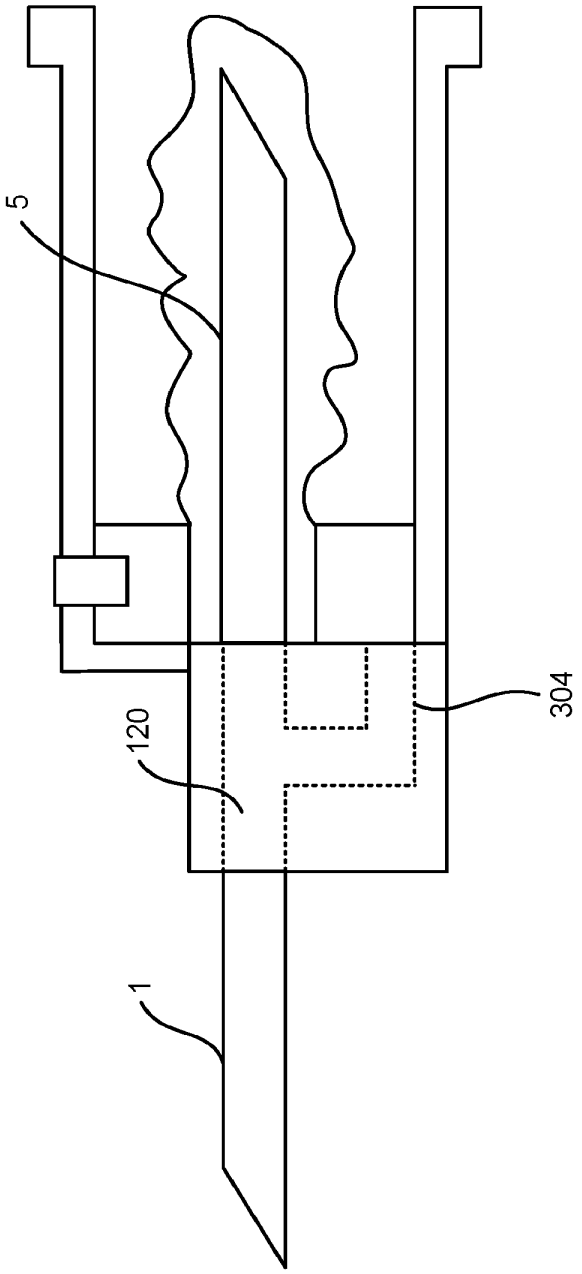


FIG. 6

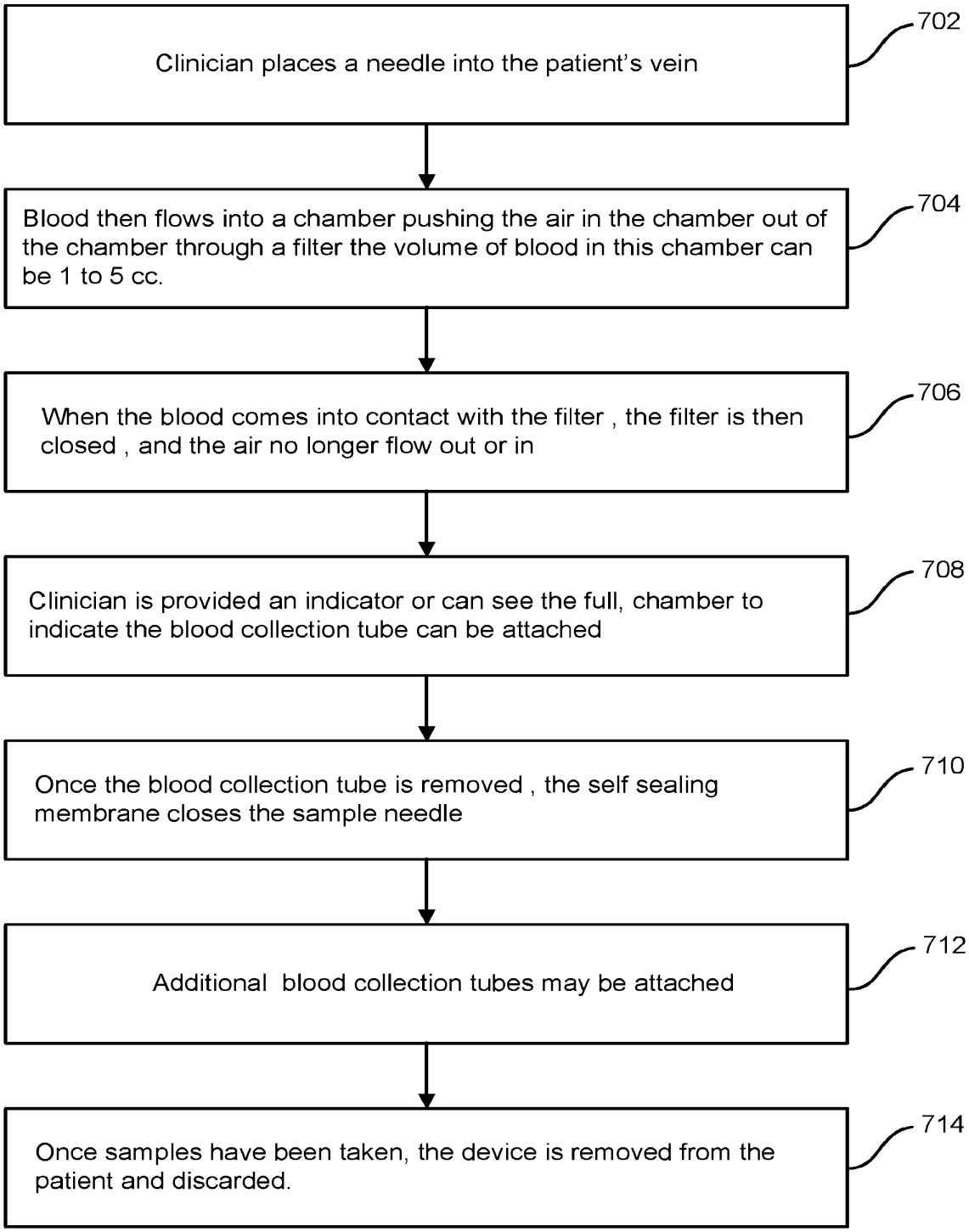
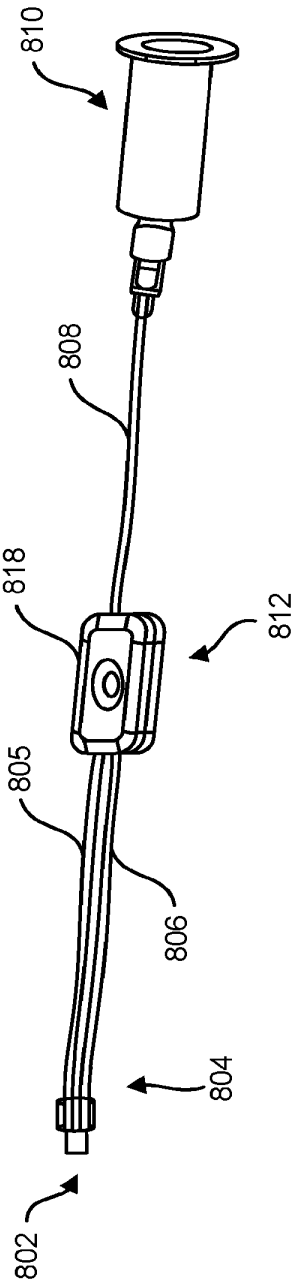

Clinician places a needle into the patient's vein
702
Blood then flows into a chamber pushing the air in the chamber out of the chamber through a filter the volume of blood in this chamber can be 1 to 5 cc.
704
When the blood comes into contact with the filter , the filter is then closed , and the air no longer flow out or in
706
Clinician is provided an indicator or can see the full, chamber to indicate the blood collection tube can be attached
708
Once the blood collection tube is removed , the self sealing membrane closes the sample needle
710
Additional blood collection tubes may be attached
712
Once samples have been taken, the device is removed from the patient and discarded.
714

FIG. 7



800

FIG. 8A

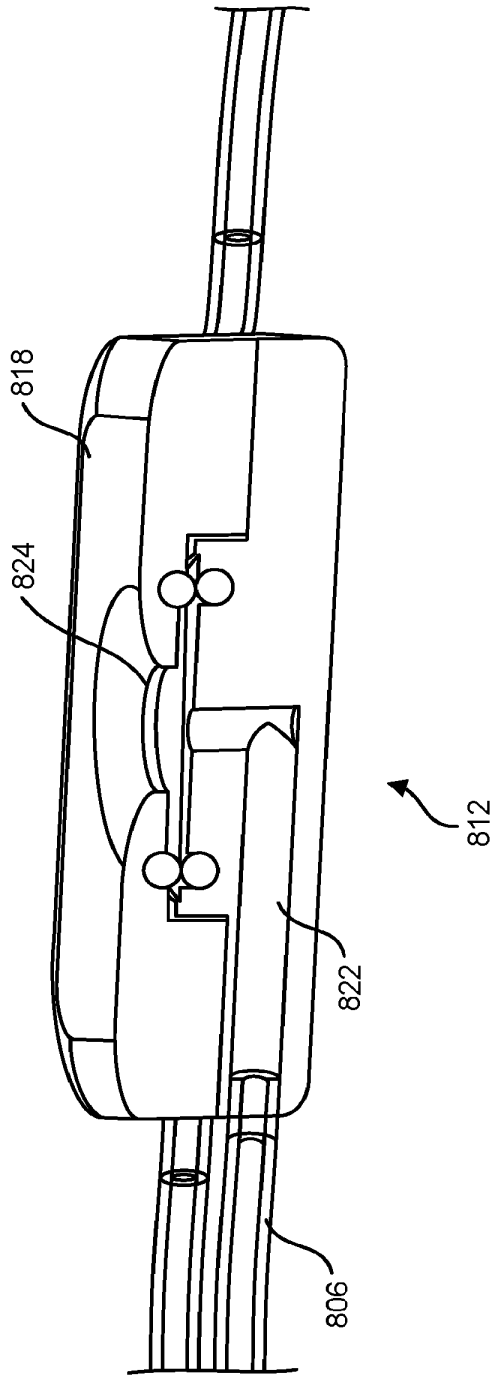


FIG. 8B

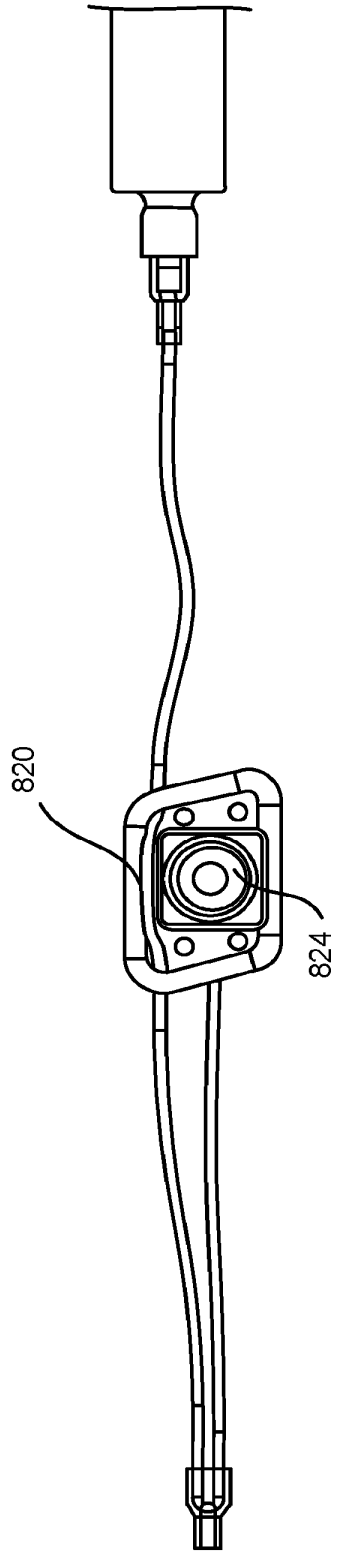


FIG. 8C

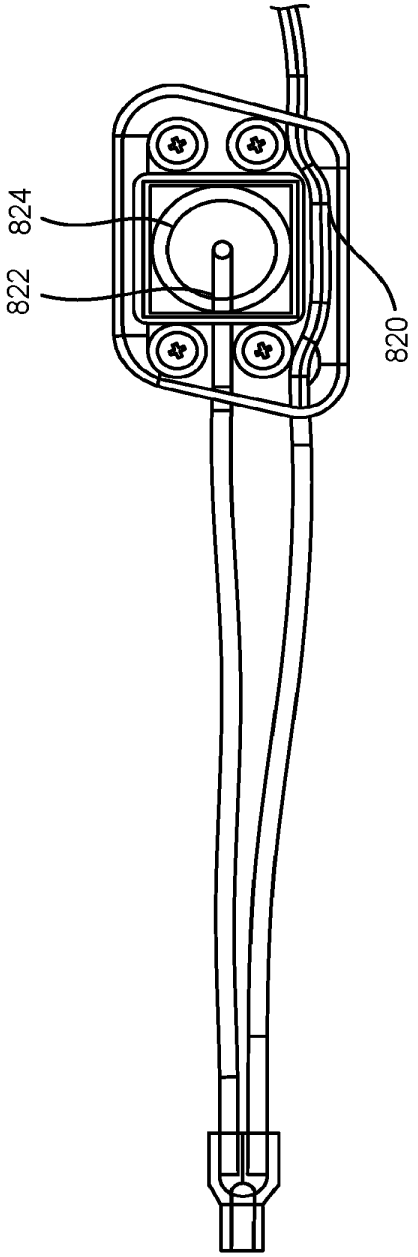


FIG. 8D

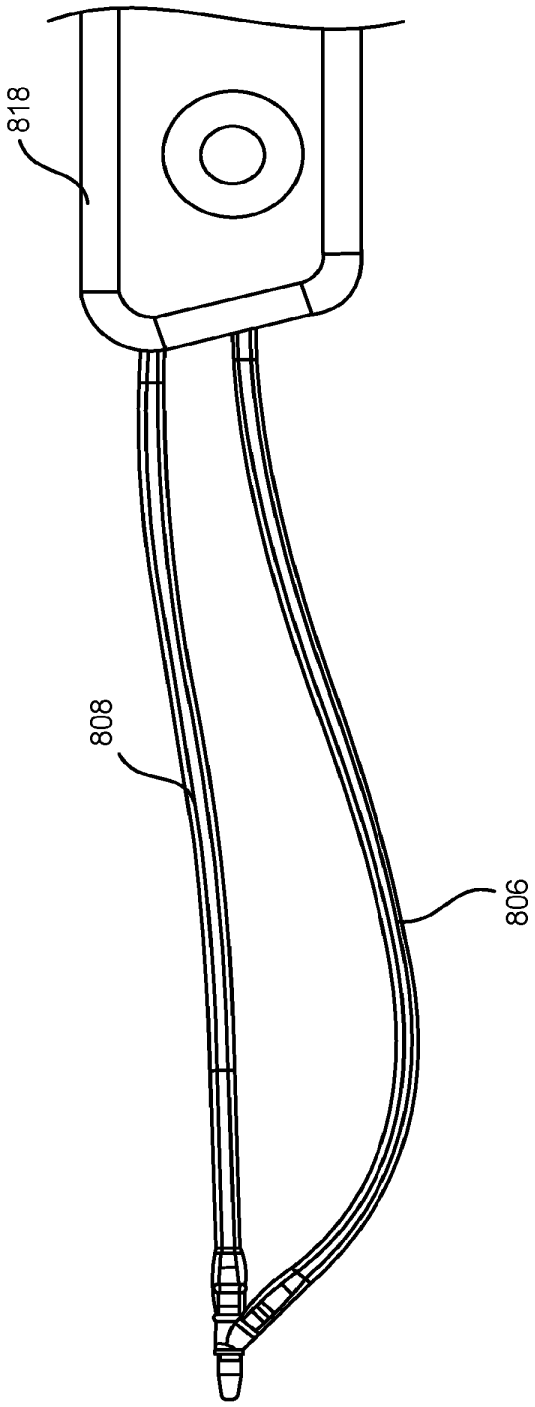


FIG. 8E

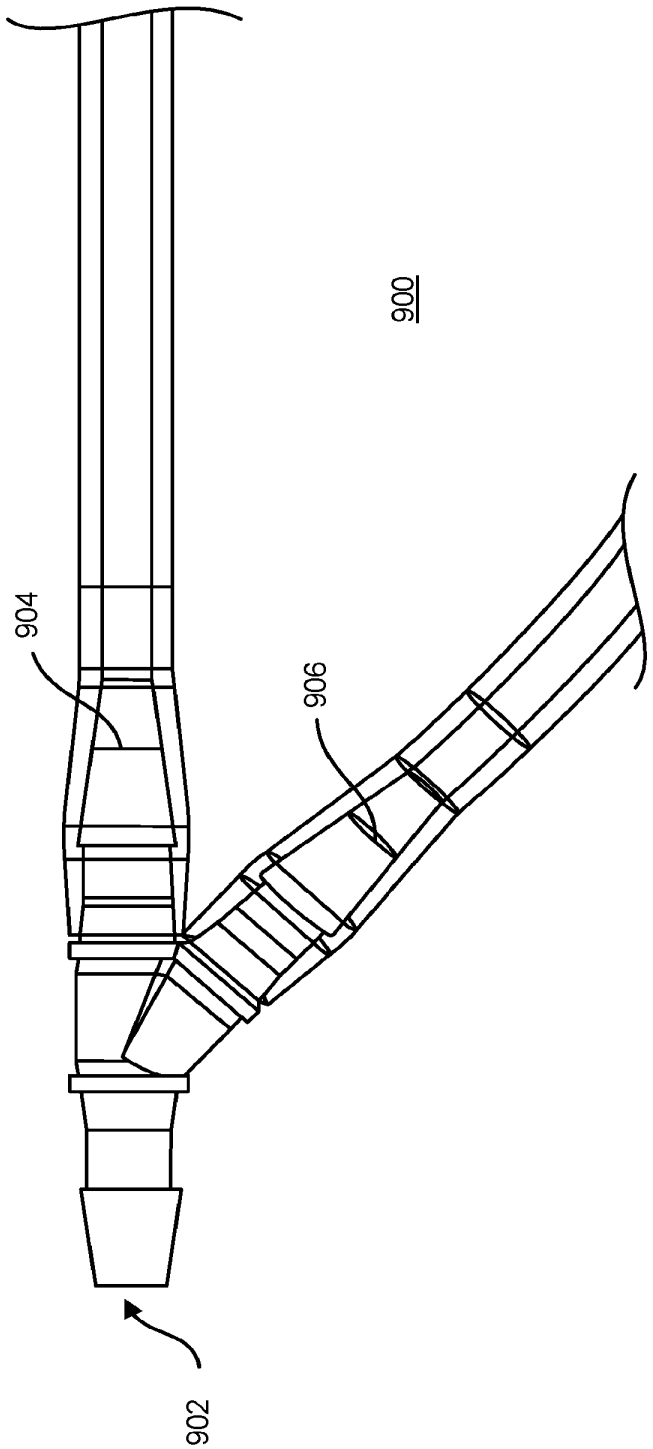


FIG. 9

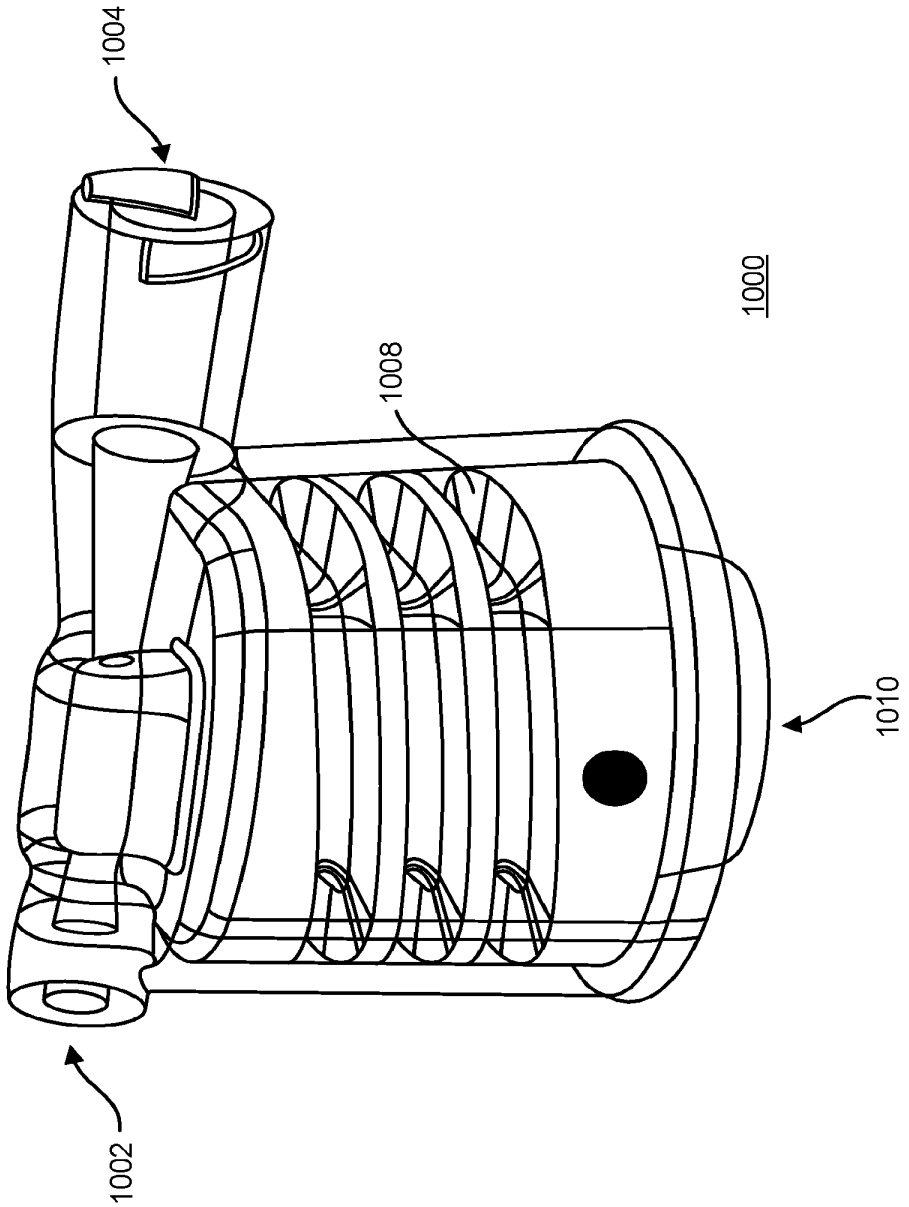


FIG. 10A

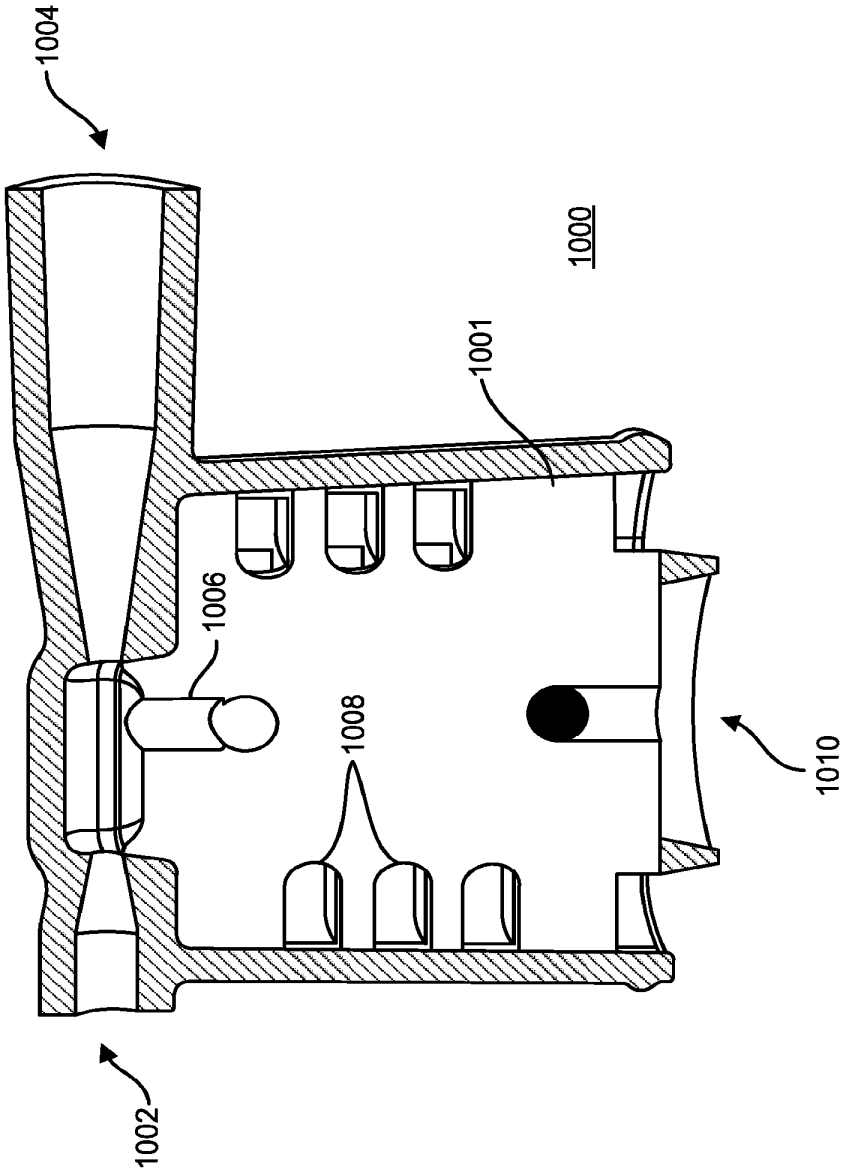


FIG. 10B

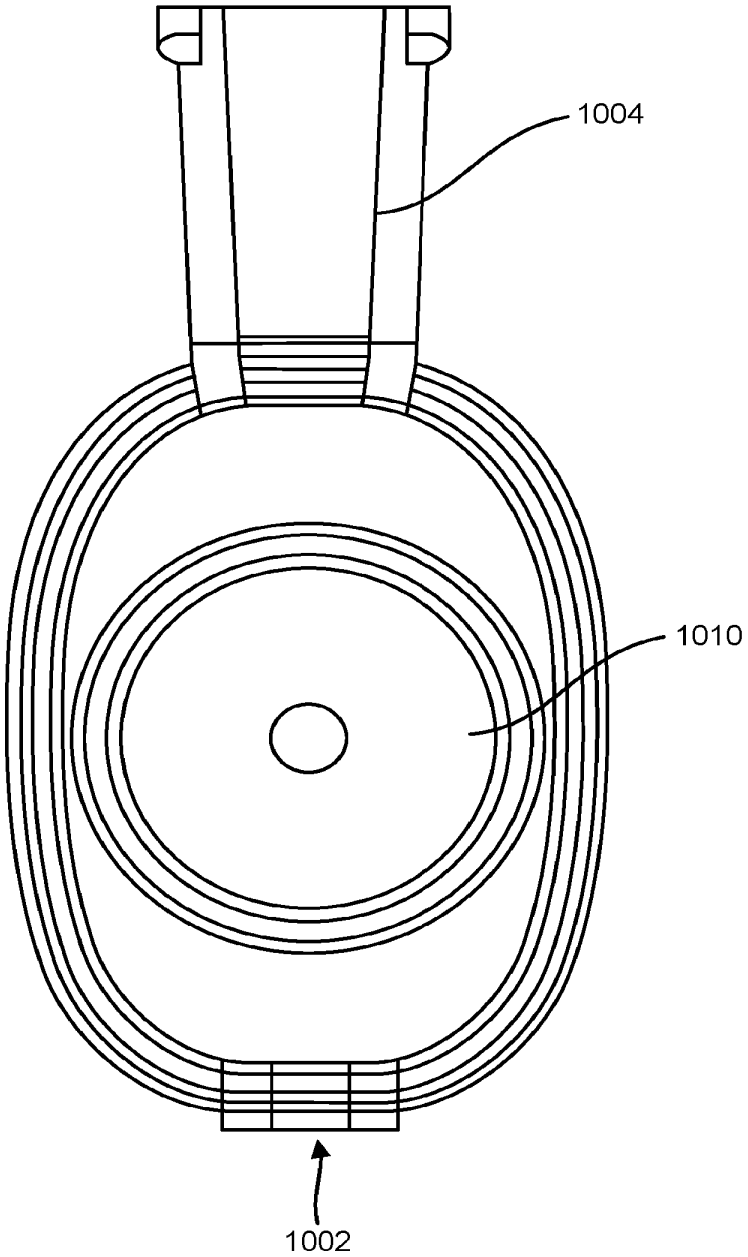


FIG. 10C

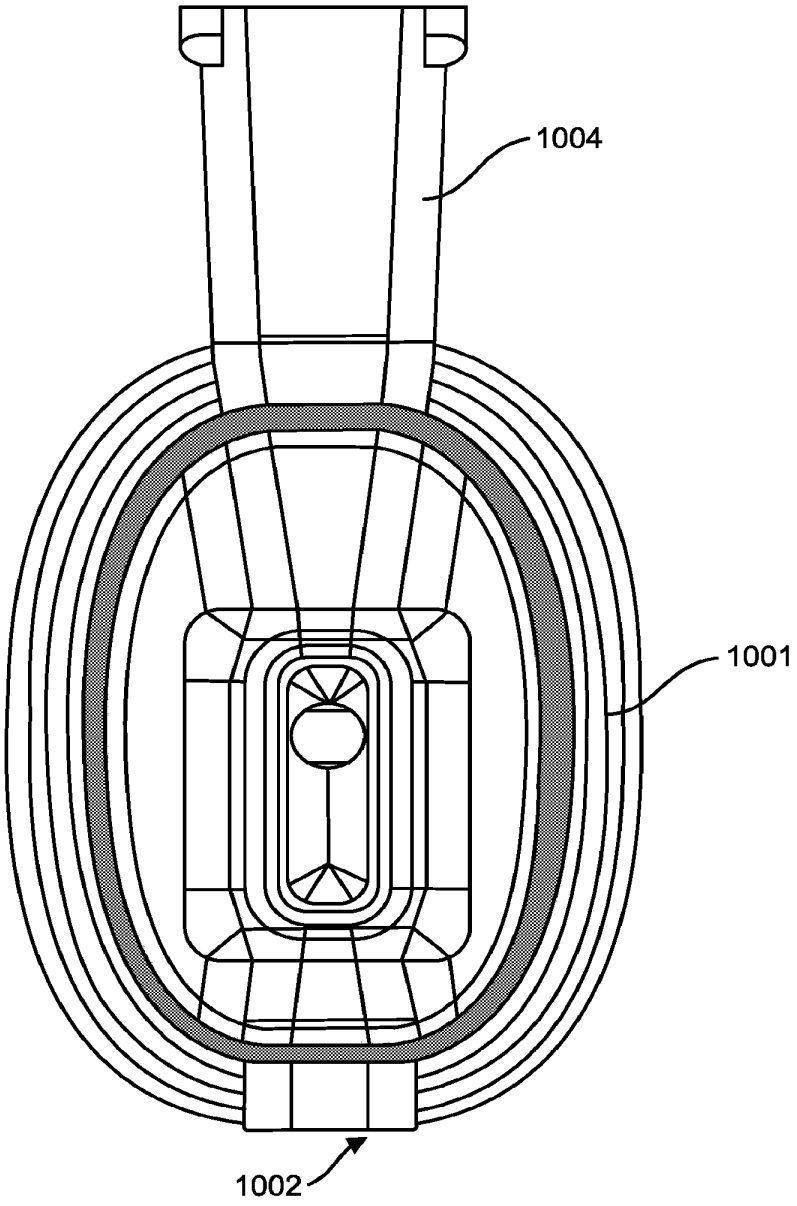


FIG. 10D

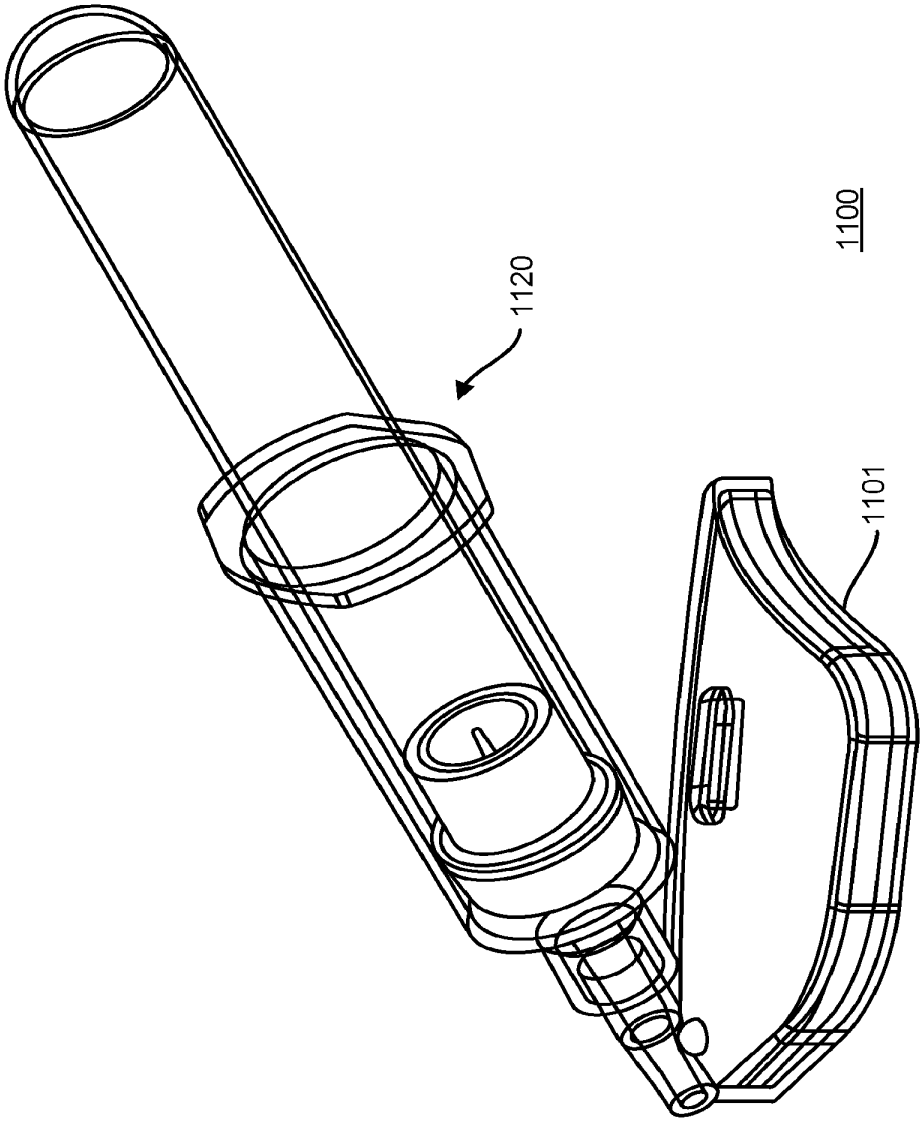


FIG. 11A

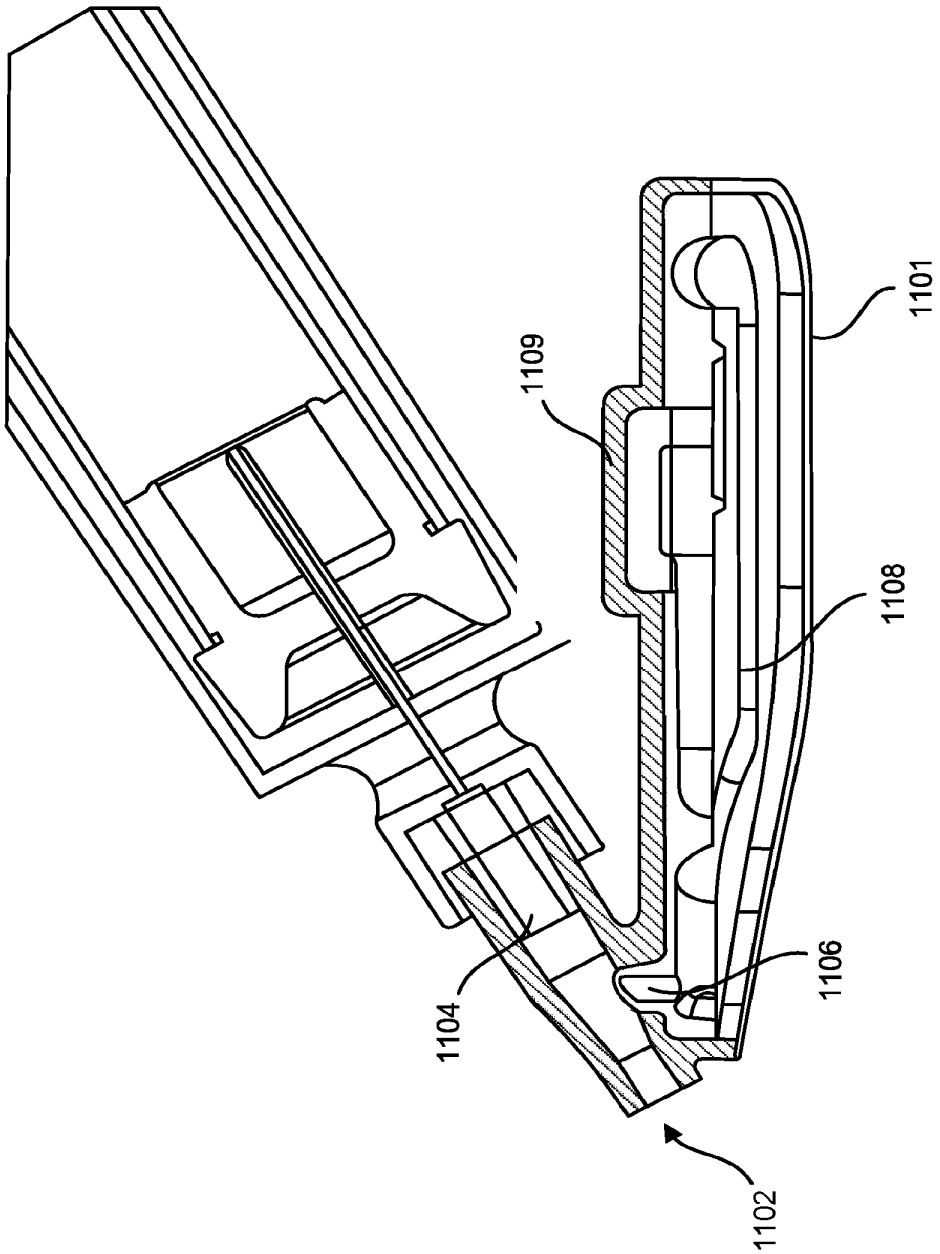


FIG. 11B

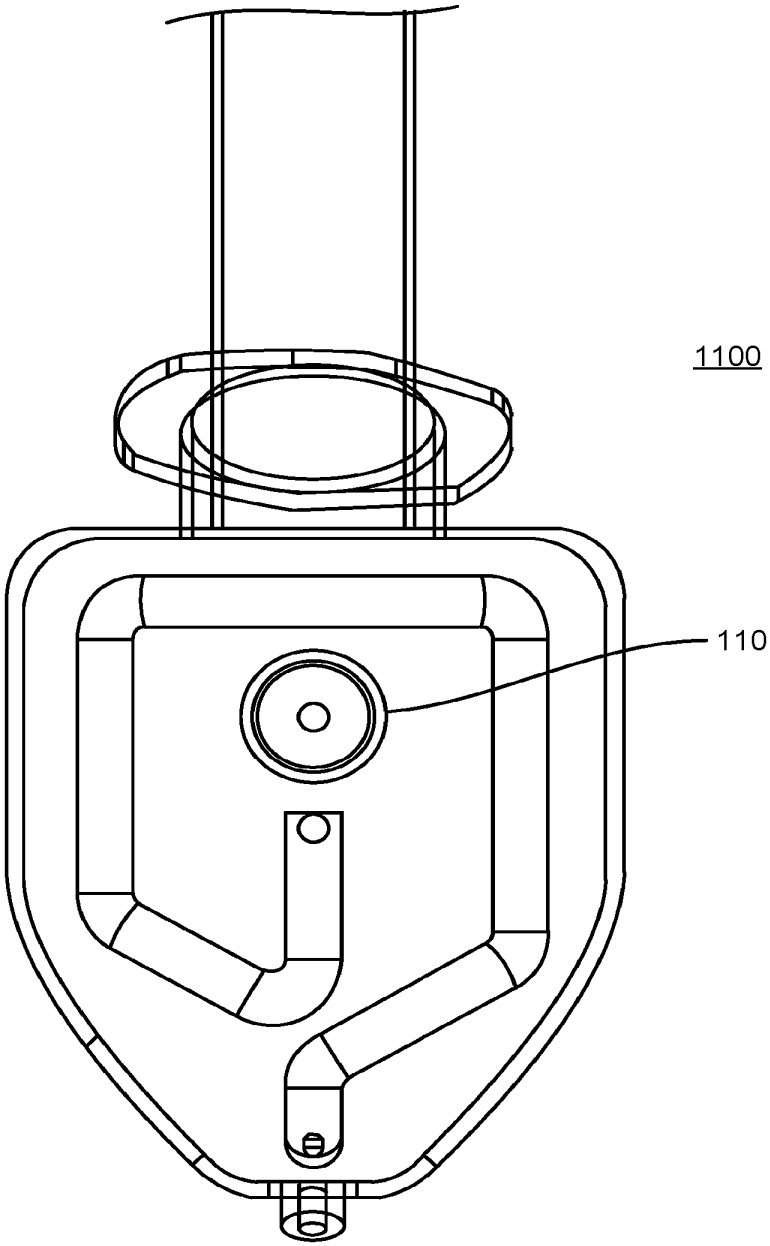


FIG. 11C

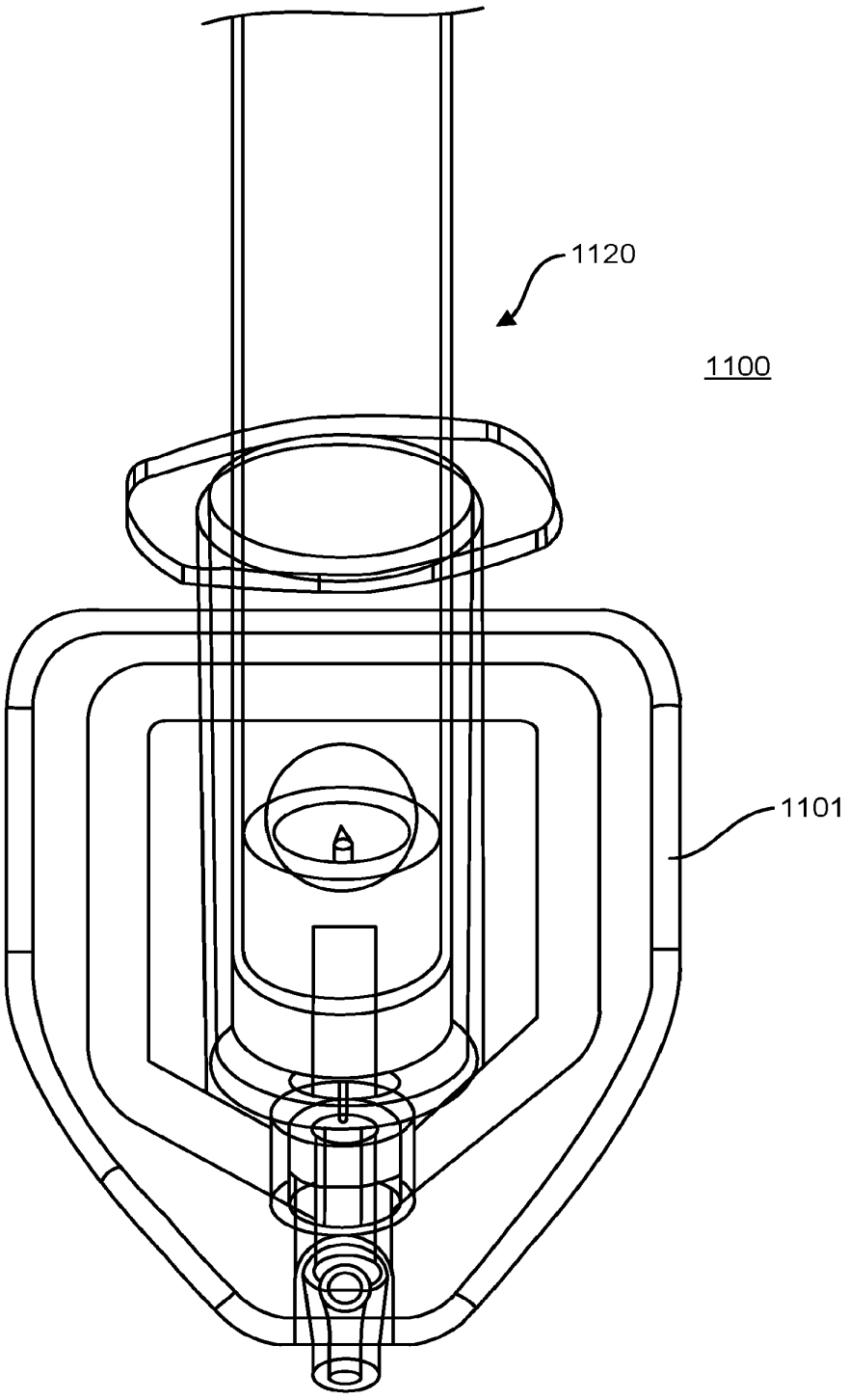


FIG. 11D

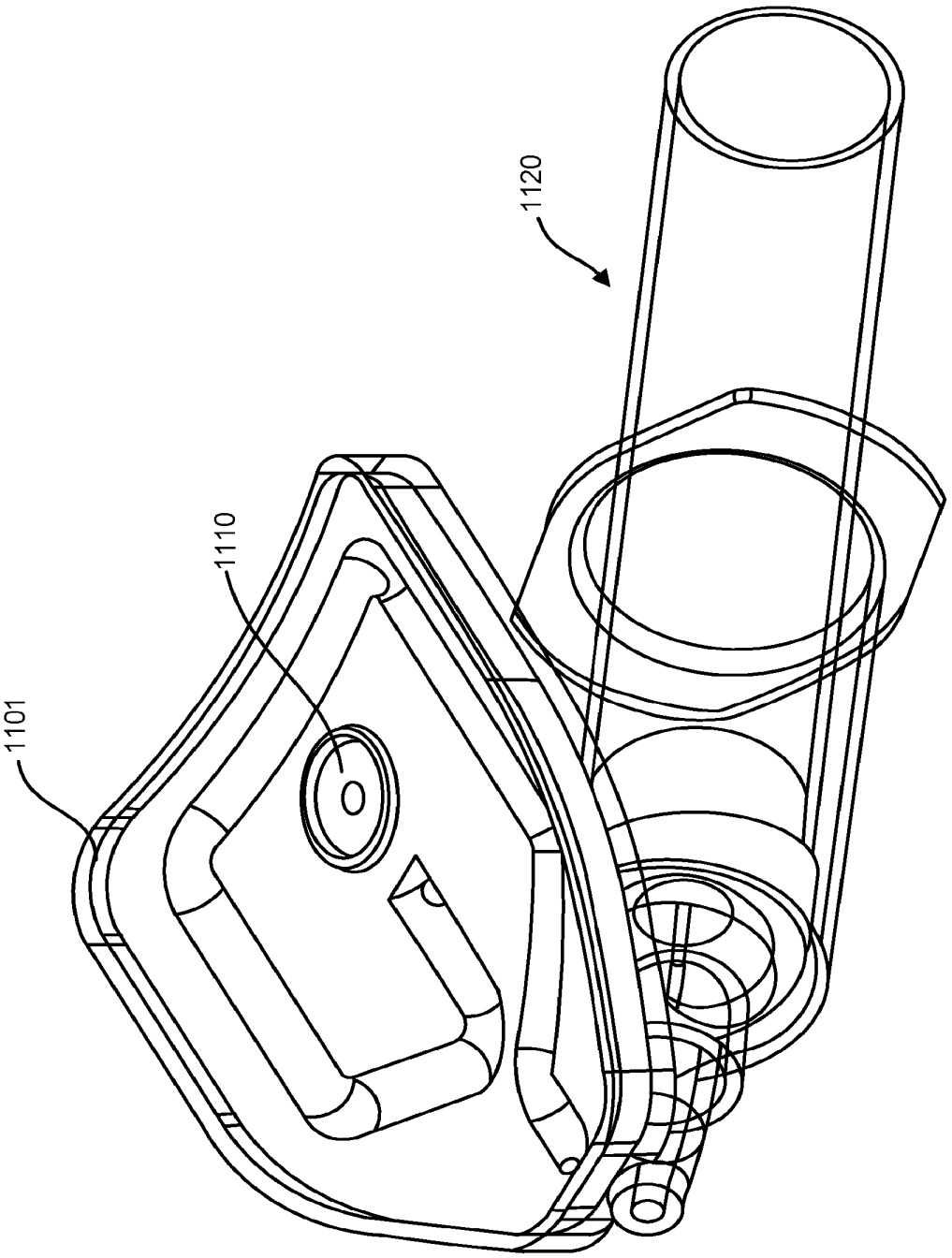


FIG. 11E

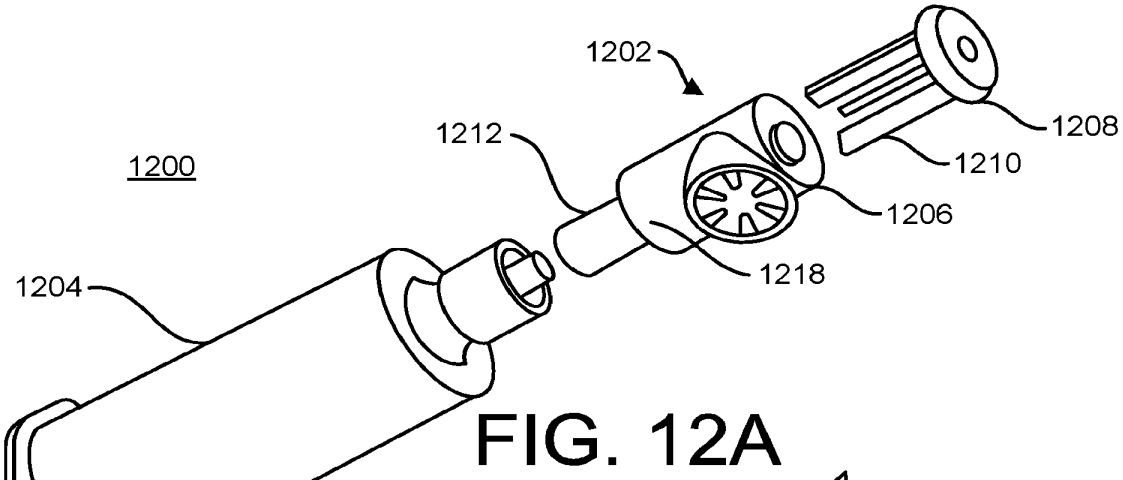


FIG. 12A

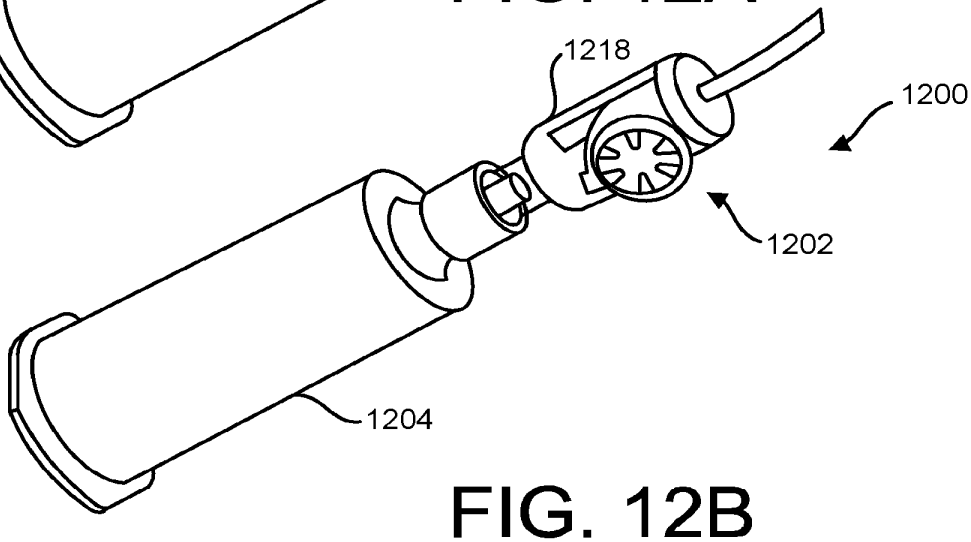


FIG. 12B

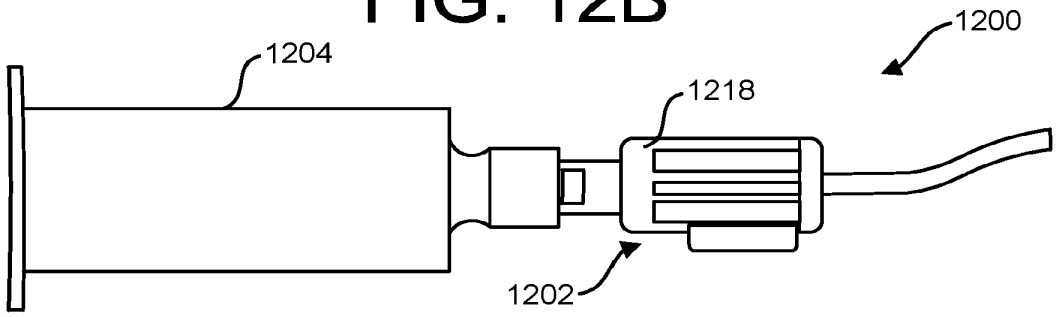


FIG. 12C

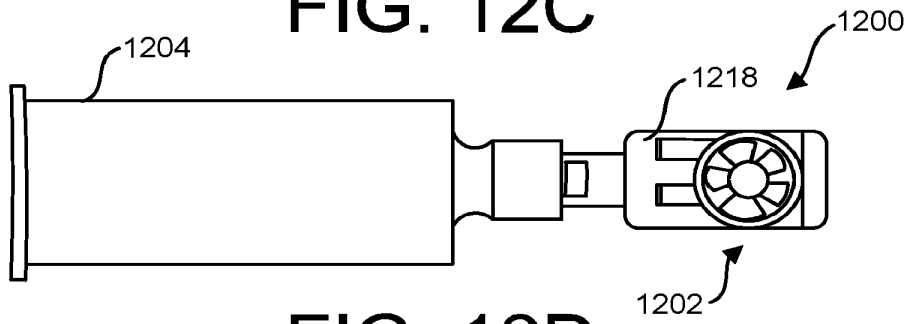


FIG. 12D

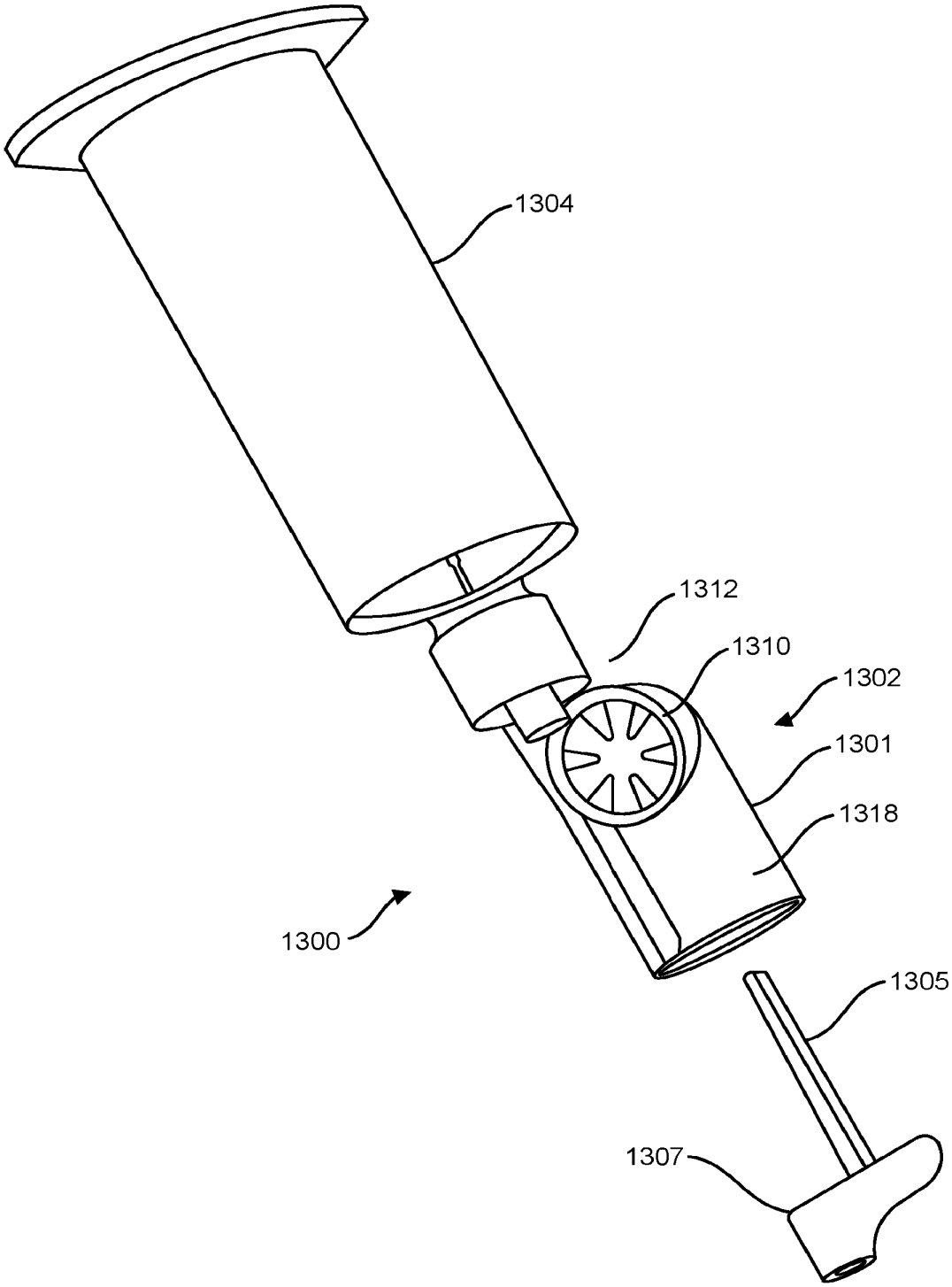


FIG. 13A

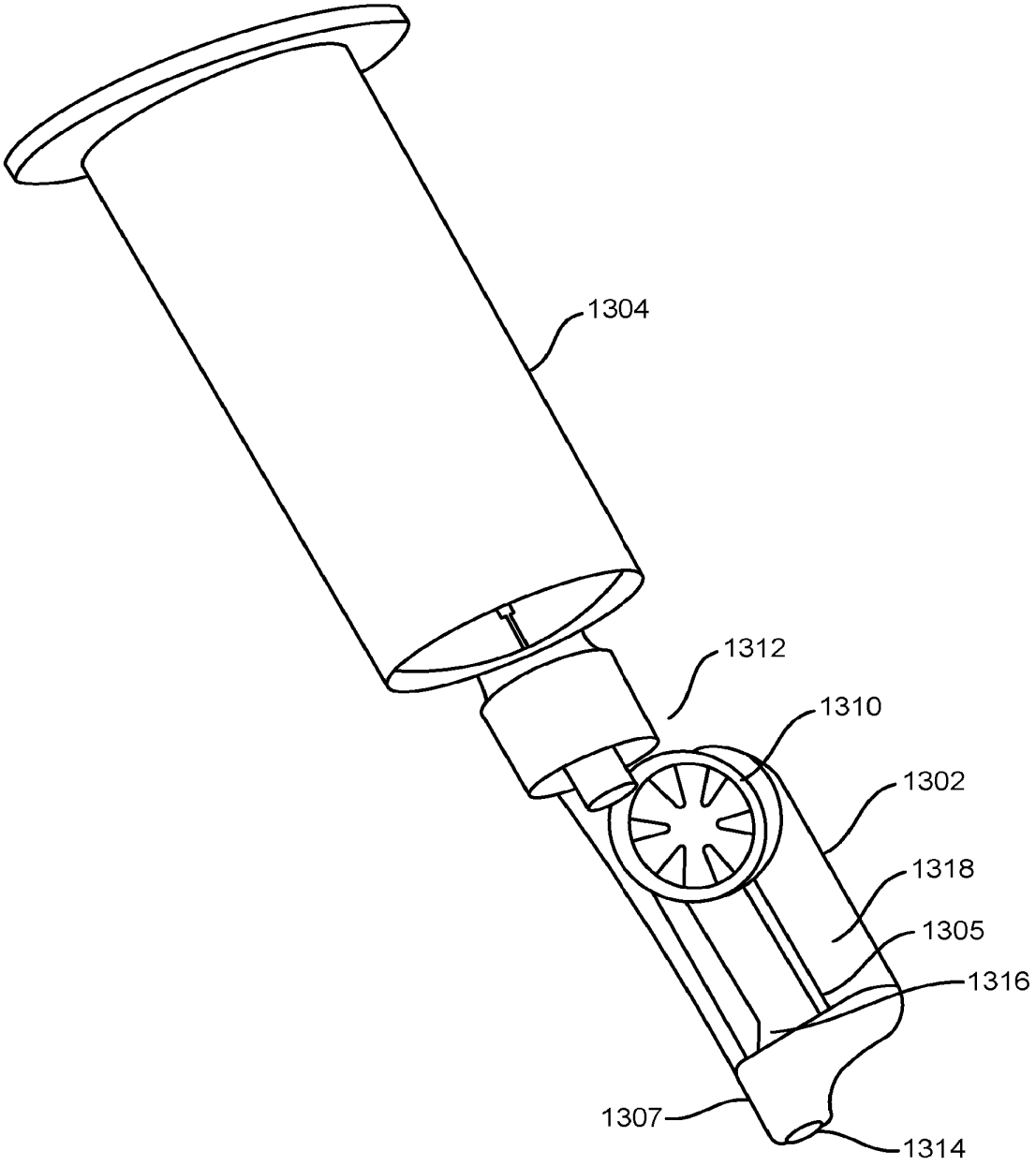


FIG. 13B

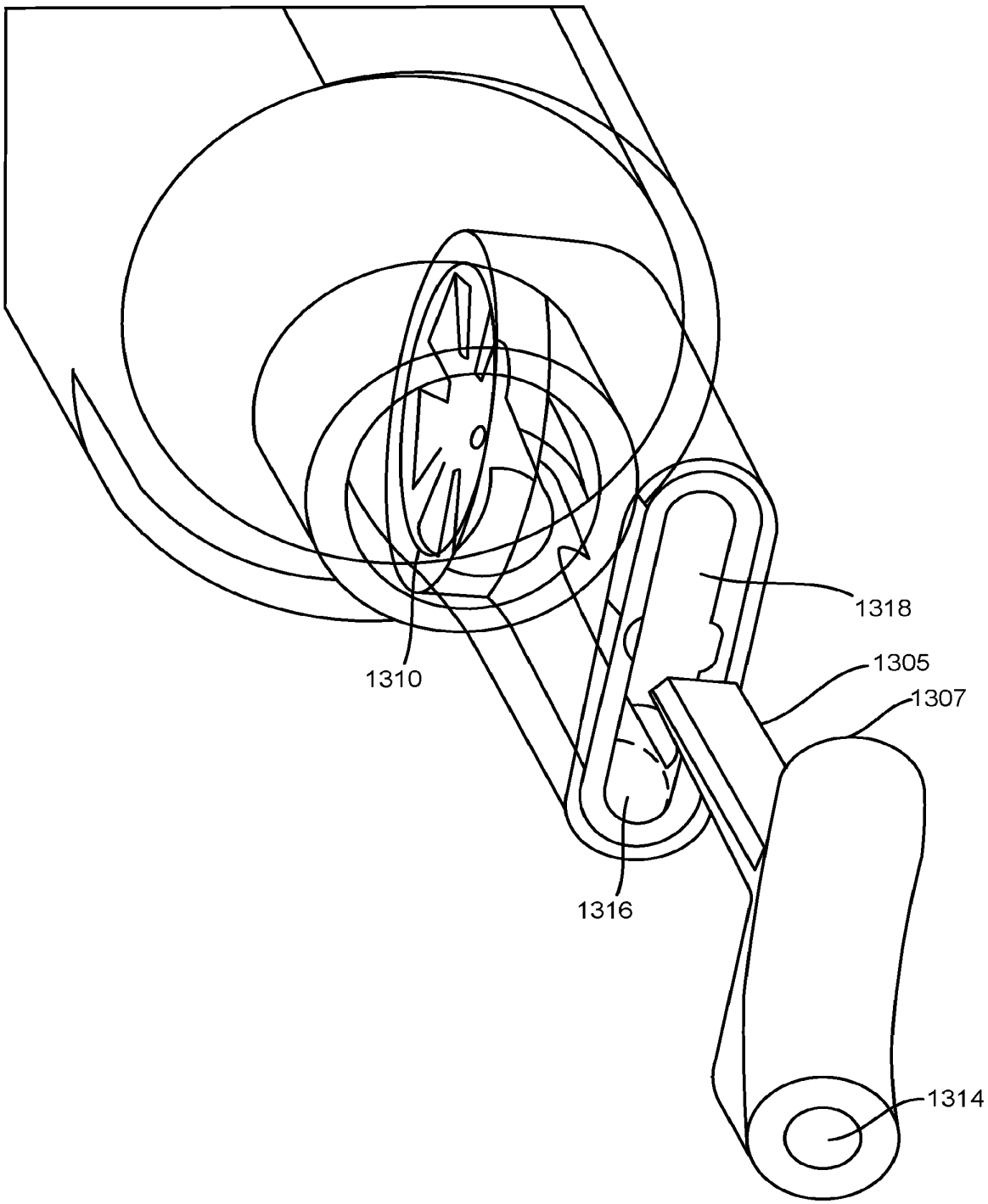


FIG. 13C

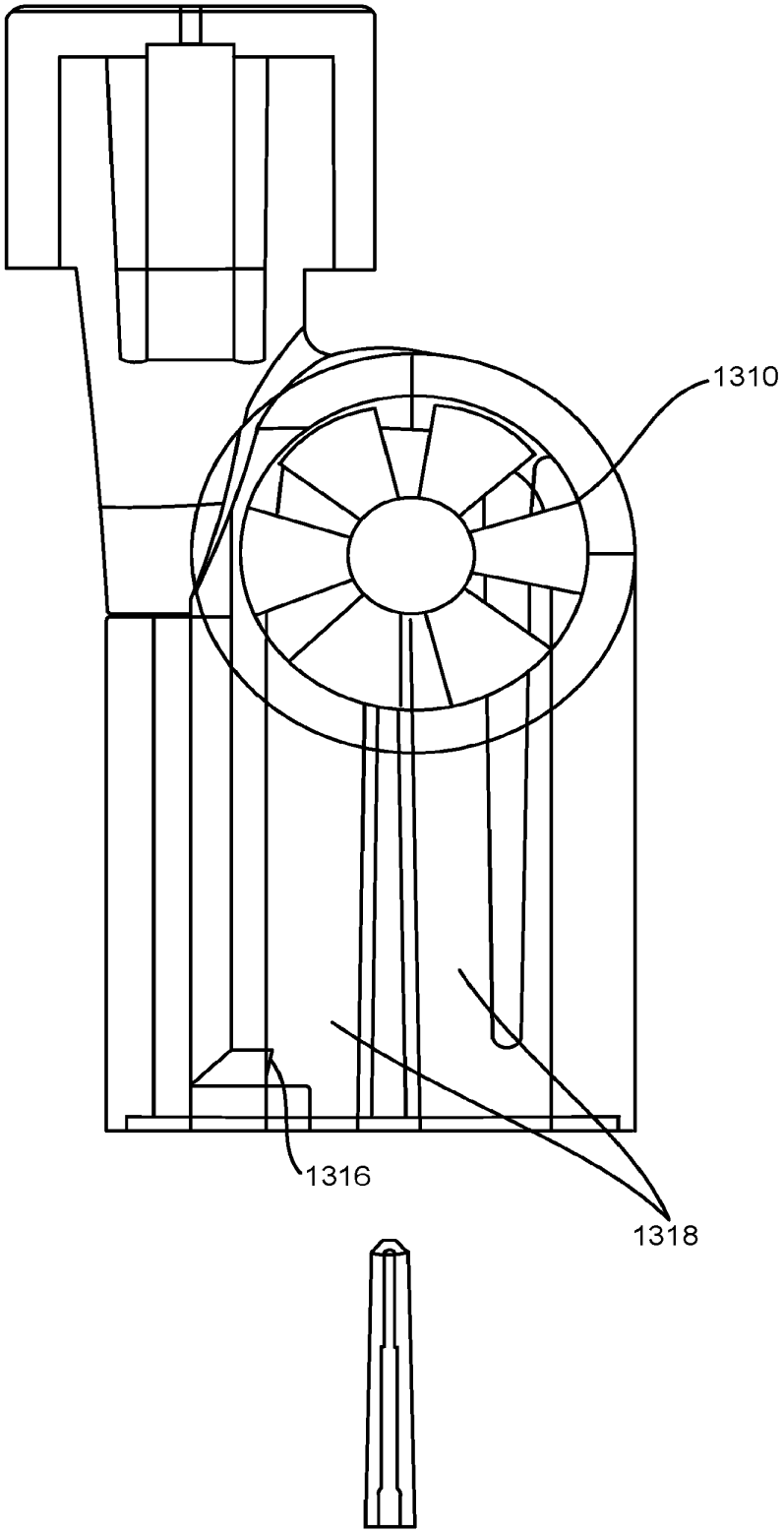


FIG. 13D

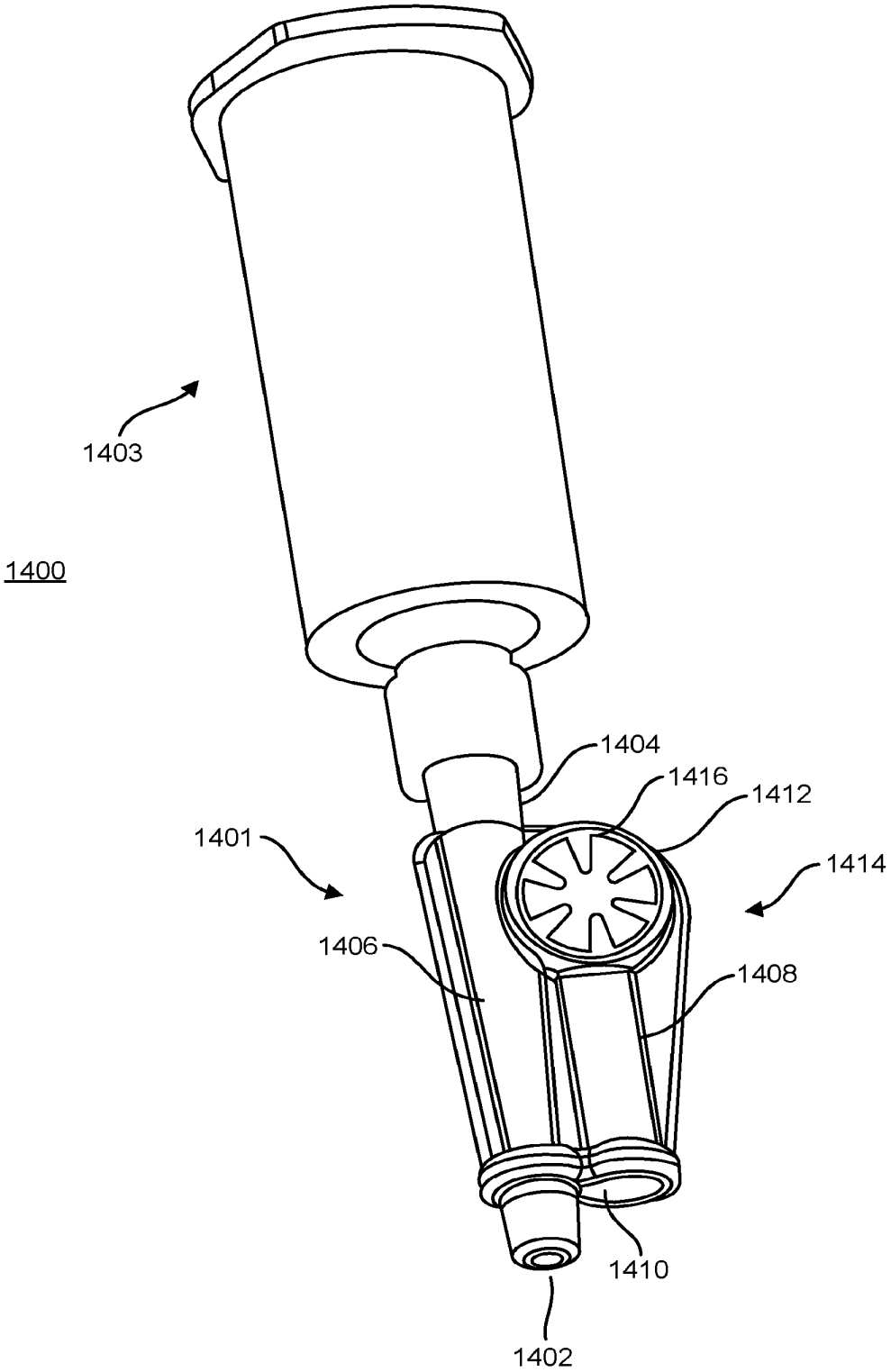


FIG. 14A

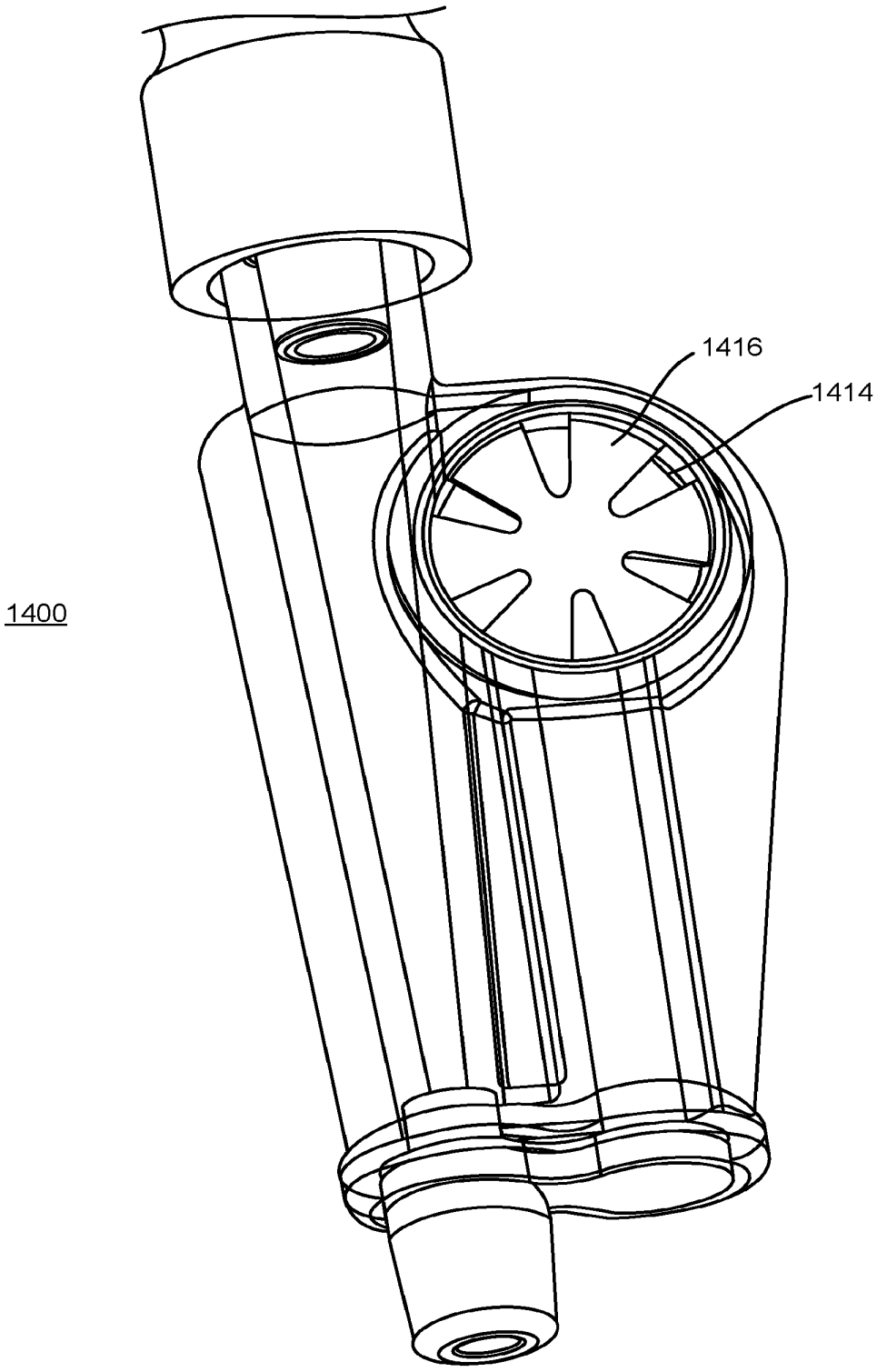


FIG. 14B

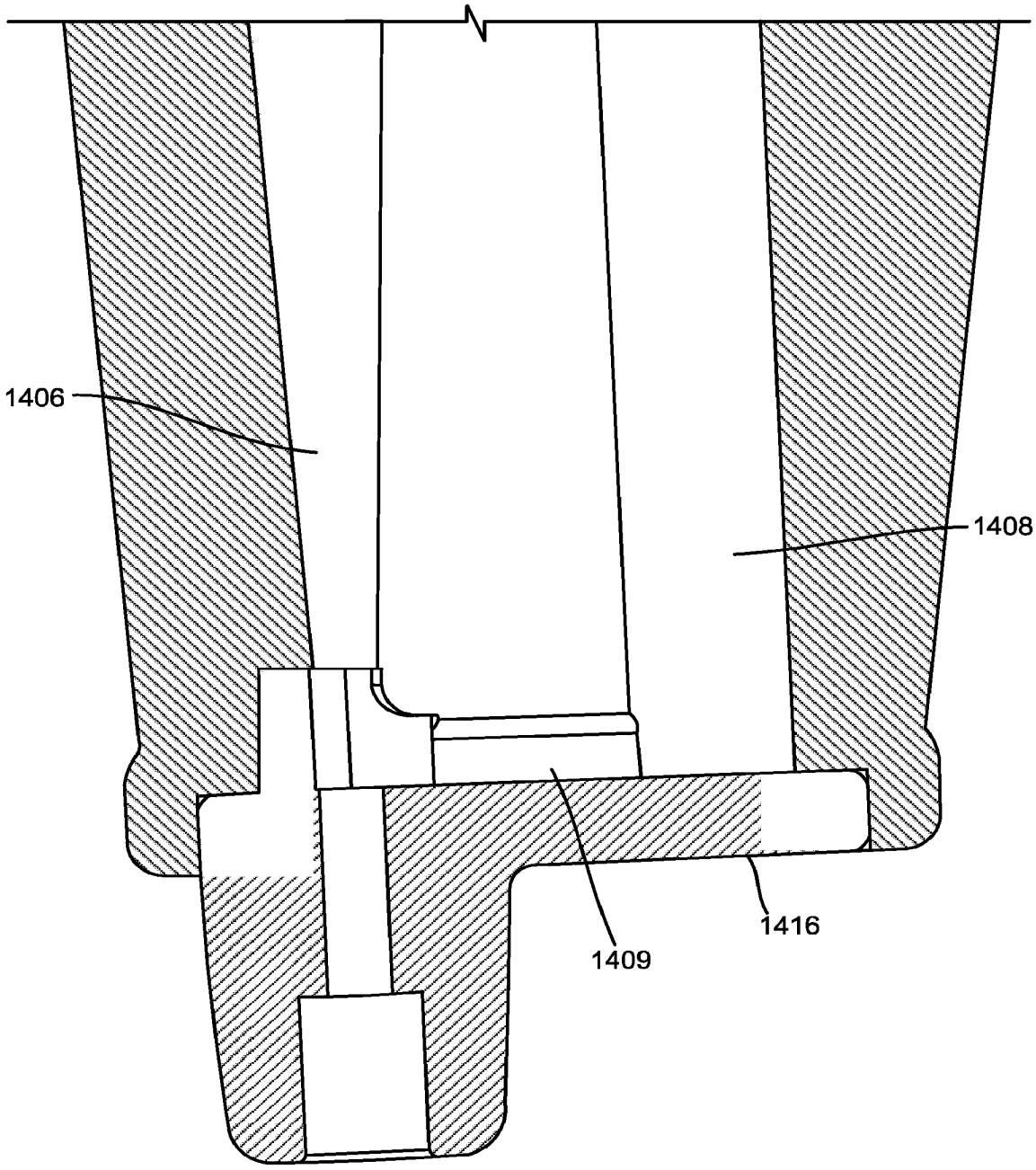


FIG. 14C

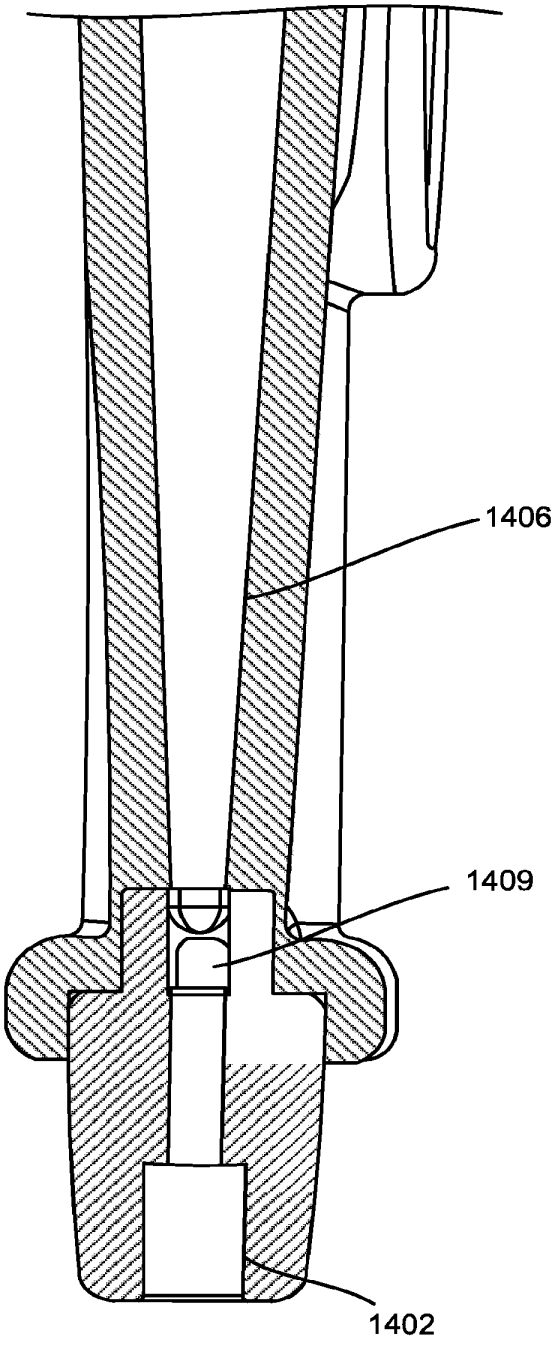


FIG. 14D

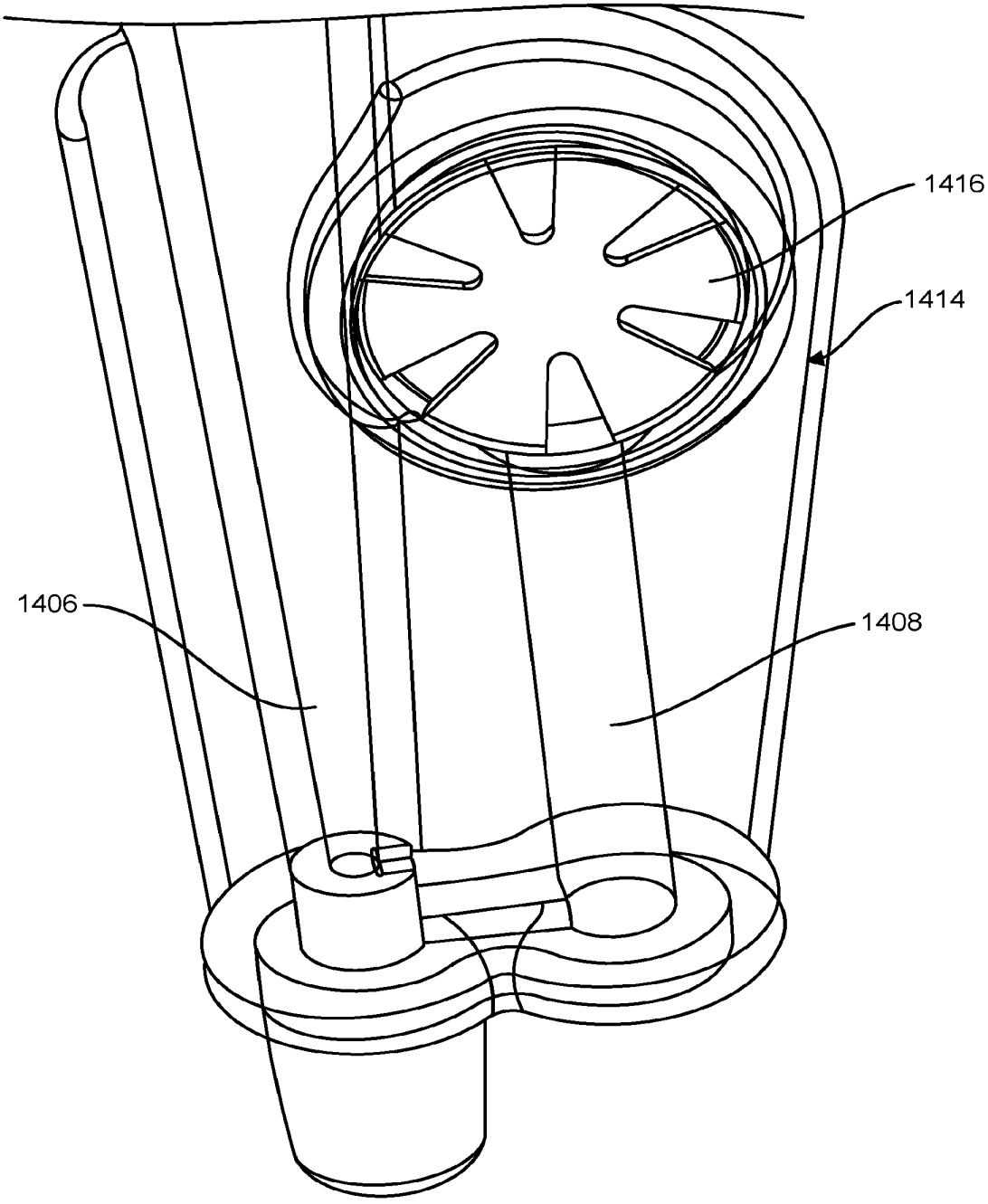


FIG. 14E

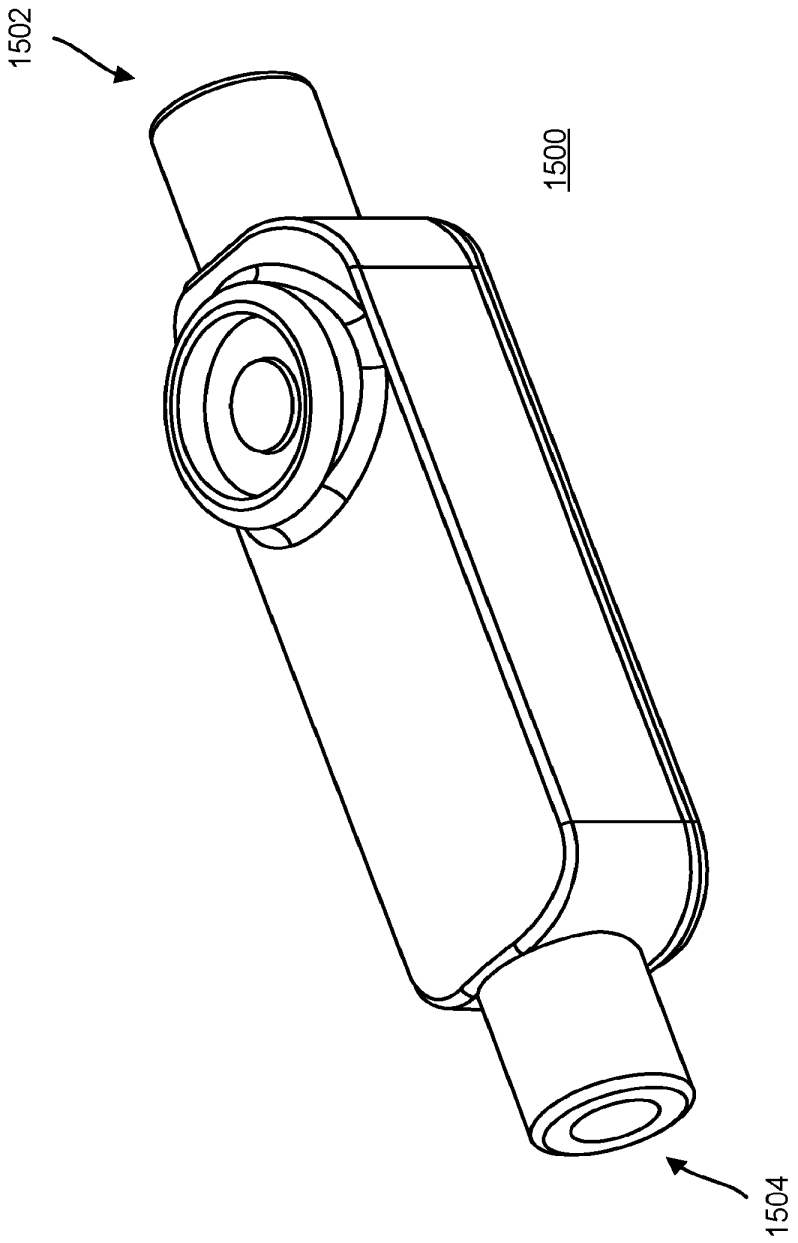


FIG. 15A

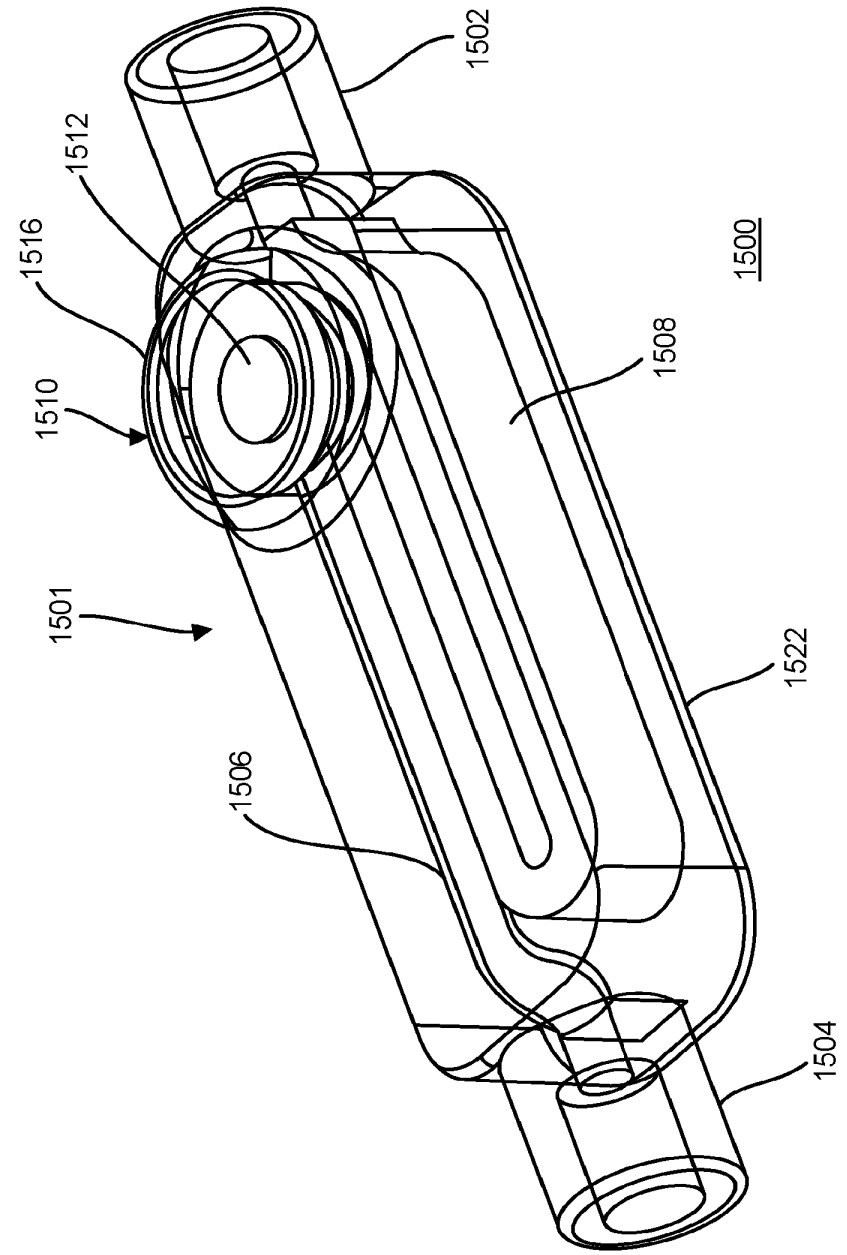


FIG. 15B

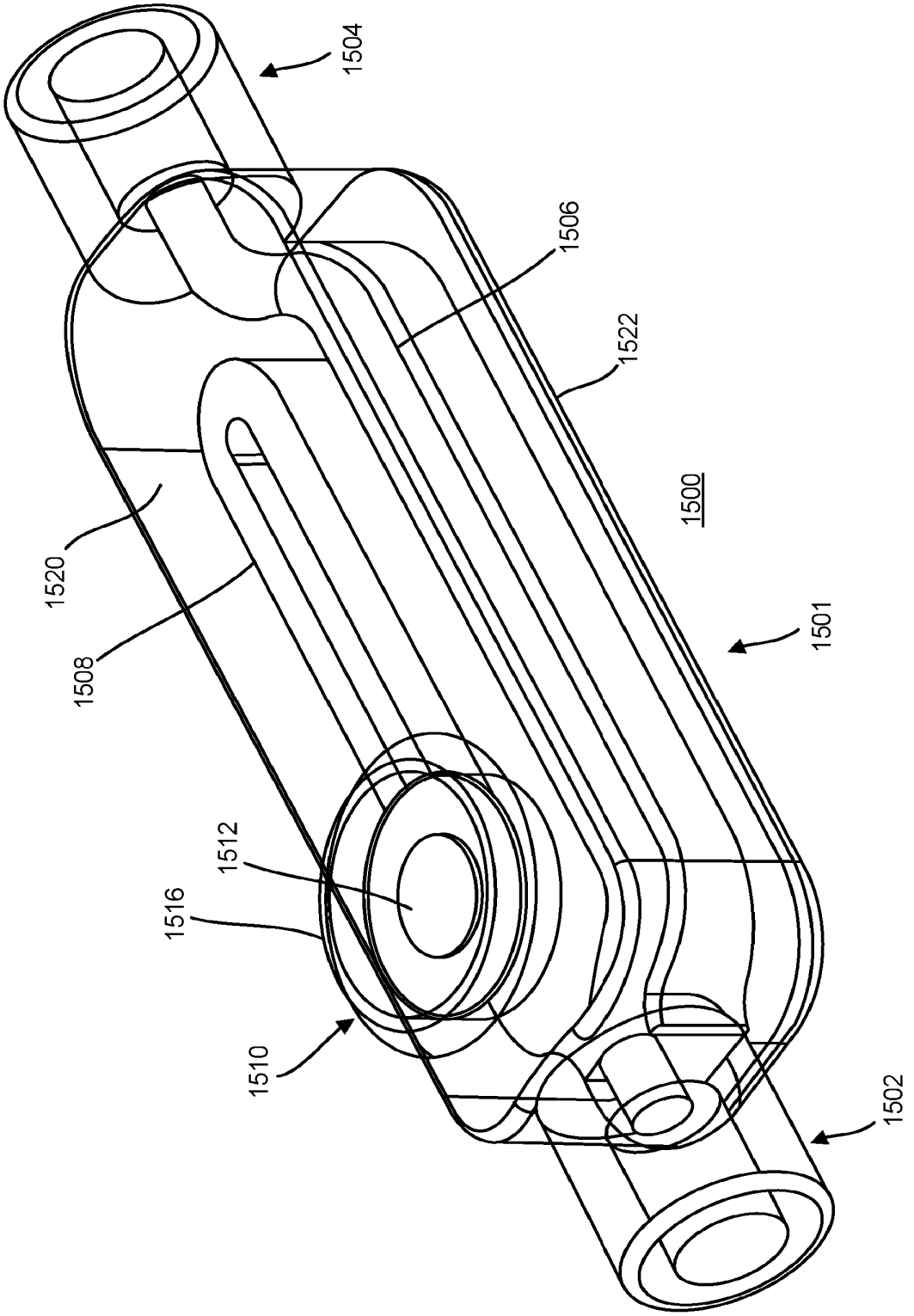


FIG. 15C

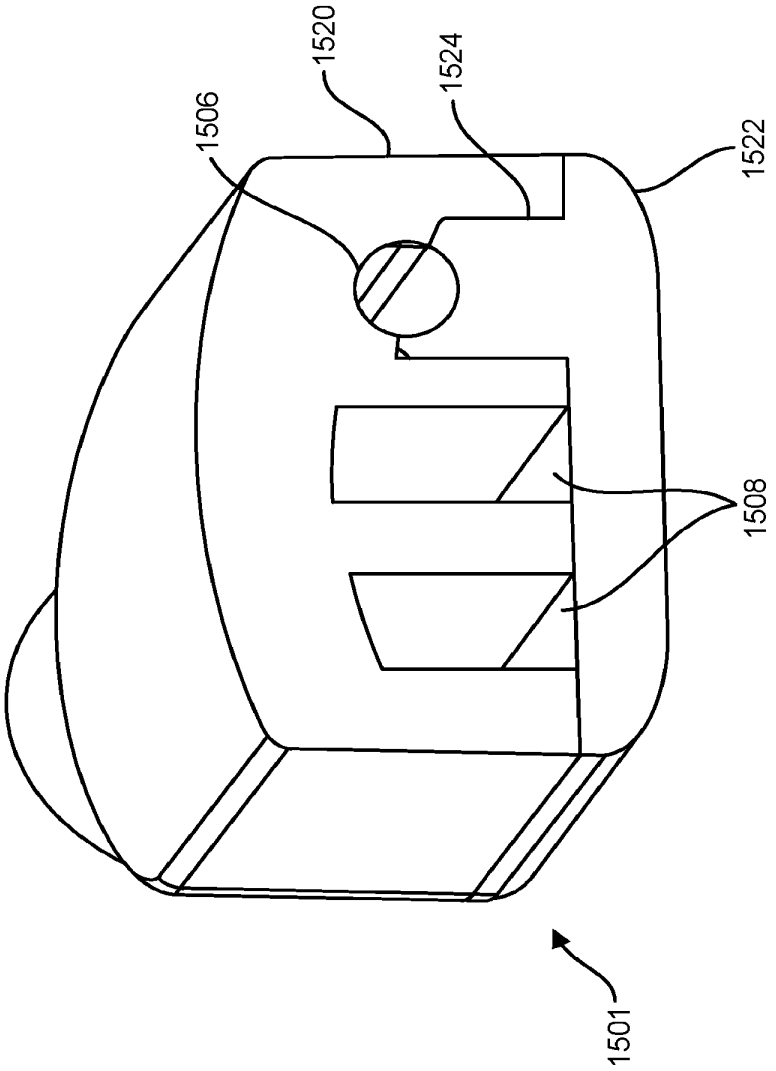


FIG. 15D

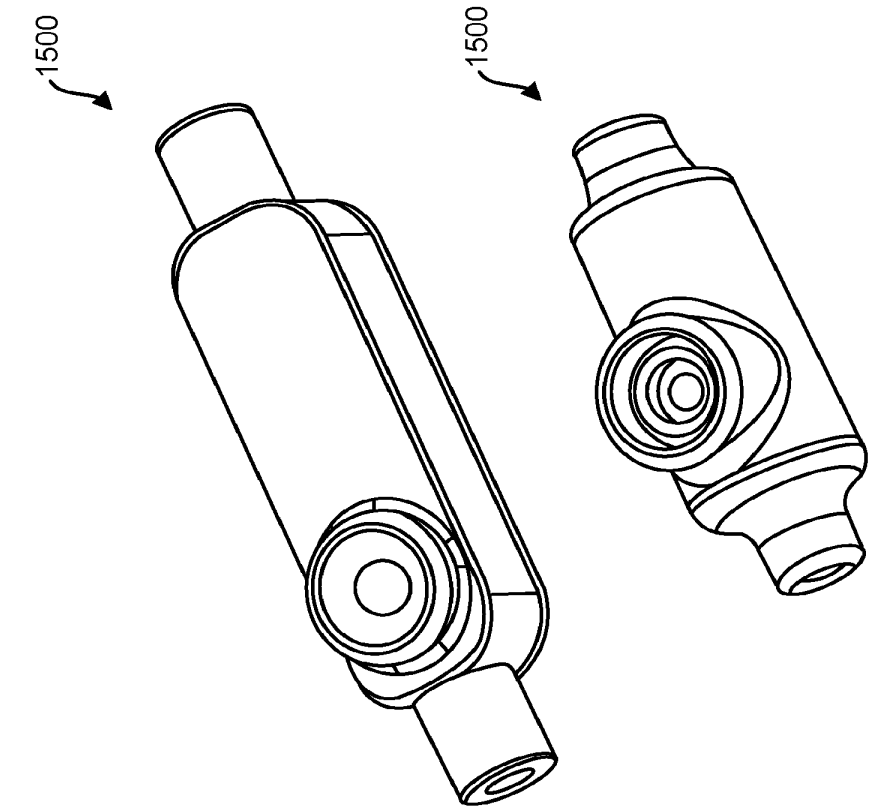


FIG. 15F

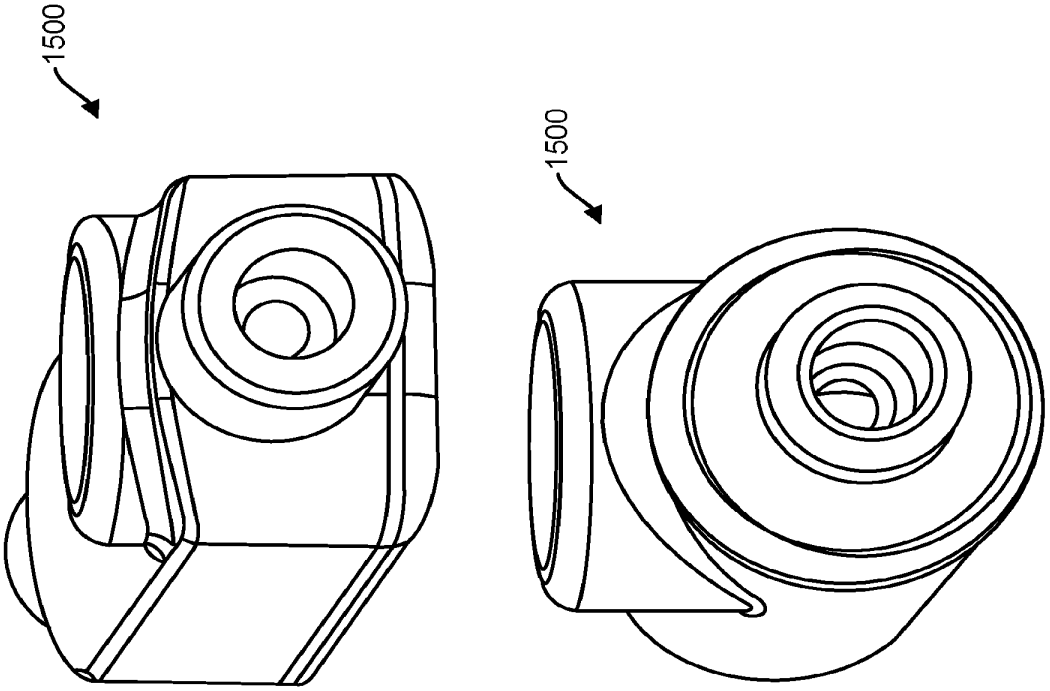


FIG. 15E

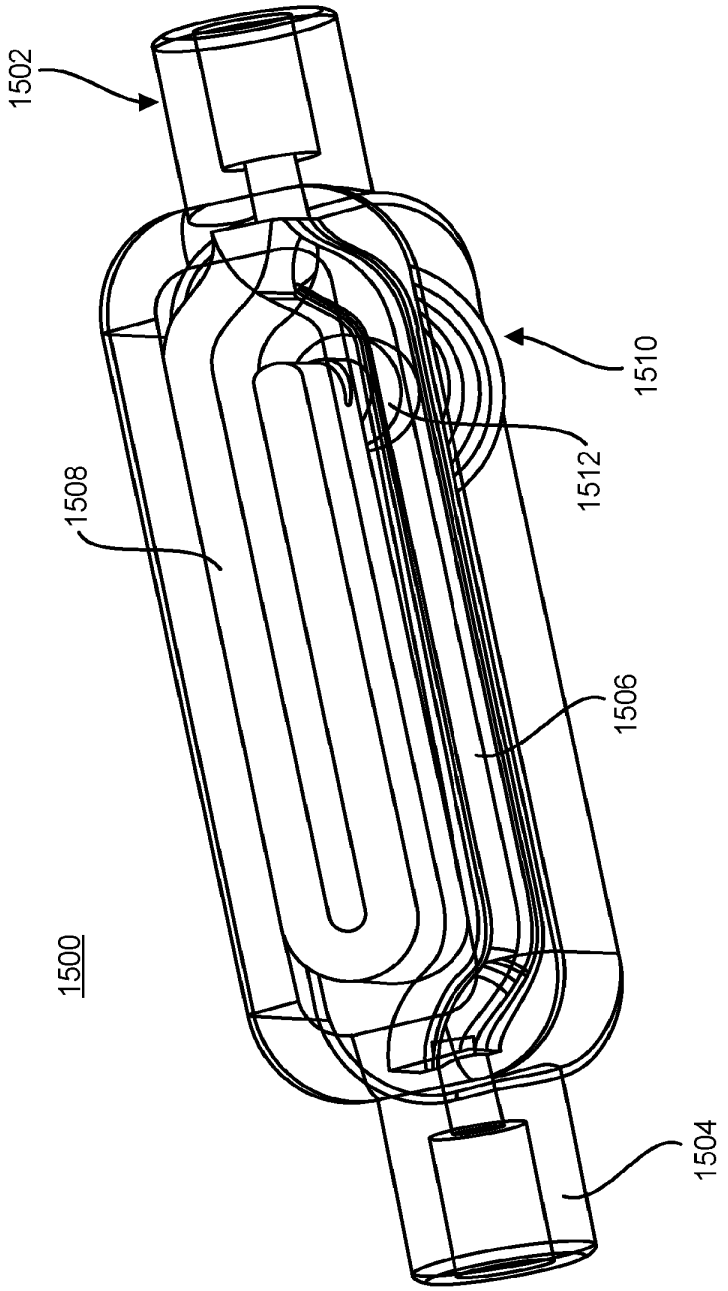


FIG. 15G

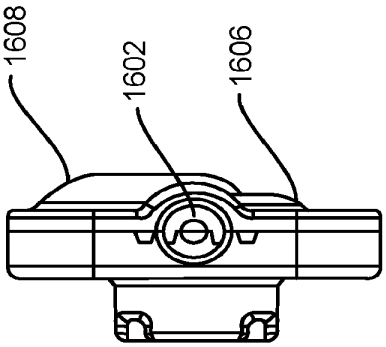


FIG. 16C

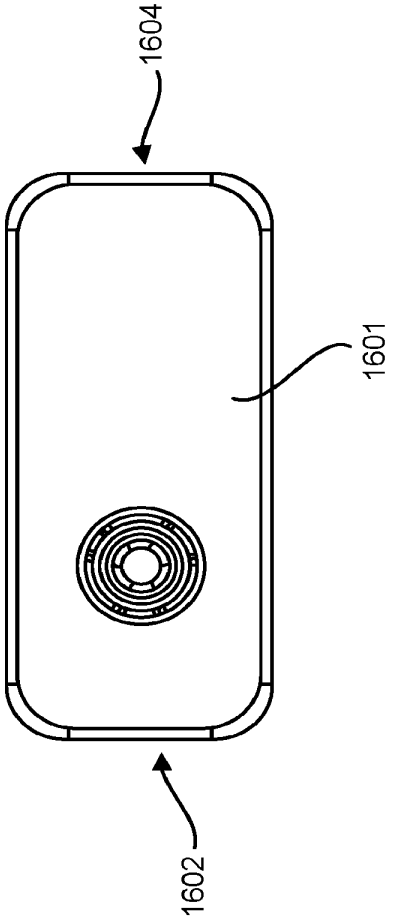


FIG. 16A

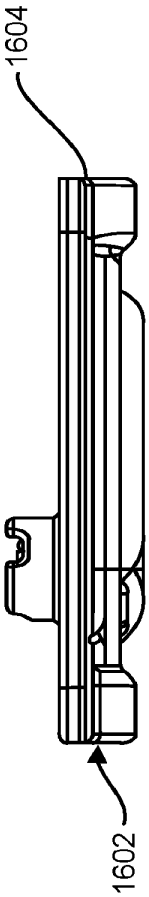


FIG. 16B

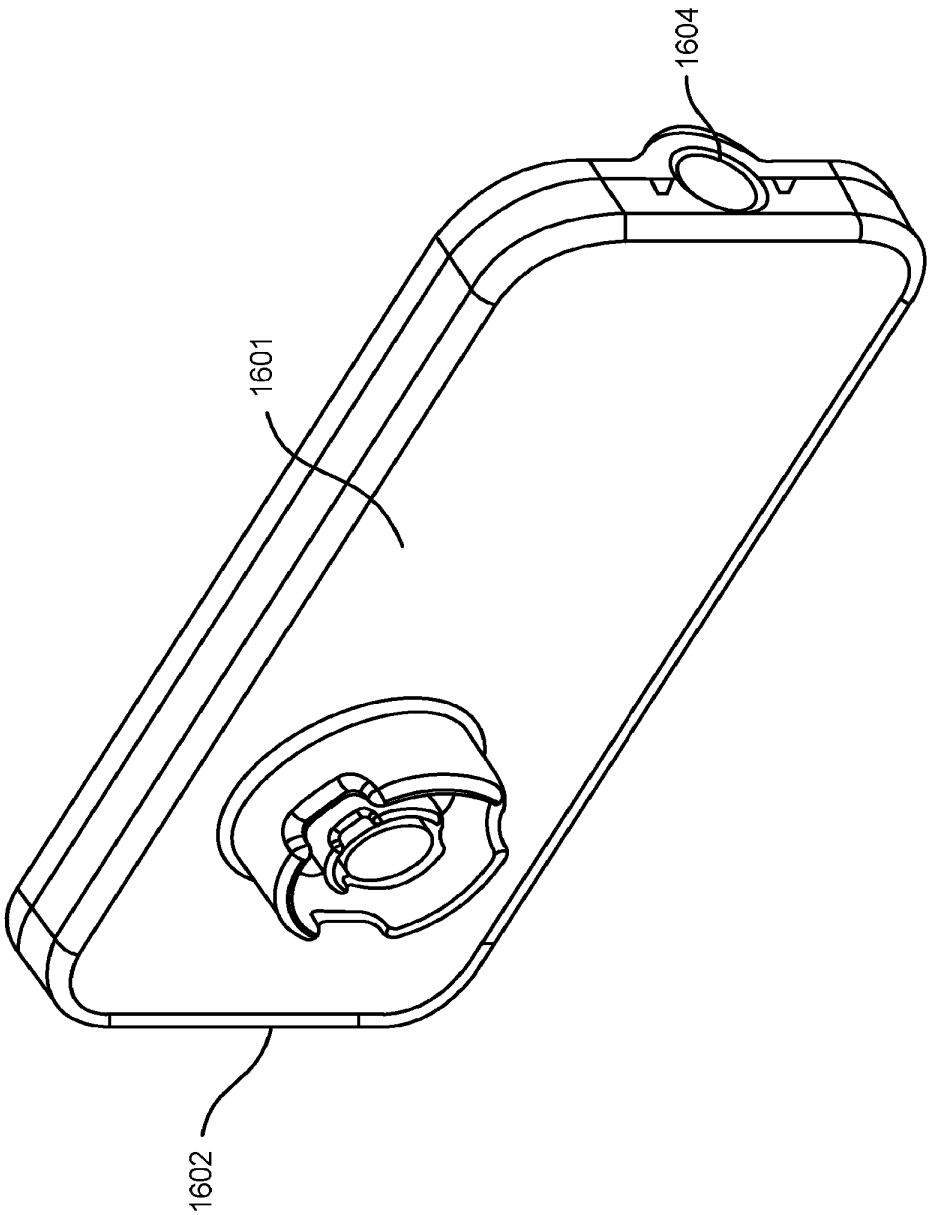


FIG. 16D

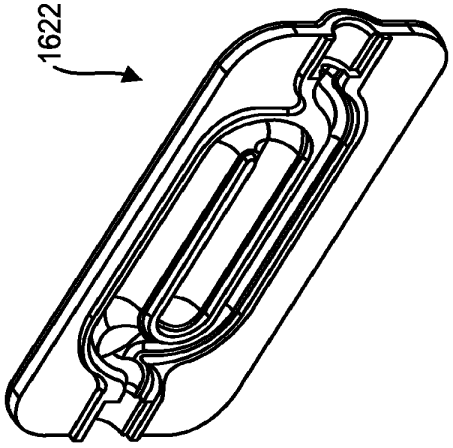


FIG. 17B



FIG. 17E

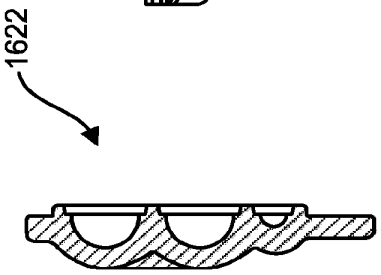


FIG. 17D

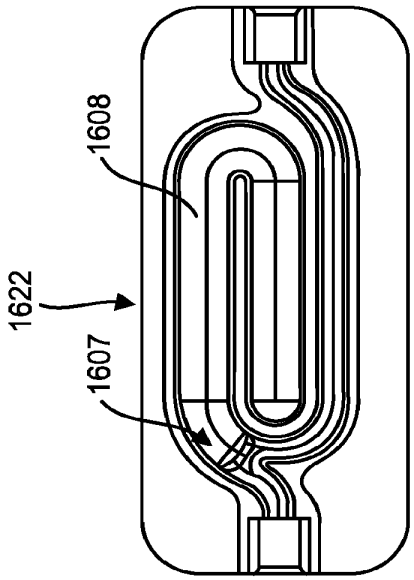


FIG. 17A

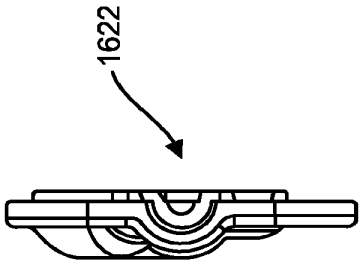


FIG. 17C

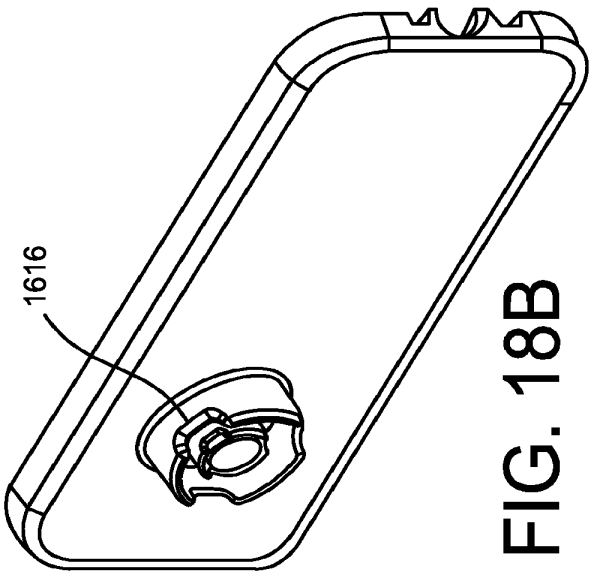


FIG. 18B

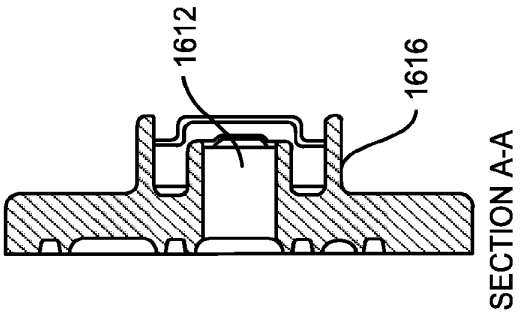


FIG. 18F

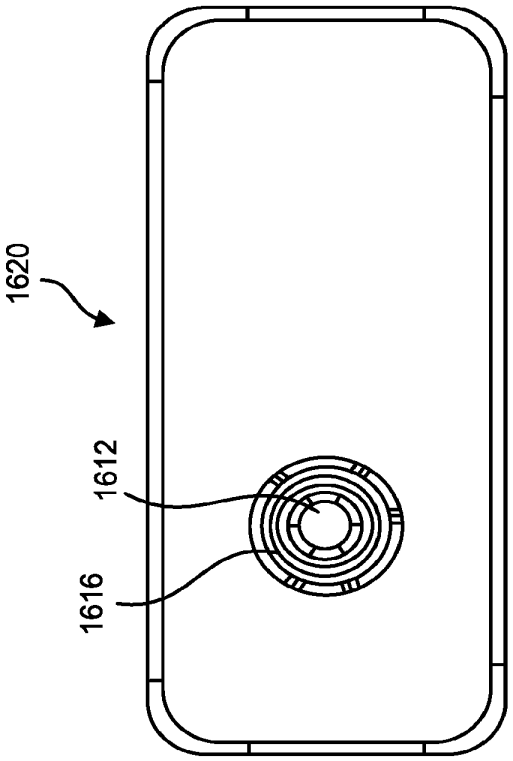


FIG. 18A

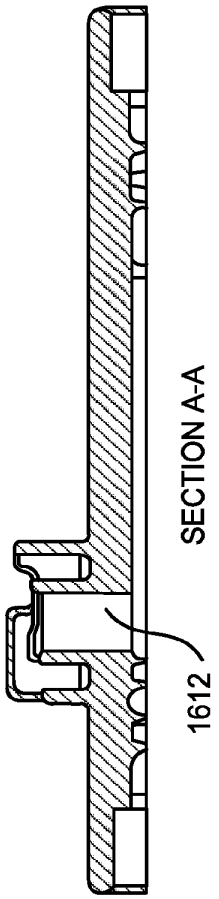


FIG. 18D

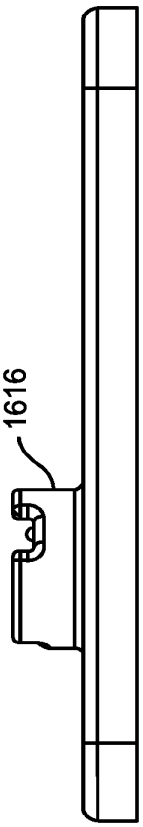


FIG. 18E

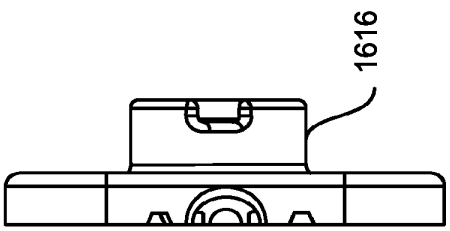


FIG. 18C

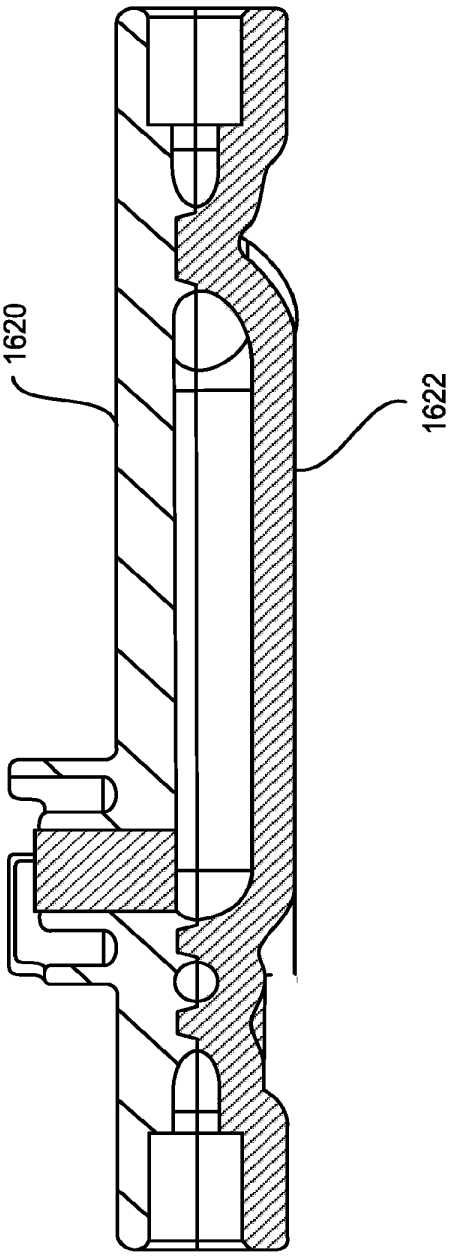


FIG. 19A

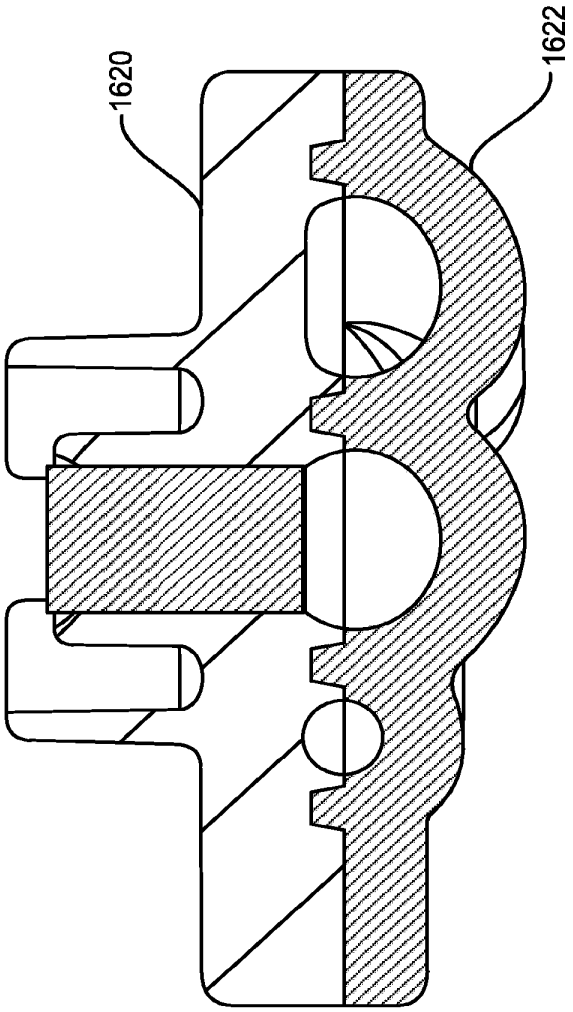


FIG. 19B

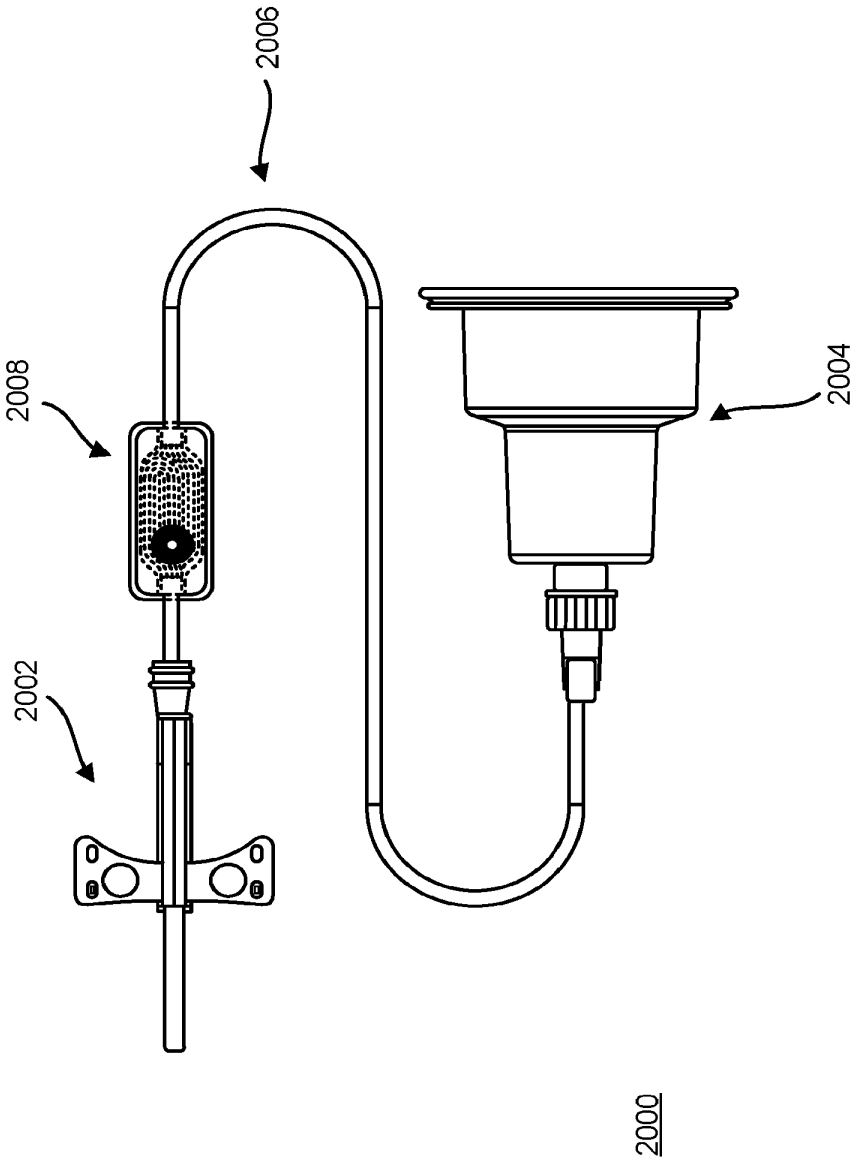


FIG. 20

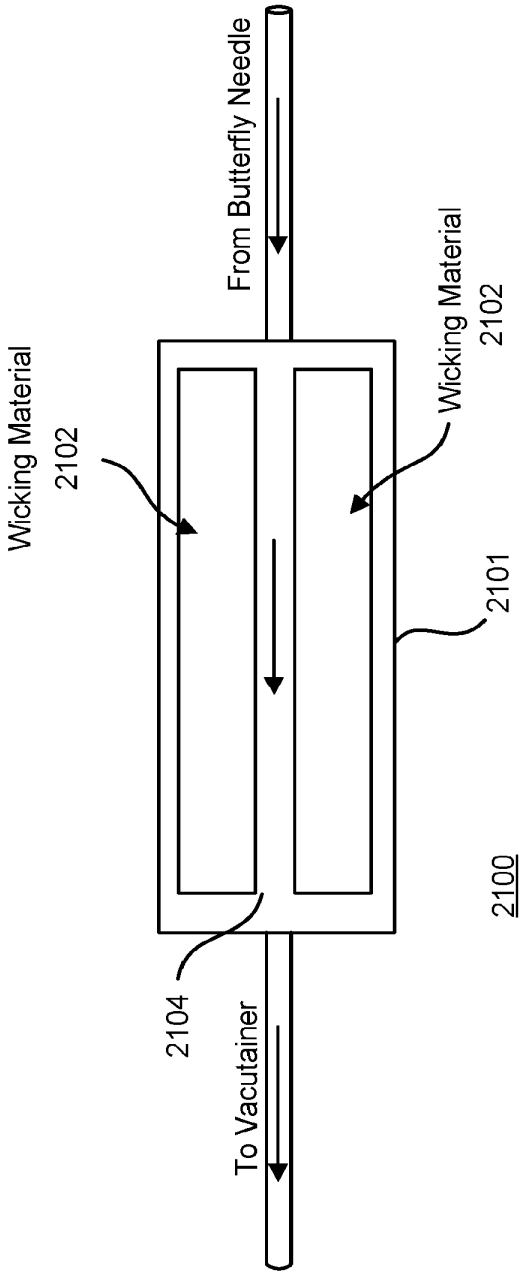

From Butterfly Needle
Wicking Material
2102
Wicking Material
2102
2101
2100
2104
To Vacutainer

FIG. 21

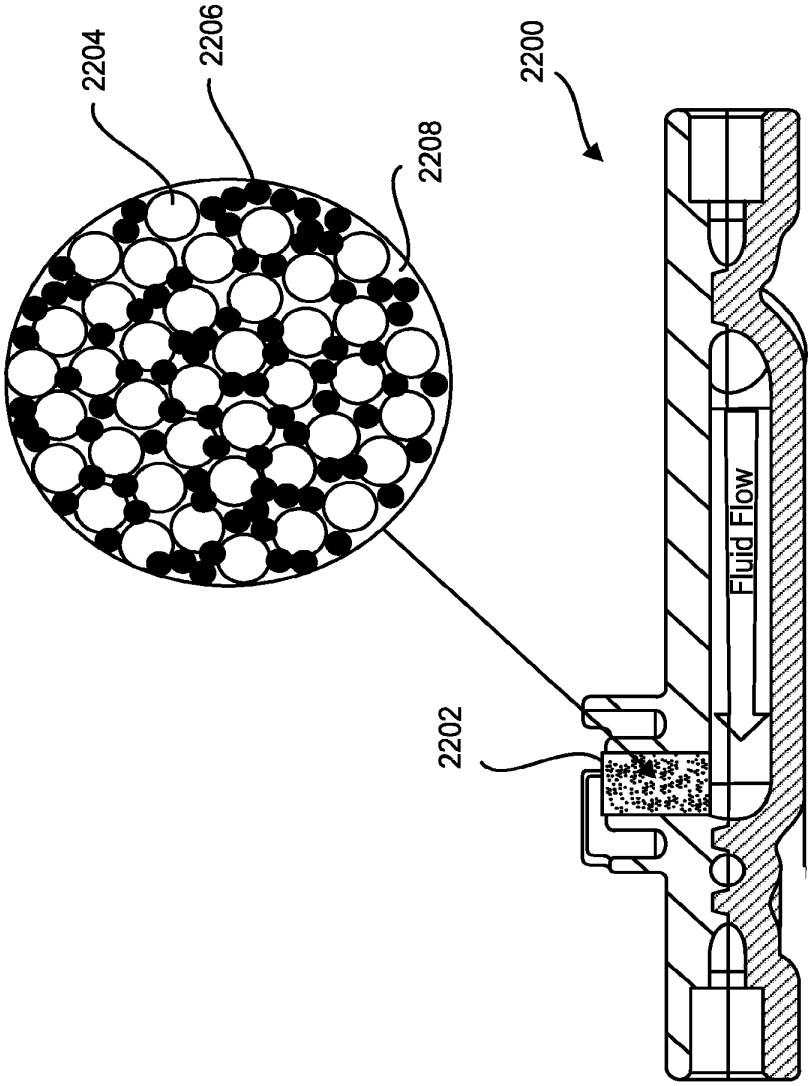


FIG. 22A

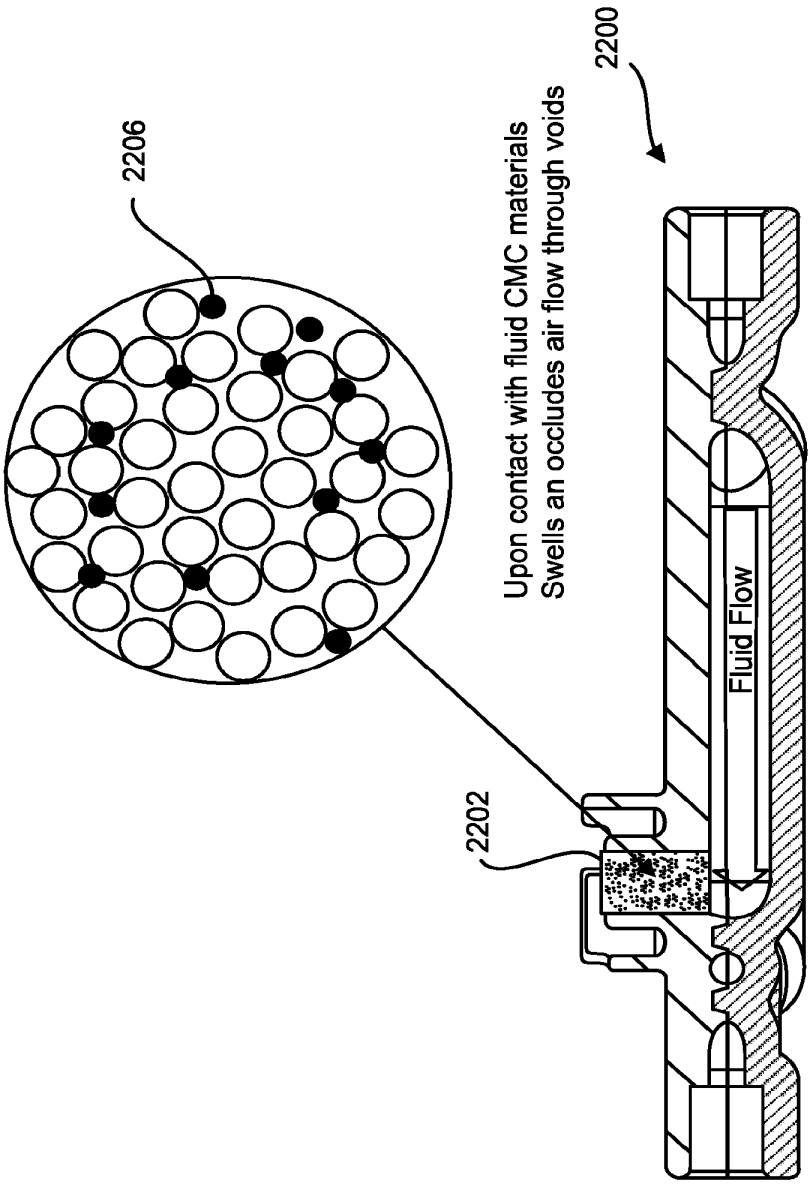

2200
2206
Upon contact with fluid CMC materials
Swells an occludes air flow through voids
Fluid Flow
2202

FIG. 22B

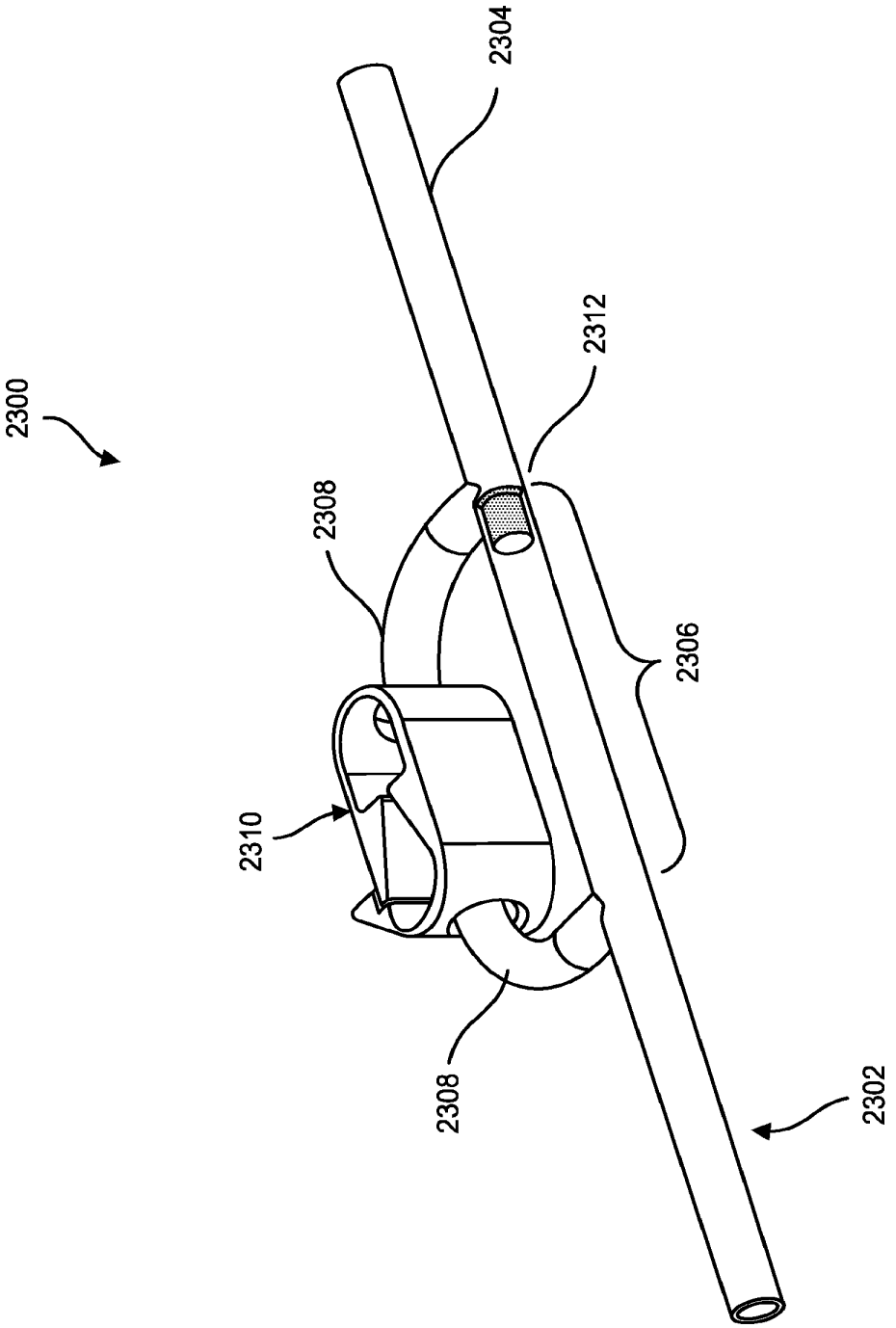


FIG. 23A

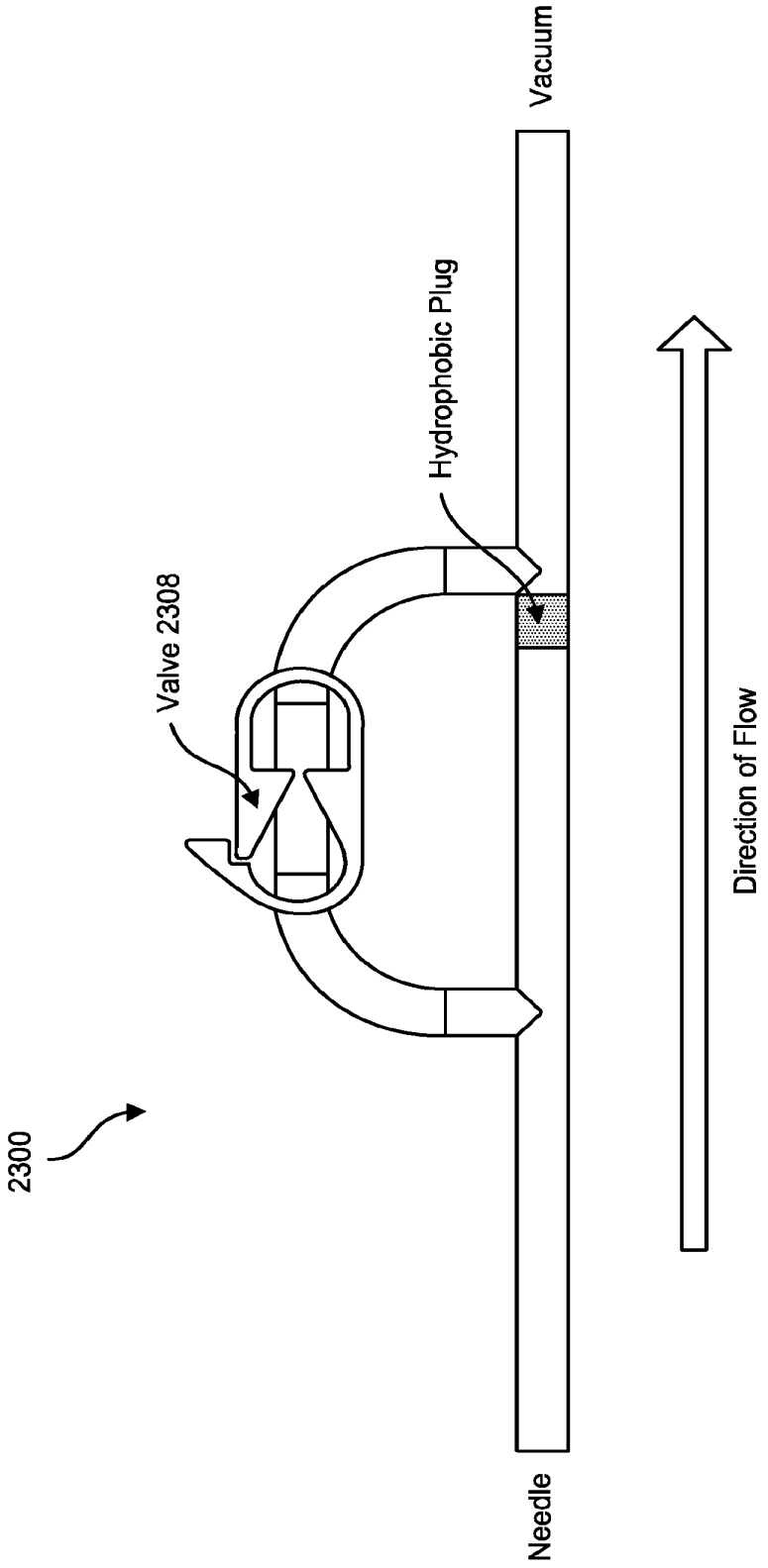

Vacuum
Hydrophobic Plug
Valve 2308
Direction of Flow
2300
Needle

FIG. 23B

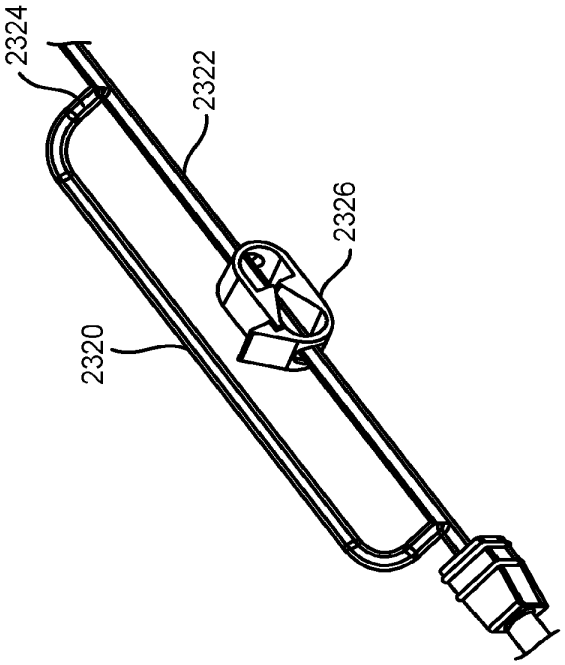


FIG. 23D

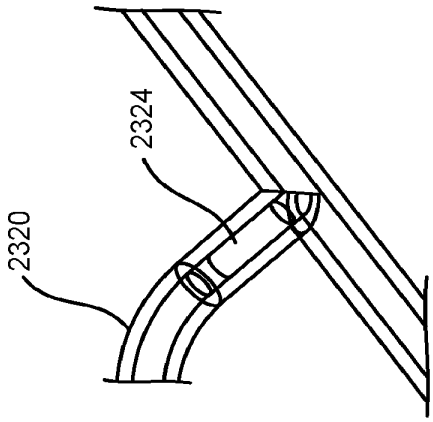


FIG. 23E

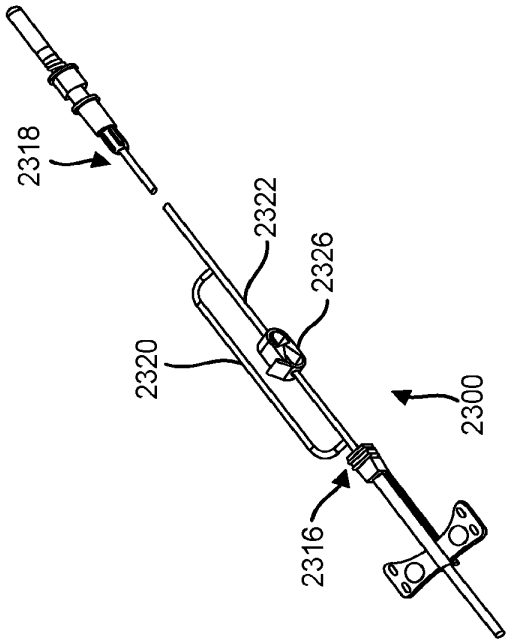


FIG. 23C

Replacement Sheet
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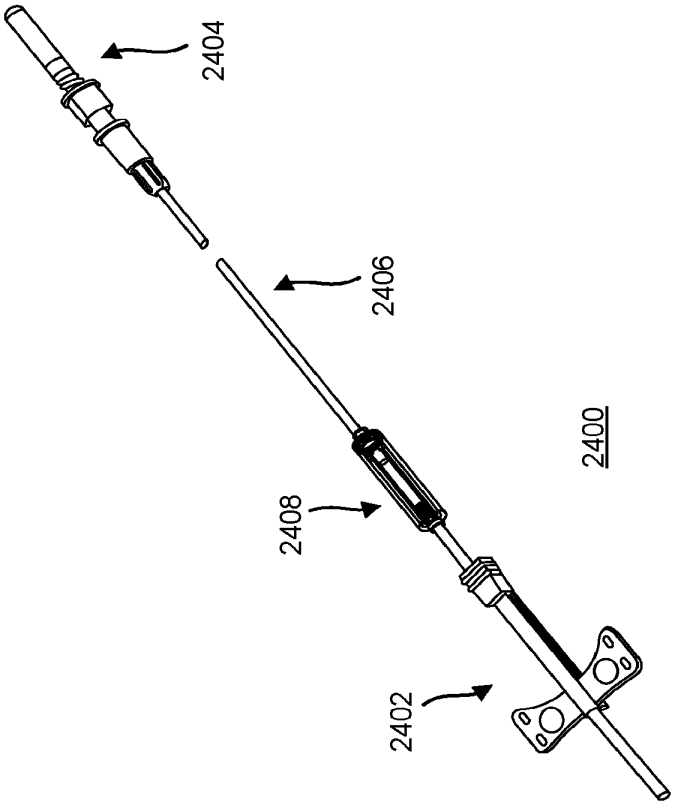


FIG. 24A

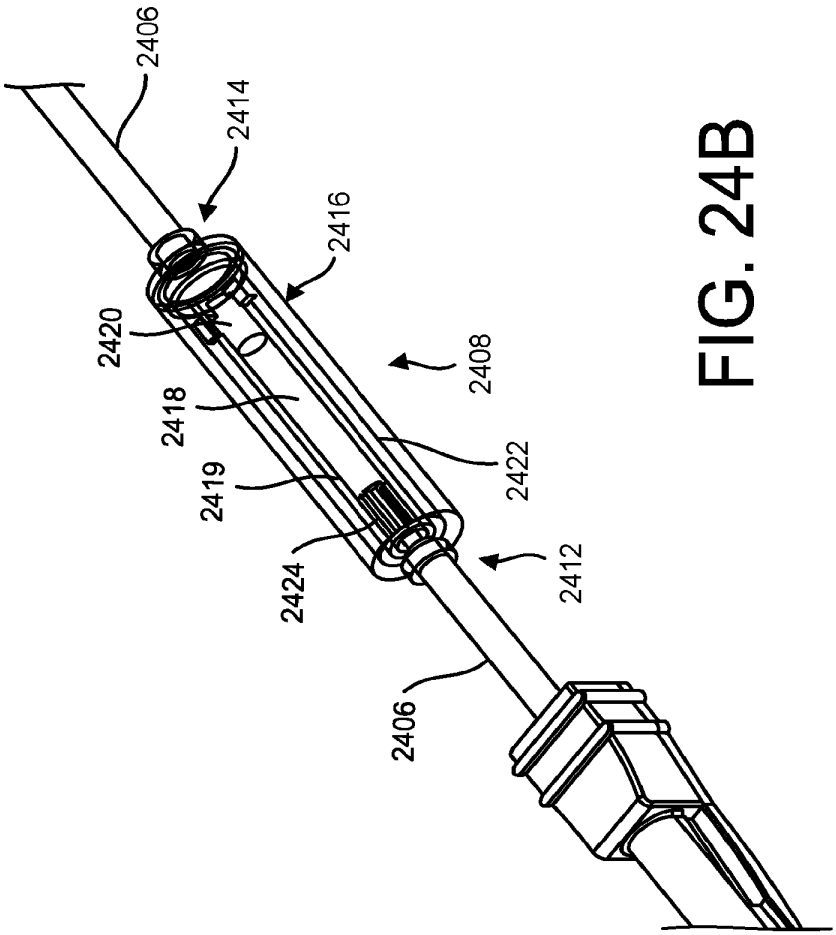


FIG. 24B

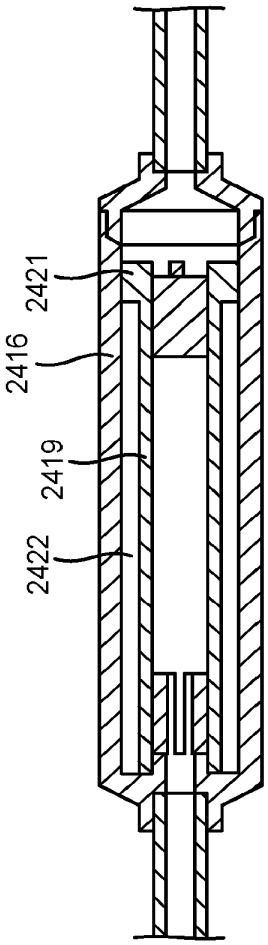


FIG. 24C

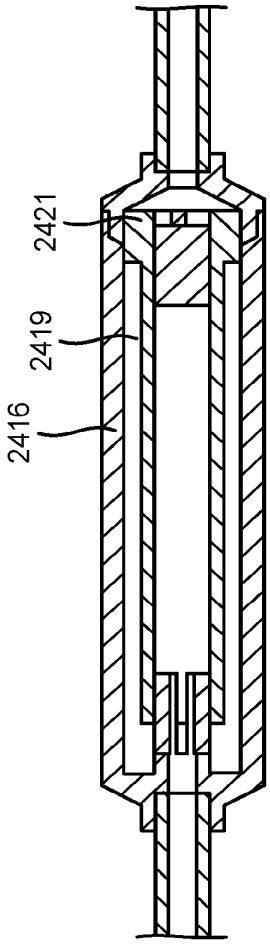


FIG. 24D

Replacement Sheet
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PCT/US2017/068569

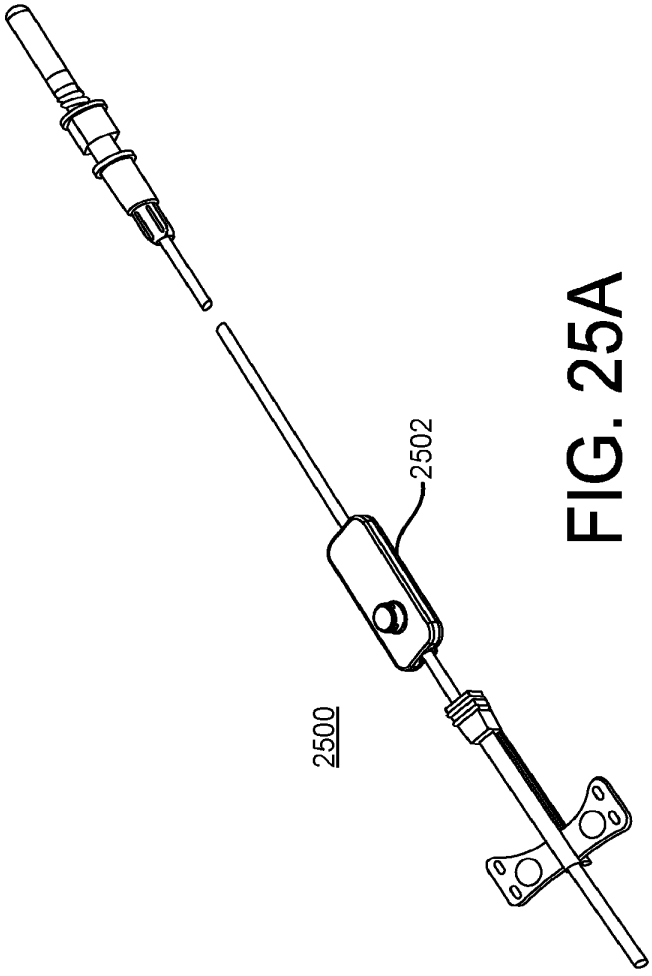


FIG. 25A

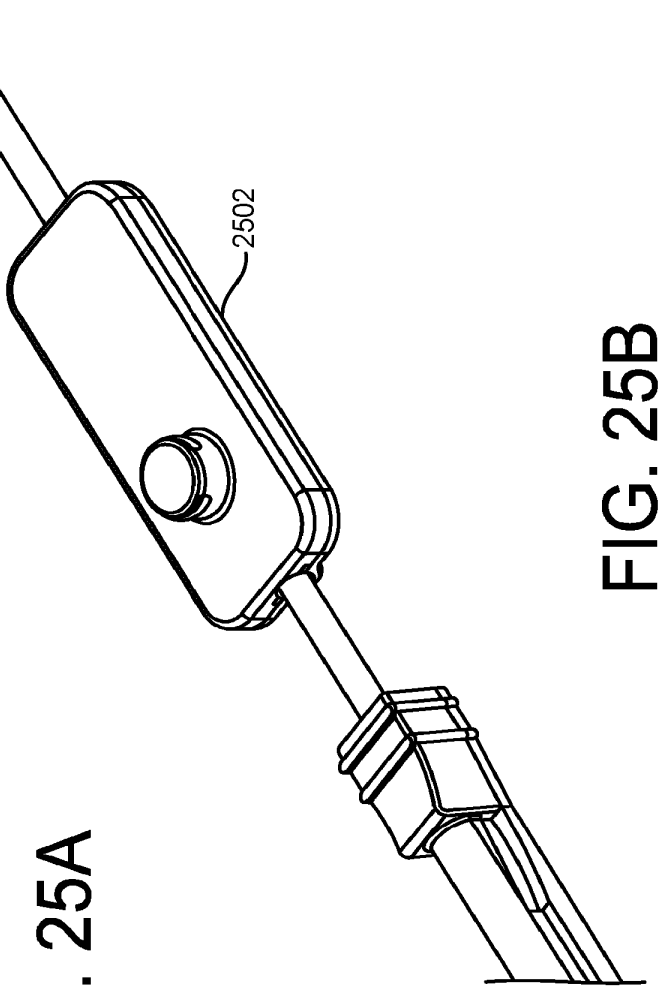


FIG. 25B

Replacement Sheet
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Docket No. KURIN3PCT
PCT/US2017/068569

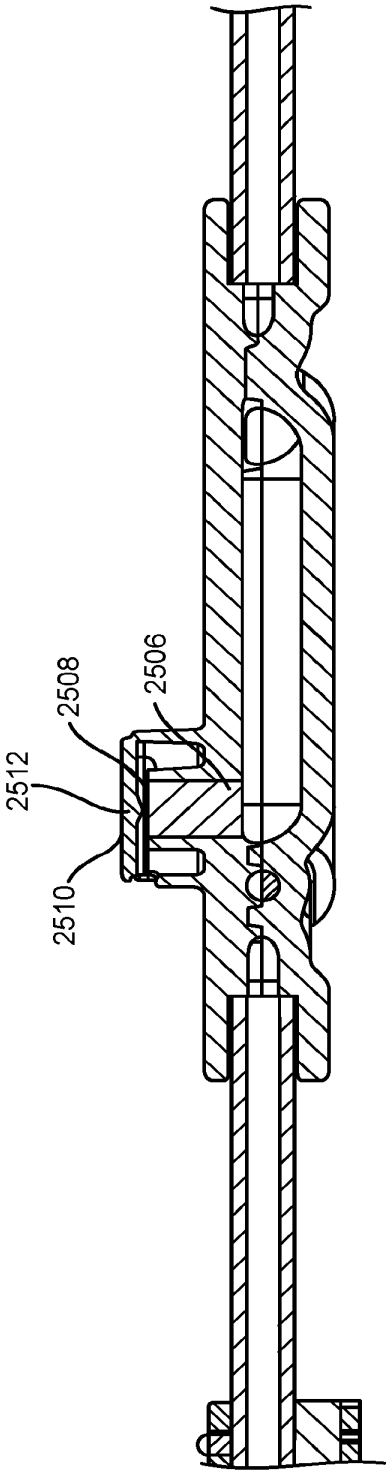


FIG. 25C

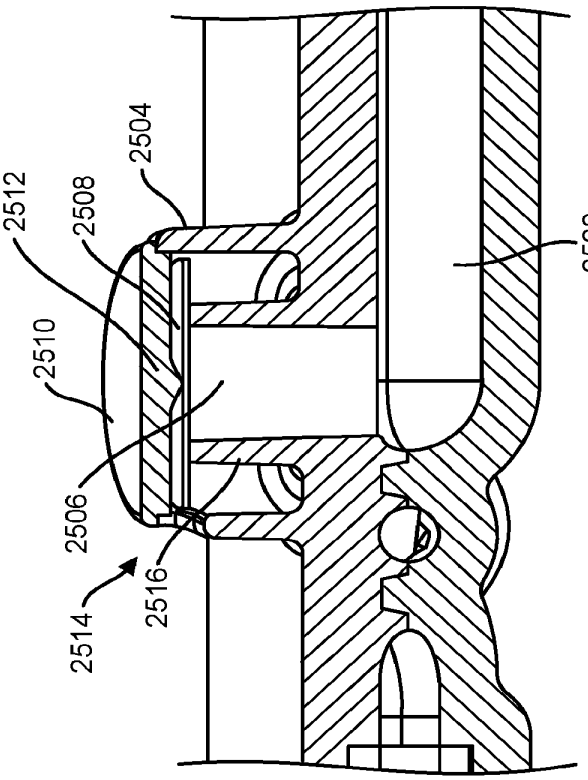


FIG. 25D

Replacement Sheet
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Docket No. KURIN3PCT
PCT/US2017/068569

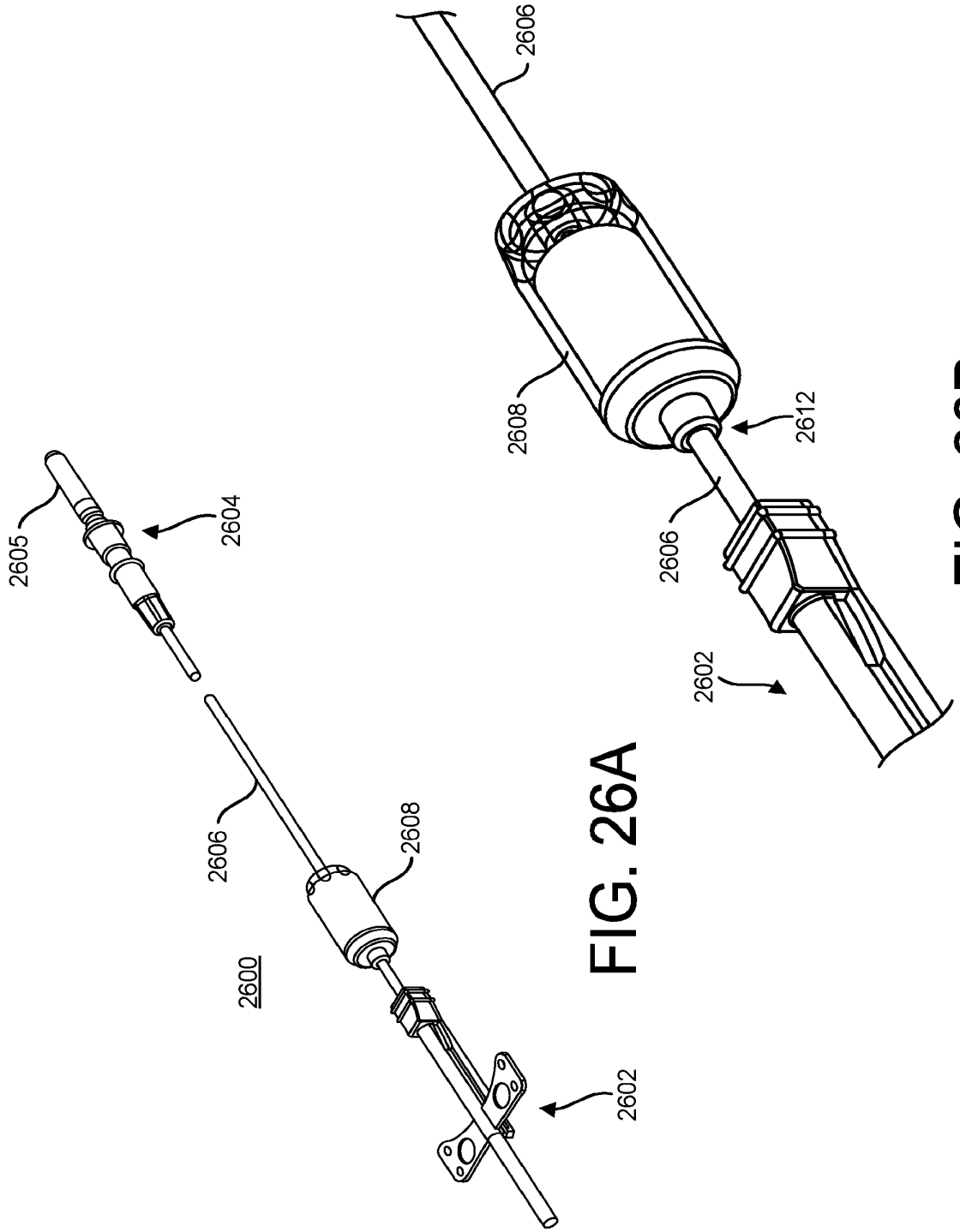


FIG. 26B

FIG. 26A

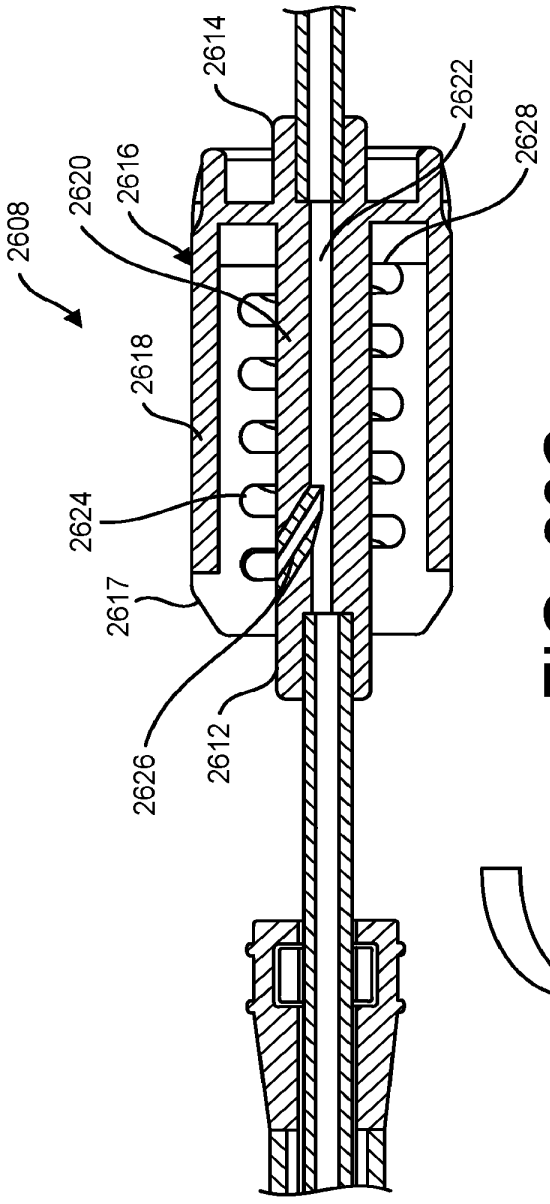


FIG. 26C

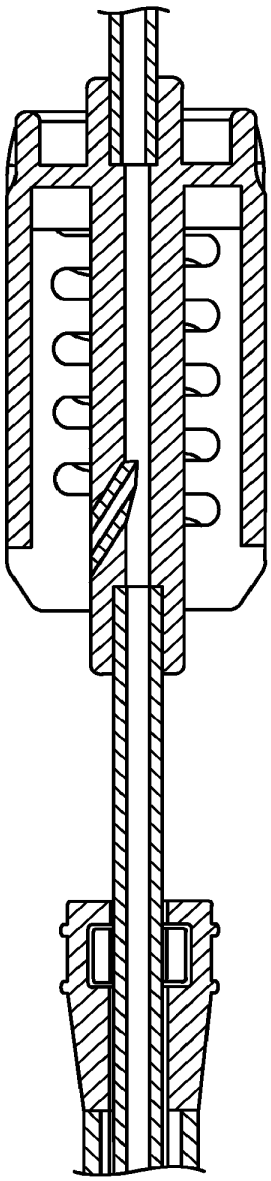


FIG. 26D

Replacement Sheet
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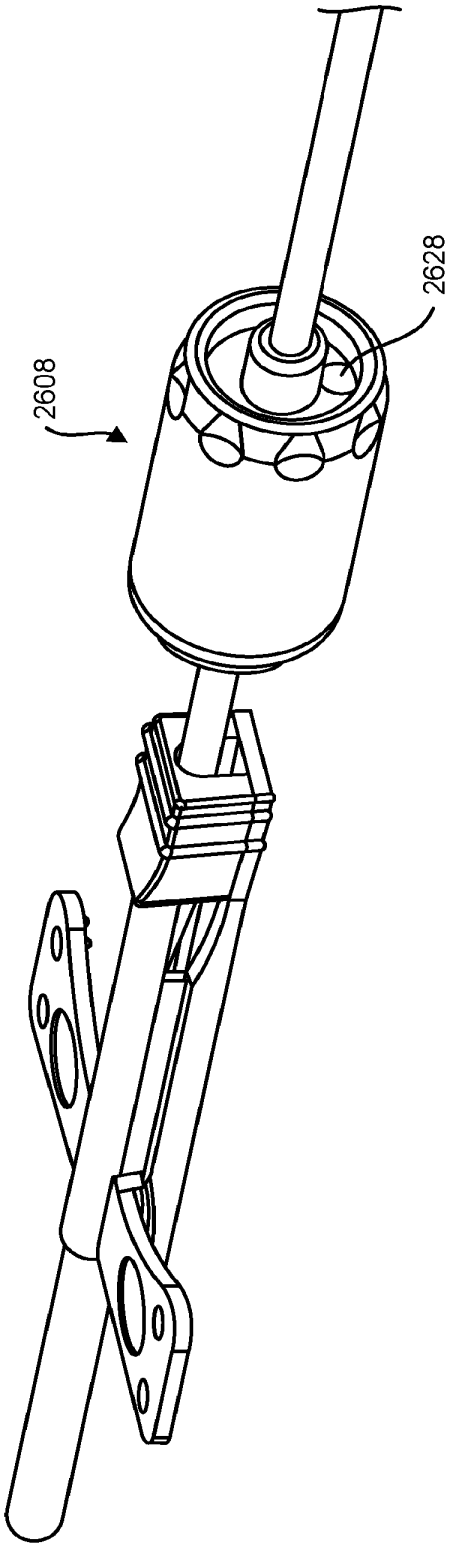


FIG. 26E

Replacement Sheet
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Docket No. KURIN3PCT
PCT/US2017/068569

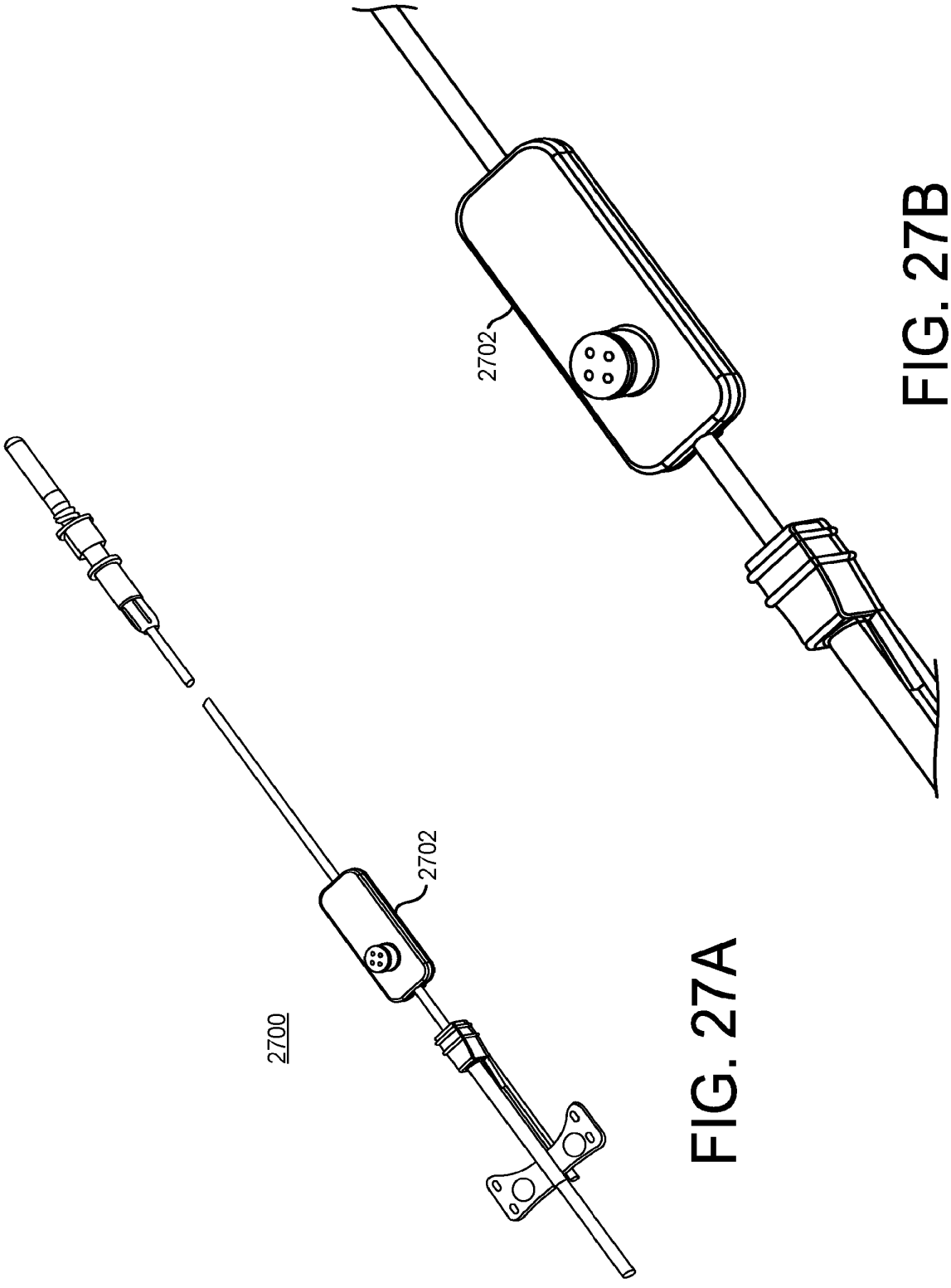


FIG. 27B

FIG. 27A

Replacement Sheet
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Docket No. KURIN3PCT
PCT/US2017/068569

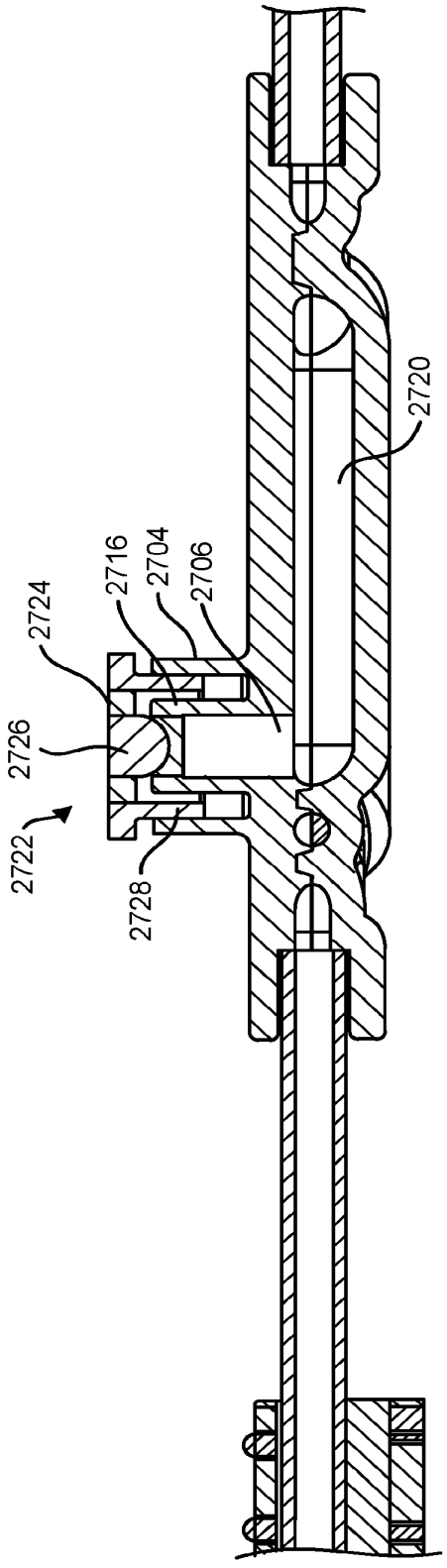


FIG. 27C

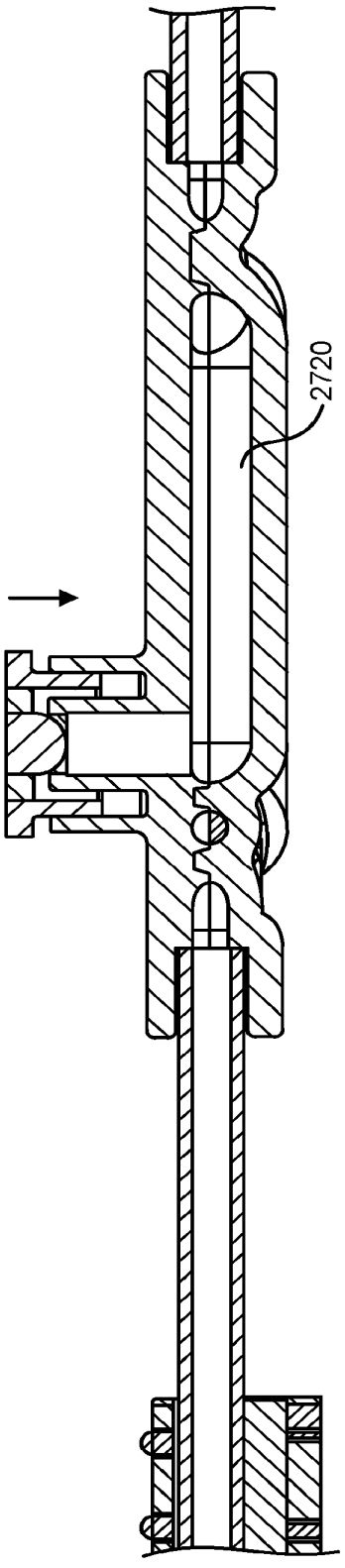


FIG. 27D

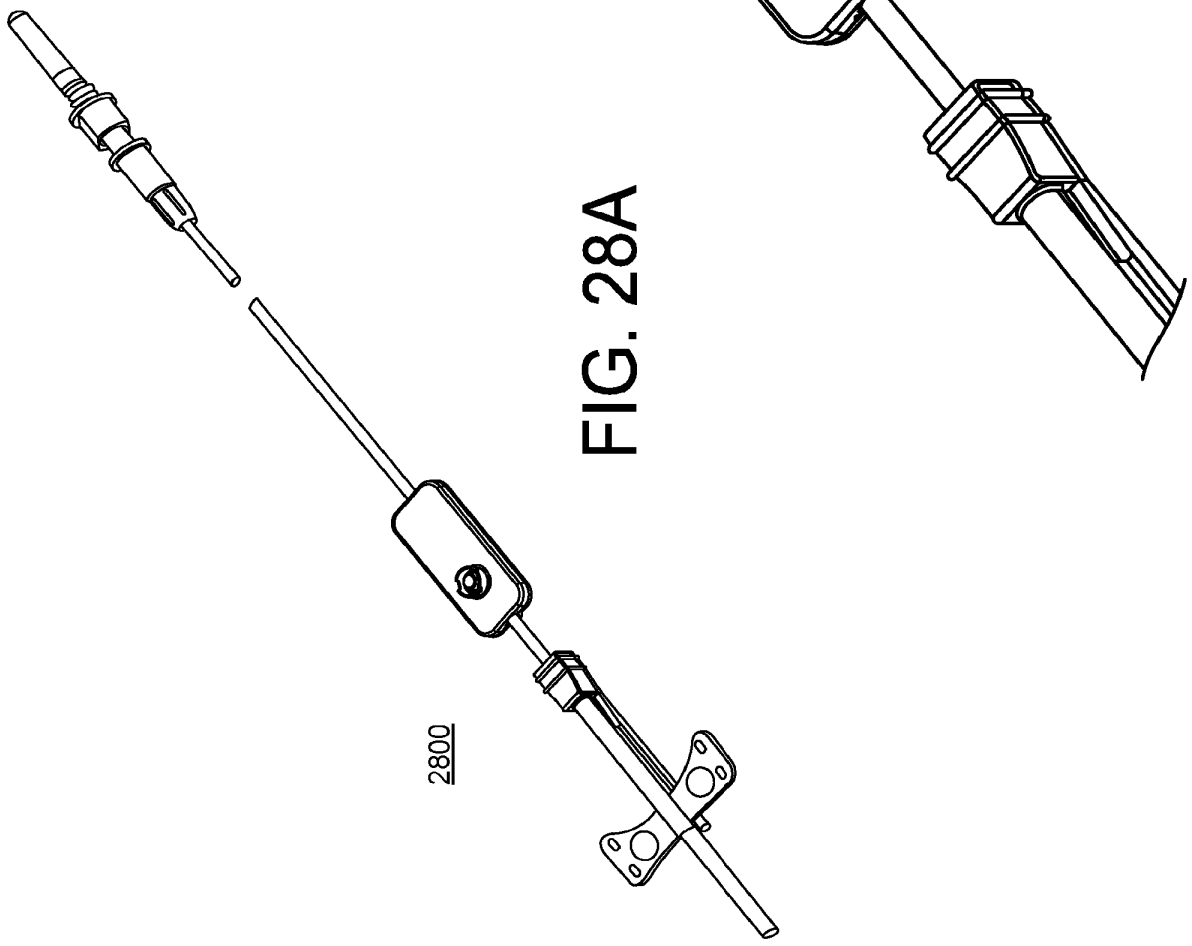


FIG. 28A

FIG. 28B

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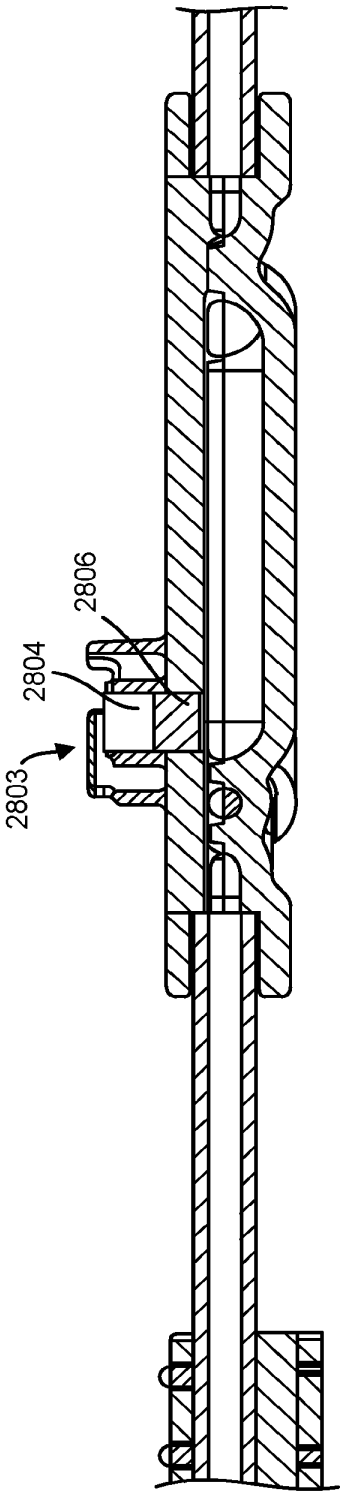


FIG. 28C

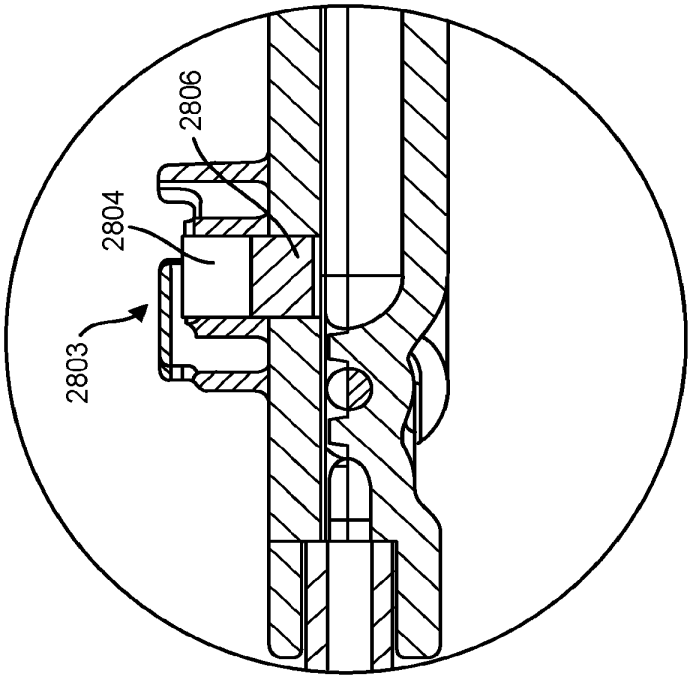


FIG. 28D

Replacement Sheet
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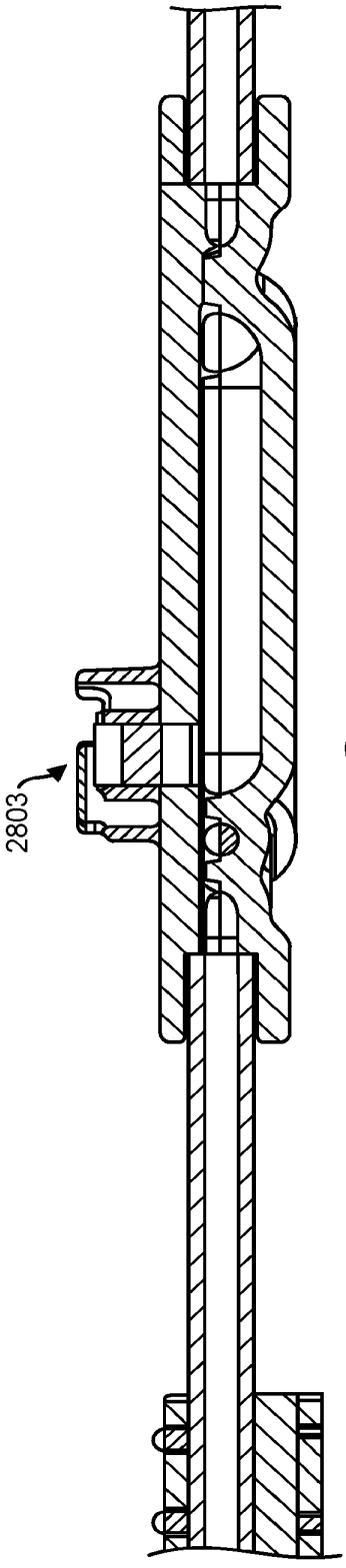


FIG. 28E

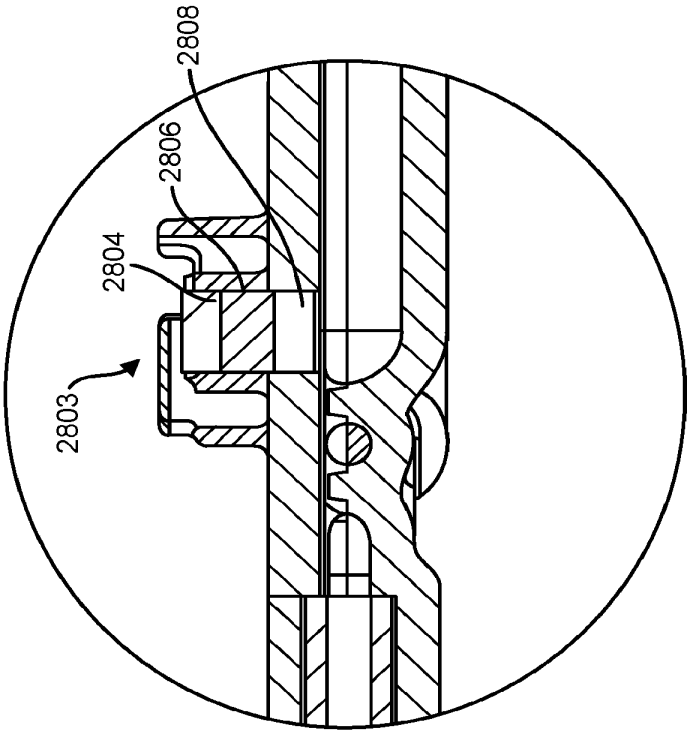


FIG. 28F

Replacement Sheet
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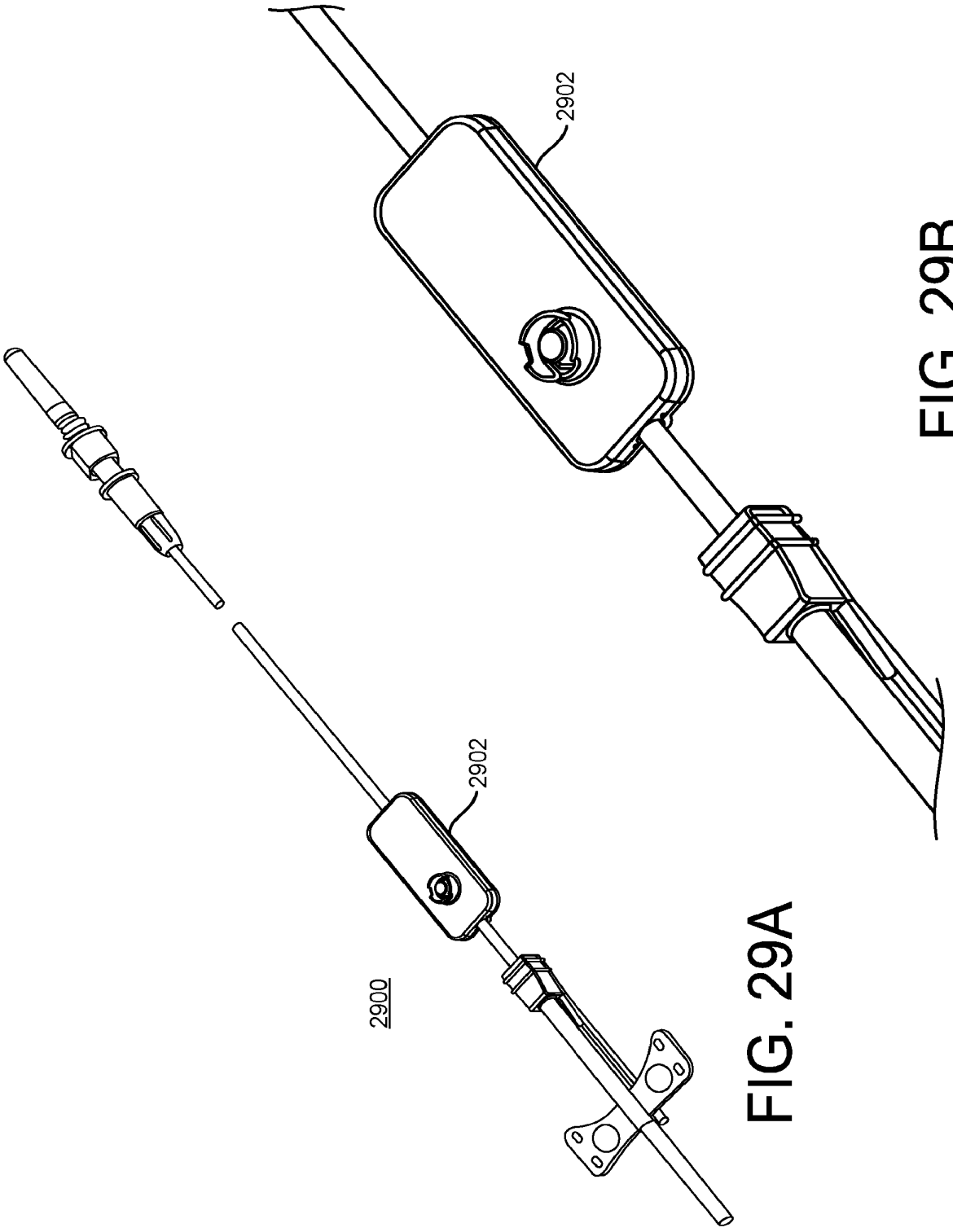


FIG. 29B

FIG. 29A

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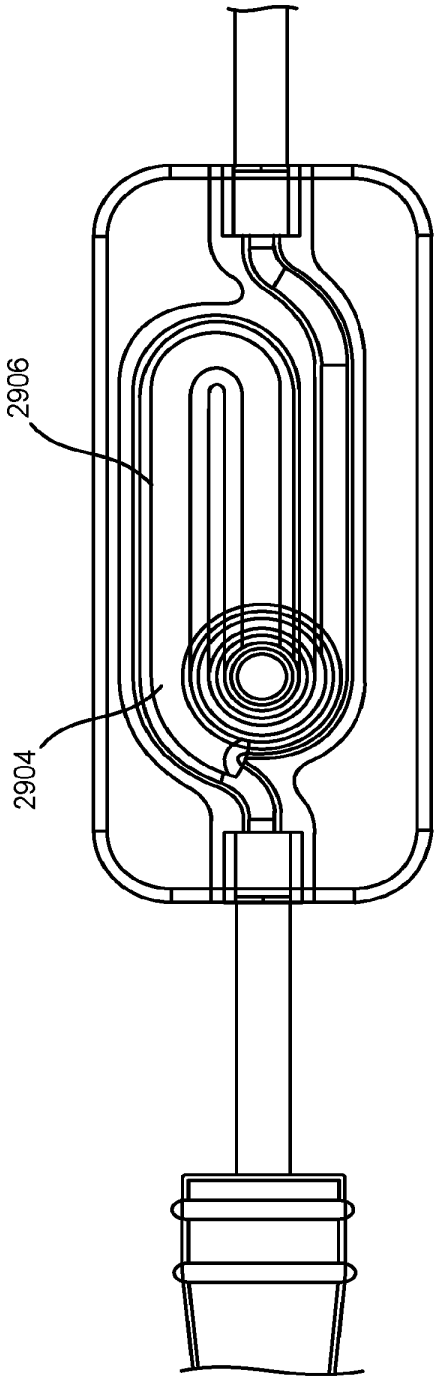


FIG. 29C

Replacement Sheet
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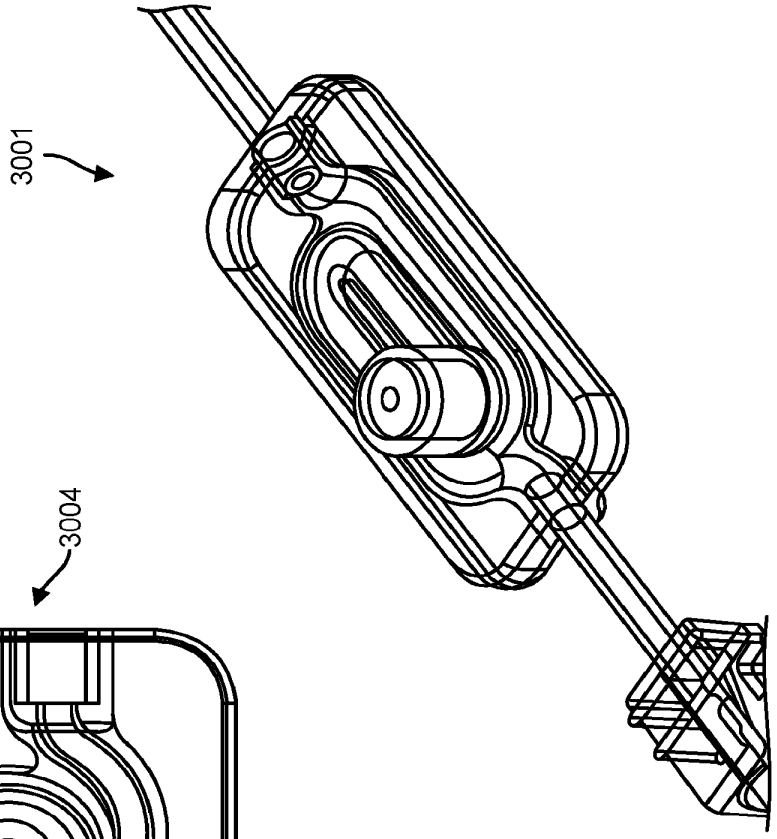


FIG. 30B

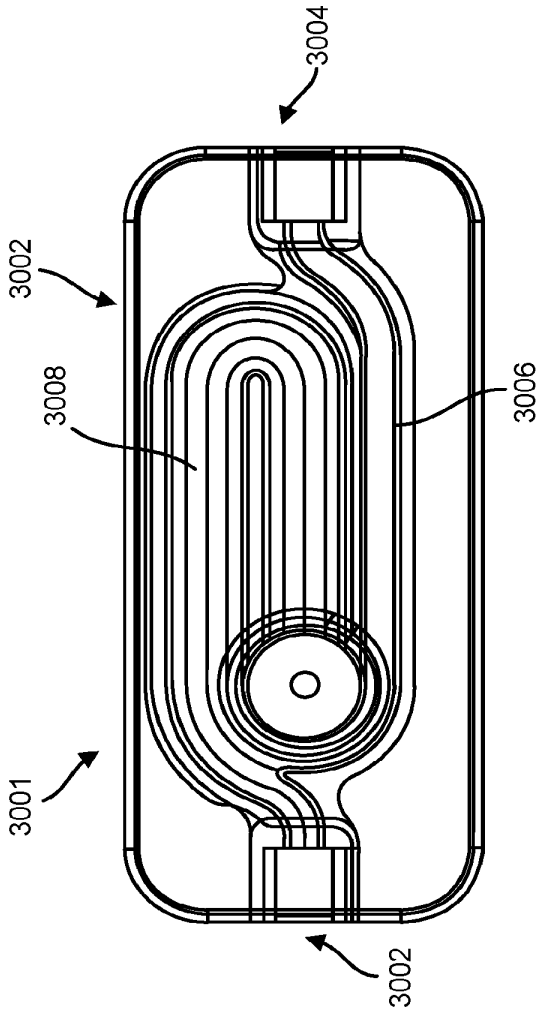


FIG. 30A

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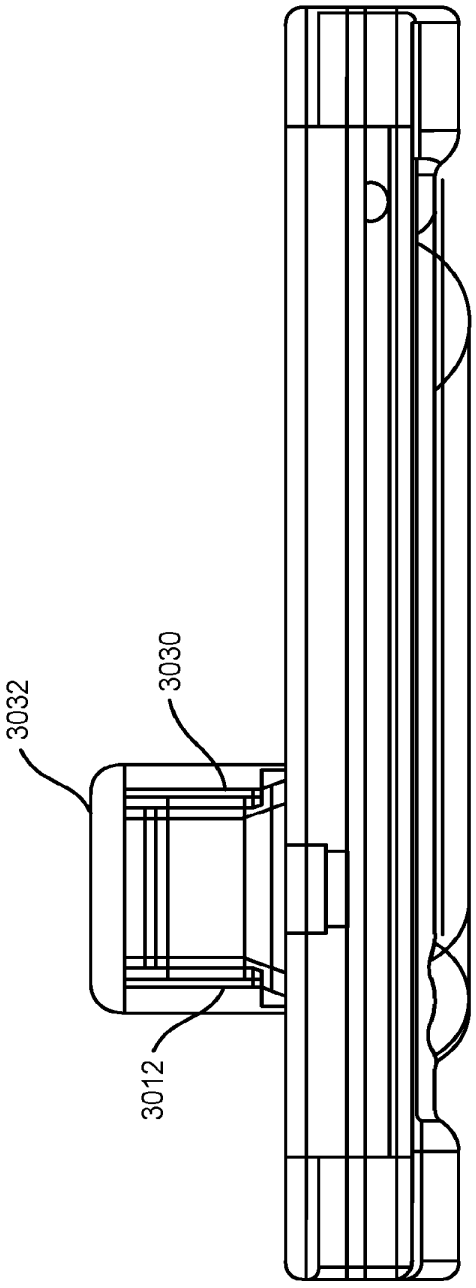


FIG. 30C

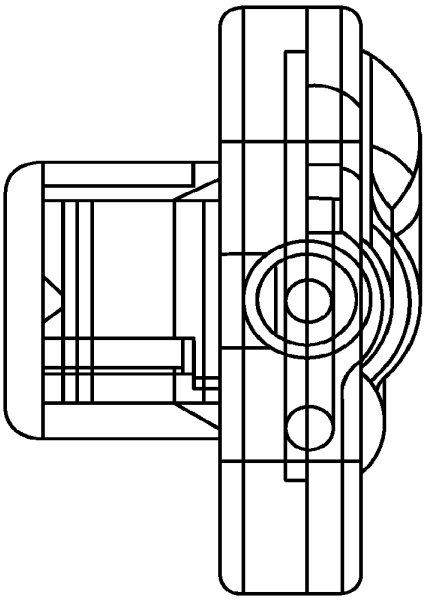


FIG. 30D

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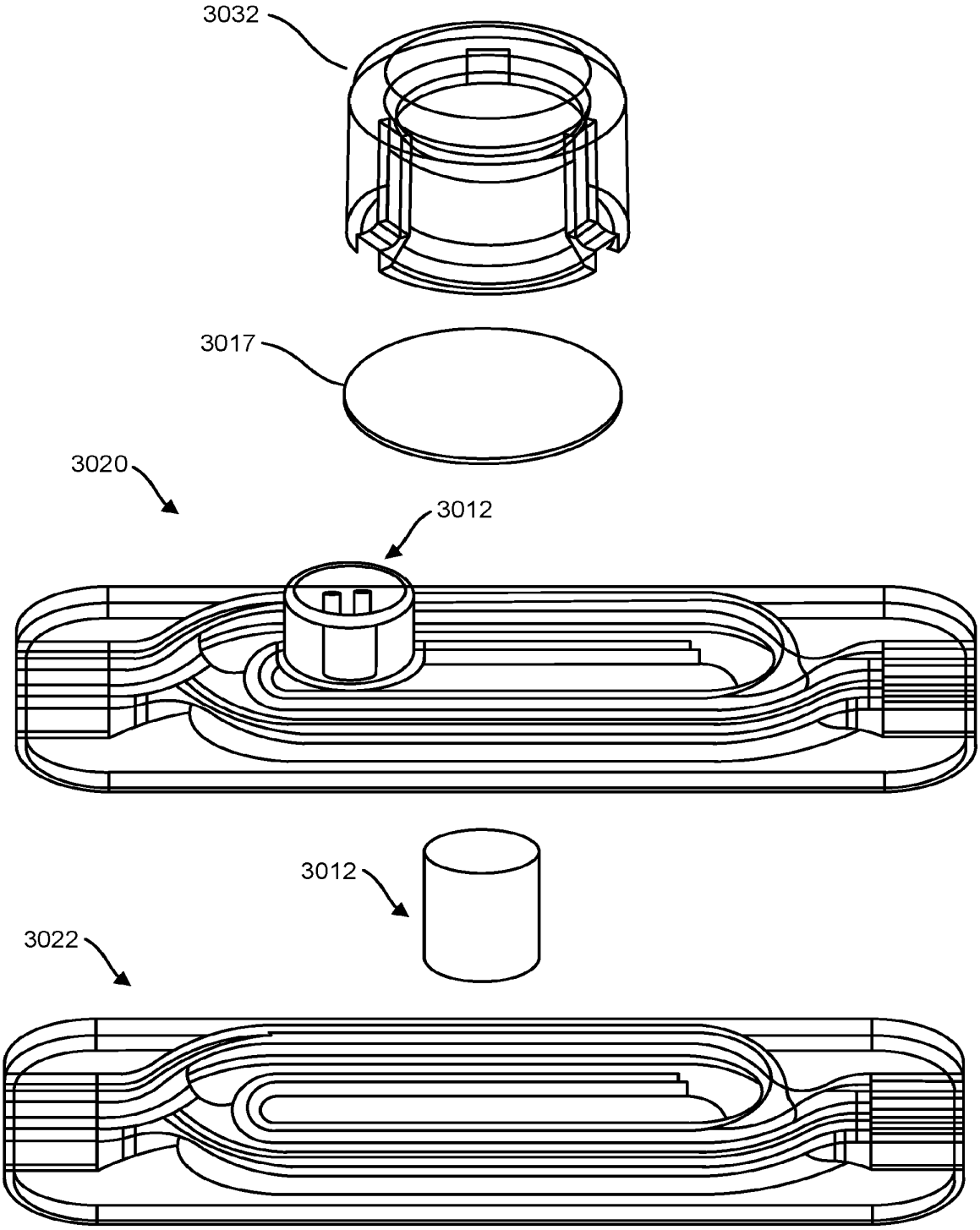


FIG. 30E

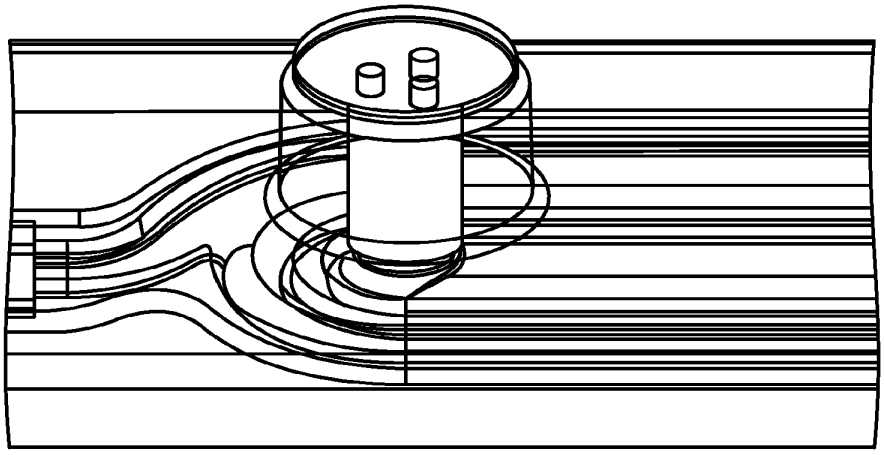


FIG. 30F

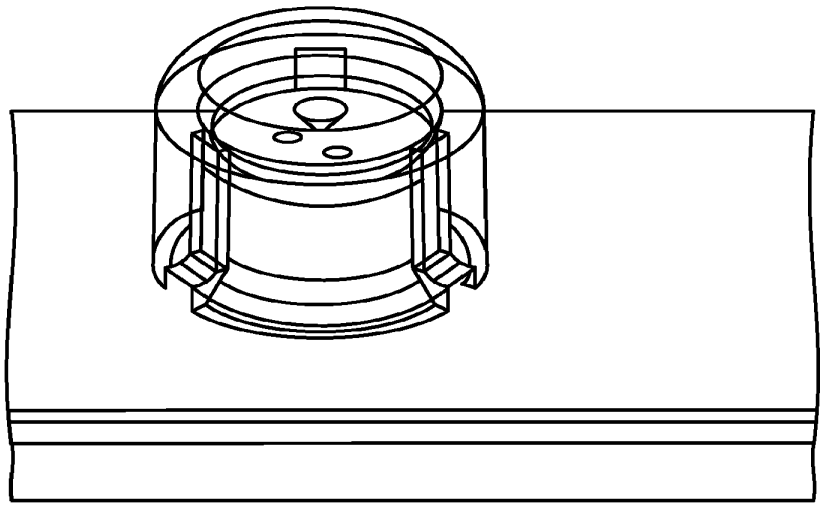


FIG. 30G

Differential Quantitative Blood Cultures in the Diagnosis of Catheter-Related Sepsis in Intensive Care Units

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The aim of this prospective study was to compare differential blood cultures and quantitative catheter tip cultures for the diagnosis of catheter-related sepsis. Over a period of 2 years, 283 central venous catheters were inserted in 190 adult patients. Catheters were removed when they were no longer needed or when infection was suspected. Immediately before removal of the central venous catheters, blood cultures were performed, with blood drawn simultaneously from the catheter and the peripheral vein. After removal, quantitative catheter culture was performed according to the Brun-Buisson modified Cleri technique. Fifty-five quantitative catheter cultures were positive. They were classified as contaminated (n = 18), colonized (n = 23), or infected (n = 14). Differential blood cultures correctly identified 13 infections. With a catheter/peripheral cfu ratio of 8, differential blood cultures had a sensitivity of 92.8% and a specificity of 98.8%. When the catheters were removed because of suspected infection, differential blood cultures had a sensitivity of 92.8% and a specificity of 100%. Differential blood culture, a technique that does not necessitate catheter removal, seems effective in the diagnosis of catheter-related sepsis in patients in the intensive care unit.

Infection is the main complication related to the use of central venous catheters (CVCs). Catheter-related infection (CRI) is a major cause of nosocomial infection and may be life-threatening [1]. The diagnosis of CRI remains difficult. Clinical signs lack sensitivity and specificity. It is widely accepted that when a patient in the intensive care unit (ICU) becomes febrile, infection of the CVC is suspected and it is removed [2]. However, 70%–85% of CVCs are removed unnecessarily [2–4]. Moreover, the insertion of a new CVC is not without complications, especially mechanical [5]. Therefore, a technique allowing the diagnosis of CRI without removal of the catheter would be of great interest.

Differential quantitative blood cultures (DBCs) of blood withdrawn from the CVC and from a peripheral vein have been evaluated in hematology and oncology patients and in patients receiving long-term parenteral nutrition [6–10]. The few studies comparing this technique to a "gold standard" have given conflicting results [11–14]. Moreover, few data are available concerning ICU patients. The aim of our study was to compare DBC with a reference technique for the diagnosis of CRI in patients treated in ICUs.

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Informed consent was obtained from all patients or their next of kin.
This study followed the guidelines of the Institutional Review Board.
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1058–4838/97/2505–0020$03.00

Patients and Methods

The study was approved by the hospital's Institutional Review Board. Informed consent was obtained from all patients or their next of kin. Patients hospitalized in a surgery-trauma ICU and in a medical ICU were included during the 25-month period of November 1992 through November 1994. Patients were eligible if a CVC (either single or multiple lumen) inserted while the patient was in the ICU was scheduled to be removed. Several CVCs inserted in the same patient could be included in the study. Many patients in the study units were not eligible because they entered the units with a CVC inserted elsewhere or were discharged with their CVC still in place. People who died in the units with their CVC in place were not included. Arterial and pulmonary catheters were excluded, but introducer sheaths were included. All inserted CVCs were polyurethane. The insertion site was the jugular, subclavian, or femoral vein. None of the CVCs were tunneled.

Physicians of both ICUs inserted the CVCs after surgical hand-washing and the donning of masks, sterile gowns, and gloves. The puncture site was prepared first with a solution of quaternary ammonium, then ether, and then iodine/alcohol. The surrounding areas were covered with sterile drapes. After insertion of the CVC, an occlusive gauze dressing was placed following application of povidone-iodine. The dressings were changed every 48 hours.

When it was decided to remove the CVC, the connection of the CVC and the venous line were externally disinfected with iodine/alcohol. Then the line was disconnected and a sterile syringe was inserted in order to withdraw 5 mL of blood. For multiple-lumen CVCs, blood was withdrawn from each port.

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Immediately after, 5 mL of blood was obtained from a peripheral vein by standard venipuncture and placed in a heparinized tube. Then each intravascular device was removed aseptically after sterilization of the skin-puncture site. The distal segment of the catheter tip (5 cm) was cut off with sterile scissors, dropped into a tube, and sent to the laboratory.

The catheter tip was cultured according to the technique described by Brun-Buisson et al. [15], adapted from Cleri et al. [16]. In brief, 1 mL of sterile water was added into the tube containing the catheter tip. The contents were mixed for 1 minute, and 0.1 mL was sampled and plated on the surface of 5% horse blood agar. The agar plates were incubated at 37°C for 5 days. If colonies were observed, the number was recorded. The culture was considered positive when bacterial growth was observed. Identification and antimicrobial susceptibility assessment were conducted according to standard laboratory methods.

Blood withdrawn from the CVC and the peripheral vein was treated with use of the pour-plate technique [6–12]: 1 mL of nondiluted blood and 1 mL of serial blood dilutions (10^{-1}, 10^{-2}, 10^{-3}) were added to 19 mL of melted brain-heart infusion agar cooled to 45°C and poured into petri dishes. All plates were incubated for 5 days, and cfu were counted. When no growth was observed, the count was taken as 1 for the calculation of catheter/peripheral ratio. The DBC was considered positive when the catheter/peripheral cfu ratio was greater than 1.

Catheter findings were divided into three categories [4–15]. Catheter contamination was defined as the presence of $<10^3$ cfu/mL by the quantitative catheter-tip technique, without any local or general sign of infection. Catheter colonization was defined as the presence of $>10^3$ cfu/mL by the quantitative technique, without any local sign of infection. In this category, general signs of infection might be present and related to a remote septic focus, and clinical sepsis did not resolve within 48 hours after catheter removal. CRI was defined as a positive tip culture with a bacterial count of $>10^3$ cfu/mL, in association with general signs of infection (which disappeared after catheter removal), without any focus of infection with the same microorganism. The CRI could be accompanied by bacteremia.

Statistical Analysis

Published studies were analyzed to estimate the sample size for catheters. Assuming a prevalence of CRI in ICU patients of 5%–10%, and using data from a preliminary study indicating sensitivity of 90% and specificity of 94%, we decided 250–300 catheters would be required to obtain a positive predictive value between 60% and 80% with a precision of 5% α level. Thus, 300 catheters were included.

Using the quantitative catheter-tip culture as a reference, the sensitivity, specificity, and positive and negative predictive values were calculated at different catheter/peripheral cfu ratios. Sensitivity was plotted against specificity with use of a receiver operating characteristic (ROC) curve [17]. Quantitative results were expressed as mean ± standard deviation. Categorical results were given with their 95% confidence interval.

Results

During the 2 years, 283 CVCs were inserted in 190 adult patients.

Quantitative cultures of the catheter tip. One hundred and fifteen patients were hospitalized in the surgical unit and 75 in the medical unit. They were comparable with respect to age (45.9 ± 19.2 vs. 56.6 ± 19.6 years), sex, simplified acute physiologic score (SAPS) (11 ± 5 vs. 14 ± 4) [18], length of ICU stay (24 ± 16 vs. 21 ± 22 days), and antibiotic treatment (112/115 vs. 73/75).

Of the 283 studied catheters, 55 (19%) were positive in quantitative catheter-tip cultures. Of these positive results, 18 were considered contaminations; 23, colonizations; and 14, infections (table 1). The organism distribution pattern was similar among contaminated, colonized, and infected catheters, with a large predominance of staphylococci (76% of all isolates).

Fourteen catheters from different patients were considered infected. These catheters were inserted in 14 patients (age, 56.9 ± 18.4 years; SAPS, 13 ± 5; ICU stay, 36 ± 18 days), of whom 12 were treated with antibiotics for a remote septic focus. Bacteremia was associated with nine of these catheters. None of the bacteria were susceptible to the antibiotics previously prescribed. For the patients with infected catheters, the quantitative cultures, indicative of infection, were positive within 18–36 hours.

Differential blood cultures. Among the 283 catheters, 19 (from 19 patients) were DBC-positive (table 2). Among the catheters, 8 were inserted in the jugular vein, 7 in the femoral vein, and 4 in the subclavian vein. Of the 14 CRIs according to the quantitative catheter-tip cultures, 13 were associated with a positive DBC.

ROC curve analysis was carried out by varying the catheter/peripheral cfu ratio (figure 1). The combined sensitivity and specificity were most satisfactory at a ratio of 8. With use of this threshold, the DBCs were positive for 16 catheters as well as for the 13 catheters previously considered infected. Sensitivity, specificity, and predictive values are reported in table 3.

Discussion

When CRI is suspected in ICU patients, the removal of the catheter is generally proposed. However, as many as 80% of the catheters removed will be sterile [4]. Furthermore, the insertion of a new catheter carries its own risk of complications, especially mechanical. In a study of 160 ICU patients, insertion of CVCs at new sites has been shown to lead to complications such as pneumothorax or arrhythmias in 9% of patients [5].

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Table 1. Characteristics of the catheters removed from ICU patients and analyzed in the study.

	Positive in catheter tip culture			Negative in culture (n = 228)	All catheters (n = 283)
	Contaminated (n = 18)	Colonized (n = 23)	Infected (n = 14)		
Insertion site					
Jugular	13	15	6	143	177
Subclavian	4	3	2	46	55
Femoral	1	5	6	39	51
Mean (±SD) duration of stay (d)	10 ± 5	10 ± 3	13 ± 5	10 ± 6	10 ± 5
Reason for catheter removal					
Infection suspected	7	11	14	86	118
No longer useful	11	12	0	142	165
Organism(s) identified					
Staphylococcus aureus	5	8	7		
Coagulase-negative staphylococci	8	10	4		
Other gram-positives	3	1	1		
Enteric gram-negatives	2	4	2		

Therefore, a technique allowing for the diagnosis of CRI without catheter removal would be useful in clinical practice. The ideal technique should have good specificity to prevent the removal of sterile catheters, but, more important, it should have good sensitivity. Indeed, this technique needs to be safe, presenting minimal risk of leaving an infected catheter in place. False-negative results should be minimized.

In 1979 Wing et al. first had the idea of performing cultures of blood withdrawn from the CVC and from a peripheral vein [6]. They compared both results and could establish the diagnosis of CRI in a patient. This observation led to the development of differential blood cultures for the diagnosis of CRI.

The aim of our study was to evaluate DBCs for ICU patients. As the ''gold standard'' for the microbiological diagnosis technique, we chose that proposed by Brun-Buisson et al. [15], adapted from Cleri et al. [16]. This technique allows for the detection of colonization of the external surface of the catheter tip and of its internal lumen. To identify false-negatives in the

Table 2. Data concerning the 19 positive differential blood cultures.

Catheter classification	Insertion site	Isolate	Differential blood cultures: cfu/mL in indicated specimen		
			CVC	P	CVC/P ratio
Sterile	Jugular	*Klebsiella oxytoca*	10^2	<1	10^2
Sterile	Subclavian	*Klebsiella oxytoca*	16	<1	16
Sterile	Femoral	*Enterobacter cloacae*	10^2	<1	10^2
Sterile	Subclavian	*Staphylococcus epidermidis*	2	<1	2
Colonized	Jugular	*Staphylococcus aureus*	2	<1	2
Colonized	Jugular	*Escherichia coli*	4.4×10^3	<1	4.4×10^3
Infected	Jugular	*Staphylococcus aureus*	10^4	20	5×10^2
Infected	Jugular	*Staphylococcus aureus*	5×10^3	10	5×10^2
Infected	Femoral	*Staphylococcus aureus*	10^4	3	3.3×10^3
Infected	Jugular	*Staphylococcus aureus*	4.6×10^3	<1	4.6×10^3
Infected	Subclavian	*Staphylococcus aureus*	7×10^2	90	8
Infected	Femoral	*Staphylococcus aureus*	3×10^5	2×10^3	1.5×10^2
Infected	Femoral	*Staphylococcus epidermidis*	8×10^2	<1	8×10^2
Infected	Femoral	*Staphylococcus epidermidis*	4×10^6	10^3	4×10^3
Infected	Femoral	*Staphylococcus epidermidis*	1.5×10^6	<1	1.5×10^6
Infected	Jugular	*Staphylococcus epidermidis*	5×10^2	<1	5×10^2
Infected	Subclavian	*Escherichia coli*	4×10^3	<1	4×10^3
Infected	Jugular	*Escherichia coli*	3.5×10^3	<1	3.5×10^3
Infected	Femoral	*Corynebacterium* species	6×10^4	<1	6×10^4

NOTE. CVC = central venous catheter; P = peripheral vein. When the number of cfu in the peripheral vein was <1, it was considered as 1 for the calculation of the CVC/P ratio.

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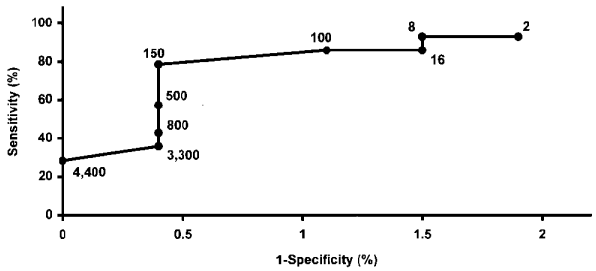


Figure 1. Receiver operating characteristic curve for ratio of bacterial counts in culture of the blood withdrawn from the catheter and culture of blood from a peripheral vein. The numbers on the curve are respective cutoffs in the differential blood cultures.

microbiological techniques, local and general signs of infection were noted at the time of the sepsis suspicion and after catheter removal. The reason for removal could be either that infection was suspected because of local signs (local inflammation or infection) or general signs (fever, chills, etc.), or else that the catheter was no longer needed.

We found a rate of 4.9% of infected catheters and 7.3% of patients with CRI. Bacteremia followed catheter infection in 3.1% of catheterized patients. *Staphylococcus aureus* was the predominant organism associated with bacteremia. This is in accordance with findings in other studies of ICU patients [11, 12, 15]. Although yeast may be responsible for CRI in the ICU, especially in immunocompromised patients, no fungal infection was identified.

DBCs have been evaluated in several studies, including a comparison with another microbiological technique. In a group of 24 patients receiving parenteral nutrition, Fan et al. found that DBC correctly identified seven of nine infected catheters [12]. They used an arbitrary threshold of seven for the catheter/peripheral cfu ratio. Sensitivity was 77.8% and specificity was 100%, with no false-positive results.

These interesting findings were brought into question by the results from Paya et al. [13]. In a study including 44 patients in a surgical ICU with suspected CRI, 15 catheters were considered infected according to a semiquantitative technique; DBC identified only 7 of these catheters. In that study, with regard to six catheters classified as DBC-false-negative, high organism concentrations (>100 cfu/mL) were observed in the blood withdrawn from the catheter and from the vein. In fact, a dilution of these samples might have yielded a positive DBC. In addition, the investigators did not include any clinical information in the definition of CRI. Thus, it was impossible to separate colonizations and infections of the catheters.

Finally, bacteria responsible for CRI were different from those found in other studies, including ours. *Pseudomonas aeruginosa* was found in more than half of the CRIs, and *S. aureus* accounted for only 6% of the isolated organisms. This difference may be explained by variations in the pathogenesis of the infections and may reflect differences in the efficiency of DBC.

In another study of patients hospitalized in internal medicine and surgical wards and the ICU, 107 catheters were evaluated, and DBCs identified 16 of 17 CRIs. DBC was found to be reliable, with a sensitivity of 94% and a specificity of 100% [11]. Recently, in patients with cancer (n = 31) and in the ICU (n = 27), DBC identified correctly 30 of 36 CRIs; the 6 remaining cases were false-negatives because removal of these catheters led to resolution of clinical signs of infection [14]. It is interesting that 16 patients with CRI had a negative tip culture, and CRIs were found to be related to hub infection. If this finding is confirmed, the efficacy of DBC as compared with that of tip cultures would be reinforced.

In all of these studies the catheter/peripheral cfu ratio was chosen arbitrarily. The range of this ratio was wide, between 2 and 30. In our study, the ROC curve technique was used to determine the ratio of the DBC that gives the best performance in diagnosis of CRI. With a threshold of 8, sensitivity was maximal, decreasing the number of false-negatives with the technique. This value is close to those chosen arbitrarily in other studies [11–14]. With this cutoff, sensitivity and specificity of DBC were very high. The few false-positive results led to the removal of sterile catheters, but these cases are few in contrast to the large number of catheters that can be safely left in place.

The DBC technique may have some potential drawbacks. First, the one false-negative result of the study raises an important issue because an infected catheter may remain inserted. All the studies of DBC have found false-negative results, but sensitivity remained up to 80%. These results may be explained by strictly external contamination of the catheter, missed by the DBC. However, to our knowledge, a method of diagnosis of CRI with 100% sensitivity and 100% specificity does not

Table 3. Sensitivity, specificity, and predictive values of differential blood cultures for all catheters and for catheters removed for a suspected infection. (Percentages and 95% confidence limits are given.)

Catheters removed	Sensitivity	Specificity	PPV	NPV	Accuracy
All (n = 283)	92.8 ± 3.0	98.8 ± 1.2	81.2 ± 4.5	99.6 ± 0.7	98.5 ± 1.4
For suspected infection (n = 118)	92.8 ± 3.0	100	100	99.0 ± 0.9	99.1 ± 1.7

NOTE. NPV = negative predictive value; PPV = positive predictive value.

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exist. In all circumstances, the results of the technique must be interpreted cautiously and clinical evaluation must remain the first criterion of CRI diagnosis, leading to the removal of the catheter if there is any doubt.

The second problem is related to the time necessary to obtain results from quantitative cultures, generally between 24 and 48 hours. In some circumstances, this delay will be too long for a patient with signs of severe infection. In this case, the catheter has to be removed. In our study, the catheters were cultured over 5 days to be certain not to miss late bacterial growth. However, no culture was positive after 48 hours.

Finally, the technique of DBC has a cost. However, this is balanced by the savings due to the limitation in wasting sterile catheters. In our study, 14 of 118 patients with a suspected CRI had a positive DBC, so 104 catheters were removed unnecessarily. Their replacement could have been avoided. A cost-benefit evaluation of the DBC technique must be done.

In conclusion, for ICU patients, DBC may be considered a useful tool for diagnosis of CRI without removal of the catheter. The possibility of false-negative results, although uncommon, must be kept in mind, and the persistence of sepsis syndrome without any evidence of other sources of infection must lead to the removal of the catheter. The technique cannot be used for all ICU patients, especially because of the time lag in obtaining culture results. However, this technique seems to decrease the waste of sterile catheters removed when ICU patients become febrile.

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however, it is hypertonia rather than muscle twitching that occurs. Glavinia and Robertshaw described a case of myoclonic spasm in a 59-year-old woman who received a bolus of 3 mg of intrathecal morphine for intractable pain [2] while Jayawardena and Hill described a case of myoclonus in a 65-year-old woman 24 h after discontinuing a diamorphine infusion into the epidural space [3].

In both the previously reported cases of myoclonic spasms following the administration of morphine and diamorphine, the drugs had been infused spinally in much smaller doses. The 100-fold difference in dose before the development of myoclonus is probably related to the concentration gradient between the intravenous and cerebrospinal compartments, this being a function of a lipid solubility of diamorphine. Terminally ill patients at the Hospice commonly receive comparable doses of diamorphine and morphine to that initially given to this patient without developing myoclonic spasms, but ureteric obstruction leading to chronic renal insufficiency may have accelerated central neuronal toxicity in this patient as it would impair excretion of unconjugated active morphine.

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Venous/arterial blood management protection system

We have recently assessed the function of the venous/arterial blood management protection system (VAMP) manufactured by Baxter and have been impressed with its simplicity and ease of operation. This disposable system, consisting of a length of pressure monitoring tubing, reservoir, shut-off valve and blood sampling site (Fig. 1) is attached distally to a pressure transducer and allows a convenient method for the periodic withdrawal of blood samples. It may be used with arterial, pulmonary artery or central venous catheters.

Five millilitres of heparinised blood/saline mixture are drawn from the patient into the VAMP reservoir over 3–5 s using the reservoir plunger. After turning the shut-off valve, undiluted blood samples are drawn from the sampling site using a guarded needleless cannula attached to either a syringe or a direct draw blood transfer unit (BTU). If the latter is used, individual vacuumed blood sample tubes may be attached directly to the BTU for filling. Following completion of blood sampling, the shut-off valve is re-opened and the reservoir volume slowly returned to the patient using firm, even pressure on the reservoir plunger. The sampling site is cleansed using an alcohol swab before and after sampling.

The VAMP system may be useful in an Intensive Care Unit for several reasons. Firstly, it is likely to reduce the risk of sampling-related anaemia which has been reported, particularly in children [1, 2]. Although some of the reduction in haemoglobin may be related to the removal of the blood samples themselves, it is often the case that the initial volume of blood/heparinised saline mixture removed from the patient is discarded. The use of a closed sampling system will reduce this effect. Secondly, the absence of potentially messy and infected three-way taps as sampling points for blood, and the use of the VAMP sampling

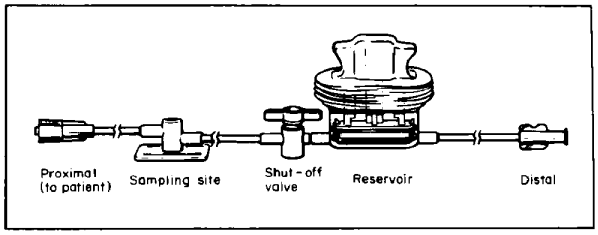


Fig. 1. Baxter venous/arterial blood management protection system (VAMPTM).

system, may reduce the risk of catheter-related sepsis. Finally, the use of needles during blood sampling is potentially hazardous to health workers [3]; the fact that the VAMP system employs a needleless sampling method will reduce the incidence of needlestick injuries.

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Dural puncture and depth of the extradural space

We read with interest the article by Sutton and Linter (*Anaesthesia* 1991; **46:** 97–8) concerning the relative risk of dural puncture as a function of the depth of the extradural space. This study prompted us to examine our own data about the same subject. Since 1989, we have recorded prospectively, and collected on standardised forms, the technical characteristics of all the epidurals performed in obstetric patients, either for labour or for elective Caesarean section. The depth of extradural space was one of the collected items, as well as the occurrence of dural

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Blood collection set with an expanded internal volume

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Abstract of EP1665986 (A1)

The blood collection set includes an IV needle assembly, a length of flexible plastic tubing extending from the IV needle assembly and a non-patient needle assembly. The set is formed with an internal chamber that increases the internal volume of the blood collection set. Thus, the increase in internal volume allowing for greater flash visualization on venous entry.

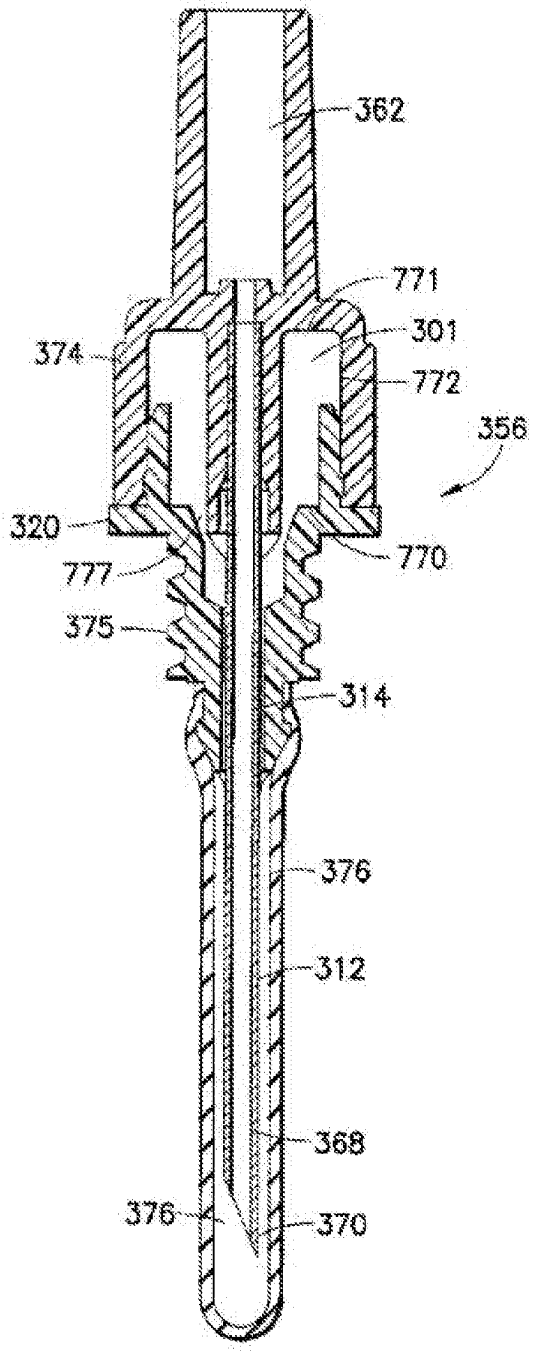


FIG.4

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(54) Blood collection set with an expanded internal volume

(57) The blood collection set includes an IV needle assembly, a length of flexible plastic tubing extending from the IV needle assembly and a non-patient needle assembly. The set is formed with an internal chamber that increases the internal volume of the blood collection set. Thus, the increase in internal volume allowing for greater flash visualization on venous entry.

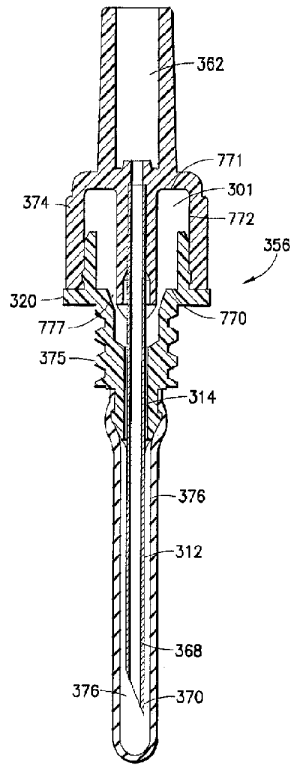


FIG.4

EP 1 665 986 A1

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Description

BACKGROUND OF THE INVENTION

[0001] This application claims priority to U.S. Provisional Application No. 60/631,515, which was filed on November 29, 2004.

1. Field of the Invention

[0002] The subject invention relates to a blood collection set with an internal chamber, which increases the internal volume of the blood collection set thereby improving flash.

2. Description of the Related Art

[0003] Phlebotomy procedures often are carried out using a blood collection set. A typical blood collection set includes an IV needle assembly with an IV cannula that has a proximal end, a sharply pointed distal end and a lumen extending between the ends. The needle assembly also includes a plastic IV hub with a proximal end, a distal end, and a passage extending between the ends. The proximal end of the IV cannula is mounted in the passage of the IV hub so that the lumen through the IV cannula communicates with the passage through the IV hub. The needle assembly may further include a shield for shielding the IV cannula after use (a so called safety blood collection set) and a packaging cover for safely covering the IV cannula prior to use. Packaging covers typically are rigid tubes with a proximal end that can be telescoped over the IV cannula and frictionally engaged with the distal end of the IV hub. Shields for shielding the IV cannula of blood collection sets have taken many forms. Some shields are telescoped over the IV hub and can be moved from a proximal position where the cannula is exposed to a distal position where the cannula is shielded. Other shields are hinged to the IV hub and can be rotated from an open position where the IV cannula is exposed to a closed position where the IV cannula is shielded. A needle assembly for a blood collection set also may include two flexible wings that project transversely from the IV hub or from the shield. The wings can be folded into face-to-face relationship with one another to effectively define a handle that facilitates manipulation of the needle assembly. The wings then can be rotated away from one another and held against the skin of the patient.

[0004] Blood collection sets also include a length of flexible plastic tubing. The tubing has a distal end that is connected to the proximal end of the IV hub, The tubing also has a proximal end that is connected to a plastic fitting. Thus, fluid communication is provided between the lumen of the IV cannula and the plastic fitting at the proximal end of the flexible tubing. The plastic fitting may be a female luer fitting that can be connected to a male luer fitting. The fitting then can be placed in communication with a reservoir or container for collecting a sample of blood.

[0005] Phlebotomy procedures often employ evacuated tubes, such as the VACUTAINER® brand of evacuated tubes sold by Becton Dickinson and Company. Evacuated tubes often are used with a tube holder that has a proximal end, a distal end, and a tubular side wall extending between the ends. The proximal end of the holder is widely open and is configured for slidably receiving the evacuated tube. The distal end of the holder typically includes an end wall with a mounting aperture. The mounting aperture includes internal threads or other mounting structures.

[0006] The tube holder may be used with a non-patient needle assembly that has a non-patient hub with external surface configurations for mounting in the mounting aperture of the holder. The non-patient needle assembly further includes a non-patient cannula extending proximally from the hub and a multiple sample sleeve telescoped over the non-patient cannula and mounted to the proximal end of the hub. The hub of the non-patient needle assembly can be threaded or otherwise engaged in the mounting aperture of the tube holder so that the non-patient needle and the multiple sample sleeve project into the tube receiving chamber of the holder.

[0007] The blood collection set may be used by mounting the fitting at the proximal end of the flexible plastic tubing to the distal end of the hub of the non-patient needle assembly. The packaging shield that covers the non-patient cannula then may be removed, and the hub of the non-patient needle assembly may be engaged with the tube holder. The medical practitioner then grips the IV needle assembly and removes the packaging cover from the IV cannula. The gripping of the IV needle assembly may include folding the flexible wings into face-to-face engagement and gripping the folded wings between a thumb and forefinger. The pointed distal end of the IV cannula then is urged into a targeted blood vessel. The wings then may be folded into engagement with the skin of the patient and may be taped in position. An evacuated tube then is urged into the open proximal end of the blood collection tube holder so that the non-patient needle pierces the stopper of the evacuated tube. As a result, the blood vessel of the patient is placed in communication with the interior of the evacuated tube, and the pressure differential between the blood vessel and the evacuated tube will generate a flow of blood through the IV cannula, through the passage of the IV hub, through the flexible tubing, through the non-patient hub and finally through the non-patient needle and into the evacuated tube.

[0008] The translucent or opaque plastic material of blood collection sets and IV cannula shields, combined with numerous cannula shield mechanism components and the length of the typical needle hub tends to inhibit a clear indication of venous or arterial access. Blood flow into the plastic tubing does provide an indication of venous or arterial access (known as "flash") as the plastic

tubing is often formed from a highly translucent or transparent plastic material. However, because of the existence of the elements associated with the IV needle assembly the length of flash obtained from a typical venous entry may not be sufficient for blood flow to be observed in the flexible tubing at a location proximal to the IV needle assembly itself. Thus, a medical practitioner may have a delayed indication of venous or arterial access and may incorrectly assume that the blood vessel was not accessed properly. In these situations, the medical practitioner may try to access the blood vessel again even though the initial access was successful. Accordingly, the patient may be subjected to unnecessary trauma during a repeated attempt to access the targeted blood vessel. Thus, improved techniques for increasing the length of flash such that initial blood flow will be observable in the flexible tubing proximal the IV needle assembly and associated shielding elements would be desirable.

SUMMARY OF THE INVENTION

[0009] The invention relates to a blood collection set with an internal chamber provided to increase the internal volume of the blood collection set when compared to a prior art blood collection set which does not have an internal chamber. In this manner, improved flash visualization, can be provided.

[0010] "Internal chamber" as used herein means an enclosed space or compartment, which is in communication with the fluid passage of the blood collection set. The "fluid passage" is defined as any part of the blood collection set in which blood flows and can include the lumen through the IV cannula, the passage through the IV hub, the passage through the flexible tubing, the passage through the non-patient hub and lumen through the non-patient cannula. "Flash" is defined as the initial blood flow into the fluid passage on venous entry, which provides an indication of venous or arterial access before an evacuated tube is urged into the open proximal end of the blood collection tube holder. "Flash length" is the linear distance that blood flows in a proximal direction along the fluid passage on venous entry. "Flash volume" is the volume of blood that flows into the fluid passage on venous entry expressed as a percentage of the total internal volume of the blood collection set.

[0011] In one embodiment, the blood collection set includes an IV needle assembly, a length of flexible plastic tubing extending from the IV needle assembly and a non-patient needle assembly. The internal chamber is advantageously disposed on or near the non-patient needle assembly to permit an increase in the internal volume of the blood collection set without being located directly in the blood flow path.

[0012] The IV needle assembly typically comprises an IV hub having a proximal end, a distal end and a passage extending between the ends. The IV needle assembly typically further comprises an IV cannula having a proximal end mounted in the passage of the IV hub, a pointed distal end projecting distally from the IV hub and a lumen that communicates with the passage through the IV hub. The flexible tubing is typically connected to the proximal end of the IV hub. The IV needle assembly typically includes a packaging cover that protectively encloses the IV needle cannula prior to use. The packaging cover is removed immediately prior to use to permit access to the IV cannula. The IV needle assembly may further include a protective shield that is moveable relative to the IV cannula from an open position where the IV cannula is exposed to a closed position where the IV cannula is substantially shielded. The shield protects against accidental sticks with the used IV cannula. A pair of flexible wings may be mounted to the IV hub or to the shield to facilitate manipulation of the IV needle assembly.

[0013] In this embodiment, the non-patient needle assembly includes a non-patient hub having a proximal end and a distal end. The non-patient needle assembly further includes a non-patient cannula having a distal end securely mounted in the hub, a proximal end projecting proximally from the non-patient hub and a lumen that communicates with the passage through the non-patient hub. A multiple sample sleeve is typically mounted over the non-patient cannula and secured to the proximal end of the non-patient hub. External portions of the non-patient hub near the proximal end thereof may be formed with an array of external threads or other mounting structure to enable the non-patient needle assembly to be mounted to a collection tube holder or other such medical device. Or, the holder may be pre-attached with the non-patient needle assembly. The blood collection set may further include a fitting mounted to the proximal end of the flexible plastic tubing and configured for mating with the distal end of the non-patient hub. For example, the fitting may be a female luer fitting that can be engaged with the male luer taper at the distal end of the non-patient hub.

[0014] In one embodiment, the internal chamber is located in the non-patient assembly beyond the non-patient cannula proximal end, which means that the air passes through the non-patient cannula proximal end from which blood is drawn, and then into the internal chamber. Specifically, on venous entry air is compressed and flows from the fluid passage and out of the non-patient cannula proximal end where it further flows through the space between needle exterior and multiple sample sleeve. The air then flows into the internal chamber, which may be at the non-patient barb, the non-patient hub thread, the non-patient hub body, or other location or combination of locations that are beyond the non-patient cannula proximal end. The collection tube, which is applied at the non-patient cannula proximal end, draws blood from only the fluid passage and not from the internal chamber.

[0015] In another embodiment, a one-way check valve is located within the internal chamber. The valve allows air and blood to enter the internal chamber but shuts closed both when vacuum is applied. Thus, when an

evacuated collection tube is applied at the non-patient needle tip, the tube draws blood from the fluid passage but not from the internal chamber, and upon removal of the IV needle from the targeted blood vessel, the check valve closes and inhibits blood from dripping from the IV needle tip.

[0016] In a further embodiment, the internal chamber utilizes a branch in the fluid passage, e.g., a "Y" or "T". The branching may be at any location or locations along the fluid passage, but is advantageously at the proximal end such as at the non-patient hub. The branching may be in the form of a separate component added into the fluid passage such as in between the female and male luer fittings or it may be integral within the hub. The branching includes some type of internal chamber as discussed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1A is a perspective view of a prior art blood collection set and collection tube holder.

[0018] FIG. 1B is a top plan view of the blood collection set and collection tube holder shown in FIG. 1A.

[0019] FIG. 2 is an exploded perspective view of a prior art blood collection set.

[0020] FIG. 3 is side elevation view of a prior art non-patient needle assembly, partly in section.

[0021] FIG. 4 is a cross-sectional side view of an embodiment of the non-patient needle assembly of the blood collection set.

[0022] FIG. 5 is a perspective view of the same embodiment shown in FIG. 4

[0023] FIG. 6 is a cross-sectional side view of an embodiment of the non-patient needle assembly of the blood collection set.

[0024] FIG. 7 is a perspective view of the same embodiment shown in FIG. 6

[0025] FIG. 8 is a cross-sectional side view of an embodiment of the non-patient needle assembly of the blood collection set.

[0026] FIG. 9 is an expanded view of the same embodiment shown in FIG. 8

[0027] FIG. 10 is a perspective view of one embodiment of a one way check valve.

[0028] FIG. 11 is a plan view of the same embodiment shown in FIG. 10

[0029] FIG. 12 is a cross-sectional side view of the same embodiment shown in FIG. 10

[0030] FIG. 13 is a perspective view of one embodiment of the blood collection set.

[0031] FIG. 14 is a perspective view of one embodiment of the blood collection set.

DETAILED DESCRIPTION

[0032] A prior art blood collection set that contains IV cannula shielding is identified generally by the numeral **10** in FIGS. 1A and 1B. Blood collection set **10** is employed in this embodiment with a collection tube holder **12.** Holder **12** has a proximal end **14,** a distal end **16** and a tubular sidewall **18** extending between the ends. Proximal end **14** of holder **12** is widely open and defines an entry to a tube receptacle within sidewall **18.** Thus, an evacuated collection tube can be slid in a proximal-to-distal direction through open proximal end **14** of holder **12** toward distal end **16.** Distal end **16** of holder **12** is characterized by an end wall **20.** End wall **20** is formed with an internally threaded mounting aperture **22,** as shown in FIG. 3.

[0033] Blood collection set **10** includes an IV needle assembly **24** that comprises an IV hub **26.** IV hub **26** includes a proximal end **28,** a distal end **30** and a passage (not shown) extending between the ends. IV needle assembly **24** further includes an IV cannula **32** with a proximal end **34,** a pointed distal end **36** and a lumen **38** extending between the ends. Proximal end **34** of IV cannula **32** is mounted securely in the passage of IV hub **26.** Thus, lumen **38** through IV cannula **32** communicates with the passage through IV hub **26.** Flexible wings **40** are mounted to IV hub **26** at a location near distal end **30.** Wings **40** can be folded into face-to-face relationship with one another for convenient gripping between a thumb and forefinger to enable manipulation of IV needle assembly **24.** Wings **40,** however, also can be rotated into a substantially coplanar disposition for taping to the skin of a patient.

[0034] IV needle assembly **24** further includes a tubular shield **42** that is telescoped over IV hub **26.** Shield **42** is formed with transverse slots **44** that slidably receive wings **40.** Thus, shield **42** can be slid from a proximal position, as shown in FIGS. 1A and 1B to a distal position. IV cannula **32** is exposed for use when shield **42** is in the proximal position shown in FIGS. 1A and 1B. However, IV cannula **32** is substantially surrounded by shield **42** when shield **42** is moved to the distal position. Additionally, slots **44** in shield **42** are configured to lockingly engage wings **40** when shield **42** is in the distal position to prevent or complicate a re-exposure of IV cannula **32.** In this case the presence of a shield does not inhibit flash visualization within the IV needle assembly. The shield illustrated in FIGS. 1A and 1B is one of many optional shield designs that can be incorporated into blood collection set **10.** Other designs may provide wings mounted directly to the shield. Still other designs may provide a hinged shield mounted to IV hub **26.** In still other designs, a shield may be entirely separate from IV needle assembly **24.**

[0035] Another prior art blood collection set is identified generally by the numeral **110** in FIG. 2. Fluid collection/infusion set **110** includes a length of flexible plastic tubing **112,** a proximal fitting **114,** a needle assembly **116,** a spring **118** and a barrel assembly that comprises a front barrel **120,** a rear barrel **122** and a wing **124.** Needle assembly **116** includes a needle cannula **134,** a needle hub **136** and a needle protector **138.** Needle cannula **134** has a proximal end **140,** a distal end **142** and a lumen

144 extending between the ends. Distal end 142 of needle cannula 134 is beveled to a sharp tip.

[0036] FIGS. 1 A and 1B also show that a blood collection set 10 further includes a length of flexible plastic tubing 46. Tubing 46 includes opposite proximal and distal ends 48 and 50 and a passage extending between the ends. Distal end 50 of tubing 46 is securely mounted to proximal end 28 of IV hub 26 so that the passage through IV hub 26 communicates with the passage through tubing 46. A female luer fitting 52 is securely mounted to proximal end 48 of tubing 46.

[0037] Blood collection set 10 further includes a non-patient needle assembly 54, as shown in FIG. 3. Non-patient needle assembly 54 includes a non-patient hub 56 with a proximal end 58, a distal end 60 and a fluid passage 62 extending between the ends. Exterior surface regions of non-patient hub 56 substantially adjacent proximal end 58 define an array of external threads 64 configured for threaded engagement with the internal threads formed in mounting aperture 22 of collection tube holder 12. External surface regions of non-patient hub 56 adjacent distal end define a male luer taper 66 configured for mating with female luer fitting 52. Non-patient needle assembly 54 further includes a non-patient cannula 68 having a pointed proximal end 70, a distal end 72 and a lumen 74 extending between the ends. Distal end 72 of non-patient cannula 68 is mounted securely in passage 62 through non-patient hub 56 and aligns substantially with external threads 64 on non-patient hub 56. Non-patient needle assembly 54 further includes a multiple sample sleeve 76 mounted over non-patient cannula 68 and securely engaged with proximal end 58 of non-patient hub 56. Multiple sample sleeve 76 effectively functions as a valve that prevents a flow of fluid from non-patient cannula 68. However, multiple sample sleeve 76 can be pierced by pointed proximal end 70 of non-patient cannula 68 in response to forces generated by a stopper on an evacuated collection tube.

[0038] It should be noted that flash visualization maybe acceptable in certain blood collection sets with safety features, such as the type shown in FIGS. 1A and 1B. The IV needle assembly and safety shield tend to be made from a translucent plastic material, and may only contain the IV cannula and flexible tubing, which may allow flash to be seen through the IV cannula hub walls. Therefore a minimum length of flash maybe sufficient, such that initial blood flow on venous entry maybe observed at the proximal end of the IV cannula. However in more advanced and complex IV cannula shielding mechanisms, such as the blood collection set shown in FIG. 2, the length of flash obtained from a typical venous entry may not be sufficient for blood flow to be observed in the flexible tubing at a location proximal to the IV needle assembly itself, therefore flash visualization tends to be inhibited within the IV needle assembly.

[0039] According to one embodiment of the invention, a blood collection set, for example of the type disclosed above, contains an internal chamber that increases the internal volume of the blood collection set. The increase in internal volume of the blood collection set provides a greater length of flash and therefore improved flash visualization, such that, advantageously, blood is observed in the flexible tubing proximal the IV needle assembly on the initial venous entry. While such improved or lengthened flash is particularly advantageous for such complex blood collection sets as shown in FIG 2, application in any blood collection set is contemplated.

[0040] According to this embodiment of the invention, a blood collection set includes a plurality of internal spaces that will initially be at ambient air pressure. These internal spaces include the lumen through the IV cannula, the passage through the IV hub, the passage through the flexible tubing, the passage through the non-patient hub and lumen through the non-patient cannula. The blood collection set is employed by folding wings into face-to-face engagement with one another and gripping the wings between a thumb and forefinger. Any packaging cover that may be mounted over IV cannula then is removed and discarded. The pointed distal end of the IV cannula then is urged into a targeted blood vessel. The healthcare practitioner then may release the grip on the wings, and if long term access to the blood vessel is required, the wings may be taped into face-to-face engagement with the skin of the patient. The venous or arterial access achieved with the IV cannula places the plurality of interior spaces of the blood collection set in communication with the pressure of the blood in the patient. Blood pressure exceeds the ambient air pressure. Accordingly, the pressure of air in the above-referenced internal spaces will increase, and blood will begin to flow into these internal spaces. The system will reach equilibrium as the air pressure within the blood collection set increases in response to a reduction of volume caused by the inflow of blood. Hence, a portion of the internal spaces in the system will remain filled with air at a pressure substantially equal to the venous or arterial pressure thereby preventing blood from flowing any further to or into the tubing. Stated differently, the system will include its original volume of air in the space between the proximal end of the non-patient needle and the blood that enters the blood collection set. This pressurized air will prevent any further flow of blood toward the non-patient assembly, thereby stopping flash. In prior art systems the total volume of the internal spaces maybe insufficient, such that flash maybe stopped before it can be observed. According to embodiments of the invention, however, the internal chamber which lacks direct communication to the exterior, provides more internal volume into which the air can be pushed, allowing blood to push further into the device before the pressure of the blood equals the pressure of the air. This increase in interior space thereby allows a greater length of flash to occur. Various embodiments of such internal chambers are described in detail below.

[0041] FIGS. 4 and 5 show an embodiment of the invention, where the internal chamber 301 is located be-

yond the proximal end **370** of the non-patient cannula in the non-patient hub **356** and lacks direct communication to the exterior. The internal chamber **301** is annular in cross-section and has opposite proximal **770** and distal ends **771** and a wall **772** extending therebetween; the proximal end **770** has an inlet **777** in communication with the passage. However all internal chamber geometries can be considered for the invention. The non-patient hub **356** is generally made from 2 separate parts; the male luer **374** and the non-patient thread assembly **375.** Other configurations are possible. On venous entry, air is compressed and flows from the fluid passage **362** and out of the non-patient cannula proximal end **370** where it further flows through the space **312** between needle exterior **368** and multiple sample sleeve interior **376,** then through a passage **314** through the non-patient barb and the male luer wall **320** into the internal chamber **301** through the inlet **777** in the male luer **374.**

[0042] FIGS 6 and 7 show another embodiment of the invention, with an elongated internal chamber to further increase the flash length. The internal chamber **301a** is annular in cross-section and has opposite proximal **770a** and distal ends **771a** and a wall **772a** extending therebetween, the proximal end **770a** has an inlet **777a** in communication with the passage. However all internal chamber geometries can be considered for the invention. The non-patient hub is made from 2 separate parts; the male luer **374a** and the non-patient thread assembly **375a.** The longer internal chamber **301a** is located beyond the proximal end **370a** of the non-patient cannula in the non-patient thread assembly **375a** and has no direct communication to the exterior. Other configurations are possible. On venous entry, air is compressed and flows from the fluid passage **362a** and out of the non-patient cannula proximal end **370a** where it further flows through the space **312a** between needle exterior **368a** and multiple sample sleeve interior **376a**, then through a passage **314a** through the non-patient barb into an internal chamber **301a** through an inlet **777a** in the non-patient thread assembly **375a.**

[0043] FIGS 8 to 12 show a further embodiment of the invention, in which a one-way valve **555** is located within an internal chamber similar to that shown in FIG. 6. The one way valve has a central core **550** surrounded by an annular flange **551** that has a sealing ring **552** around its outer diameter. The central core **550** is located around the non-patient needle exterior **368b** within the internal chamber **301b** and has a tapered base **553** which mates to the taper of inlet **777b.** Typically the one way valve **555** is formed from a resilient polymer such as an elastomer or thermoplastic.

[0044] As apparent to one skilled in the art, on venous entry, air flows from the fluid passage **362b** and out of the non-patient cannula proximal end **370b** where it further flows through the space **312b** between needle exterior **368b** and multiple sample sleeve interior **376b,** then through a passage **314b**, through the non-patient barb and the male luer wall **320b,** through the inlet **777b** where it moves the one-way valve **555,** flowing past the valve core base **553,** valve sealing ring **552** and into an internal chamber **301b** in the male luer **374b.** A vacuum is applied to the fluid passage, when an evacuated collection tube is applied at the non-patient needle tip. The resultant positive pressure differential between the internal chamber and the fluid passage causes the one way valve **555** to close, by the valve sealing ring **552** being pressed against the proximal end of the internal chamber **770b** and the valve core tapered base **553** being pressed into inlet 777b thereby preventing outflow of air or blood from the internal chamber,. It should be noted that the one way valve is not limited to the particular design described in this embodiment as all types of one way valves can be contemplated for this invention.

[0045] The one way valve **555** also inhibits blood from dripping from the IV needle tip upon removal of the IV needle from the targeted blood vessel after the blood collection has been completed. In prior art blood collection sets, at the instance of removal of the IV needle, the fluid passage of the blood collection set, will contain a reservoir of air and blood at venous pressure, which will be greater than the ambient atmospheric pressure. Thus a back pressure is created within the fluid passage which may cause a back-flow of blood to drip from the IV needle tip. In the embodiment of the invention shown in FIGS 8 to 12, the reservoir of air at venous pressure is within the internal chamber **301b**, therefore the back pressure causes the one way valve **555** to shut upon removal of the IV needle thereby preventing such a back-flow of blood in the fluid passage **362b.**

[0046] FIGS 13 and 14 show another embodiment of an internal chamber **401** which is branched from the fluid passage using a "Y" or "T" branched internal chamber in the fluid passage into which air is displaced. The branching may be at any location or locations along the fluid passage, but is typically near the proximal end such as at the non-patient hub. FIG 13 shows a "Y" branched internal chamber **454** in the form of a separate component added into the fluid passage **462** such as in between the female **455** and male luer **456** fittings. FIG 14 shows a "T" branched internal chamber **457,** which is an integral part of the non-patient hub, thus reducing the number of components. The use of a "Y" or "T" branched internal chamber may be accomplished with any convenient terminal shapes at the interfaces of each component. The embodiments exemplified previously are shown with luer tapered fittings but other interface designs such as direct connection to the flexible tubing may also be applied. Although typical applications use a three port "Y" or "T" branched internal chamber the use of a multiple port branched internal chamber system is also possible. The internal chamber **401**, can be a separate component which is affixed into a port **460** of the branch system as shown in FIG 13 or an integral part of the branched system as shown in FIG 14. All internal chamber geometries can also be contemplated.

Claims

1. A blood collection set comprising;
a first needle assembly comprising a first hub and a first cannula having a lumen therethrough, wherein said cannula is mounted to said first hub,
a length of flexible tubing having opposite first and second ends and a tubing passage extending between said ends, said first hub located proximate said first end for providing communication between said lumen of said first cannula and said tubing passage,
a second hub located proximate said second end and having a passage extending therethrough, said second hub passage being in fluid communication with said tubing passage,
a non-patient cannula having opposite proximal and distal ends and a lumen extending between said ends, said distal end of said non-patient cannula being mounted to said second hub such that said lumen through said non-patient cannula communicates with said second hub passage,
a multiple sample sleeve covering said non-patient cannula and mounted to said second hub, and
an internal chamber in communication with said second hub passage, wherein said internal chamber is located within said second hub or is branched from said second hub passage, and wherein said internal chamber lacks direct communication to the exterior.

2. The blood collection set of claim 1, wherein said second hub further comprises a male luer and a non-patient thread assembly, which form said internal chamber.

3. The blood collection set of claim 1, wherein said internal chamber communicates with said second hub passage beyond said proximal end of said non-patient cannula.

4. The blood collection set of claim 1, further comprising a one way valve, wherein said one way valve inhibits an outflow of air or fluid from said internal chamber.

5. The blood collection set of claim 4, wherein said one way valve is located within said internal chamber.

6. The blood collection set of claim 1, wherein upon venous access by said first needle cannula, venous pressure causes blood to flow into said tubing passage, such that the total internal volume of said internal chamber and tubing passage results in a flash length of at least approximately 0.25 inches in linear distance in a proximal direction along said tubular passage from said first end of said flexible tubing.

7. The blood collection set of claim 1, wherein upon venous access by said first needle cannula, venous pressure causes blood to flow into said tubing passage, such that the total internal volume of said internal chamber and tubing passage results in a flash length of at least approximately 0.50 inches in linear distance in a proximal direction along said tubular passage from said first end of said flexible tubing.

8. The blood collection set of claim 1, wherein said internal chamber is branched from said second hub passage.

9. The blood collection set of claim 8, wherein said internal chamber is a Y branched internal chamber or a T branched internal chamber.

10. The blood collection set of claim 1, wherein the volume of said internal chamber is at least approximately 1.0 ml.

11. The blood collection set of claim 10, wherein said volume of said internal chamber is approximately 1.0 ml to approximately 3.0 ml.

12. The blood collection set of claim 11, wherein said volume of said internal chamber is approximately 1.0 ml to approximately 2.0 ml.

13. A blood collection set comprising;
a first needle assembly comprising a first hub and a first cannula having a lumen therethrough, wherein said cannula is mounted to said first hub,
a length of flexible tubing having opposite first and second ends and a tubing passage extending between said ends, said first hub located proximate said first end for providing communication between said lumen of said first cannula and said tubing passage,
a second hub located proximate said second end and having a passage extending therethrough, said second hub passage being in fluid communication with said tubing passage,
a non-patient cannula having opposite proximal and distal ends and a lumen extending between said ends, said distal end of said non-patient cannula being mounted to said second hub such that said lumen through said non-patient cannula communicates with said second hub passage,
a multiple sample sleeve covering said non-patient cannula and mounted to said second hub, and
an internal chamber in communication with said second hub passage, wherein said internal chamber is located within said second hub or is branched from said second hub passage, and wherein said internal chamber lacks direct communication to the exterior,
wherein upon on venous access by said first needle cannula, venous pressure causes blood to flow into said tubing passage, such that the total internal volume of said internal chamber and tubing passage

results in flash being observed within said flexible tubing.

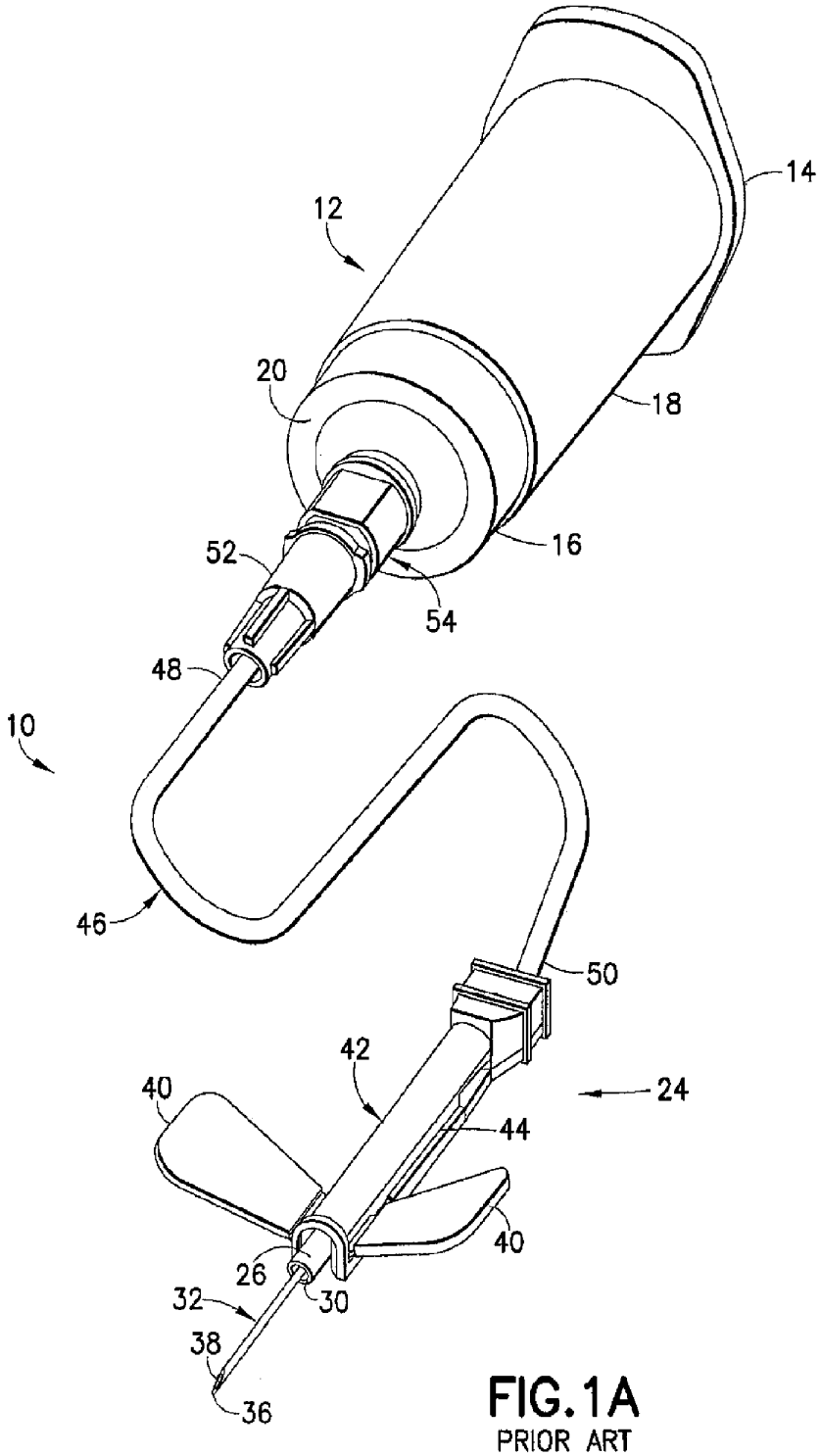


FIG. 1A
PRIOR ART

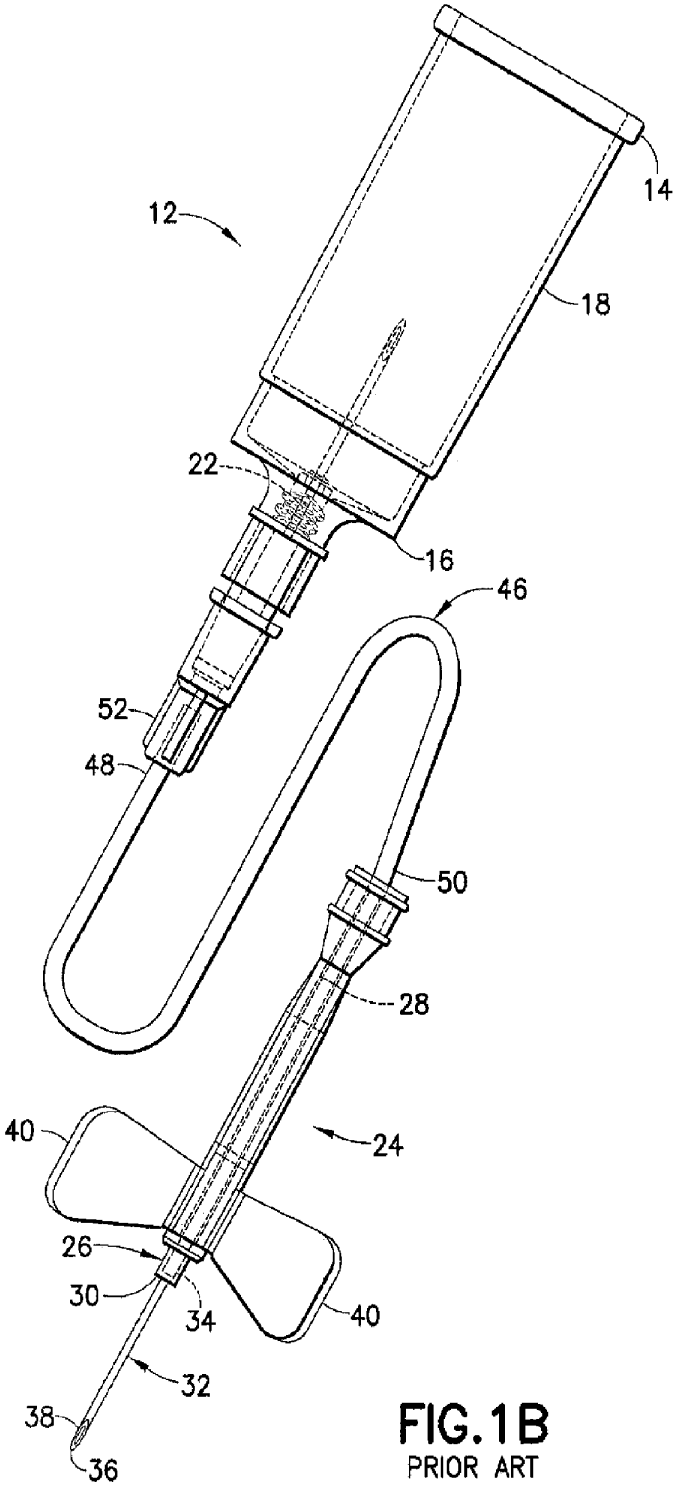


FIG.1B
PRIOR ART

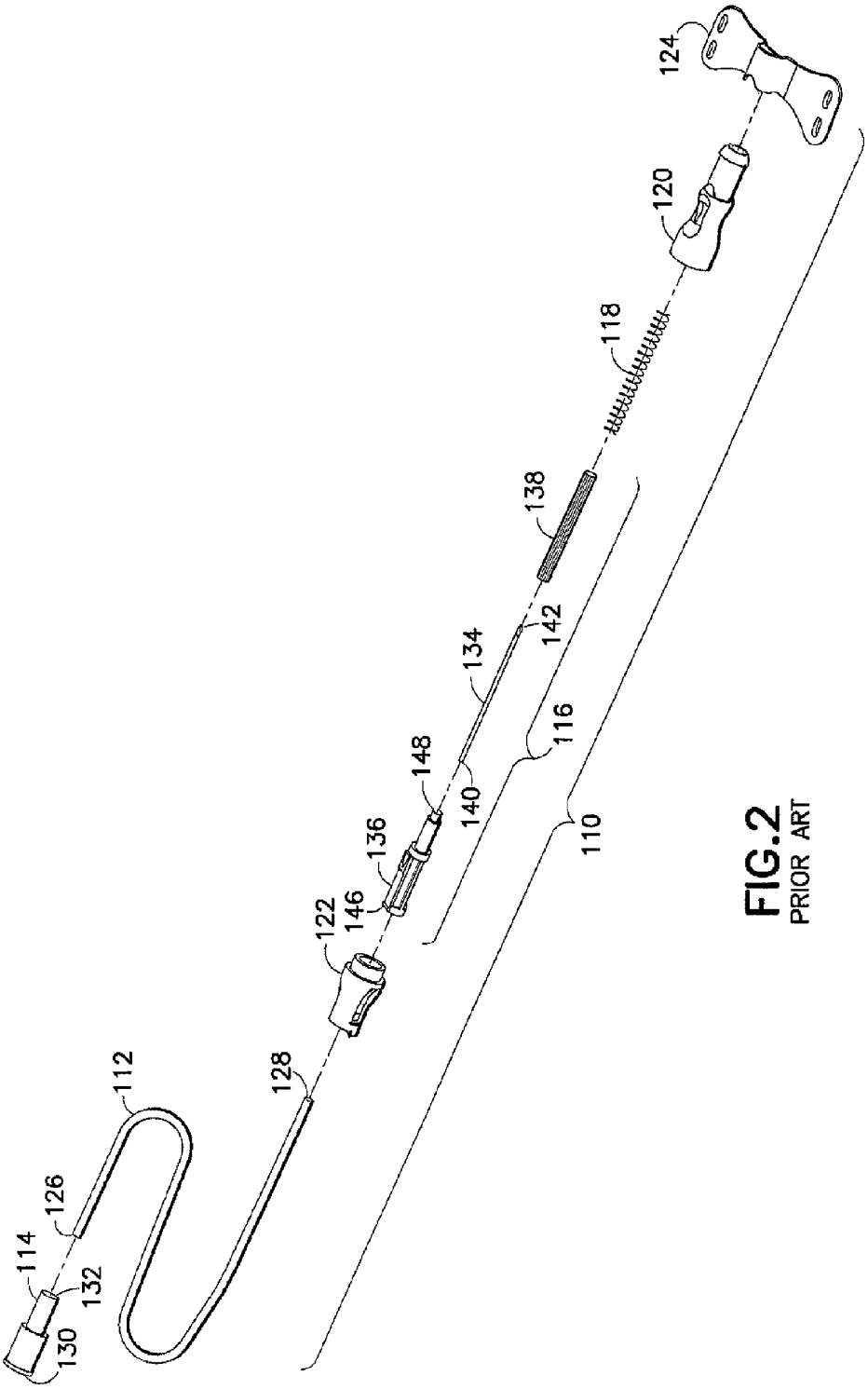


FIG.2
PRIOR ART

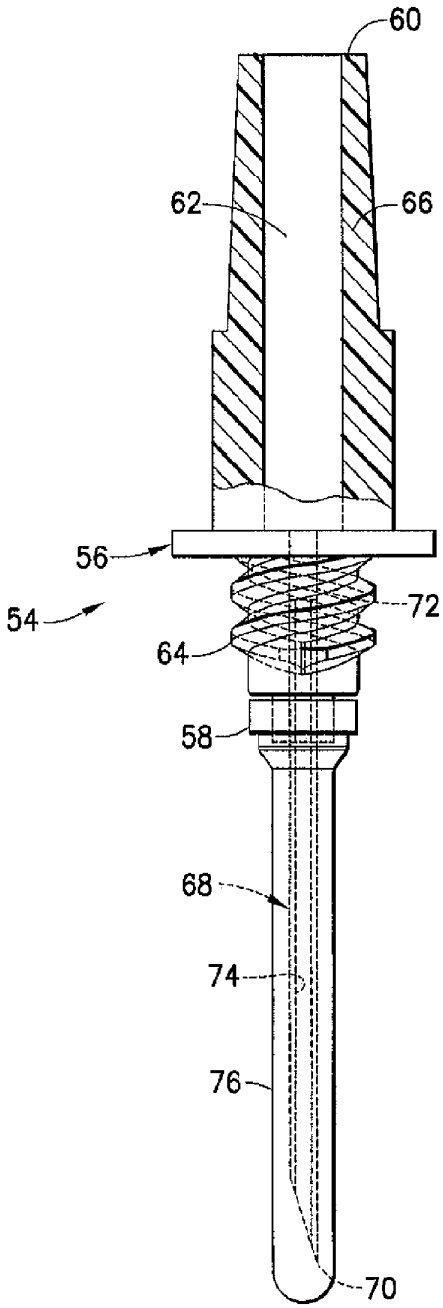


FIG.3
PRIOR ART

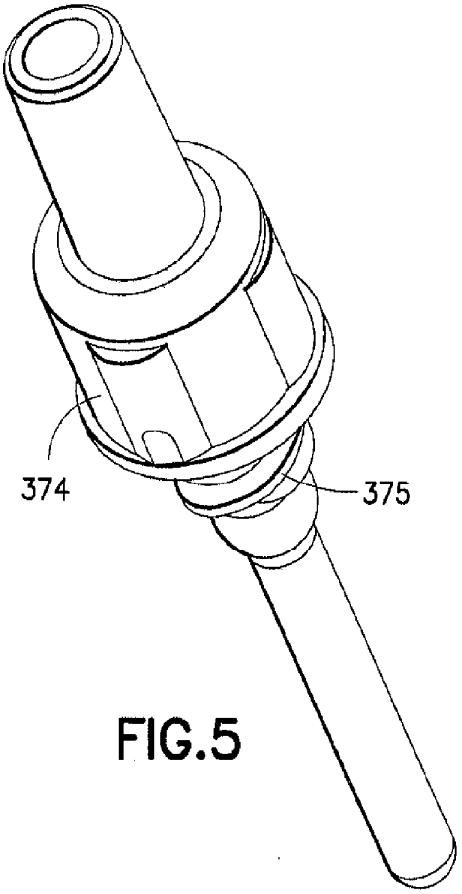

374
375

FIG.5

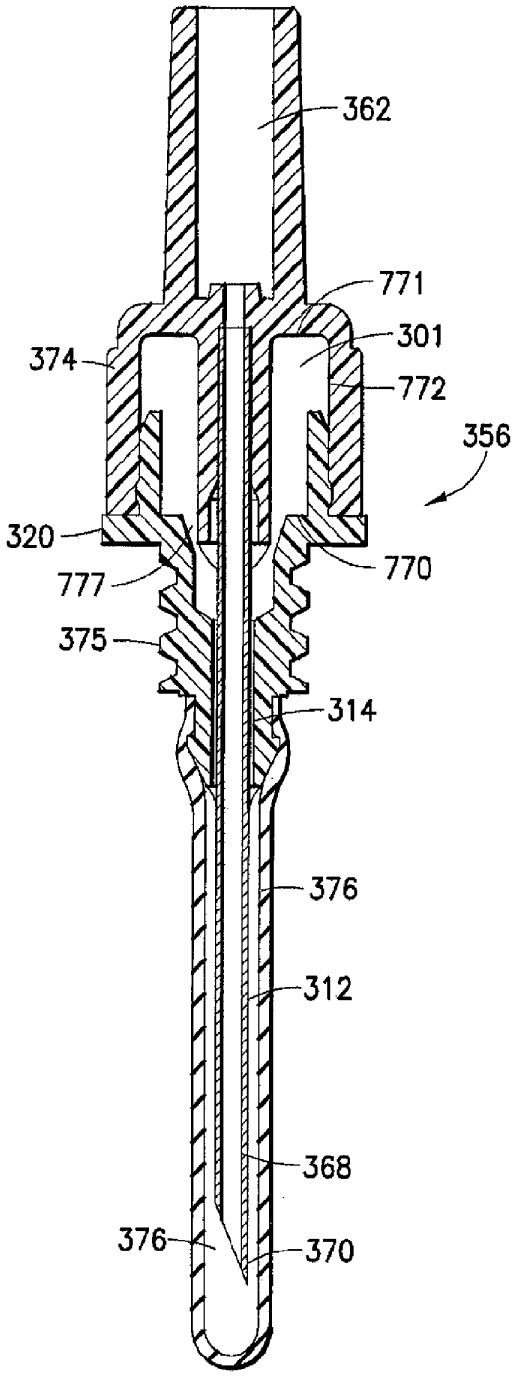

362
771
301
374
772
356
320
770
777
375
314
376
312
368
376
370

FIG.4

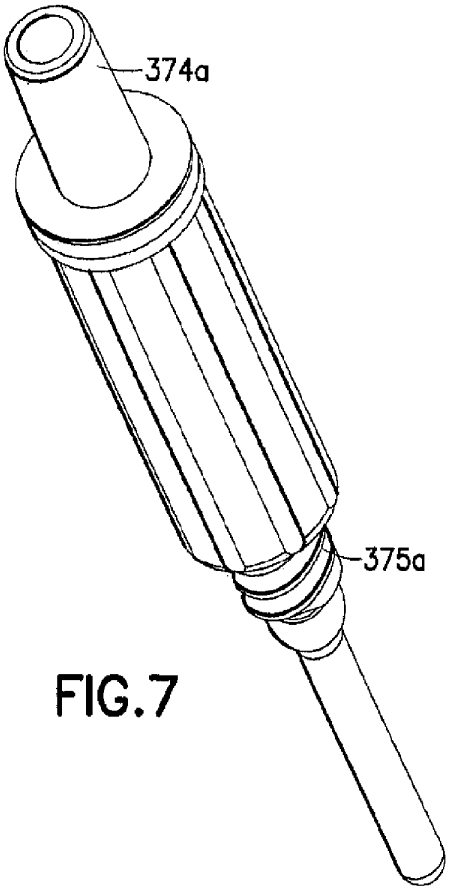

374a
375a

FIG.7

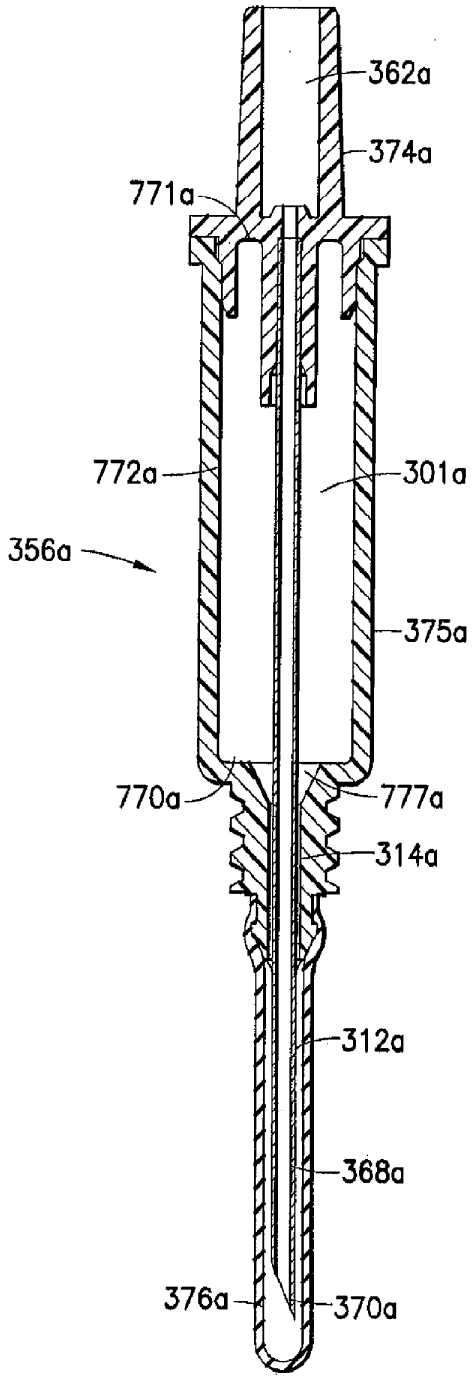

362a
374a
771a
772a
301a
356a
375a
770a
777a
314a
312a
368a
376a
370a

FIG.6

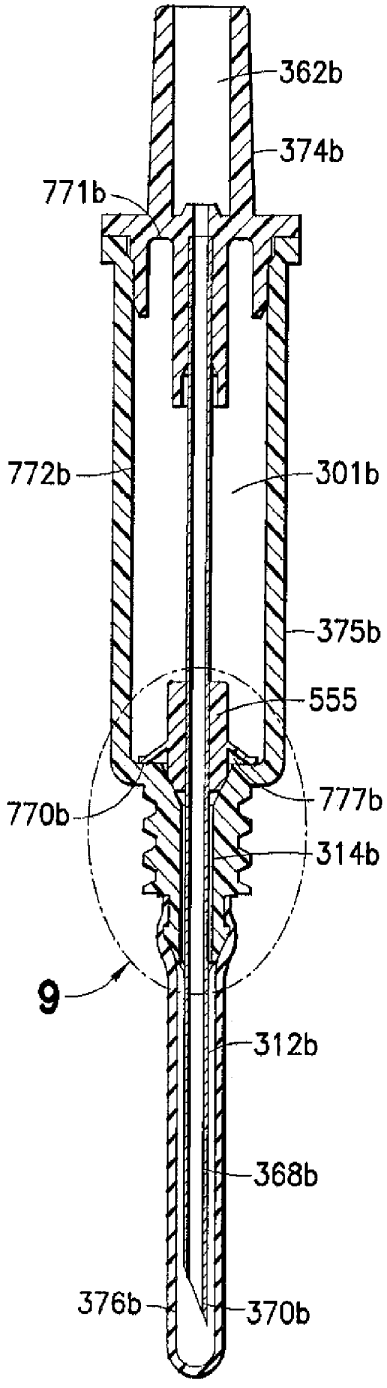

362b
374b
771b
772b
301b
375b
555
770b
777b
314b
9
312b
368b
376b
370b

FIG.8

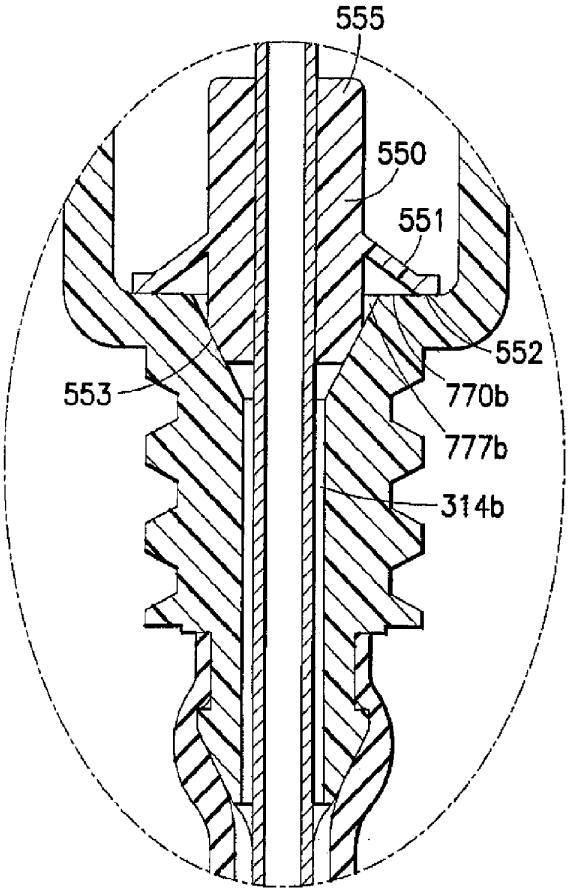

555
550
551
552
553
770b
777b
314b

FIG.9

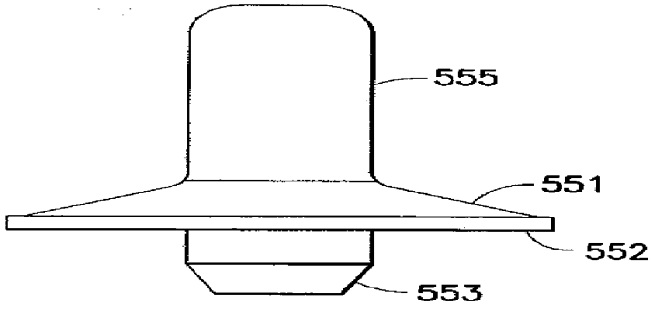


FIG. 10

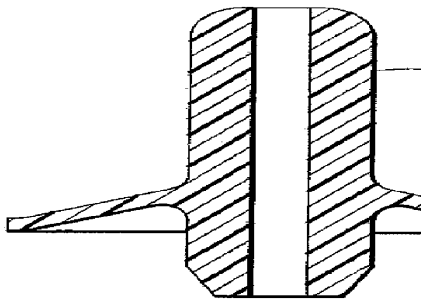


FIG. 12

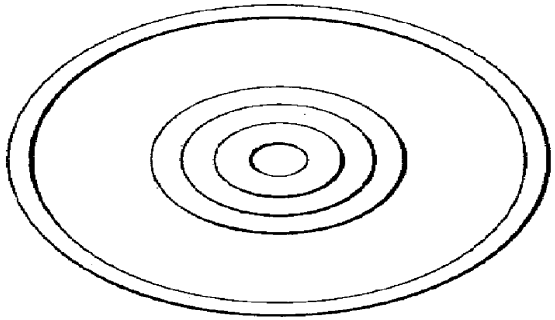


FIG. 11

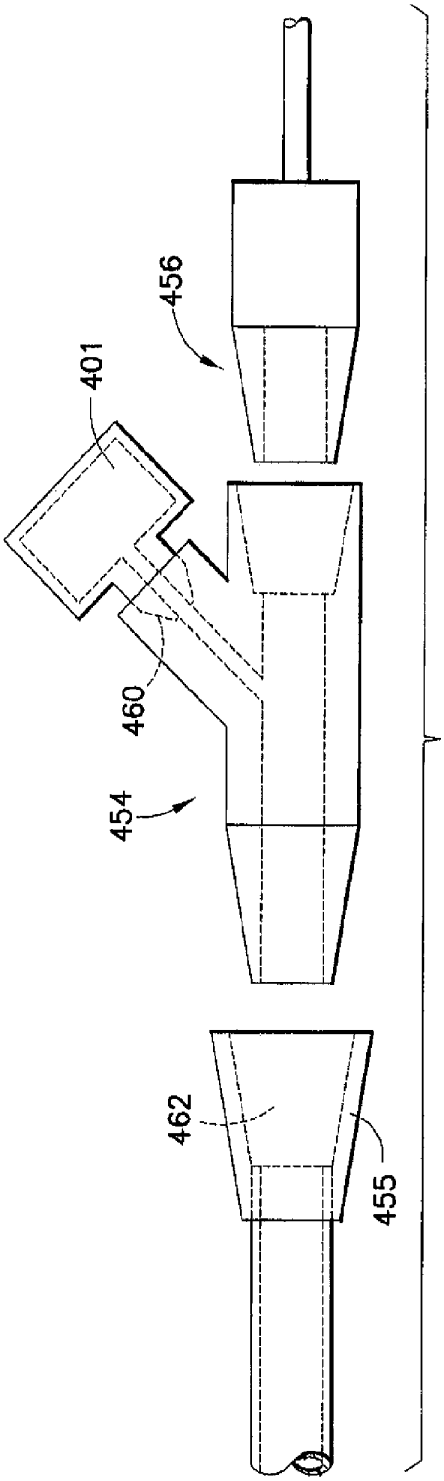


FIG.13

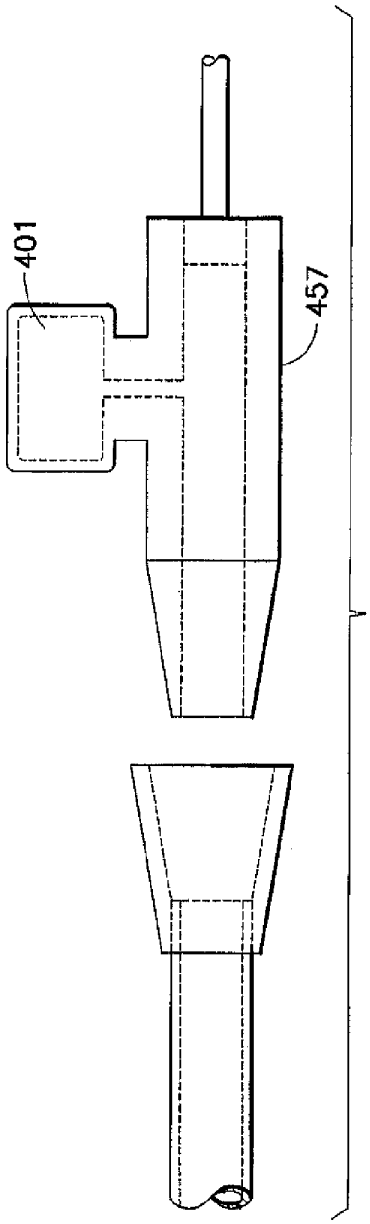


FIG.14

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 11 1371

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	US 6 261 263 B1 (HUET JEAN-MAX ET AL) 17 July 2001 (2001-07-17) * the whole document *	1-3,6-13	
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A61B
A61M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 March 2006	Ceccarelli, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 11 1371

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Patent 6643474

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(54) [Title of the invention] Blood sample optimization system and blood isolation device
(51) [International Patent Classification]
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A61B 5/154 (2006.01)
[FI]
A61B 5/15 200
A61B 5/154 200
[Number of Claims] 16
[Total Number of Pages] 39
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(86) (22) [Application date] July 22, 2016 (2016.7.22)
(65) [Publication number] Special table 2018-525191 (P2018-525191A) (43) [Publication d

e] September 6, 2018 (2018.9.6) (86) [International application number] PCT/US2016/043709 (87) [International publication number] WO2017/019552 (87) [International publication Date] February 2, 2017 (2017.2.2)

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(33) [Country/region or organization claiming priority] United States (US)
(31) [Priority claim number] 62/318,194
(32) [Priority date] April 4, 2016 (2016.4.4)
(33) [Priority claiming country/region or organization] United States (US)
(31) [Priority claim number] 62/196,797
(32) [Priority date] July 24, 2015 (2015.7.24)
(33) [Priority Country/Territory or Organization] United States (US)
(31) [Priority claim number] 15/140,448
(32) [Priority date] April 27, 2016 (2016.4.27)
(33) [Priority claim Country/region or organization] United States (US)
(31) [Priority claim number] 15/140,443
(32) [Priority date] April 27, 2016 (2016.4.27)
(33) [Priority claim country/ Region or institution] United States (US)
[Application subject to accelerated examination]
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(74) [Agent]
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[Name or name] Yuko Hara

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[Name] Rogers, Bobby
(72) [Inventor]
[Name] Kan, Gino
(72) [Inventor]
[Name] Detrov, John
[Examiner] Hirokatsu Shimizu
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(58) [Investigated field] (Int.Cl., DB name)
A61B 5/153-5/154

The scope of the claims open ----

(57) [Claims]
[Claim 1]
A blood sample optimization system, a blood
collection system,
a patient configured for venipuncture of a patient to allow withdrawal of a patient blood sample. a needle,
a blood collection path connected to said patient needle and configured to carry said blood sample, and a
sample configured to receive an evacuated blood collection tube for collecting and contain

g a subsequent portion of said blood sample. a blood isolation
device
connected along the blood collection path between the patient needle and the sample needl e, the inlet port
configured to receive the blood sample
; An isolation chamber connected to the inlet port and having a vent including an air perme able blood barrier for receiving said initial volume of blood sample and isolating at least a first portion of said initial volume of blood sample. a configured isolation chamber and a samplin g flow path having a proximal end connected to the inlet port and configured to receive a s ubsequent portion of the blood sample; the passageway and the inlet port are connected to th e blood sample

bypassing the isolation chamber and a first portion of the blood sample isolated in the isolatio n chamber and connecting the subsequent portion of the blood sample to the distal end of the sampling channel. an outlet port configured to direct a subsequent portion of the blood sampl e into the evacuated blood collection tube, the inlet port, the outlet port, the isolation chambe r and
the
blood sample optimization system, further comprising a housing containing and defining a sa mpling flow path; and a blood isolation device .
2.
The isolation chamber of the blood isolation device is at ambient air pressure, and wherein t he isolation chamber receives a first portion of the blood sample by patient blood pressure ov ercoming the ambient air pressure within the isolation chamber. 2. The blood sample optimiza tion system of claim 1. 3. The blood of claim 2, wherein said sample needle includes a seal p ierced by said evacuated blood collection tube to open access to said patient needle via said bl ood collection path and said sampling flow path
.
Sample optimization system.
4. The
blood isolation device of claim 3, wherein said sampling channel of said blood isolation devic e permits a subsequent portion of said blood sample to enter said inlet port under vacuum pre ssure by said evacuated blood collection tube opening said sample needle. blood sample opti mization system.
5.
The blood sample optimization system of claim 1, wherein said air permeable blood barrier o f said blood isolation device comprises an air permeable material that seals upon contact wit

blood.

[Claim 6]

3. The blood sample optimization system of Claim 1, wherein the blood collection path of the blood collection system comprises a tube.

7. A

patient needle configured to enable removal of a blood sample from a patient and a sealed s ample needle, wherein the sample needle is unsealed and the blood sample adapted to be re moved from the patient. a blood isolation device connected to a blood collection system comp rising a sample needle adapted to receive an evacuated blood collection tube

for receiving a blood sample from a patient connected to said patient needle; an isolation ch amber having a configured inlet port,

an outlet port connected to the inlet port, and

a vent connected to the inlet port and including an air permeable blood barrier, wherein the sample needle is connected to the vacuum an isolation chamber configured to receive and isol ate a first portion of the blood sample before it is opened by a blood vessel; and a proximal e nd connected to the inlet port for receiving subsequent portions of the blood sample

. a sampling channel configured to receive said isolation chamber

,

said sampling channel and said inlet port are adapted to receive said blood sample with subs equent portions of said blood sample isolated within said isolation chamber and said isolation chamber. and to direct subsequent portions of the blood sample to the outlet port connected t o the distal end of the sampling channel, said inlet port, said outlet

port , a blood isolation device, further comprising a housing containing and defining said isol ation chamber and said sampling channel.

[Claim 8]

8. The blood isolation device of claim 7, wherein the isolation chamber is at ambient air pres sure and the isolation chamber receives an initial portion of the blood sample by patient blood pressure overcoming the ambient air pressure within the isolation chamber.

[Claim 9]

8. The blood isolation device of Claim 7, wherein the air permeable blood barrier comprises a n air permeable material that seals upon contact with blood.

10.

The blood isolation device of claim 7, wherein said isolation chamber includes an isolation ch annel defined within said housing.

11.

A blood sample optimization system, a blood

collection system, comprising:

a patient needle configured for venipuncture of a patient to enable withdrawal of a patient blood sample; and a patient

needle connected to the patient needle. a blood collection system comprising: a blood colle ction path configured to carry said blood sample; and a sample needle

configured to receive an evacuated blood collection tube for withdrawing and containing a s ubsequent portion of said blood sample; A blood isolation device connected along the blood co llection path between a patient needle and the sample needle, the inlet port configured to rec eive the blood sample, and a sample needle of the inlet port and the blood collection syste m . and an isolation chamber having a vent connected to the inlet port and including an air permeable blood barrier for receiving the initial volume of the blood sample and for removi ng the initial volume of the blood sample. an isolation chamber configured to isolate at least a first portion ;

a sampling channel having a proximal end connected to said inlet port and configured to re ceive a subsequent portion of said blood sample, said isolation chamber, said sampling channe l and said inlet port being connected to said blood
sample

; allowing a subsequent portion of the blood sample to bypass the isolation chamber and a first portion of the blood sample isolated within the isolation chamber and directing the subse quent portion of the blood sample to a distal end of the sampling channel; and a blood isolatio n device configured to direct the outlet port connected to a

blood vessel and further comprising a housing containing and defining the inlet port, the ou tlet port, the isolation chamber and the sampling flow path.
Sample optimization system.
12.
The isolation chamber of the blood isolation device is at ambient air pressure, and wherein t he isolation chamber receives a first portion of the blood sample by patient blood pressure ov ercoming the ambient air pressure within the isolation chamber. 12. The blood sample optimiz ation system according to 11.
13.
The blood sample optimization system of claim 11, wherein said sample needle includes a se al pierced by said evacuated blood collection tube to open access to said patient needle via sai d blood collection pathway.
14.
The blood sample optimization system of claim 11, wherein said air permeable blood barrier of said blood isolation device comprises an air permeable material that seals upon contact wit h blood.

15.

The blood sample optimization system of claim 11, wherein said isolation chamber includes a n isolation flow path defined within said housing.

[Claim 16]

12. The blood sample optimization system of Claim 11, wherein the blood collection path of t he blood collection system includes a tube.

detailed description open —

[Detailed description of the invention]

[Background art]

CROSS

-REFERENCE TO RELATED APPLICATIONS

This application is based on US Nonprovisional Application Serial No. 15/140,443, entitled "B lood Sample Optimization System and Blood Contaminant Isolation Apparatus and Method," fil ed April 27, 2016. and U.S. nonprovisional application Ser. and both of these U.S. nonprovisio nal applications are U.S. Provisional Patent Application Serial No. 62/196,797, entitled "Blood Culture Improvement Systems and Methods," filed on Jul. 24, 2015, dated Oct. 7, 2015; U.S. Provisional Application No. 62/238,636, entitled "Blood Isolation System for Clean Blood Colle ction," filed on April 4, 2016, and "Blood Sample Optimization System and Blood Contaminant Isolation Device and No. 62/318,194 entitled "Methods", the disclosure of which is hereby inc orporated by reference in its entirety.

Bacteremia

is the presence of microorganisms in the blood. Sepsis, on the other hand, is bacteremia wit h clinical symptoms and signs such as fever, tachycardia, tachypnea and hypotension. Bactere mia and sepsis are associated with high mortality, hospitalization incidence and length of stay and associated costs. Many bacteremia, sepsis, fungemia, and other pathogens do occur withi n hospitals or other medical facilities, and catheters and venipunctures are sources of contami nation as potential carriers of these pathogens.

[0003]

Blood cultures are the standard test used to detect microbial pathogens associated with bact eremia and sepsis in the blood of patients. The term blood culture refers to a single venipunct ure from a peripheral site or central or arterial line in which blood is inoculated into one or mo re blood culture bottles or vessels. One bottle is considered one blood culture and two or mor e are considered a set. Multiple sets are obtained from multiple venipunctures and are associa ted with different sites in the patient.

[0004]

Although these methods enable microbial identification and susceptibility testing, which are important factors in the management of sepsis, their lack of rapid results and low sensitivity to nasty pathogens pose challenges for improvement. This has led to the development of refined systems and adjunctive molecular or proteomics tests.

[0005]

The collection of blood samples for blood culture is an important component of modern patient care, both positively impacting patient outcome by providing an accurate diagnosis and eliminating unnecessary antimicrobial therapy. It can also adversely affect outcomes by prolonging morbidity, lengthening hospital stays, and increasing costs.

One

consequence of blood culture collection is contamination. Contamination of blood cultures can lead to false positive culture results and/or significantly increased healthcare-related costs. Sources of blood culture contamination include inadequate skin disinfection, inadequate collection tube disinfection, and contamination of the initial blood draw, which can skew results.

[0007]

Blood culture collection kits generally include "butterfly" sets, infusion sets, or other types of venipuncture devices provided by companies such as BD, Smith, and B.Brown, as well as aerobic and anaerobic blood culture bottles. Consists of a bottle and A variety of different bottles are also available depending on inspection requirements. These bottles are specially designed to optimize the collection of both aerobic and anaerobic organisms. In conventional kits, the bottle used is commonly known as a "vacutainer", which is used to create a vacuum inside the tube to facilitate the collection of a predetermined amount of liquid, such as blood. A blood collection tube formed from a sterile glass or plastic tube with a lid that is evacuated to a vacuum.

[0008]

False positive blood cultures are generally the result of poor sampling techniques. They cause antibiotics to be used when they are not needed, increasing hospital costs and patient anxiety. Blood cultures are taken from a needle prick into the skin, after which a Vacutainer® is attached to take a sample of blood. Contamination can result from improper or incomplete disinfection of the puncture site and the surrounding skin area. It can also result from the piercing of the skin by the needle during insertion, which draws pierced skin cells and associated contaminants into the sample.

[0009]

Blood flow through a hypodermic needle is laminar, which causes a flow velocity gradient across the flow tube when a pressure drop is applied across the hypodermic needle. Strong aspiration of blood or use of a very small hypodermic needle can cause lysis and release of potassium from red blood cells, thereby making the blood sample abnormal.

[0010]

In another example, some patients have delicate veins that are subject to pressure drops or vacuums, such as those exerted by the plunger of a syringe that is withdrawn too rapidly, esp ecially for the patient's condition. can collapse under Such venous collapse is dangerous and v ery difficult to control because such a condition cannot be known in advance. Various strateg ies have been implemented to reduce the contamination rate of blood cultures, such as staff t raining in sterile collection techniques, feedback on contamination rates, and the introduction of blood culture collection kits

.

Skin antisepsis can reduce contamination concerns, but more than 20% of skin microbes are l ocated deep in the dermis and are not affected by antisepsis. Changing needles prior to bottle inoculation is not recommended as it increases the risk of needlestick injuries without reducin g contamination rates.

[0012]

Some conventional systems and techniques for reducing contamination of blood cultures inv olve discarding the initial aliquot of blood drawn from central venous catheters, venous punctu res and other vascular access systems. However, these systems either require the user to me chanically manipulate the intravascular device or require a complex series of steps that are dif ficult to ensure.

SUMMARY OF THE INVENTION

[

0013]

The present specification presents systems and methods for reducing blood culture contamin ation, cell lysis, and venous collapse. In some implementations, the systems and methods can eliminate variability in user disinfection and also eliminate the risk of skin cells entering blood culture samples. The systems and methods disclosed herein potentially indicate when to attac h a Vacutainer® or other blood collection device (i.e., a syringe) to obtain a contaminant-free blood sample. , does not require changes to existing clinical processes. In some implementat ions of the systems and methods disclosed herein, blood sampling is accomplished passively t hrough the use of the patient's own blood pressure, thereby reducing the risk of venous collap se and reducing current practice

.

eliminates further user steps beyond The system and method can be adapted to suit short-pat h direct puncture or butterfly venipuncture systems. It can also be used with samples taken t hrough a catheter. Means

for Solving the Problems

In one aspect, a blood isolation device is presented. A blood isolation device includes an inlet port and an outlet port. The blood isolation device further includes an isolation chamber conne cted to the inlet port, the isolation chamber having a vent including an air permeable blood b

rrier. The blood isolation device has a proximal end connected with the inlet port and a distal e nd connected with the outlet port, a sampling channel
further includes

[0016]

In another aspect, a blood isolation device is described that is connected to a blood collectio n path. The blood collection path has a patient needle and a sample collection device. The blo od isolation device includes an entry port connected to the patient needle and an isolation cha mber connected to the entry port, the isolation chamber having a vent including an air perme able blood barrier. The blood isolation device further includes a sampling channel having a pro ximal end connected to the inlet port, and an outlet port connected to the distal end of the sa mpling channel and the sample collection device.

[0017]

In yet another aspect, a blood isolation device is described that interfaces with a blood collec tion system. The blood collection system includes a patient needle for allowing a blood sample to be drawn from a patient and a sample needle that is sealed and adapted to receive an evac uated blood collection tube. A blood isolation device includes an inlet port connected to a patie nt needle for receiving a blood sample from a patient. A blood isolation device is an isolation c hamber connected to an inlet port and having a vent containing an air permeable blood barrie r for receiving and receiving an initial portion of a blood sample before the sample needle is o pened by an evacuated blood collection tube. Further includes an isolating isolation chamber. The blood isolation device further includes a sampling channel having a proximal end connect ed to the inlet port for carrying a subsequent portion of the blood sample when the sample ne edle is opened by the evacuated blood collection tube. The blood isolation device further inclu des an exit port connected with the distal end of the sampling channel for carrying subsequen t portions of the blood sample to the sample needle.

[0018]

In yet another aspect, a blood sample optimization system is disclosed and described. The bl ood sample optimization system includes a blood collection system for enabling and obtaining one or more samples of a patient's blood and false positive identification of pathogens in the p atient's blood that may have been contaminated by the venipuncture process. a blood isolatio n device for receiving and isolating an initial portion of one or more samples of the patient's bl ood that may result in

A

blood collection system includes a patient needle configured for venipuncture of a patient to enable withdrawal of a sample of the patient's blood, a blood collection channel connected to t he patient needle for carrying the blood sample, and a blood sample. and a sample needle co nfigured to receive an evacuated blood collection container for collecting and containing a sub sequent portion of the blood sample.

[0020]

In yet another aspect, a blood isolation device is disclosed and described. In some implementations, a blood isolation device can include an inlet port, an outlet port connected to the inlet port, and an isolation chamber connected to the inlet port. The isolation chamber can have a vent containing an air permeable blood barrier.

[0021]

A blood isolation device is connected along the blood collection path between the patient needle and the sample needle and includes an entry port for receiving the blood sample. A blood isolation device is an isolation chamber connected with an inlet port for receiving an initial volume of blood sample and includes an air permeable blood barrier to isolate at least a first portion of the initial volume of blood sample. Further includes an isolation chamber having a vent. The blood isolation device is a sampling channel having a proximal end connected with the inlet port, the isolation chamber isolating at least a first portion of a first volume of blood sample and a subsequent volume of blood sample into the evacuated blood collection container. It further includes a sampling channel that carries to. The blood isolation device further includes an outlet port connected to the distal end of the sampling channel for outputting a subsequent volume of the blood sample. The details of one or more embodiments are set forth in the accompanying drawings and the description below

.

Other features and advantages will be apparent from the specification and drawings, and from the claims.

[Brief description of the drawing]

These and other aspects will now be described in detail with reference to the following drawings .

1 shows a blood sample optimization system; FIG.

FIG. 2 shows a blood sample optimization system according to an alternative implementation;

FIG. 3 shows a blood sample optimization system according to another alternative implementation;

FIG. 4 shows a blood sample optimization system according to another alternative implementation;

FIG. 5 shows a blood sample optimization system according to another alternative implementation;

FIG. 6 shows a blood sample optimization system according to an alternative implementation;

FIG. 7 is a flowchart of a method for optimizing blood culture quality;

FIG. 8A illustrates a blood isolation system for non-contaminated blood collection, according to some implementations;

FIG. 8B illustrates a blood isolation system for clean blood collection, according to some implementations.

FIG. 8C illustrates a blood isolation system for clean blood collection, according to some imp

mentations;

FIG. 8D illustrates a blood isolation system for clean blood collection, according to some implementations.

FIG. 8E illustrates a blood isolation system for clean blood collection, according to some implementations.

FIG. 9 shows a path splitter for use in a blood sequestration system;

FIG. 10A shows a blood isolation system for non-contaminated blood collection according to an alternative implementation;

FIG. 10B shows a blood isolation system for non-contaminated blood collection according to an alternative implementation;

FIG. 10C shows a blood isolation system for non-contaminated blood collection according to an alternative implementation;

FIG. 10D shows a blood isolation system for non-contaminated blood collection according to an alternative implementation;

FIG. 11A shows a blood isolation system for non-contaminated blood collection according to another alternative implementation;

FIG. 11B shows a blood isolation system for non-contaminated blood collection according to another alternative implementation;

FIG. 11C shows a blood isolation system for non-contaminated blood collection according to another alternative implementation;

FIG. 11D shows a blood isolation system for non-contaminated blood collection according to another alternative implementation;

FIG. 11E shows a blood isolation system for non-contaminated blood collection according to another alternative implementation;

FIG. 12A shows a blood sample optimization system including a blood isolation device according to yet another alternative implementation;

12B shows a blood sample optimization system including a blood isolation device according to yet another alternative implementation; FIG.

FIG. 12C shows a blood sample optimization system including a blood isolation device according to yet another alternative implementation;

FIG. 12D shows a blood sample optimization system including a blood isolation device according to yet another alternative implementation;

FIG. 13A shows blood sample optimization system 1300 according to yet another alternative implementation.

FIG. 13B shows blood sample optimization system 1300 according to yet another alternative implementation.

FIG. 13C shows blood sample optimization system 1300 according to yet another alternative implementation.

FIG. 13D shows blood sample optimization system 1300 according to yet another alternative

mplementation.

FIG. 14A illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14B illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14C shows yet another implementation of a blood collection system that isolates contami nants in the initial aliquot or sample to reduce false positives in blood cultures or tests perfor med on patient blood samples.

FIG. 14D illustrates yet another implementation of a blood collection system that isolates cont aminants in the initial aliquot or sample to reduce false positives in blood cultures or tests per formed on patient blood samples.

FIG. 14E further illustrates a blood collection system that isolates contaminants of an initial ali quot or sample to reduce false positives in blood cultures or tests performed on patient blood samples.

Show another implementation.

15A-B illustrate a blood isolation device and method of using the same according to yet anoth er implementation.

15B illustrates a blood isolation device and method of using the same according to yet anothe r implementation; FIG.

FIG. 15C illustrates a blood isolation device and method of using the same according to yet an other implementation;

FIG. 15D illustrates a blood isolation device and method of using the same according to yet an other implementation;

FIG. 15E illustrates a blood isolation device and method of using the same according to yet an other implementation;

Figure 15F illustrates a blood isolation device and method of using the same according to yet another implementation;

FIG. 15G shows a blood isolation device and method of using the same according to yet anoth er implementation;

FIG. 16A shows a blood isolation device according to yet another implementation;

16B shows a blood isolation device according to yet another implementation; FIG.

16C shows a blood isolation device according to yet another implementation; FIG.

16D shows a blood isolation device according to yet another implementation; FIG.

Figure 17A shows a lower member of a housing for a blood isolation device;

Figure 17B shows a lower member of a housing for a blood isolation device;

Figure 17C shows a lower member of a housing for a blood isolation device;

Figure 17D shows a lower member of a housing for a blood isolation device;

Figure 17E shows a lower member of a housing for a blood isolation device;
Figure 18A shows a top member of a housing for a blood isolation device;
Figure 18B shows a top member of a housing for a blood isolation device;
Figure 18C shows a top member of a housing for a blood isolation device;
Figure 18D shows a top member of a housing for a blood isolation device;
Figure 18E shows a top member of a housing for a blood isolation device;
Figure 18F shows a top member of a housing for a blood isolation device;
Figure 19A shows a blood isolation device having an upper member that mates with a lower member.
Figure 19B shows a blood isolation device having an upper member that mates with a lower member.
FIG. 20 shows a blood sample optimization system including a blood sequestration device;
Figure 21 shows a non-vented blood isolation device using a wicking material chamber.
Figure 22A shows the material composition of a filter for isolating blood in an isolation chamb er of a blood isolation device;
Figure 22B shows the material composition of a filter for isolating blood in an isolation chamb er of a blood isolation device;
FIG. 23A shows another implementation of a blood isolation device using vacuum force from a blood collection device;
Figure 23B shows another implementation of a blood isolation device using vacuum force from a blood collection device. Like numbers in the various drawings indicate like elements.
DETAILED DESCRIPTION OF THE INVENTION
[0024]
The present specification provides a blood sample optimization system that reduces or elimin ates contaminants in a blood sample taken, thereby reducing or eliminating false positive read ings in blood cultures or other tests of the blood sample taken. and methods. In some implem entations, the blood sample optimization system includes a patient needle for vascular access to the patient's bloodstream and a blood collection container such as a vacutainer or evacuate d blood collection tube or other and a blood isolation device positioned between the patient ne edle and the sample needle. The blood isolation device includes an isolation chamber for isolat ing a first aliquot of blood that may be contaminated, and after the first aliquot of blood is isol ated in the isolation chamber, the blood is isolated between the patient needle and the sample needle. A sampling flow path bypassing the isolation chamber for carrying potentially unconta minated blood may also be included.
FIG .
1 shows a blood sample optimization system according to some implementations. The syste m includes a patient needle 1 for puncturing the patient's skin to access the patient's vein and intravenous blood therein. The system may include a resealable boot 10, a luer actuated valv e, or another sampling interface.

or with a sample needle (i.e., a Vacutainer®, etc.) that can be housed within the device and i nitially sealed by a resealable boot 10, a luer-actuated valve, or another collection interface or device. It further includes a resealably sealed needle) 5 for. The resealable boot 10 can be pus hed by or around the sample needle 5 by using a Vacutainer® bottle (not shown) for collectin g the patient's blood. The system can further include a low volume chamber 30 leading to the sample needle 5, but also includes a hole or one or more channels 45 leading to the isolation chamber 55 formed by the housing 50. FIG. Isolation chamber 55 includes chambers, chann els, passages for receiving and holding an initial aliquot of patient blood, which can be of a pr edetermined or measured volume, depending on the volume of isolation chamber 55

.

, locks, or other structures. Initial blood draws generally contain or are more susceptible to co ntain microorganisms or other pathogens that cause bacteremia and sepsis than subsequent blood draws. The isolation chamber 55 can be contained within a rigid housing, can be a conta iner formed in or defined by the housing itself, or can be realized as a tube or lumen. Isolation chamber 55 can have a predetermined volume, regardless of how it is formed and implement ed. In some implementations, the predetermined volume is based on the volume of the patien t needle, i.e., ranges from a volume less than the volume of the patient needle to any volume to a volume greater than 20 times the volume of the patient needle. can be done. The predet ermined volume of isolation chamber 55 can also be set to conserve or minimize the amount of blood that is isolated and disposed of.

[0027]

Isolation chamber 55 may be formed, contained, or housed within chamber housing 50 and may be made of plastic, rubber, steel, aluminum, or other suitable material. For example, isol ation chamber 55 can be formed from flexible tubing or other elastomeric material. The isolati on chamber 55 further includes an air permeable blood barrier 20 that allows air to exit the is olation chamber 55 . As used herein, the term "air permeable blood barrier" means an air per meable but substantially blood impermeable substance, material or structure. Representative examples are hydrophobic membranes and hydrophobic coatings, hydrophilic membranes or h ydrophilic coatings in combination with hydrophobic membranes or coatings, meshes, filters, mechanical valves, antimicrobial materials, or isolation chamber 55 is blood. Any other means capable of expelling air from the isolation chamber 55 when filled with air may be included. In various exemplary embodiments, the air permeable blood barrier can be formed by one or mo re materials that allow air to pass through until it contacts liquid, such materials being air per meable. and/or completely or partially sealed to prevent or block the passage of liquids. In ot her words, the material forms an air permeable barrier prior to contact with the liquid. After c ontact with liquid, the material substantially or completely prevents further passage of air an d/or liquid.

[0028]

Holes or channels 45 can be of any desired length, cross-sectional shape or size and/or can

be formed away from low volume chamber 30 at any desired angle or orientation. The hole or channel 45 may also include a one-way flap or valve 60 that retains the first aliquot of blood sample within the isolation chamber 55 . In some particular implementations, hole or channel 45 may include a "duckbill" valve or flapper valve 60 or the like for unidirectional blood flow from low volume chamber 30 to isolation chamber 55 . Air permeable blood barrier 20 may also be constructed of a material that allows air to escape but seals upon contact with blood, thereby not allowing outside air to enter isolation chamber 55 . This seal eliminates the need for valves.

Valve 60

can be any type of valve or opening/closing mechanism. The chamber 30 is designed to retain substantially no residual blood and retains a specific volume or percentage of blood in the isolation chamber.

It can be configured to hold or pass through the member 55 . Similarly, the isolation chamber 55 may also include any type of coating, such as an antimicrobial coating, or a coating that assists in identifying and/or diagnosing components of the isolated primary blood draw. Housings 50 and 40 may be formed from any suitable material, including plastics such as acrylonitrile butadiene styrene (ABS) or other thermoplastic or polymeric materials, rubber, steel, or aluminum

.

The air permeable blood barrier 20 is activated upon contact with blood from the first draw or when the expulsion of air is stopped, or upon any combination of events and blood in the isolation chamber 55, color A donator or other signaling mechanism may be included. The air permeable barrier can also include an outer layer such as a hydrophobic membrane or cover that inhibits or prevents inadvertent or premature sealing of the filter by external fluid sources, splashes, and the like. The isolation chamber 55 can also be translucent or transparent to allow the user to visually confirm that the chamber has been filled.

[0031]

FIG. 2 shows a blood sample optimization system according to some alternative implementations. In the implementation shown in FIG. 2, an isolation chamber 55 or waste chamber surrounds the patient needle 1 and an open-ended cuff or housing is connected to the waste chamber and surrounds the sample needle housing base and housing. The patient needle 1 and the sample needle 5 are connected to each other by a boot 56 which forms a continuous blood collection flow path therethrough. Boot 56 includes a single hole or channel leading from the blood collection channel to isolation chamber 55 . The device can include multiple holes or channels in other implementations. Each hole or channel can include a one-way valve and can be sized and adapted for a predetermined amount of blood flow.

Isolation

chamber 55 contains an air permeable blood barrier. The filter may further include sensors or indicators, respectively, for sensing and/or indicating when a predetermined volume of bloc

has been collected in the isolation chamber 55 . The instructions alert the user to attach an ev acuated blood collection tube or bottle, such as a Vacutainer®, to the sample needle 5 . The h ousing for isolation chamber 55 can be of any size or shape and can include any type of mater ial to define an interior space or volume within the housing. The interior space is initially filled with air only, but can also be coated with agents or substances such as decontamination agen ts, coagulants, and the like. When the evacuated blood collection tube is attached to the samp le needle 5, blood automatically flows into the patient needle 1, through the blood collection c hannel and the sample needle 5 into the bottle. The sample needle 5 is covered by a resealabl e boot, coating or membrane that seals the sample needle when no blood collection bottle is a ttached to the sample needle.

[0033]

FIG. 3 shows a blood sample optimization system according to some alternative implementa tions. In the illustrated implementation, sample needle 5 is surrounded by a resealable boot o r membrane and is also connected to patient needle 1 . A blood flow path is formed through t he sample needle and the patient needle. The connection between the sample needle and the patient needle includes a 'T' or 'Y' connector 102 that includes a flow path, port or opening lea ding from the main blood flow path to the isolation chamber 104 .

The T or Y connector 102 includes a

flap or one-way valve and has holes sized and adapted for a predetermined flow rate of bloo d. The isolation chamber 104 can be formed from a tube or formed by a rigid housing and is i nitially filled with air. The isolation chamber 104 receives blood flowing out of the patient auto matically, ie, under pressure due to the patient's own blood pressure. The isolation chamber 1 04 preferably includes an air permeable blood barrier 106 at the distal end of the tube formin g the isolation chamber 104 and connected at the proximal end to the T or Y connector 102 . The T or Y connector 102 can branch at any desired angle for most efficient blood flow and to minimize or eliminate mixing of the initial aliquot of blood with the main blood sample. Minimi ze the interface between the openings and channels and the main blood channel

can be configured to In some alternative implementations, the sample needle can be attache d to any length of tubing whose opposite end is connected to a T or Y connector 102, as show n in FIG

.

can be done. The isolation chamber 104 can be of any shape or volume so long as the initial a liquot contains a predetermined amount of blood sample. The T or Y connector 102 can also in clude openings or channels parallel to the main blood flow channel. The air permeable blood b arrier may further include an indicator 107 or other mechanism to indicate when a predetermi ned amount of blood has been collected in the isolation chamber or when the released air has reached a certain threshold, i.e. zero. . The tube can also include a clip 109 that can be used t o pinch and prevent fluid flow through the tube. Once the air permeable blood barrier and pr imary chamber are sealed, the first aliquot of blood is confined to the isolation chamber 104

nd a vacuum blood collection tube, such as a Vacutainer® bottle, is attached to the sample ne edle to obtain a sample

.

5 is attached. The blood collection tube can be removed and the sample needle 5 resealed. An y number of subsequent blood collection tubes can be attached for additional blood draws or s amples. When all blood draws are completed, the system is discarded, leaving the first aliquot of blood trapped in isolation chamber 104 .

FIG.

5 shows a blood sample optimization system according to some alternative implementations. In the illustrated implementation, the sample needle 5 is connected by tubing to the patient n eedle. A "T" or "Y" connector 120 is added at any desired location along the tube to include an opening, port or flow path leading to isolation chamber 204, substantially as described above.

[0038]

FIG. 6 illustrates a blood sample optimization system according to some alternative impleme ntations in which an isolation chamber 304 configured as the primary collection flow path rece ives the first aliquot of blood and is provided adjacent to the blood collection flow path. show. The isolation chamber 304 can surround the blood collection channel, patient needle 1 and/or sample needle 5 . The primary collection channel may include T or Y connectors 120, or other types of openings or channels. The isolation chamber 304 includes an air permeable blood bar rier and, as described above, may also include an indicator of contact with fluid such as blood.

In some implementations, either or both of the patient needle 1 or the sample needle 5 can be replaced with luer lock male or luer lock female connectors

.

However, in various implementations, the connector at the sample needle end of the blood sa mple optimization system is first sealed and the first aliquot is transferred to an isolation cha mber pressurized with ambient air pressure and containing the air outlet of the air permeable blood barrier. Allows blood to be diverted. In this way, the system passively and automatically uses the patient's own blood pressure to overcome the ambient air pressure in the isolation c hamber, force air through the air permeable blood barrier, and replace the air in the isolation c hamber with blood.

[0040]

FIG. 7 is a flowchart of an exemplary method for optimizing blood culture quality. At 702, a c linician inserts a needle into a patient's vein. At 704, blood flows into the isolation chamber, fo rcing air within the isolation chamber out of the isolation chamber through the air permeable blood barrier. In some implementations, the volume of the isolation chamber is from less than 0.1 cubic centimeters (cc) to 5 cubic centimeters (cc) or more. The isolation chamber is sized and adapted to collect a second portion of the blood sample and other subsequent portions or a first portion of the blood sample that is more susceptible to contamination than subsequent collections. The isolation chamber has an air permeable blood barrier through which air can

e expelled by the blood expelled from the patient's veins so that such blood can be placed in a vacutainer for receiving and storing blood samples. ® or other bottle, it necessarily and auto matically flows into the isolation chamber before being drawn into or otherwise entering the b ottle.

As the isolation chamber fills, blood collects or otherwise contacts an air permeable blood ba rrier that blocks or prevents blood from passing through . At 706, once the blood contacts the entire internal surface area of the air permeable blood barrier, the air permeable blood barrier is closed and air no longer flows out or in. At 708, the clinician is provided an indication or can view the full chamber indicating that an evacuated blood collection tube, such as a Vacutainer ®, can be attached. The indicator may include visibility of the primary chamber to see if the p rimary chamber is full, eg, a blood barrier that changes color, or other indicator. Since the fill t ime of the isolation chamber may be substantially instantaneous, such an indication, if presen t, may simply be that the isolation chamber is filled. Before the evacuated blood collection tu be is attached, communication between the needle, the sampling channel, and the isolation c hamber is restricted by the sealing of the isolation chamber's blood barrier, thus allowing air t o re-enter the system through isolation

.

do not. Sealing of the communication path is accomplished by mechanical twisting or other ac tion, small hole or tortuous path, obviating the need for a separate valve or mechanical action or manipulation by the clinician. At 710, the evacuated blood collection tube is removed, a self -sealing membrane seals the sample needle, and at 712, a further subsequent evacuated bloo d collection tube can be attached. At 714, once the sample has been taken, the device is rem oved from the patient and discarded.

[0043]

Figures 8A-8E show an exemplary blood sample optimization system 800 for non-contaminat ed blood collection, according to some implementations. Blood sample optimization system 80 0 includes an entry port 802 that can be connected to tubing, a patient needle (or both), or ot her vascular or venous access device, and a first exit to isolation chamber tubing 806 and sa mple collection tubing. a path splitter 804 with a second exit to 808; One or both of isolation c hamber tube 806 and sample collection tube 808 can be formed from tubing. In some implem entations, isolation chamber tube 806 is sized to accommodate a specific amount of initial blo od sample. A sample collection tube 808 receives a blood sample once the isolation chamber t ube 806 is filled. The sample collection tube 808 can be connected to a Vacutainer® base or h ousing 810, or other blood sample collection device. Blood isolation system 800 further inclu des blood isolation device 812, which includes housing 818, shown in more detail in FIGS

.

or connected at either end to a non-contaminated sample collection tube 808 . The sampling f low path 820 can be curved through the housing 818 to better secure and stabilize the hous

g 818 in position along the clean sample collection tube 808 .

[0045]

Blood isolation device 812 further includes an isolation chamber 822 or other chamber conne cted with isolation chamber tube 806 . Isolation chamber 822 terminates in air permeable blo od barrier 824 . The air permeable blood barrier 824 can also include a coloring agent that ch anges to a different color upon full contact with blood as an indicator that a blood sample (i. e., non-contaminated blood sample) can be properly taken. . Other indicators such as small li ghts, sound generating mechanisms, etc. can be used. In some implementations, the air per meable blood barrier is positioned perpendicular to the orientation of isolation chamber 822, b ut may be positioned at any distance or orientation to conserve space and materials used for housing 818. be able to. Housing 818 and its contents can be formed from any rigid or semi-ri gid material or range of materials.

FIG.

9 illustrates a path splitter for use in, for example, blood sequestration systems such as thos e shown in FIGS. 8A-8E.

900 is shown. Path splitter 900 includes inlet port 902 , main conduit outlet port 904 and isola tion channel outlet port 906 . The entry port 902 can be connected to a main tube that is also connected to the patient needle system or directly to the patient needle. The main line outlet port 904 can be connected to a main line tube to a blood collection system, such as a Vacutai ner® base or housing, or directly to such a blood collection system. The isolation channel outl et port 906 can be connected to an isolation tube for receiving and isolating the first sample o f blood up to a measured volume or predetermined threshold. Alternatively, the isolation flow path outlet port 906 can connect to the isolation chamber. The isolation channel outlet port 90 6 is preferably angled from 20 to 70 degrees from the main conduit outlet port 904 while the main conduit outlet port 904 is preferably in line with the inlet port 902 . Once an initial blood sample of predetermined volume has been isolated in an isolation tube or isolation chamber a ccording to the mechanisms and techniques described herein, subsequent blood samples can f low into inlet port 902 and pass unobstructed. It flows out directly from the main conduit outl et port 904 . 10A-10D show blood isolation device 1000 according to another implementatio n

.

Blood isolation device 1000 includes inlet port 1002 , main outlet port 1004 , and isolation flo w port 1006 . Entry port 1002 can be connected with a patient needle or associated tubing. T he main exit port 1004 can be connected to a blood sampling device such as a Vacutainer®, a ssociated tubing, or a luer-actuated valve. An isolation flow port 1006 separates from the mai n exit port 1004 into an isolation chamber 1008 . In some implementations, isolation chamber 1008 is formed as a spiral channel within housing or other container 1001 .

[0048]

Isolation chamber 1008 is connected at its distal end to air permeable blood barrier 1010, s

bstantially as described above. Air within the isolation chamber 1008 is expelled by the first al iquot of blood directed into the isolation flow path port 1006 through the air permeable blood barrier 1010 . Once the isolation chamber 1008 is filled, further blood draws through the main exit port 1004 are accomplished and these samples are clean.

11A -

11E show blood isolation device 1100 according to another alternative implementation. Bloo d isolation device 1100 includes an inlet port 1102 similar to the inlet ports described above, a main outlet port 1104 and an isolation flow port 1106 separate from main outlet port 1104 and inlet port 1102 . The isolation flow port is connected to isolation chamber 1108 . In the i mplementation shown in FIGS. 11A-11E, the blood isolation device includes a base member 1 101 having a flow path therein that functions as an isolation chamber 1108 . The flow path ca n be formed as a tortuous path through the base member 1101 while the base member 1101 is shaped and shaped to rest on the patient's limb. A portion of isolation chamber 1108 may protrude from or near the top surface of the base member just prior to exiting air permeable blood barrier 1110 to serve as blood isolation indicator 1109

.

Indicator 1109 can be made of a transparent material or a material that changes color when i n contact with blood.

[0051]

In some implementations, the blood isolation device 1100 can include a blood collection devi ce 1120, such as a normally closed needle, Vacutainer® shield, or other collection device. Blo od collection device 1120 may be manufactured and sold with blood isolation device 1100 for efficiency and convenience so that the initial aliquot of blood that may be contaminated by the patient needle insertion process can be isolated. can. Accordingly, the blood collection device 1120 can collect and ensure a clean blood sample so as to reduce the risk of false positive tes ts.

[0052]

Figures 12A-12D show a blood sample optimization system 1200 according to yet another al ternative implementation. System 1200 includes a blood isolation device 1202 for attachment to a blood collection device 1204, such as a Vacutainer® or other collection and sampling devi ce. Blood isolation device 1202 receives an initial aliquot or volume of blood before a Vacutain er® container or vial is attached to the collection needle of blood collection device 1204 and t ransfers that initial aliquot or volume to blood isolation device 1202 . Constructed and arrange d to isolate within the isolation channel.

[0053]

In some implementations, the blood isolation device 1202 can include an inlet port 1212, a main outlet port, and an isolation flow path port. Entry port 1212 can be connected to a patie nt needle or associated tubing. The main exit port 1214 is a normally closed needle or needle to allow connection with other collection devices such as evacuated blood collection containe

or vacutainers, associated tubing, luer connectors, syringes, luer actuated valves. It can be co nnected to a device. The isolation flow port separates the isolation chamber 1218 from the ma in exit port.

[0054]

In some implementations, isolation chamber 1218 is formed as a channel within the body of isolation device 1202 . The isolation chamber 1218 can be a tortuous channel, such as a U-sh aped channel, an S-shaped channel, a spiral channel, or any other tortuous channel. Isolation device 1202 can include a housing or other enclosure and one or more channels formed therei n. As shown in FIGS. 12A and 12B, isolation device 1202 includes body 1206 and cap 1208 . One or more cavities or channels are formed in the body 1206, and the cavities or channels ar e further formed with one or more arms 1210 extending from the cap 1208, the one or more arms 1210 extending from the cavities or channels of the body 1206. A primary collection por t and a main outlet port are formed against the flow path.

[0055]

Figures 13A-13D illustrate a blood sample optimization system 1300 according to yet anothe r alternative implementation. System 1300 includes a blood isolation device 1302 for attachm ent to a blood collection device 1304, such as a Vacutainer® or other body fluid collection and sampling device. Blood isolation device 1302 receives an initial aliquot or volume of blood and receives that initial aliquot or volume of blood or other bodily fluid before a Vacutainer® conta iner or vial is attached to the collection needle of blood collection device 1304 . within the isol ation channel of the blood isolation device 1302 .

[0056]

Blood isolation device 1302 includes housing 1301 having inlet port 1314 , main outlet port 1312 , and isolation flow path port 1316 . Entry port 1314 can be connected to a patient need le or associated tubing. The main exit port 1312 is a normally closed needle or needle to allow connection with other collection devices such as evacuated blood collection containers or vacu tainers, associated tubing, luer connectors, syringes, luer actuated valves. It can be connecte d to a device. An isolation flow port 1316 separates from the main inlet port 1314 into an isol ation chamber 1318 . In the embodiment shown in FIGS. 13A-13D, isolation chamber 1318 i s formed as a cavity or chamber within housing 1301 or is formed by walls defining housing 1 301

.

The isolation chamber 1318 is a tortuous flow path such as a U-shaped flow path, an S-shape d flow path, a spiral flow path, or any other tortuous flow path defined by the cooperation and connection of the housing 1301 and the cap 1307. There can be and the cap 1307 can include protrusions 1305 that provide one or more walls or directors for the tortuous flow path within the isolation chamber 1318 . Projections 1305 from cap 1307 can be straight or curved, can b e embedded with various channels, openings or grooves, and can extend from cap 1307 at an y angle or orientation. can be done. isolation chamber 13

When the cap 1307 is connected with the housing 1301 to complete the formation of 18 , the protrusions 1305 form at least a portion of the tortuous flow path and the isolation flow forme d by the tortuous flow path within the isolation chamber 1318 . Isolate the first aliquot or volu me of blood or other bodily fluid in the tract.

Isolation chamber 1318

includes air permeable blood barrier 1310 substantially as described above. Air within the iso lation chamber 1318 is expelled through the air permeable blood barrier 1310 by the first aliq uot of blood supplied into the isolation chamber 1318 by the patient's blood pressure. Once th e isolation chamber 1318 has been filled and the air within the isolation chamber 1318 has be en expelled, a force such as a vacuum or other pressure such as provided by a blood sampling device such as a Vacutainer® is applied to the next aliquot or Until a volume of blood or fluid has been provided to withdraw, the patient's blood pressure is insufficient to drive or provide additional blood to blood isolation device 1302 , particularly outlet port 1312 . Further blood d raws can be taken through the main exit port 1312 and these samples are not contaminated a s any contaminants are sequestered in the isolation chamber 1318 along with the first aliquot of blood.

[0059]

Figures 14A-14E illustrate yet another implementation of a blood collection system 1400 that sequesters contaminants in an initial aliquot or sample to reduce false positives in blood cultur es or tests performed on patient blood samples. Blood collection system 1400 includes a bloo d isolation device 1401 that can be connected between a blood sample collection device 1403 and a patient needle (not shown). The blood sample collection device 1403 can be a Vacutain er® or the like. Blood isolation device 1401 includes an entry port 1402 that can be connecte d to a patient needle that is inserted into the patient's vasculature for access to and collection of a blood sample. Inlet port 1402 may also be connected to a tube or other conduit that is al so connected to a patient needle.

Inlet port 1402

defines an opening to blood isolation device 1401, which opening can be of the same cross-s ectional dimensions as a tube or other conduit connected to the patient needle or the patient needle itself. For example, the opening can be circular with a diameter of about 0.045 inch (1. 143 mm), but may be from 0.01 inch (0.254 mm) to 0.2 inch (5.08 mm) or more. can have a diameter of Blood isolation device 1401 further includes an exit port 1404 that defines an ope ning from blood isolation device 1401 and to blood sampling device 1403 . Exit port 1404 can also be connected to a tube or other conduit that is also connected to blood isolation device 1 403 . The exit port 1404 has a connector device such as an unthreaded interference or glue jo int for attachment to a variety of devices including, but not limited to, threaded caps, luer con nectors (male or female), tubing, and the like. can further include

[0061]

Blood isolation device 1401 further includes a sampling channel 1406 between inlet port 14

2 and outlet port 1404, which functions as a blood sample path once the first aliquot of blood has been isolated. Sampling channel 1406 can be a channel or conduit of any size, shape or c onfiguration. In some implementations, sampling channel 1406 has a cross-sectional area sub stantially similar to the opening of inlet port 1402 . In other implementations, sampling chann el 1406 can gradually widen from inlet port 1402 to outlet port 1404 .

Blood isolation device 1401 further includes isolation chamber 1408 , which

is connected to and separated from sampling channel 1406 at any location between inlet por t 1402 and outlet port 1404 . redirected, but preferably connected to the proximal end of sam pling channel 1406 near inlet port 1402 and from the proximal end.

separated or diverted from the The isolation chamber 1408 is initially maintained at atmosphe ric pressure and includes an air outlet 1412 at or near the distal end of the isolation chamber 1408 opposite the turning point from the sampling channel 1406 . Air outlet 1412 includes air permeable blood barrier 1412 . The air permeable blood barrier 1412 can be covered with a p rotective cover 1416, as shown in FIG. 14B. The protective cover 1416 can be sized and confi gured to prevent a user from touching the air permeable blood barrier 1412 with their fingers or other external instruments while still allowing the patient's own blood pressure to pressure the isolation chamber 1408. Allowing air to exit the air permeable blood barrier 1412 as the ai r is forced out of the isolation chamber by forcing blood into it. Protective cover 1416 can also be configured to block or prevent accidental exposure of the air permeable blood barrier to su rrounding fluids or droplets. This can be done in a variety of mechanical ways including, but n ot limited to, adding a hydrophobic membrane to the protective cover. As shown in FIGS. 14 C and 14D, the sampling channel 1406 may be cylindrical or frusto-conical in shape from a sm aller diameter to a larger diameter to minimize the possibility of lysing red blood cells

.

can. Similarly, the sampling channel 1406 is formed with a minimal amount or no sharp bends or sharp angles that could lyse red blood cells. Sampling channel 1406 splits near inlet port 1 402 through diverting path 1409 into isolation chamber 1408 . Diversion pathway 1409 can h ave any cross-sectional shape or size, but is preferably similar to the cross-sectional shape of at least a portion of inlet port 1402 .

[0064]

In some implementations, sampling channel 1406 and isolation chamber 1408 are formed b y grooves, channels, locks or other pathways formed in housing 1414 . Housing 1414 can be made of plastic, metal or other rigid or semi-rigid material. The housing 1414 can have a lowe r member that sealably mates with the upper member. One or both of the lower and upper m embers can include a sampling channel 1406 and an isolation chamber 1408 as well as a dive rting passageway 1409 , an inlet port 1402 and an outlet port 1404 . In some other implemen tations, one or more of diverting path 1409 , inlet port 1402 , and/or outlet port 1404 are at l east partially closed by a cap member connected to either end of housing 1414 . can be forme d in In some implementations, the upper and lower members and the cap member can be co

nected together by laser welding, heat sealing, gluing, snapping, screwing, bolting, or the lik e. In other implementations, some or all of the interior surfaces of the diversion pathway 140 9 and/or the isolation chamber 1408 can be coated or filled with agents or substances such as decontamination agents, coagulants, and the like. For example, when the sequestration cham ber 1408 fills and the first aliquot of blood returns to the diverting path 1409, the final volume of sequestered blood clots, creating a barrier between the sequestration chamber 1408 and th e sampling channel 1406. As such, turning path 1409 may be provided with a coagulant. 15 A-15G show a blood isolation device 1500. FIG

.

The blood isolation device 1500 includes a needle or needle that is normally closed to allow co nnection with other collection devices such as evacuated blood collection containers or vacutai ners, associated tubing, luer connectors, syringes, luer actuated valves, and the like. It can b e connected to a device.

[0066]

Blood isolation device 1500 includes an entry port 1502 that can be connected to a patient n eedle that is inserted into the patient's vasculature for access to and collection of a blood sam ple. Entry port 1502 can also be connected to a tube or other conduit that is also connected t o a patient needle. Entry port 1502 defines an opening to blood isolation device 1500, which o pening can be of the same cross-sectional dimensions as a tube or other conduit connected to the patient needle or the patient needle itself. For example, the opening has a diameter of ap proximately 0.045 inches (1.143 mm).

It can be circular, but can have a diameter of 0.01 inch (0.254 mm) to 0.2 inch (5.08 mm) or more. Inlet port 1502 may also include a sealed or fluid tight connector or connection such a s a threaded or luer fitting or the like

.

In some implementations, a tube or other conduit that is coupled to the patient needle can be integrated with the entry port 1502, such as by co-molding, gluing, laser welding, or heat bon ding the parts together. This allows the blood isolation device 1500 to be manufactured and s old as a single unit with the patient needle, eliminating the need to connect the patient needle to the blood isolation device 1500 during blood draw or sampling.

Blood isolation device 1500 further includes an exit port 1504 that

defines an opening from blood isolation device 1500 and to the blood sampling device. Exit p ort 1504 may also be connected to a tube or other conduit that is also connected to a blood is olation device and may include a sealed or fluid tight connector or connection such as a threa ded or luer fitting. Thus, as noted above, the blood isolation device 1500 is manufactured and sold as a single unit with the patient needle and/or tubing and blood sample collection device such that the patient needle and blood sample collection device are connected to blood isolati on during blood collection or sampling. The need to connect to device 1500 can be eliminated.

[0069]

Blood isolation device 1500 further includes a sampling channel 1506 between inlet port 150 2 and outlet port 1504, which functions as a blood sample path once the first aliquot of blood has been isolated. Sampling channel 1506 can be a channel or conduit of any size, shape, or c onfiguration. In some implementations, sampling channel 1506 has a cross-sectional area sub stantially similar to the opening of inlet port 1502 . In other implementations, sampling chann el 1506 can gradually diverge from inlet port 1502 to outlet port 1504 .

Blood isolation device 1500 further includes isolation chamber 1508 , which

is connected to and separated from sampling channel 1506 at any location between inlet por t 1502 and outlet port 1504 . Although diverted, it is preferably connected to and disconnecte d or diverted from the proximal end of sampling channel 1506 near inlet port 1502 . In some i mplementations, the diversion channel includes a Y-junction. The isolation chamber 1508 is pr eferably maintained at atmospheric pressure and includes a vent 1510 at or near the distal en d of the isolation chamber 1508 . Vent 1510 includes air permeable blood barrier 1512 . FIG. 15C shows blood isolation device 1500 with isolation chamber 1508 filled with an initial aliquo t or sample of blood from a patient.

[0071]

Air permeable blood barrier 1512 can be covered with protective cover 1516 . The protective cover 1516 can be sized and configured to prevent a user from touching the air permeable blo od barrier 1512 with their fingers or other external instruments while still allowing the patien t's own blood pressure to pressure the isolation chamber 1508. Allowing air to exit the air per meable blood barrier 1512 as the air is forced out of the isolation chamber by forcing blood int o it. The protective cover 1516 can be configured to block or prevent accidental exposure of t he filter to ambient fluids or splashes. This can be done in a variety of mechanical ways, inclu ding but not limited to adding a hydrophobic membrane to the protective cover.

FIG.

15B is a perspective view of blood isolation device 1500 from the top of housing 1501 includi ng outlet port 1504 and vent 1510 of blood isolation device 1500 and sampling channel 1506 before the sample collection device is activated. The first aliquot of blood is separated while th e is empty.

Filling the separation chamber 1508 is shown. Figure 15G is a perspective view of the blood is olation device 1500 from the bottom of the housing 1501 and the exit port 1504 of the blood i solation device 1500, showing the initial flow while the sampling channel 1506 is empty befor e the sample collection device is activated. An aliquot of blood is shown filling the isolation ch amber 1508 . FIG. 15C is another perspective view of blood isolation device 1500 from the to p of housing 1501, including inlet port 1502 and vent 1510 of blood isolation device 1500, wit h the isolated blood substantially remaining within isolation chamber 1508. FIG. Blood is draw n through sampling channel 1506 during the period of time.

FIG .

15D is a cross-sectional view of blood isolation device 1500 according to some implementat

ons, showing housing 1501 defining sampling channel 1506 and isolation chamber 1508 . 15E and 15F illustrate various form factors of housings for blood isolation devices according to one or more implementations described herein. Isolation chamber 1508 can have a larger cross-sectional area than sampling channel 1506, and the cross-sectional area or length can be conf igured such that a predetermined or specific blood volume is isolated or locked

.

can. The sampling channel 1506 can be sized to fit tubing for either or both the patient needle tubing or the blood collection device tubing.

[0075]

Housing 1501 can be formed from multiple pieces or a single unitary piece. In some implem entations, as shown in FIG. 15D, housing 1501 includes an upper member 1520 and a lower member 1522 that mate with each other, one or both of which may be formed by, for exampl e, an injection molding process or by etching, cutting, cutting, or molding. It has grooves, cha nnels, locks, conduits or other pathways pre-formed by perforations or the like. The upper me mber 1520 may be attached by any mating or connecting mechanism, such as using laser wel ding, thermal bonding, ultrasonic welding, adhesives, screws, rivets, bolts, etc., or latches, gr ooves, tongues, pins, flanges. Other mating mechanisms, such as, can connect with lower me mber 1522 . In some implementations, the upper member 1520 can include grooves, chann els, locks, conduits or other pathways, while the lower member 1522 is the upper member 15 20, as shown in FIG. 15D

.

A protrusion 1524 sized and adapted to fit into at least one of a groove, channel, lock or other pathway may be included. Protrusions 1524 can provide surface features such as partial groov es or partial channels, for example, to complete the formation of either sampling channel 150 6 and/or isolation chamber 1508 . In some implementations, the protrusions 1524 can be for med with one or more slanted sides or faces to fit more snugly within corresponding grooves, channels, locks or other pathways. In still other implementations, both the upper member 15 20 and the lower member can include grooves, channels, locks or other pathways, as well as one or more protrusions 1524 .

[0077]

In some implementations, sampling channel 1506 and isolation chamber 1508 are formed b y grooves, channels, locks or other pathways formed in housing 1501 . Housing 1501 can be made of any suitable material including rubber, plastic, metal or other material. Housing 1501 can be formed from a transparent or translucent material, or from an opaque or non-transluce nt material. In other implementations, the housing 1501 can be largely opaque or non-transp arent, but the housing surfaces immediately adjacent the sampling channel 1506 and/or the i solation chamber 1508 are transparent or translucent and initially A visual cue or sign that the sequestration chamber 1508 is filled to the required or desired degree and/or the sequestered blood is then released while a clean blood sample is drawn through the sampling channel 15

6. Provide visual cues or signs to remain isolated.

give to the artist. Other visual cues or signs of isolation include, but are not limited to, contact, penetration, or partial penetration of blood, the air permeable blood barrier 1512 turning a different color; Color-coded tabs or indicators at any location along or adjacent to the isolation chamber, audible, vibratory, or other signals may be included. After venipuncture with a patient needle (not shown), which can collect many pathogens from the patient's skin, the patient's own blood pressure overcomes the atmospheric pressure in isolation chamber 1508 to form air permeable blood barrier 1512

.

As the air in the isolation chamber 1508 is expelled through, the initial volume of the patient's blood with these pathogens enters the blood isolation device 1500 inlet port 1502 and flows into the isolation chamber 1508 by following the path of least resistance. . The patient's blood pressure is not sufficient to overcome the rising air pressure within the sealed sampling channel 1506 . Ultimately, an isolation chamber 1508 of predetermined volume is filled with blood that drives air out through an air permeable blood barrier 1512 . When blood impinges on the air permeable blood barrier, the blood interacts with the material of air permeable blood barrier 1512 to completely or partially seal vent 1510 . A signal or indication can be provided that the practitioner can now utilize the VACUTAINER® capsule or other blood sampling device to obtain the next volume of the patient's blood for sampling. The blood in the isolation chamber 1508 is now effectively isolated within the isolation chamber.

[0079]

Upon filling the blood isolation channel 1508, and prior to use of a Vacutainer® or other blood sampling device, the patient's blood pressure causes compression of the air in the sampling channel 1506 and possibly a small amount of blood. It moves past the turning point into the isolation chamber 1508 into the sampling channel 1506 and queues clean blood to be drawn through the sampling channel 1506 .

Figures 16-19

show yet another implementation of a blood isolation device. 16A-16D are connected between a blood sample collection device such as an evacuated blood collection container such as a Vacutainer® (not shown) and a patient needle (not shown) and/or associated tubing. 16 shows a blood isolation device 1600 that can be used. Figure 17 shows the lower member of the blood isolation device and Figure 18 shows the upper member of the blood isolation device, the upper and lower members interfitting to provide an inlet port as described in more detail below. Ports, exit ports, isolation chambers and sampling channels can be formed. Figures 19A and 19B show the upper and lower members mating together. It should be appreciated that FIGS. 16-19 show one exemplary method of constructing the blood isolation devices described herein and that other forms of construction are possible.

[0081]

16A-16D, blood isolation device 1600 includes an entry port 1602 that can be connected to

patient needle that is inserted into a patient's vasculature for access and collection of a blood sample. Inlet port 1602 can also be connected to a tube or other conduit that is also connecte d to a patient needle. Entry port 1602 defines an opening to blood isolation device 1600, whic h opening can be of the same cross-sectional dimensions as a tube or other conduit connecte d to the patient needle or the patient needle itself. For example, the opening can be circular w ith a diameter of about 0.045 inch (1.143 mm), but may be from 0.01 inch (0.254 mm) to 0. 2 inch (5.08 mm) or more. can have a diameter of

Inlet port 1602

may also include a sealed or fluid tight connector or connection such as a threaded or luer fit ting or the like. In some implementations, a tube or other conduit coupled to the patient need le can be integrated with the entry port 1602, such as by co-molding, gluing, laser welding, or heat bonding the parts together. Blood isolation device 1600 is thereby manufactured and sol d as a single unit along with the patient needle and/or tubing,

The need to connect the patient needle to the blood isolation device 1600 during blood draw o r sampling can be eliminated.

Blood isolation device 1600 further includes an exit port 1604 that

defines an opening from blood isolation device 1600 and to the blood sampling device. Exit p ort 1604 may also be connected to a tube or other conduit that is also connected to a blood is olation device and may include a sealed or fluid tight connector or connection such as a threa ded or luer fitting. Thus, as noted above, the blood isolation device 1600 is manufactured and sold as a single unit along with the patient needle and/or tubing and blood sample collection d evice such that the patient needle and blood sample collection device are connected to blood i solation during blood collection or sampling. The need to connect to device 1600 can be elimin ated.

[0084]

Blood isolation device 1600 is connected to sampling channel 1606 between inlet port 1602 and outlet port 1604, and at any location between inlet port 1602 and outlet port 1604, and s ampling channel 1606. and an isolation chamber 1608 that is isolated or diverted from. Sampl ing channel 1606 functions as a blood collection path once the first aliquot of blood is sequest ered in sequestration chamber 1608 . Sampling channel 1606 can be a channel or conduit of a ny size, shape or configuration. In some implementations, sampling channel 1606 has a cross -sectional area substantially similar to the opening of inlet port 1602 . In other implementatio ns, sampling channel 1606 can gradually widen from inlet port 1602 to outlet port 1604 . The isolation chamber 1608 widens toward the path of the isolation channel so that blood first atte mpts to enter the reservoir as opposed to entering the smaller diameter of the sampling chan nel 1606, as shown in more detail in FIGS. It can have a larger cross-section to form a reserv oir. In some exemplary implementations, the diversion between sampling channel 1606 and i solation chamber 1608 is accomplished by diversion junction 1607

.

Turning junction 1607 can be substantially Y-shaped, T-shaped, or U-shaped. In some preferr ed exemplary implementations, redirection junction 1607 is configured such that flow from inl et port 1602 is preferentially directed into isolation chamber 1608, as shown in FIGS. 17A-17 B. The isolation chamber 1608 can also include or form a bend or ramp to move the initial blo od flow toward and into the isolation chamber 1608 .

[0086]

The isolation chamber 1608 is preferably maintained at atmospheric pressure and includes a vent 1610 at or near the distal end of the isolation chamber 1608 . Vent 1610 can include an air permeable blood barrier 1612 as described above. Blood isolation device 1600 can includ e a housing 1601 that can be formed from multiple pieces or a single unitary piece

.

In some implementations, as shown in FIGS. 17A-17D and 18A-18F, housing 1601 includes an upper member 1620 and a lower member 1622 that fit together. Blood isolation device 1600 i ncludes a gasket or other sealing member (not shown) such that when upper member 1620 is mechanically attached to lower member 1622, the junction therebetween is sealed by the gas ket or sealing member. can also include 17A-17D show the lower member 1622 of the housing for the blood isolation device 1600. FIG. The lower member 1622 includes pre-formed groove s, channels, locks, conduits, such as by an injection molding process or by etching, cutting, dr illing, etc., to form the sampling channels 1606, the isolation chambers 1608, and the turning junctions 1607. or other routes.

Isolation chamber 1608

prevents blood from entering the smaller diameter of sampling channel 1606 .

, can have a larger cross-section than the sampling channel 1606 so as to preferentially move into the isolation chamber first.

FIGS.

18A-18F may be attached by any mating or connecting mechanism such as using laser weldi ng, thermal bonding, gluing, screws, rivets, bolts, etc., or latches, grooves, tongues, pins, flan ges. Upper member 1620 is shown connectable with lower member 1622 by other mating me chanisms such as. Top member 1620 can include some or all of grooves, channels, locks, con duits or other pathways to form sampling channels 1606 , isolation chambers 1608 and turnin g junctions 1607 . In still other implementations, both upper member 1620 and lower membe r 1622 can include grooves, channels, locks or other pathways.

[0090]

In some implementations, sampling channel 1606 and isolation chamber 1608 are formed b y grooves, channels, locks or other pathways formed in housing 1601 . Housing 1601 can be made of rubber, plastic, metal or any other suitable material. Housing 1601 can be formed fro m a transparent or translucent material, or from an opaque or non-translucent material. In ot her implementations, housing 1601 can be largely opaque or non-translucent, but housing sur faces directly adjacent sampling channel 1606 and/or isolation chamber 1608 can be transpa

ent or translucent. There may be first a visual cue or sign that the isolation chamber 1608 is fi lled to the required or desired degree, and/or a subsequent isolation while a clean blood samp le is taken through the sampling channel 1606. Gives the practitioner a visual cue or sign that the sequestered blood remains sequestered. Other visual cues or signs of isolation include, bu t are not limited to, contact, penetration, or partial penetration of blood, causing the air perm eable blood barrier 1612 to turn a different color; Color-coded tabs or indicators at any locatio n along or adjacent to the isolation chamber, audible, vibratory, or other signals may be includ ed.

[0091]

The air permeable blood barrier 1612 can be covered or surrounded by a protective member 1616, as shown in FIGS. 18A-18F. Protective member 1616 can be sized and configured to pre vent a user from touching air permeable blood barrier 1612 with their fingers or other externa l instruments, while still allowing air to be expelled from isolation chamber 1608. Occasionally allow air to exit the air permeable blood barrier 1612 . In some implementations, protective member 1616 includes protrusions that extend from the top surface of top member 1620 up a nd around air permeable blood barrier 1612 . The protective cover 1616 can be configured to block or prevent accidental exposure of the filter to ambient fluids or splashes. This can be do ne in a variety of mechanical ways, including but not limited to adding a hydrophobic membra ne to the protective cover. In use, blood isolation device 1600 includes sampling channel 160 6 and isolation chamber 1608

.

Both pathways are initially filled with air at atmospheric pressure, but the sampling channel 1 606 is initially sealed by a Vacutainer® or other such sealed blood collection device at the outl et port 1604. , the isolation chamber 1608 terminates in a vent 1610 to the atmosphere that i ncludes an air permeable blood barrier 1612 .

[0093]

After venipuncture with a patient needle (not shown), which can collect many pathogens fro m the patient's skin, an initial volume of the patient's blood with these pathogens passes thro ugh inlet port 1602 of blood isolation device 1600 . do. This initial volume of potentially conta minated blood preferentially enters isolation chamber 1608 by finding the path of least resista nce. The patient's own blood pressure overcomes the atmospheric pressure in the vented isol ation chamber 1608 and expels the air in the isolation chamber 1608 through the air permeab le blood barrier 1612, while the air pressure builds up in the sealed sampling channel 1606. is insufficient to overcome the various exemplary

In some embodiments, isolation chamber 1608 and sampling channel 1606 can be configured such that the force generated by the patient's blood pressure is sufficient to overcome the eff ects of gravity regardless of the orientation of the blood isolation device. can.

Ultimately

, the isolation chamber 1608 fills with blood that drives air out through the air permeable b

od barrier 1612 . When blood contacts the air permeable blood barrier, the blood interacts wit h the material of air permeable blood barrier 1612 to completely or partially seal vent 1610 . A signal or indication can be provided that the practitioner can now utilize the Vacutainer® or other blood collection device. Upon filling blood isolation channel 1608 and prior to use of a Vacutainer® or other blood sampling device, the patient's blood pressure causes compression of air within sampling channel 1606, possibly a small amount

.

of blood moves past the turning point into sampling channel 1606 , queuing clean blood to be drawn through sampling channel 1506 .

FIG .

19A is a side view of blood isolation device 1600 and FIG. 19B is a cross-sectional view of bl ood isolation device 1600 showing upper member 1620 mating with lower member 1622 .

[0097]

FIG. 20 illustrates a patient needle 2002 for vascular access to a patient's bloodstream, a blo od sample collection device 2004 that facilitates the collection of one or more blood samples, and the patient needle 2002 and blood sample collection device 2004. A blood sample optimiz ation system 2000 is shown including a conduit 2006 providing a fluid connection between. In some implementations, the blood sample collection device 2004 includes a protective shield th at includes a sealed collection needle such that once a sealed vacuum container is placed on t he collection needle and the container is pierced once by the collection needle, the patient nee dle is exposed to the patient needle. A blood sample is drawn from 2002 through conduit 200 6 with vacuum pressure or force.

Blood sample optimization system 2000

further includes a blood isolation device 2008 located at any point on conduit 2006 between patient needle 2002 and blood sampling device 2004, as described herein. .

FIG.

21 shows a non-vented blood isolation device 2100 that uses wicking material chambers. Blo od isolation device 2100 includes a housing 2101 having a sampling channel 2104 at least par tially surrounded or abutted by an isolation chamber 2102 filled with wicking material. A first aliquot of blood is drawn from the patient needle into the sampling channel 2104 where it im mediately escapes into the wicking material of the isolation chamber 2102 . The wicking mate rial and/or isolation chamber 2102 is filled with a predetermined volume such that subsequent or subsequent blood draws flow past the wicking material and through the sampling channel 2 104 directly to a sampling device such as a vacutainer. Dimensioned and adapted to receive a nd retain blood. The wicking material can include substances such as solidifying agents, decon taminating agents, or other additives.

[0100]

As described herein, air permeable blood barriers can be made using a wide variety of differ ent structures and materials. As shown in Figures 22A and 22B, an air permeable blood barr

r 2202 of a blood isolation device 2200 can include a polymeric bead matrix 2204 that has be en treated to render at least some of the beads hydrophilic. Air permeable blood barrier 2202 further comprises a self-sealing material 2206 such as carboxymethylcellulose (CMC) or cellul ose gum, or other sealing material. Air permeable blood barrier 2202 may further include void s 2208 that allow air flow prior to or during partial contact with a fluid such as blood. Self-seal ing material 2206 expands upon contact with fluid, as shown in FIG. 22B.

Tightens to close void 2208, occluding air flow through void 2208, and completely or partially sealing. Figures 23A and 23B show an entry port 2302 for connection with a patient needle, an exit port 2304 for connection with a blood sampling device, an isolation chamber 2306, an isolation chamber 2306, and a contaminant to be isolated

.

23 shows yet another implementation of the blood isolation device 2300 having a sampling ch annel 2308 that bypasses the isolation chamber 2306 once the isolation chamber is filled to th e first aliquot of blood that may be present. Isolation chamber 2306 includes a hydrophobic pl ug 2312 at the distal end of isolation chamber 2306 furthest from inlet port 2302 . A vacuum or other suction force applied from outlet port 2304, such as from a Vacutainer®, draws blood into inlet port 2302 and directly into isolation chamber 2306, where the first aliquot of blood i s removed. Contacting the hydrophobic plug 2312, the first aliquot of blood is returned to the sequestration chamber 2306 where it is sequestered. A small amount of blood can enter samp ling channel 2308 which is initially closed by valve 2308 . When valve 2308 is released, a subs equent volume of blood, under additional vacuum or other force, flows into inlet port 2302, by passes isolation chamber 2306, and through sampling channel 2308 to outlet port 2304. flow towards and sent to the collection device. Sampling channel 2308 can have any suitable geo metry and can be formed from plastic tubing or any other suitable material

.

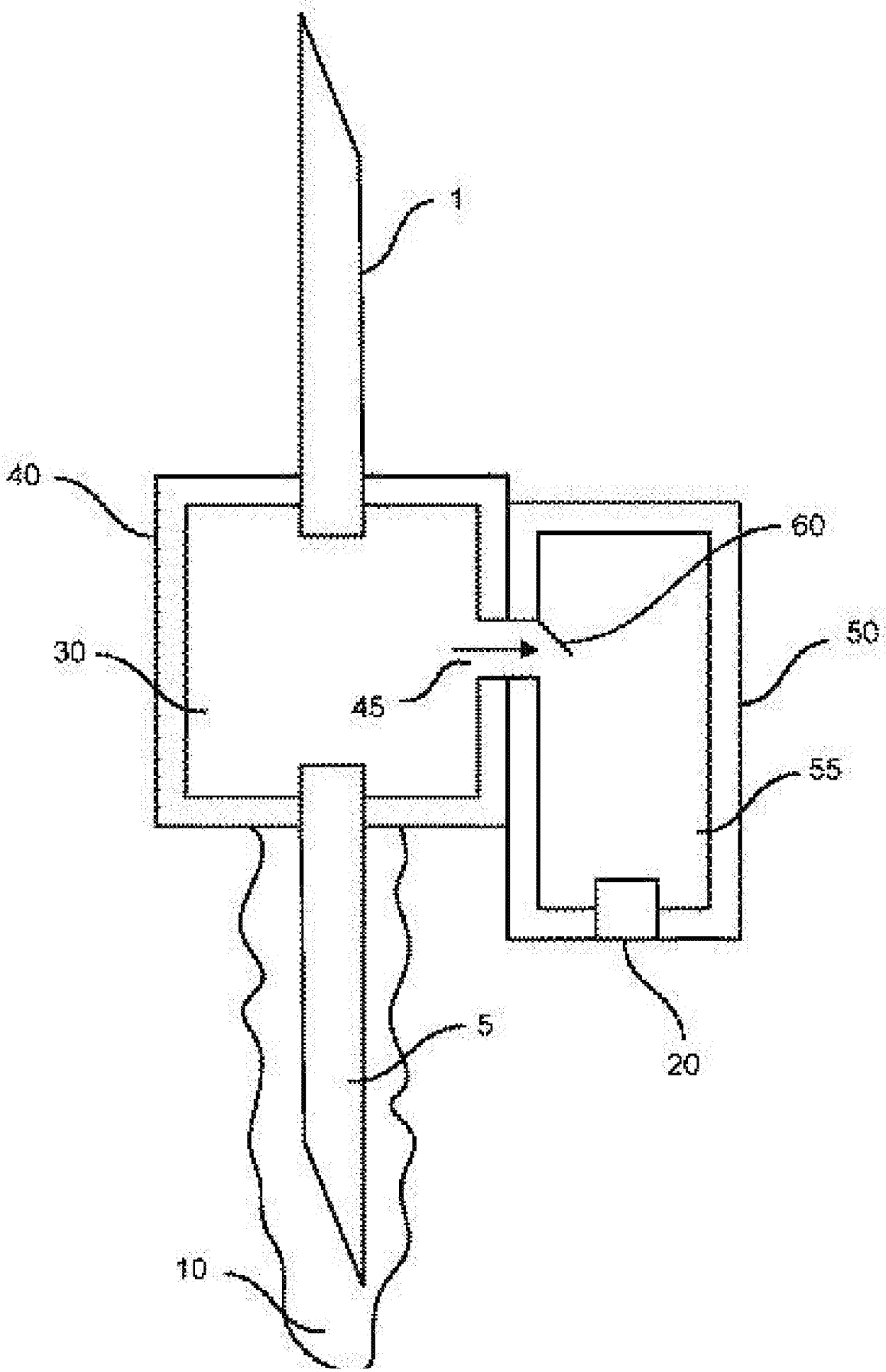
Valve 2308 can be a clip or other enclosing device to pinch, deflect, bend, or otherwise close t he sampling channel before the first aliquot of blood is sequestered in sequestration chamber 2306 . can.

[0103]

While various embodiments have been described in detail above, other modifications are pos sible. Other embodiments may be within the scope of the following claims.

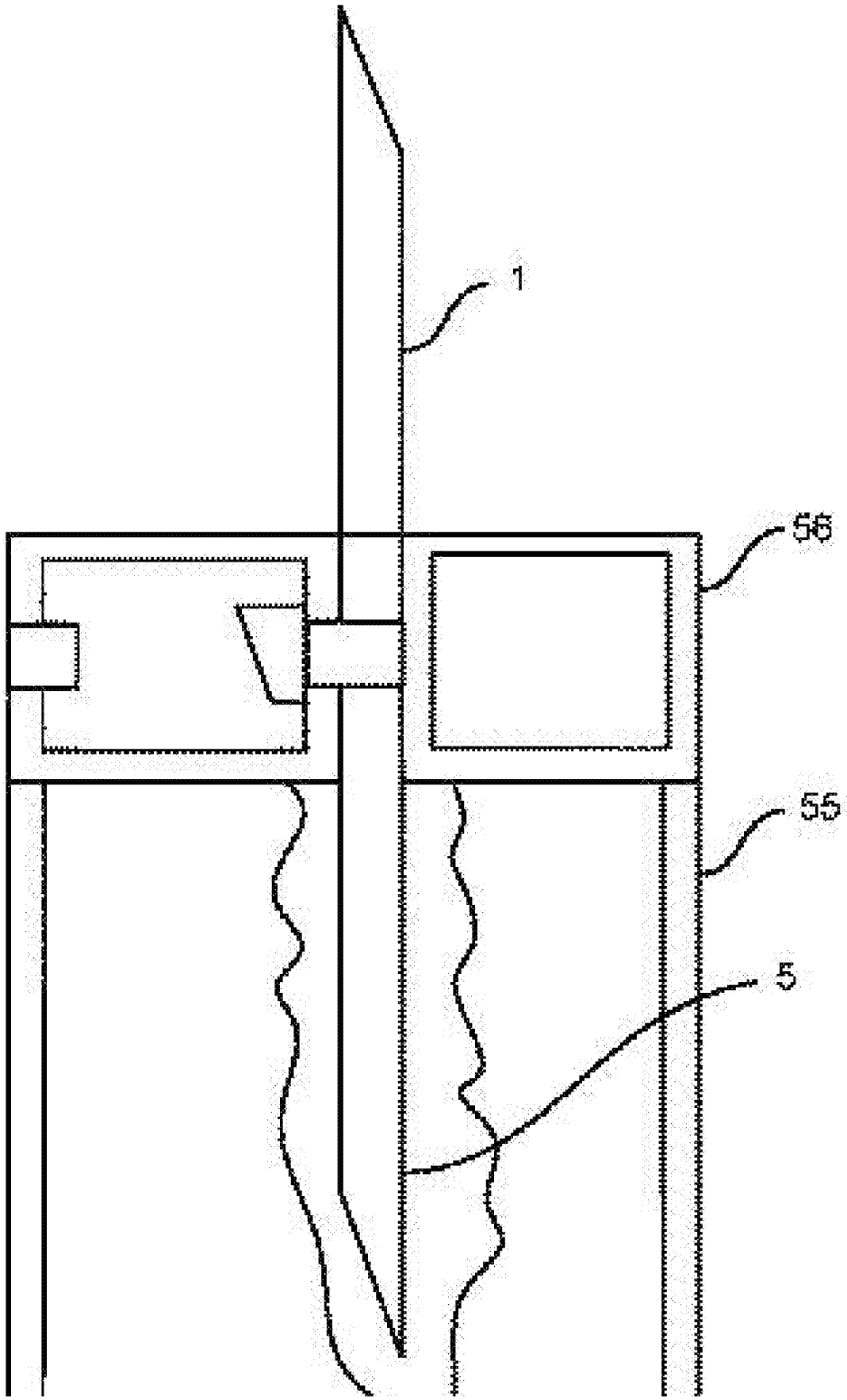
drawing open —

[Fig. 1]


1
40
60
30
50
45
55
5
20
10

[Figure 2]

FIG. 1


1
56
55
5

[Figure 3]

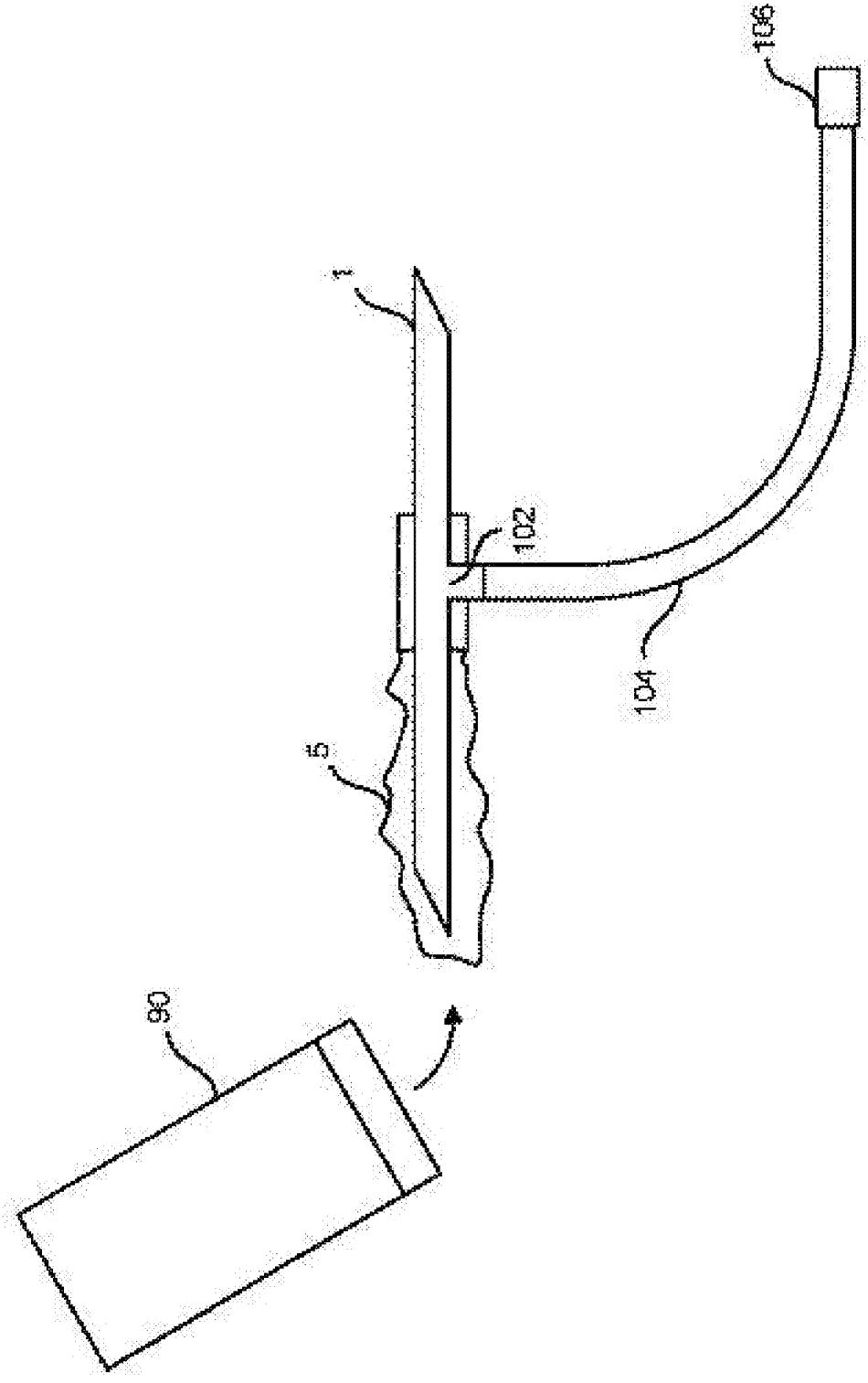


FIG. 3

[Figure 4]

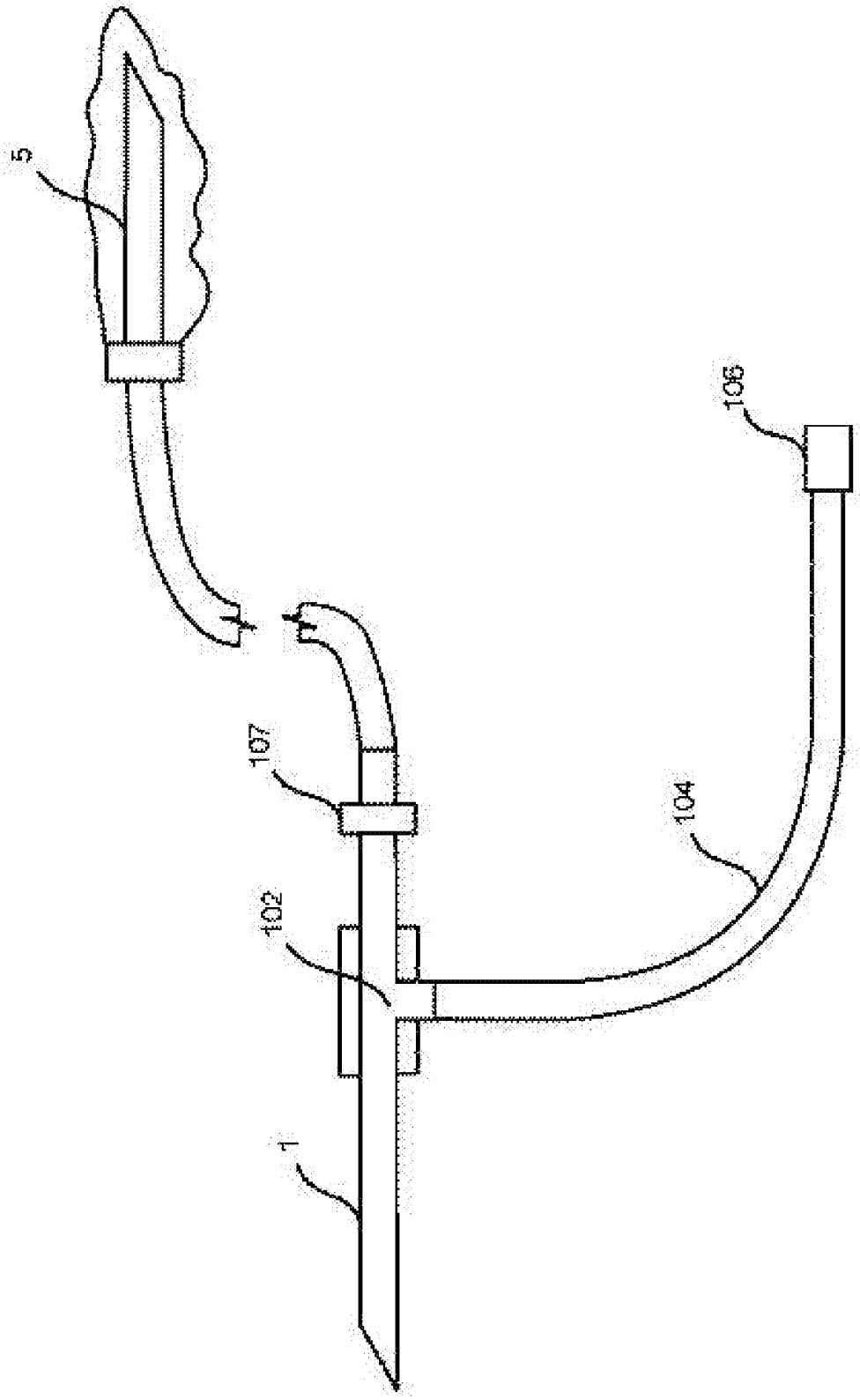


FIG. 4

[Figure 5]

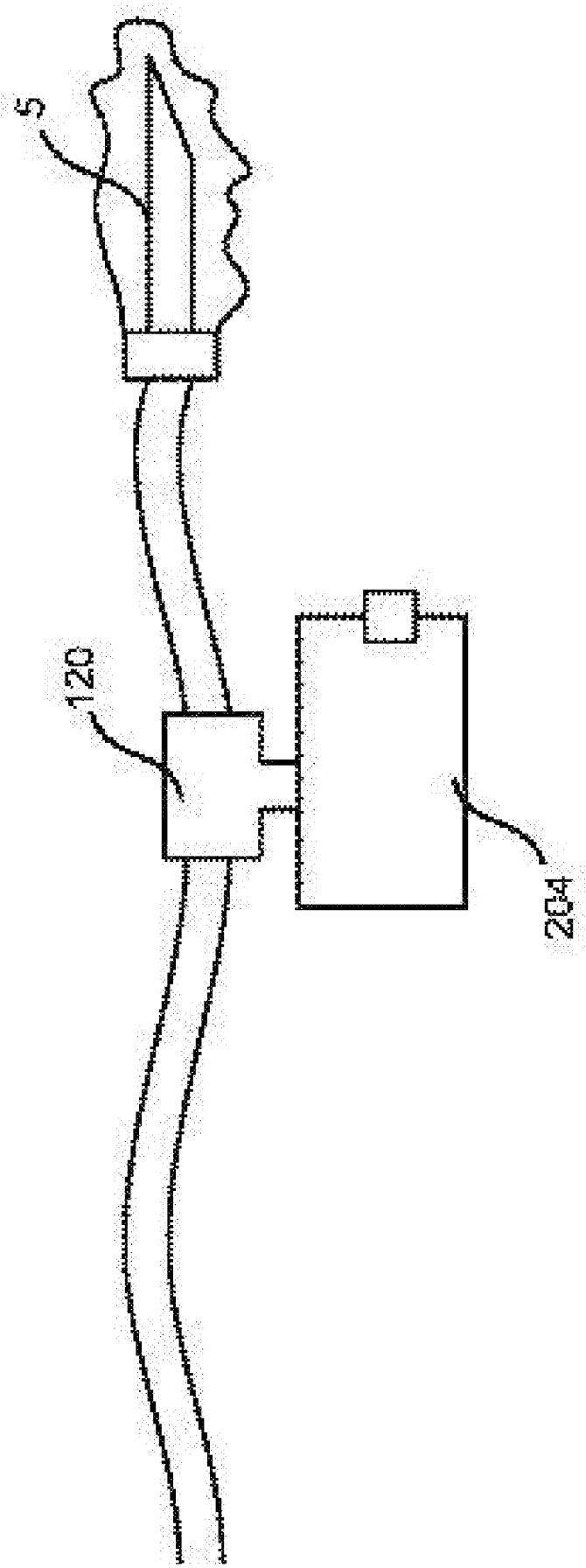
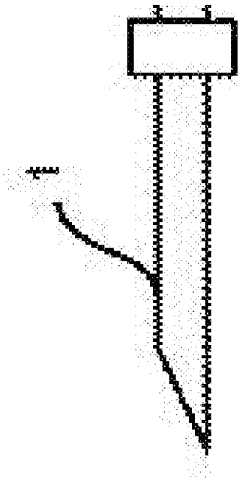


FIG. 5

[Fig. 6]



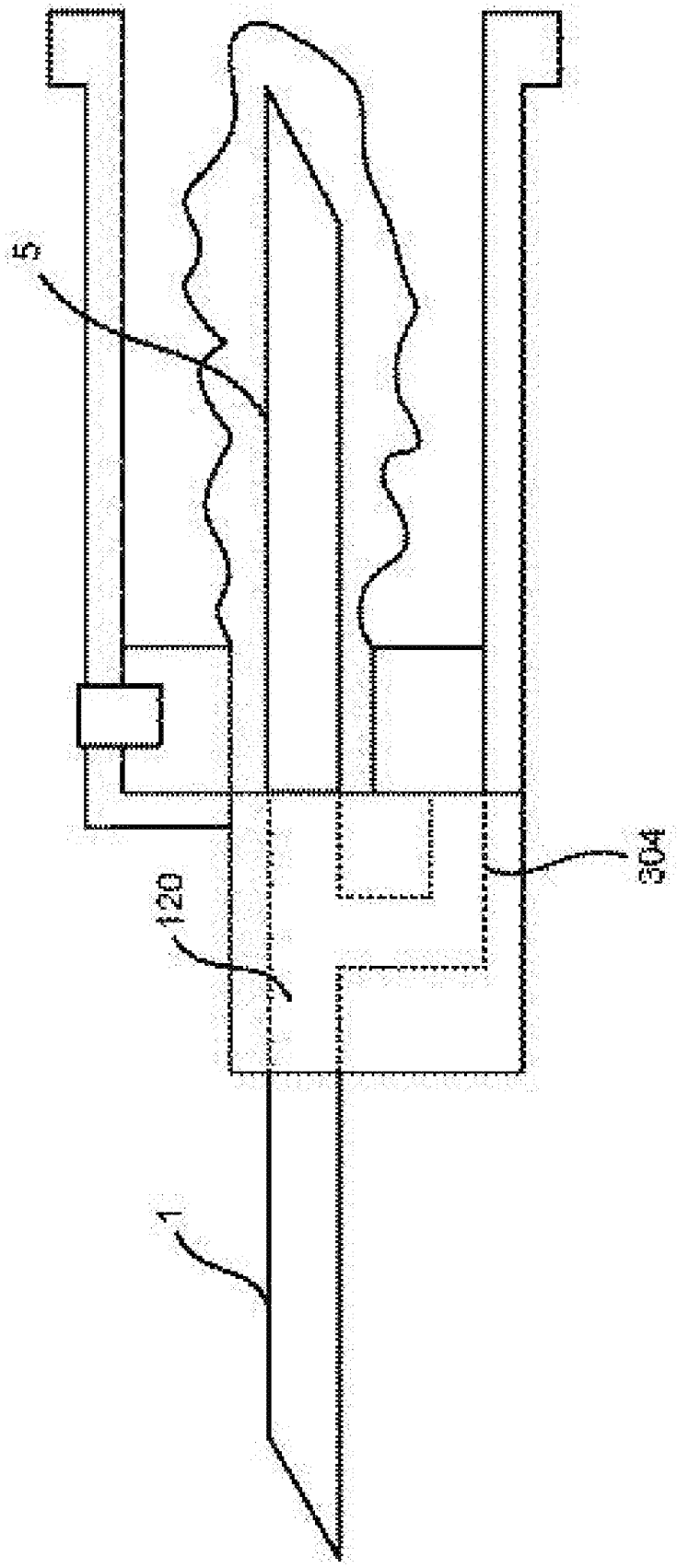


FIG. 6

[Fig. 7]

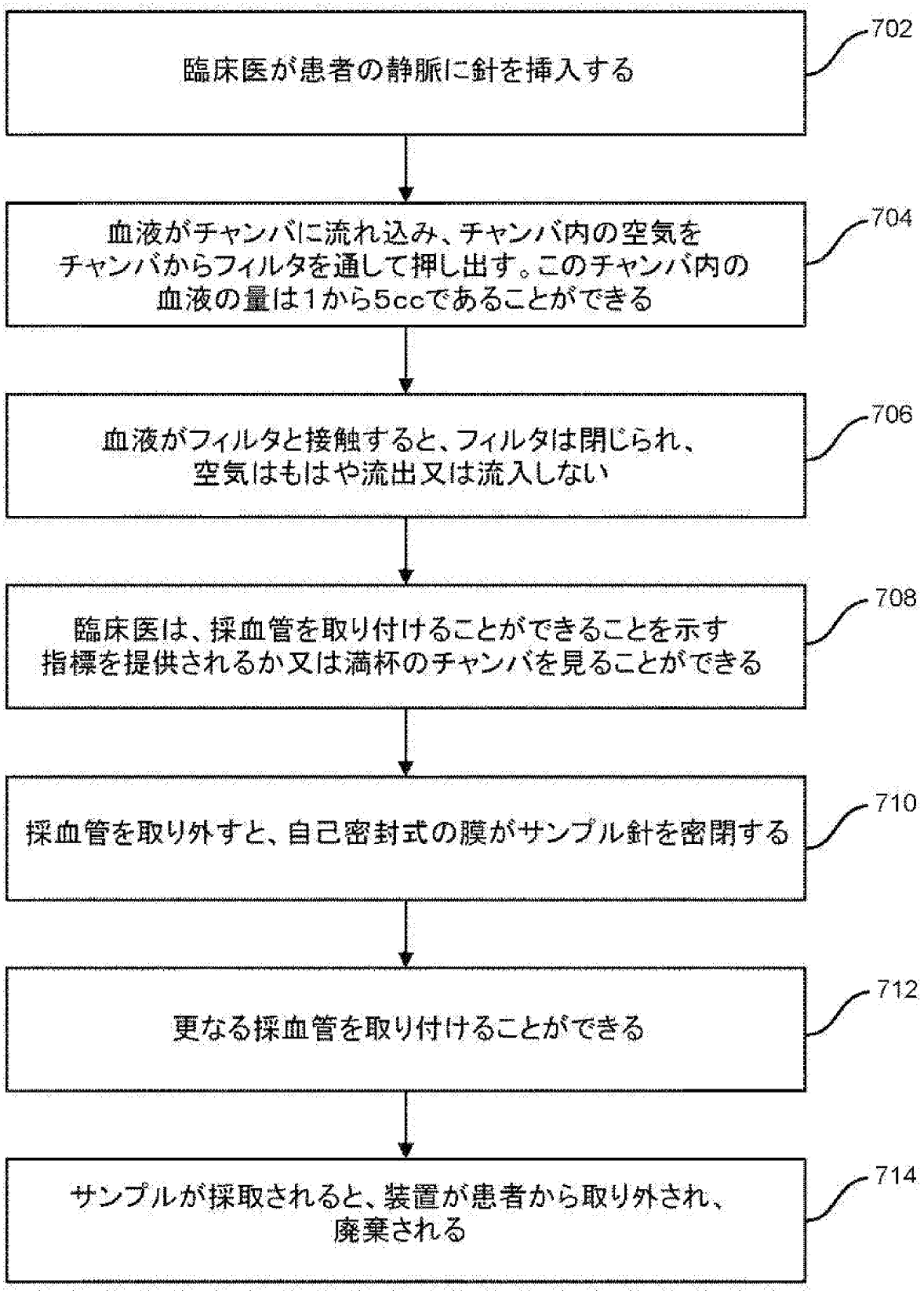
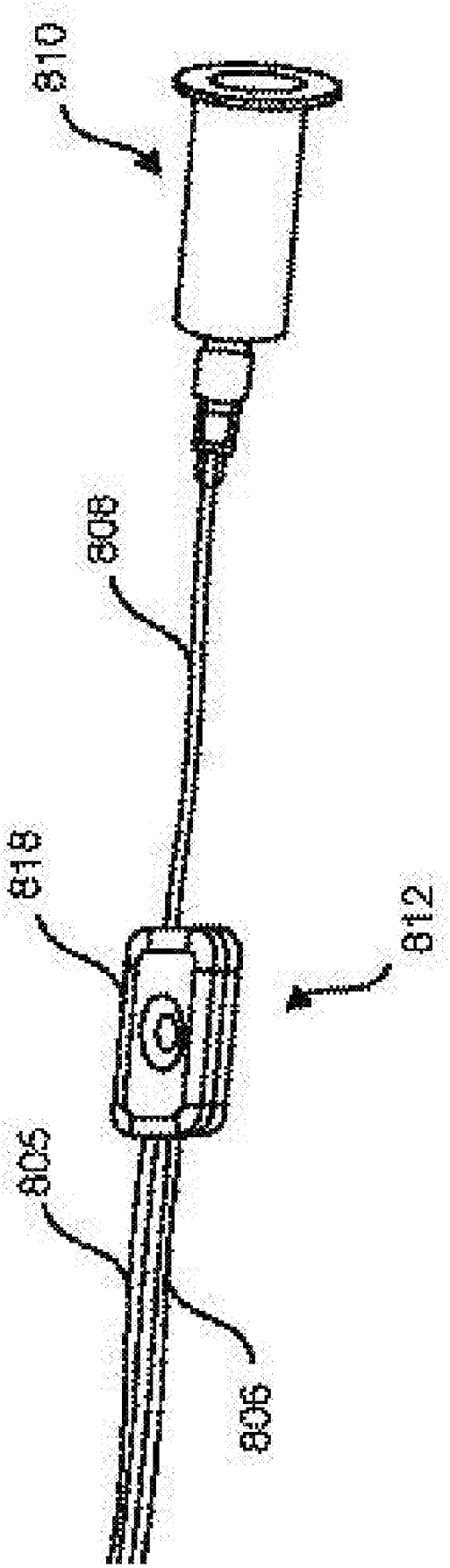

臨床医が患者の静脈に針を挿入する
702
血液がチャンバに流れ込み、チャンバ内の空気を
チャンバからフィルタを通して押し出す。このチャンバ内の
血液の量は1から5ccであることができる
704
血液がフィルタと接触すると、フィルタは閉じられ、
空気はもはや流出又は流入しない
706
臨床医は、採血管を取り付けることができることを示す
指標を提供されるか又は満杯のチャンバを見ることができる
708
採血管を取り外すと、自己密封式の膜がサンプル針を密閉する
710
更なる採血管を取り付けることができる
712
サンプルが採取されると、装置が患者から取り外され、
廃棄される
714

FIG. 7

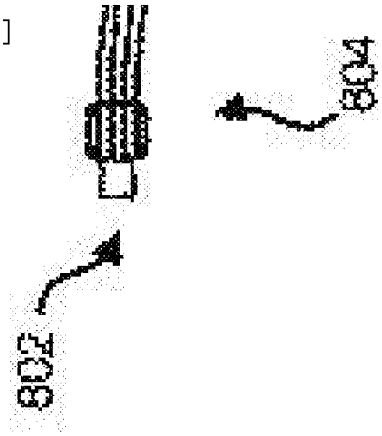
[Fig. 8A]



803

FIG. 8A

[Fig. 8B]



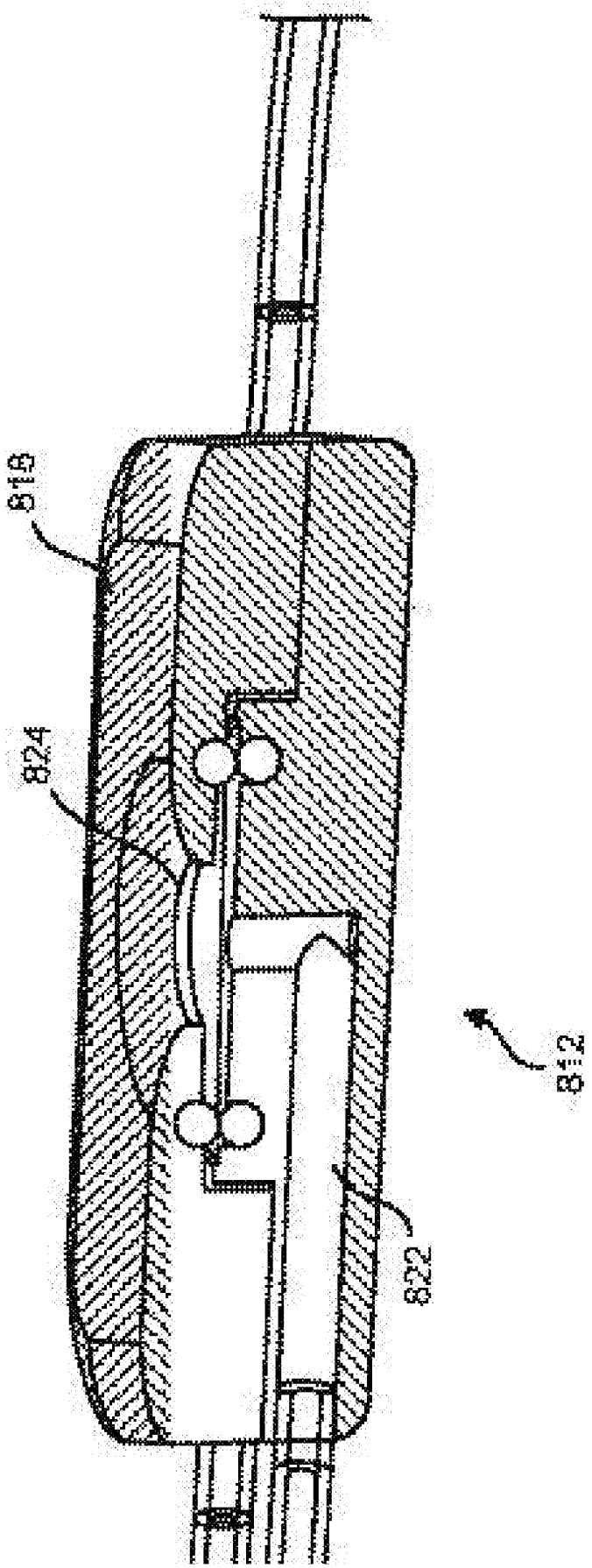
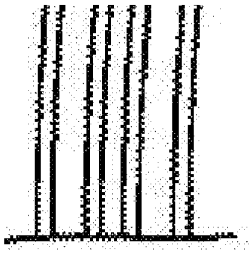


FIG. 8B

[Fig. 8C]



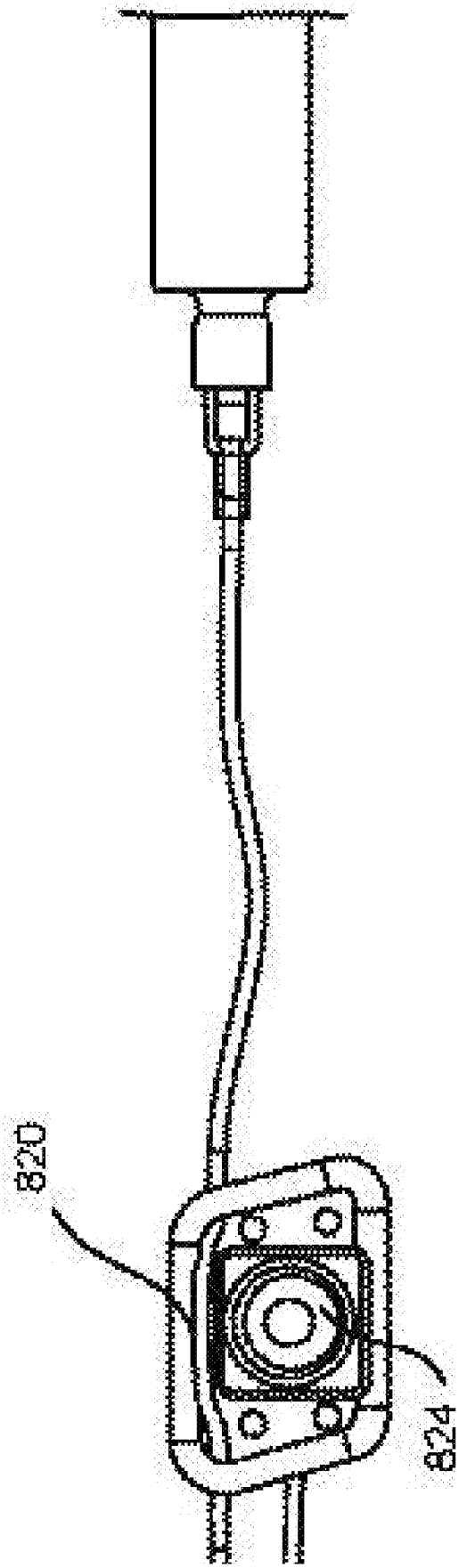
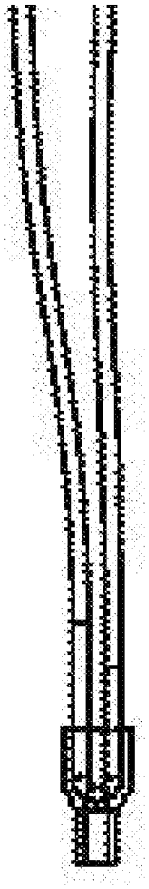


FIG. 8C

[Fig. 8D]



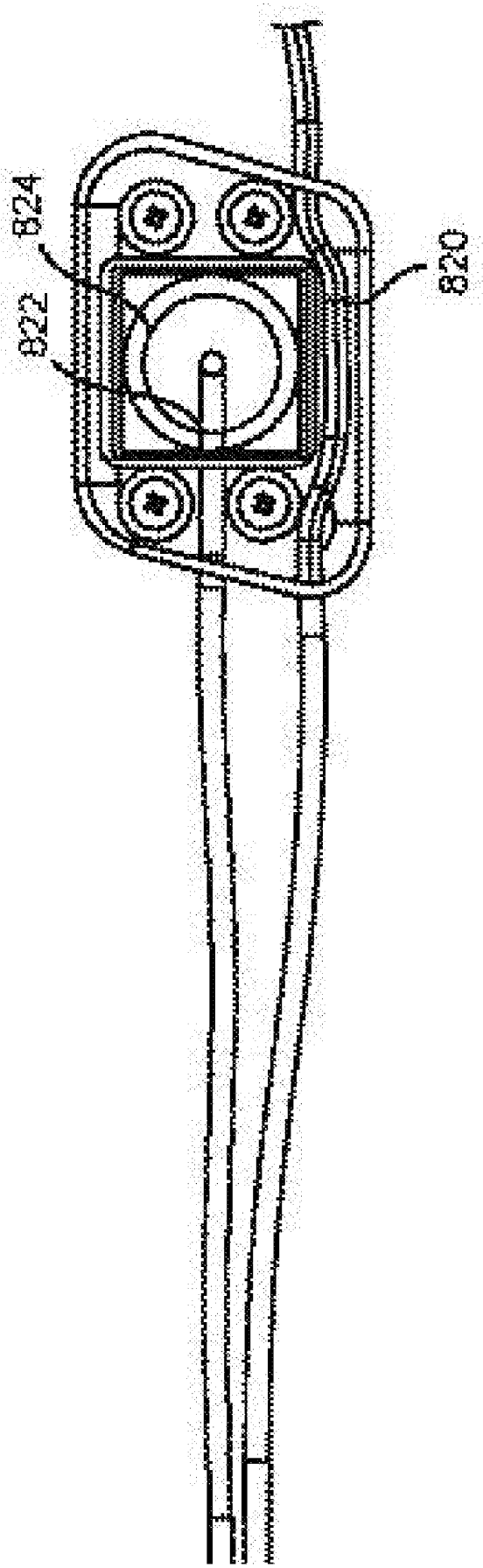
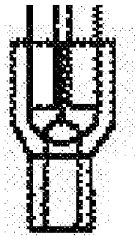


FIG. 8D

[Fig. 8E]



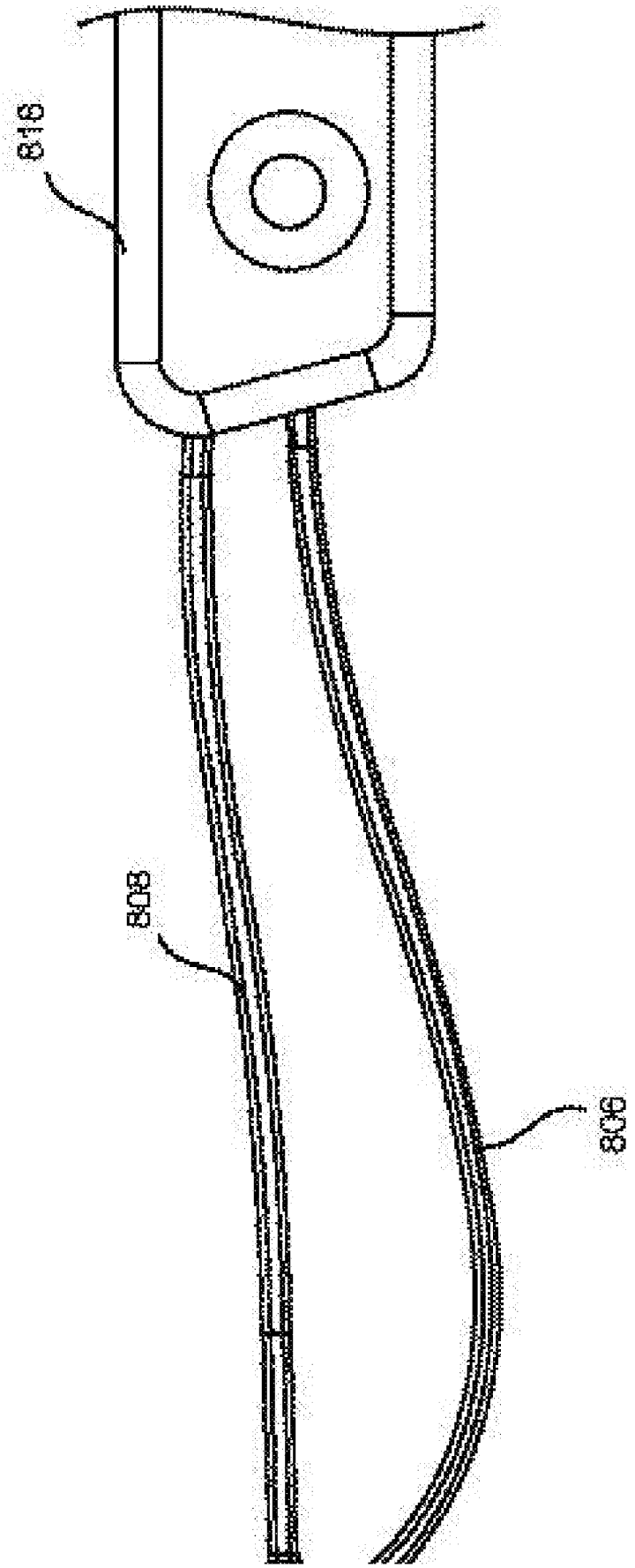
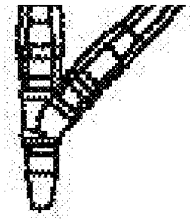


FIG. 8E

[Fig. 9]



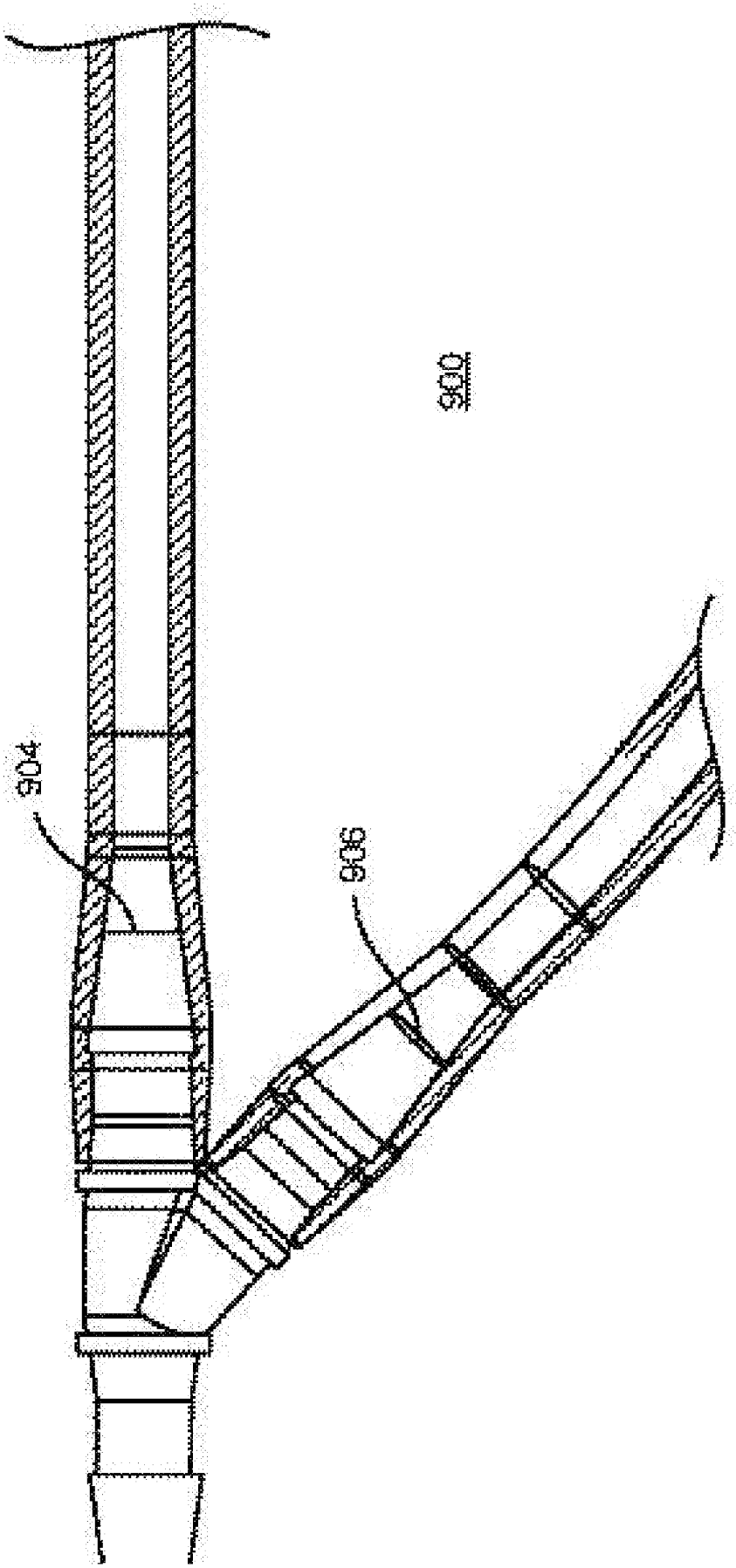


FIG. 9

[Fig. 10A]

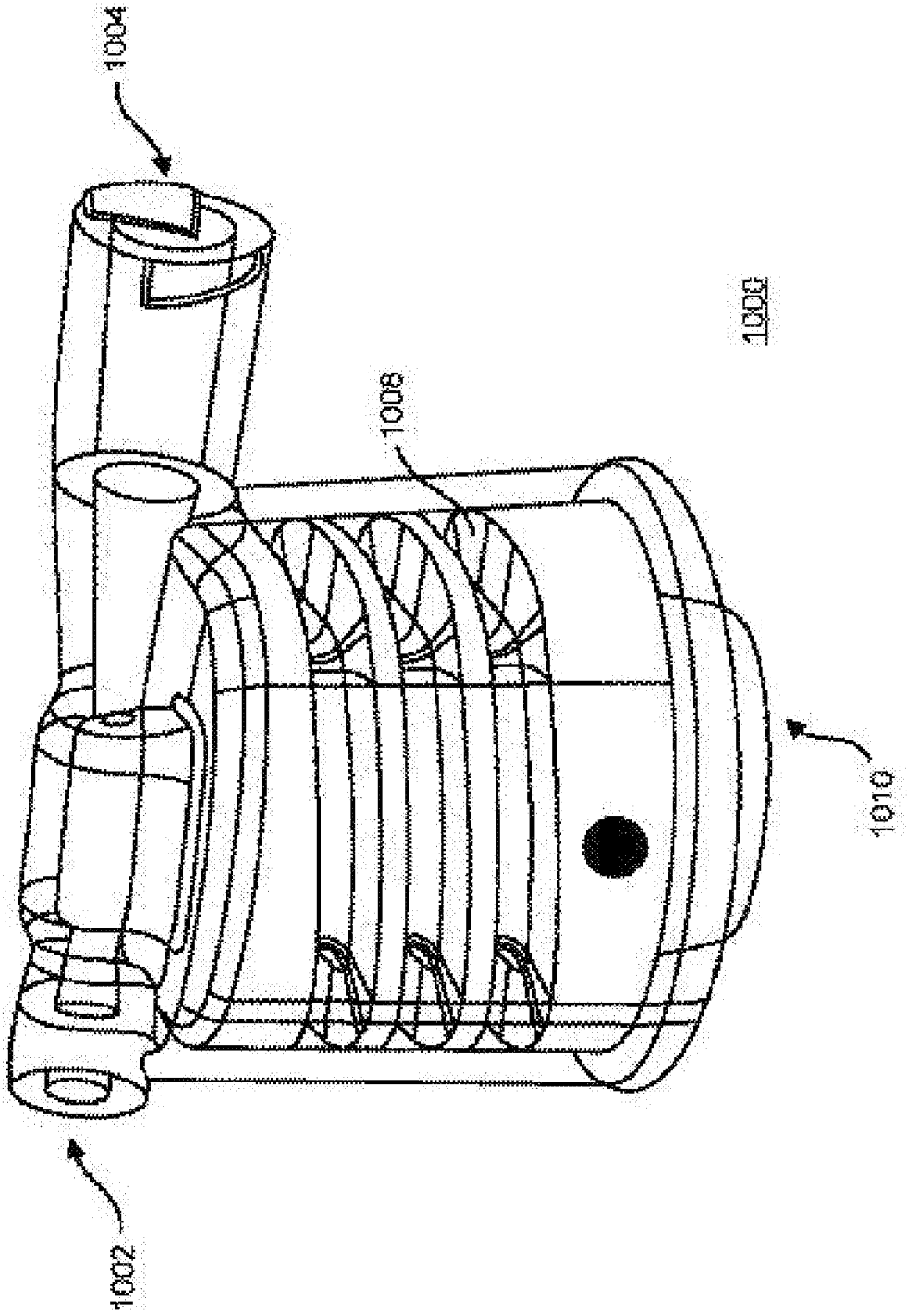


FIG. 10A

[Fig. 10B]

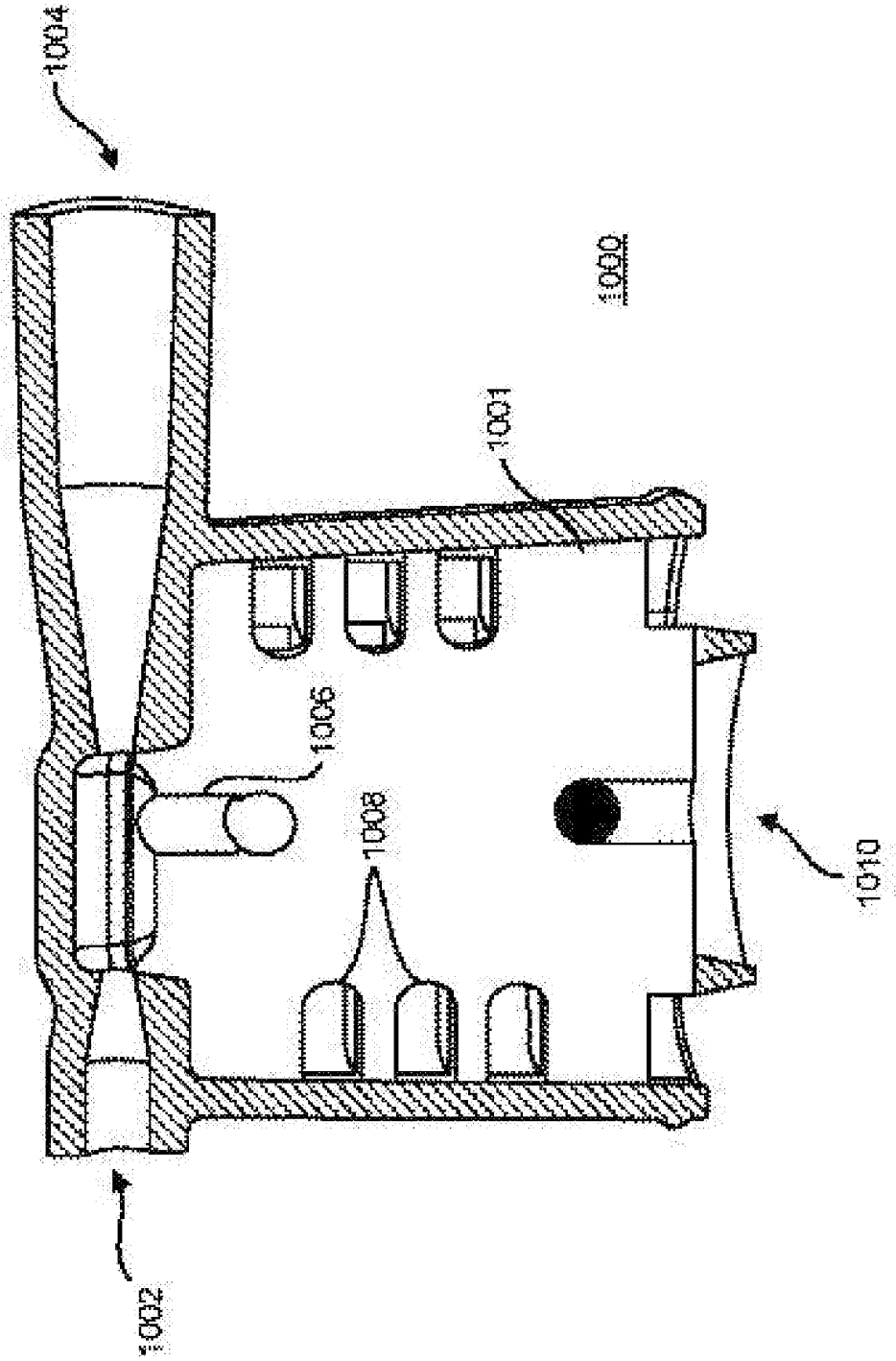
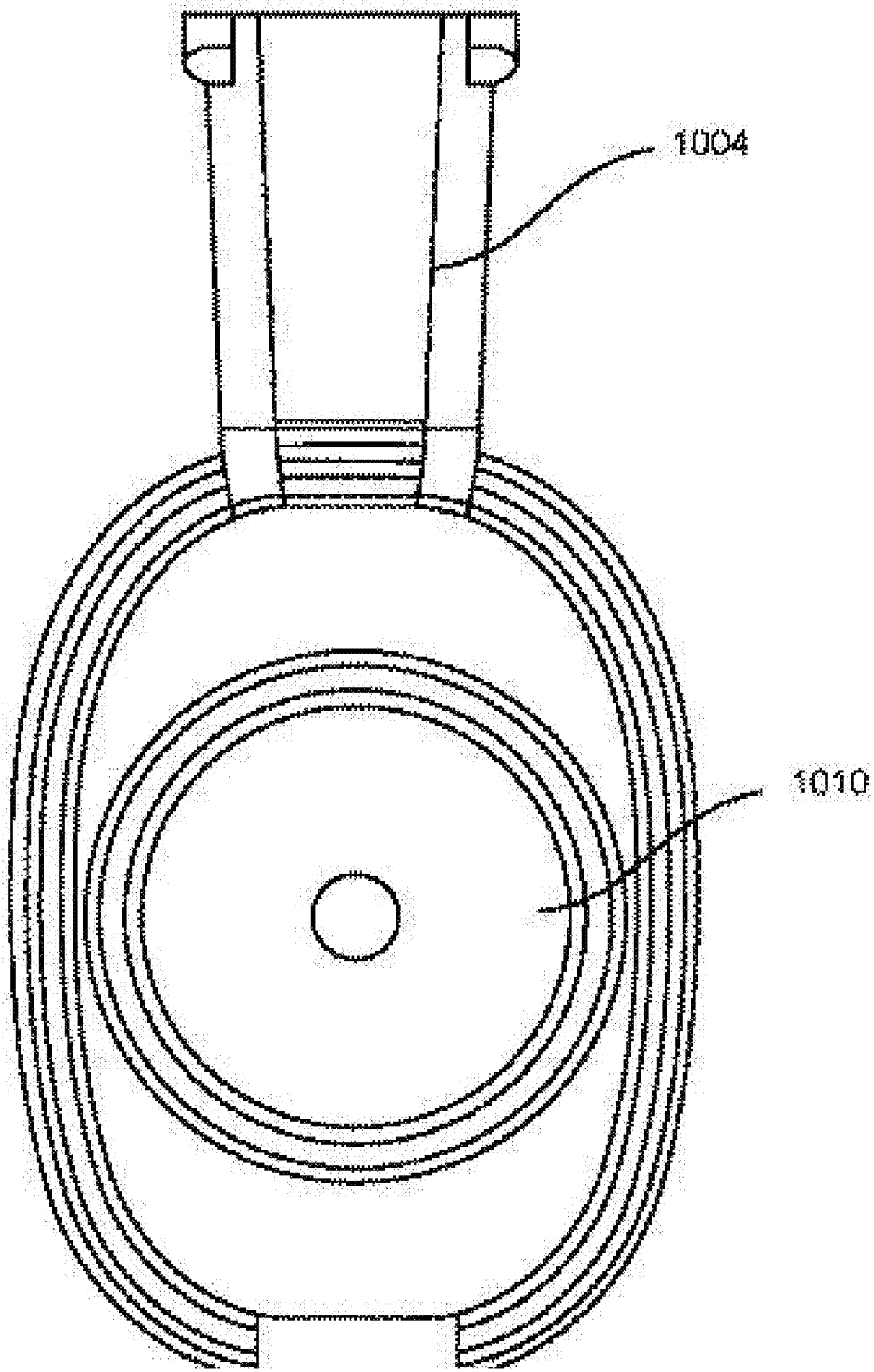


FIG. 10B

[Fig. 10C]


1004
1010

[Fig. 10D]

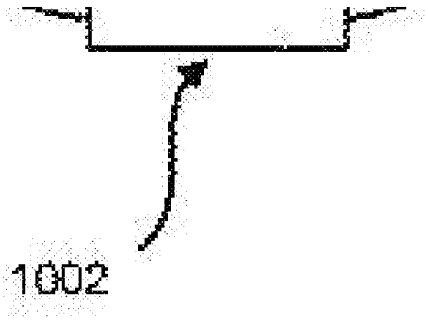
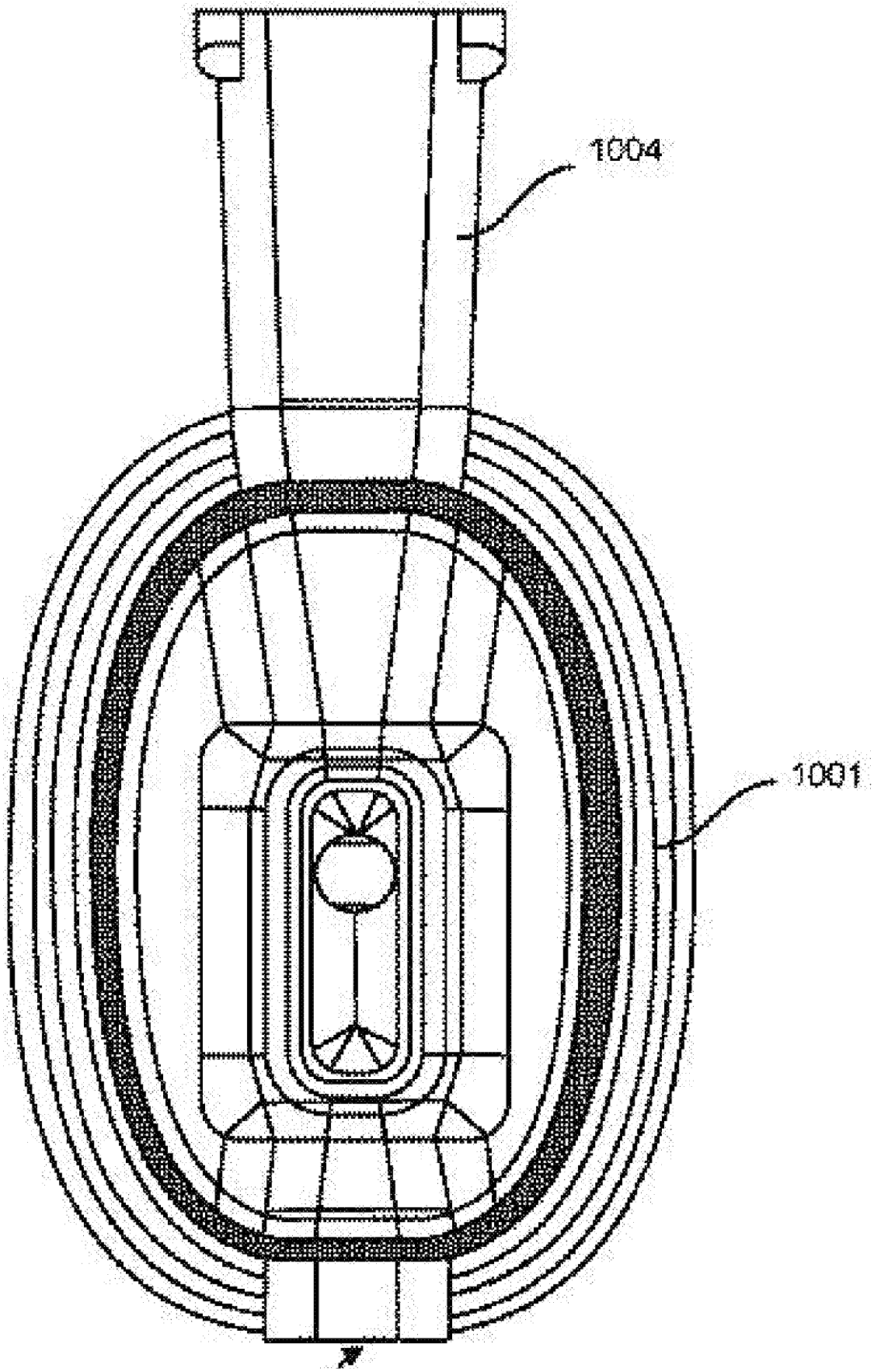


FIG. 10C


1004
1001

[Fig. 11A]

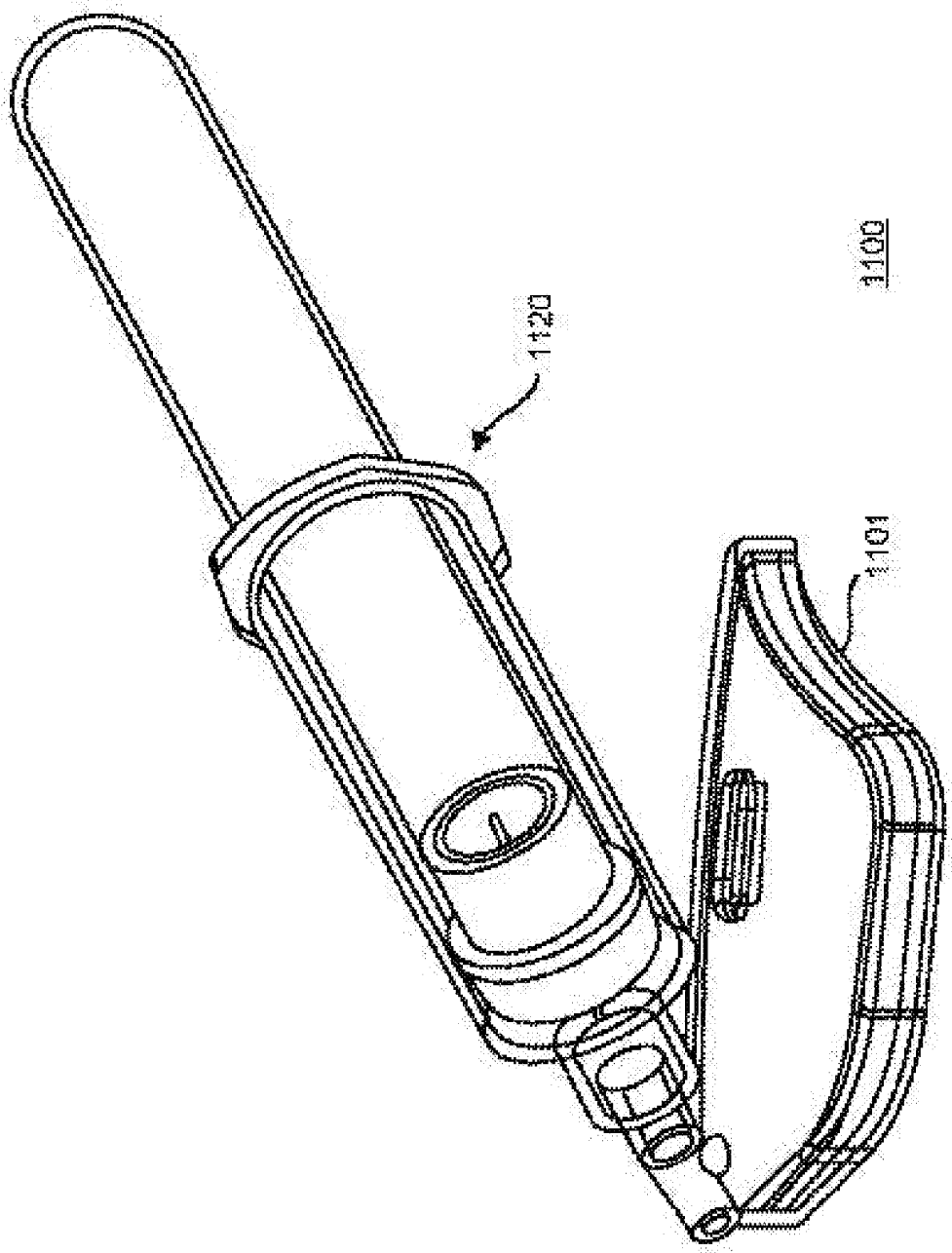


FIG. 11A

[Fig. 11B]

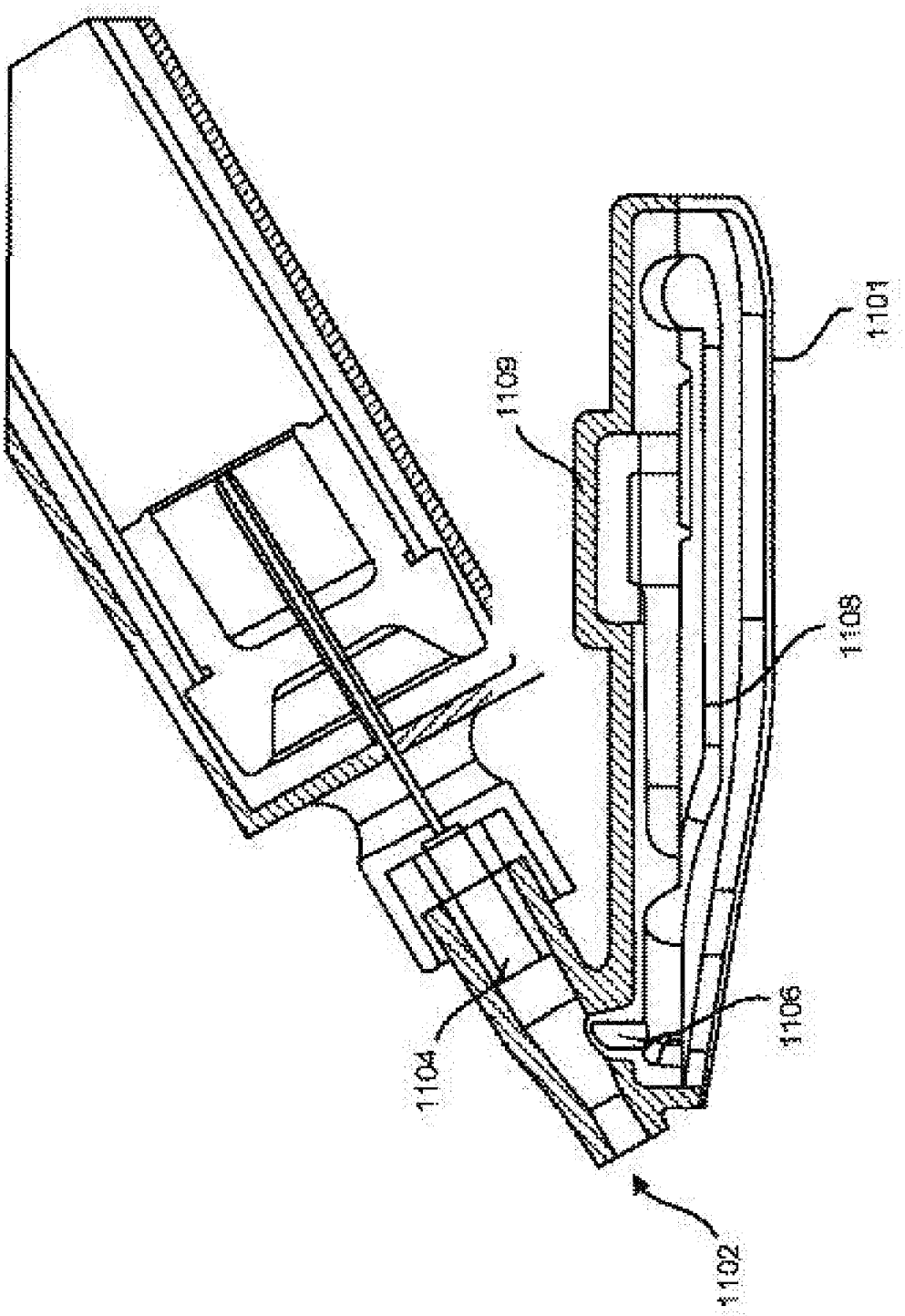
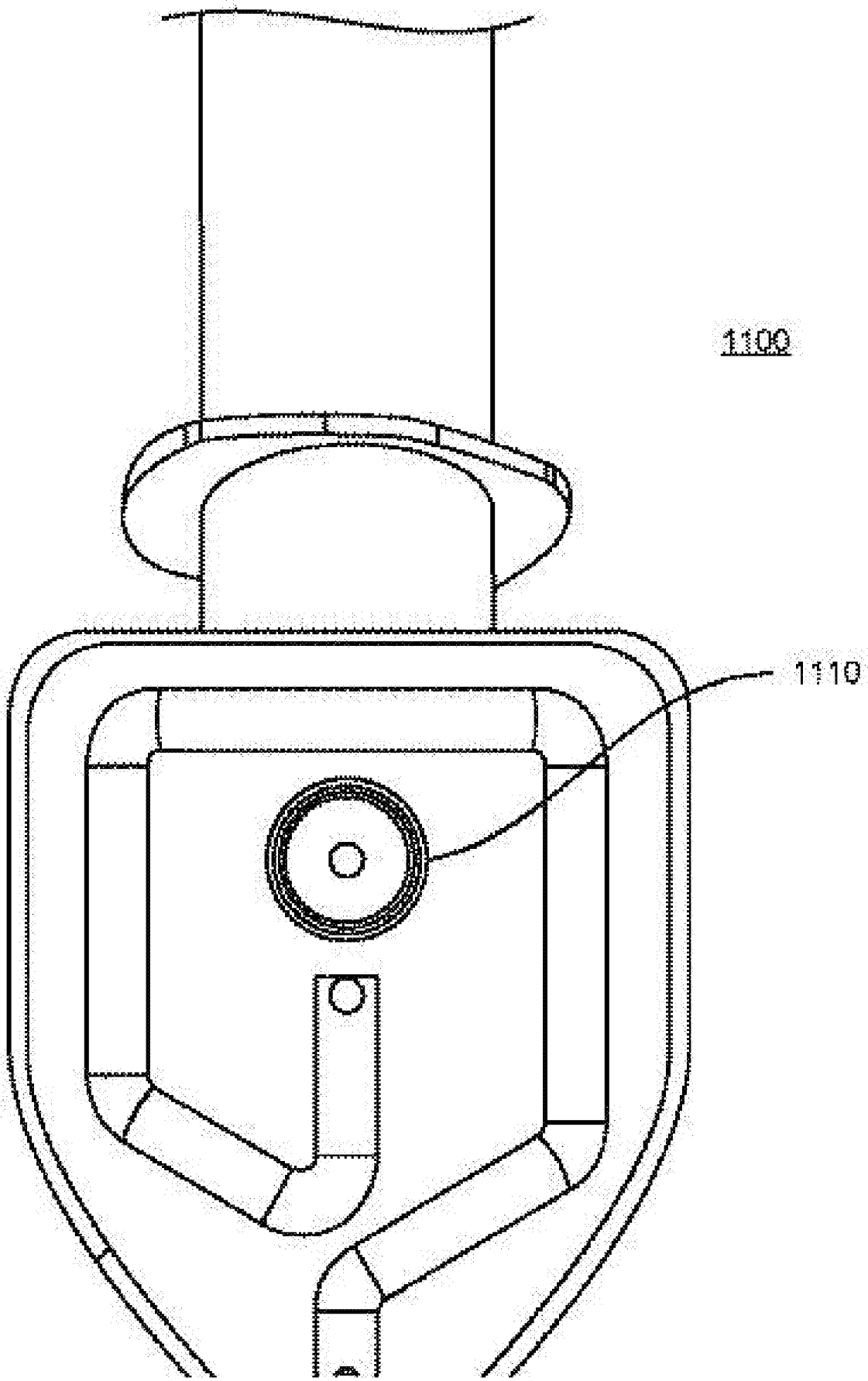


FIG. 11B

[Fig. 11C]


1100
1110

[Fig. 11D]

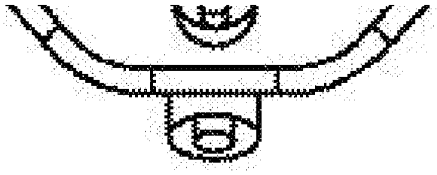
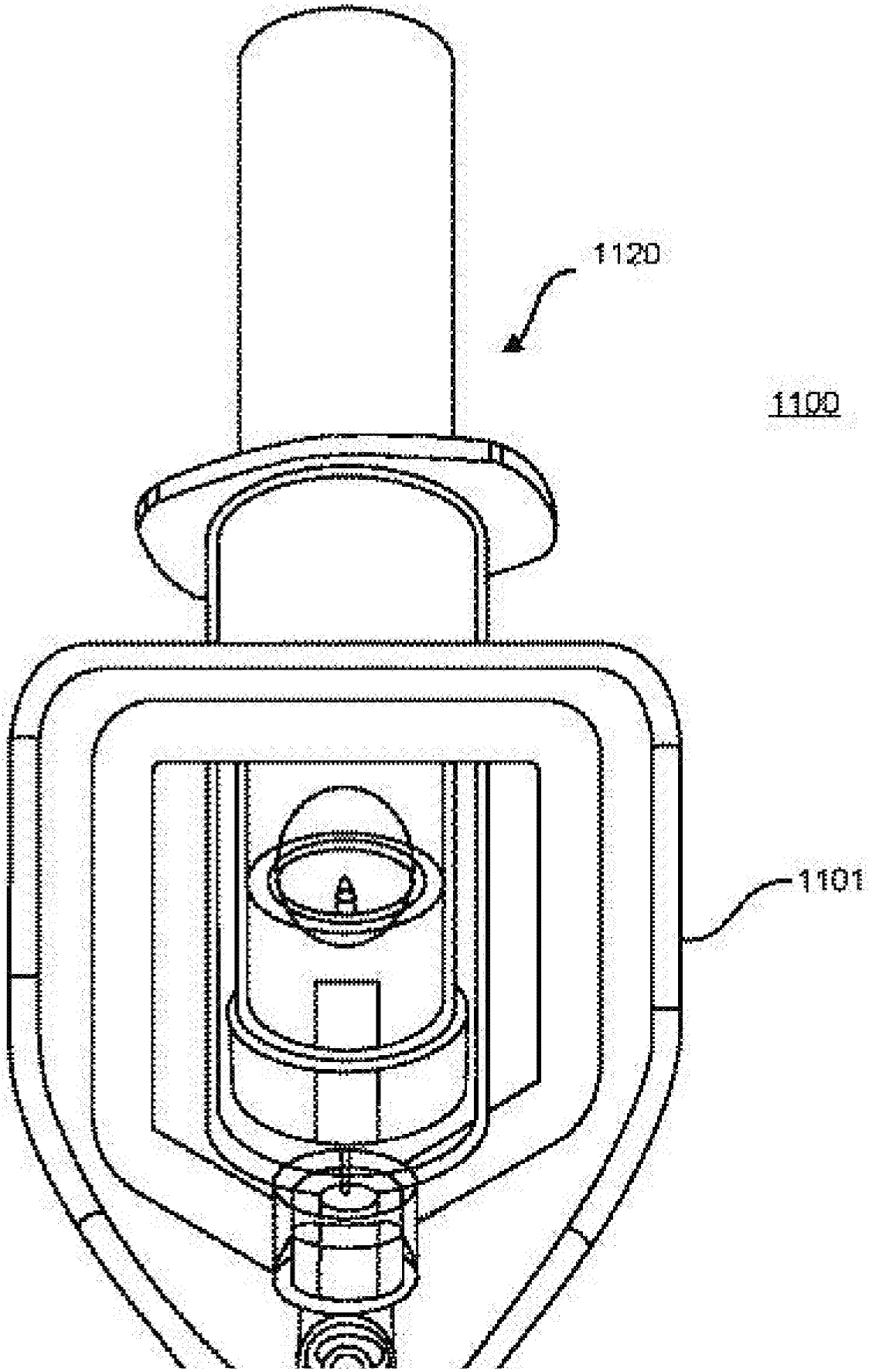


FIG. 11C


1120
1100
1101

[Fig. 11E]

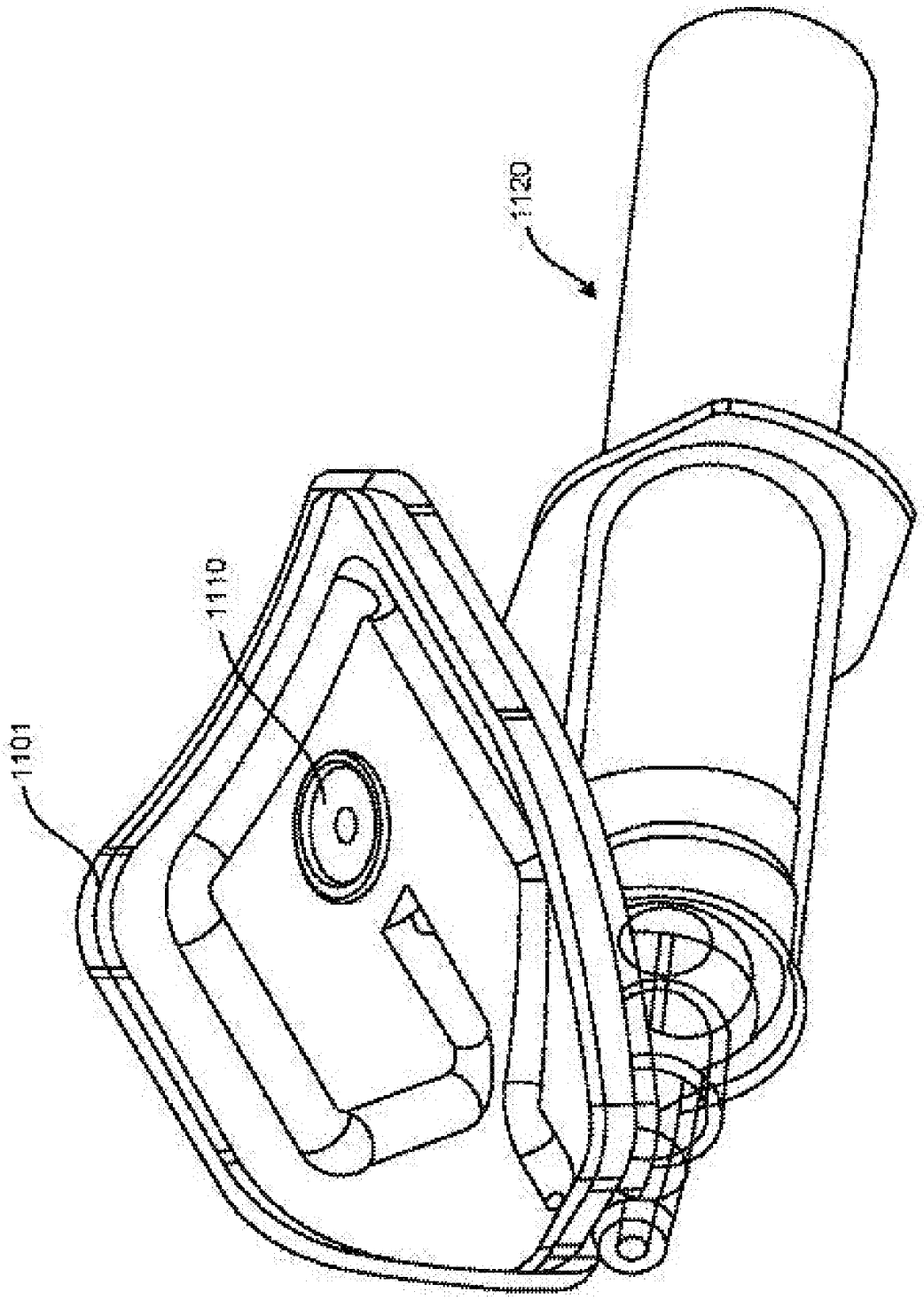


FIG. 11E

[Fig. 12A]

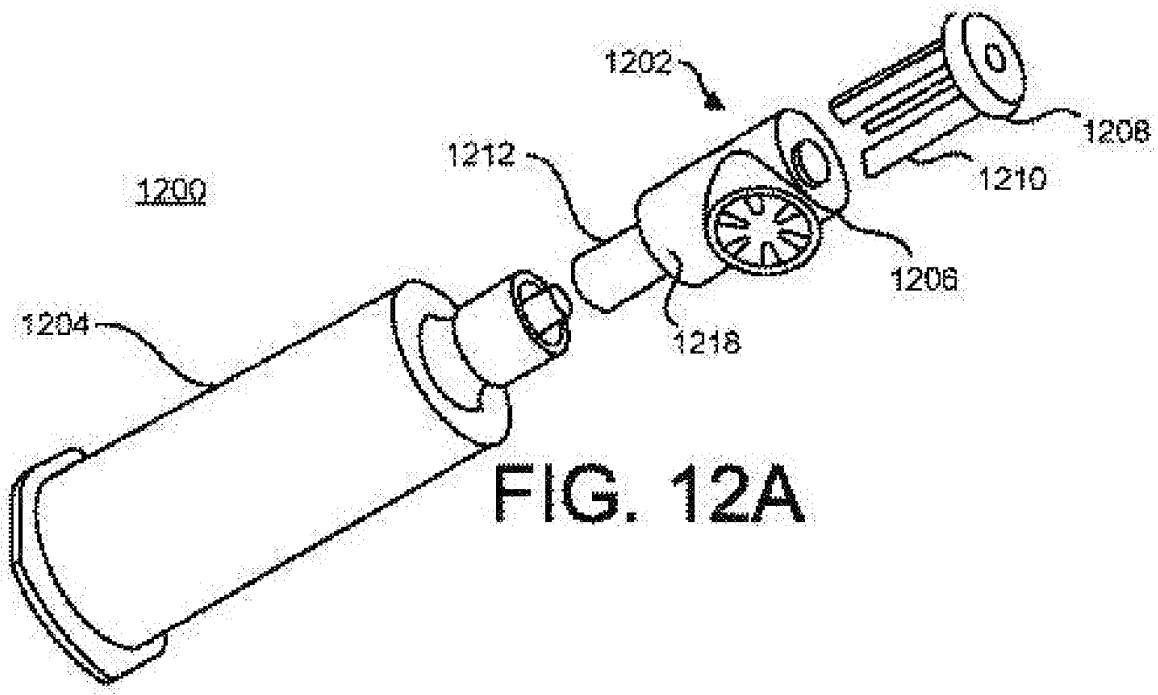


FIG. 12A

[Fig. 12B]

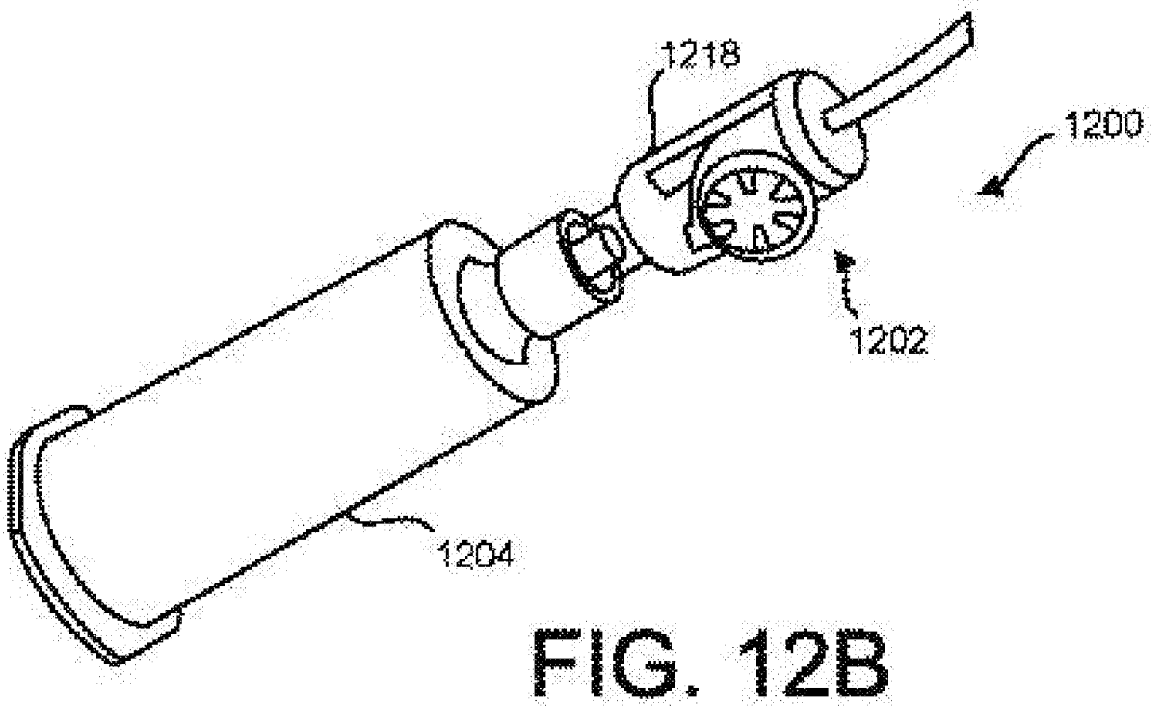


FIG. 12B

[Fig. 12C]

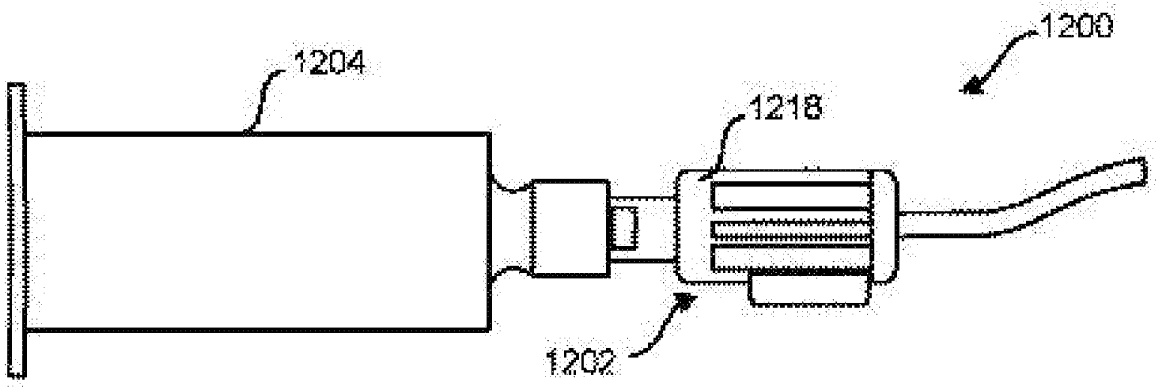


FIG. 12C

[Fig. 12D]

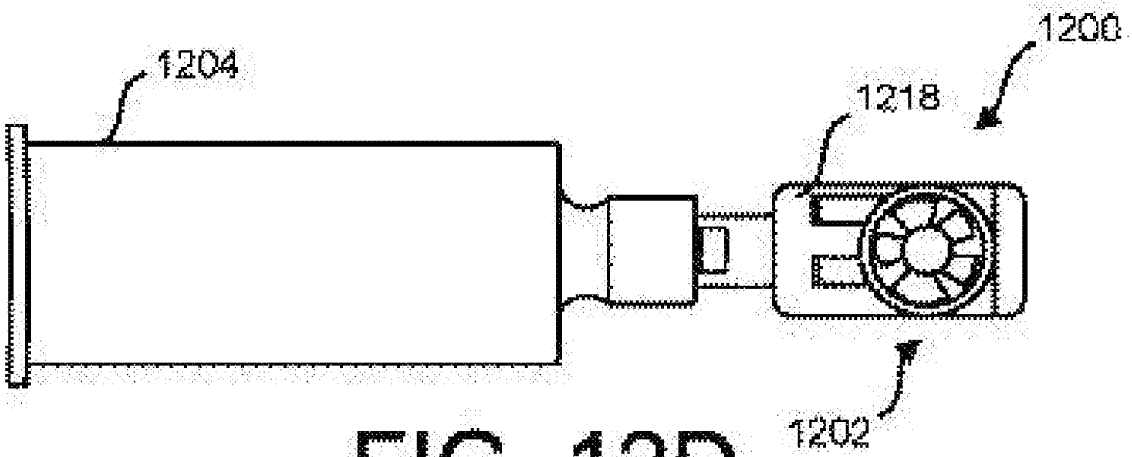


FIG. 12D

[Fig. 13A]

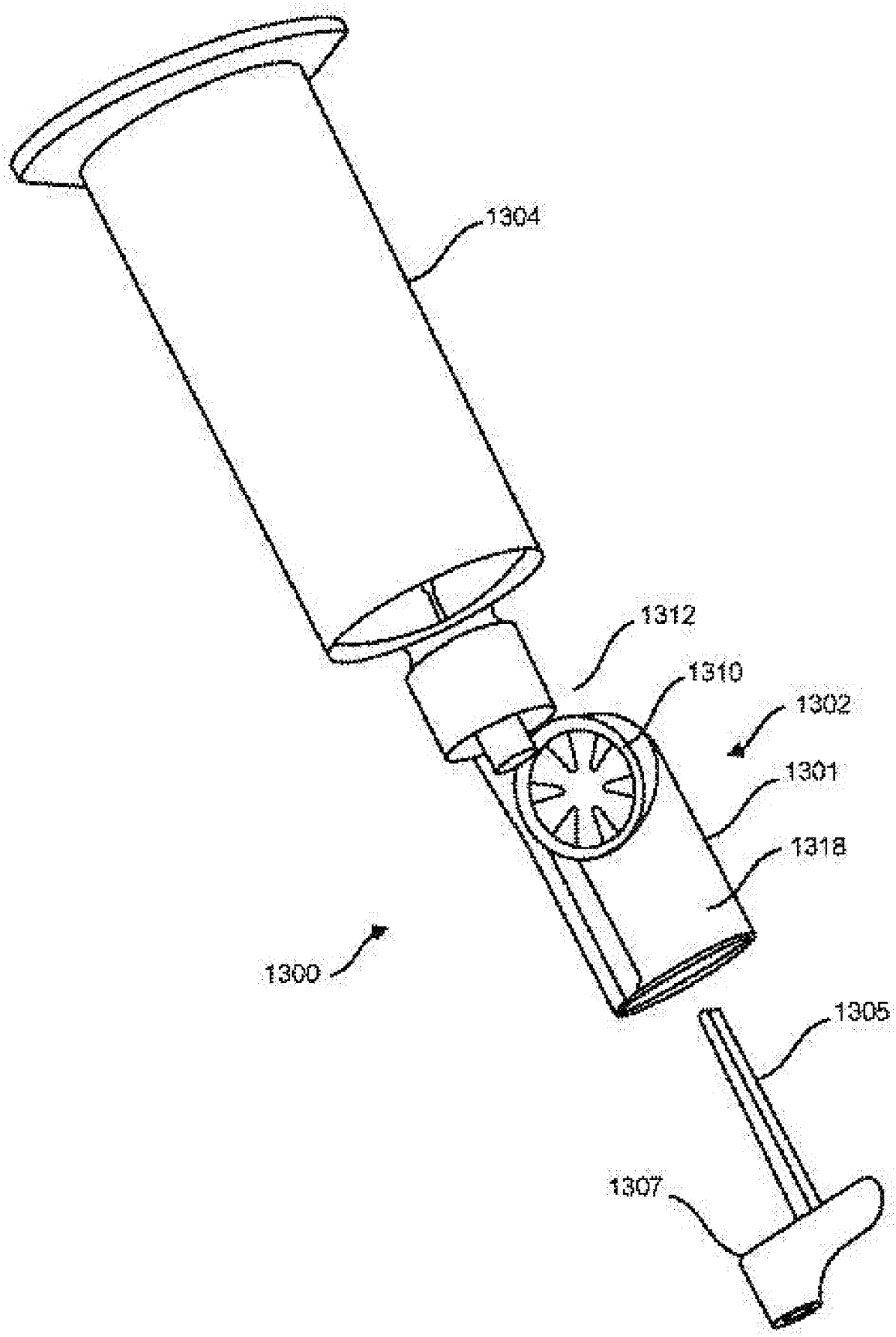


FIG. 13A

[Fig. 13B]

FIG. 13A

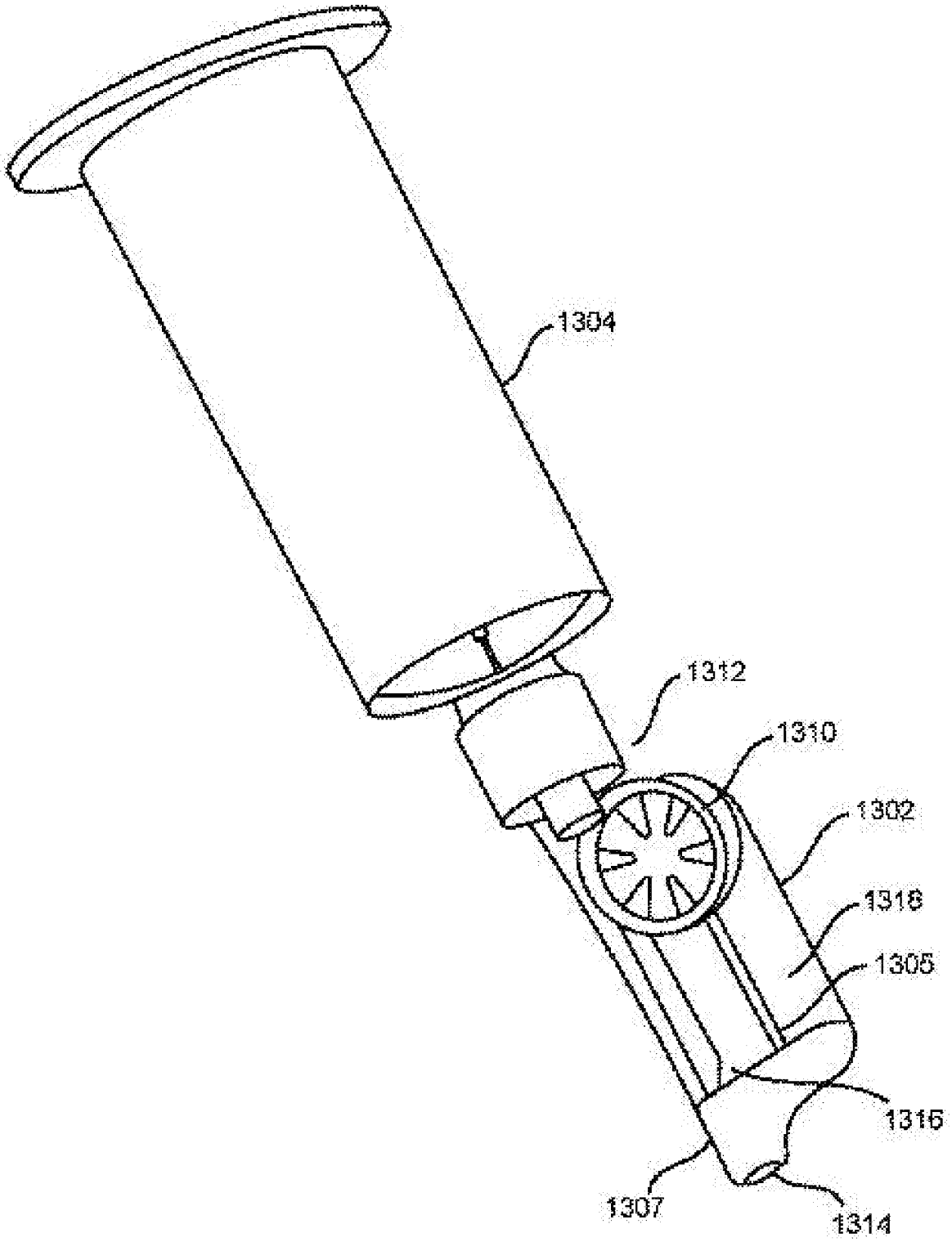


FIG. 13B

[Fig. 13C]

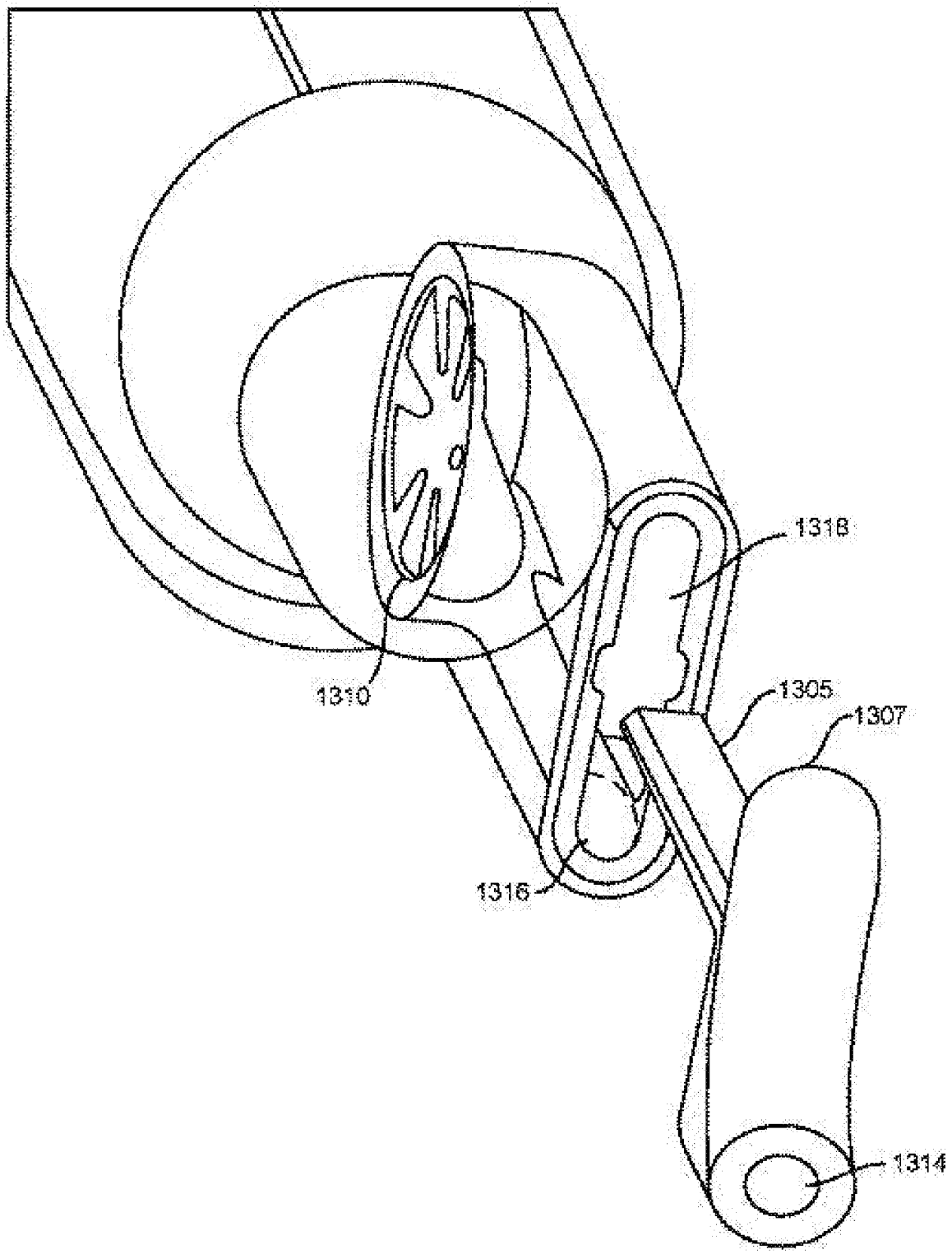
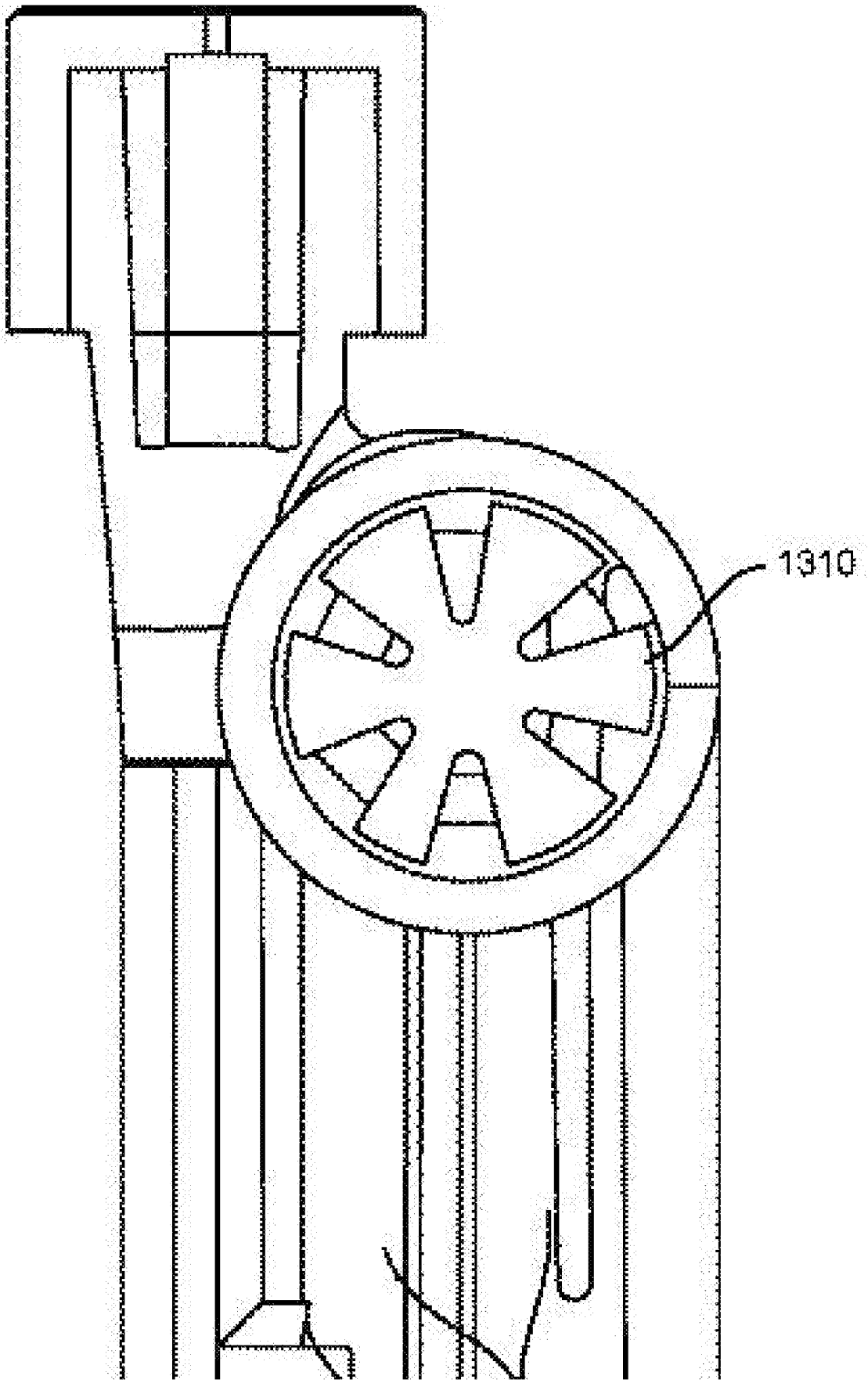


FIG. 13C

[Fig. 13D]


1310

[Fig. 14A]

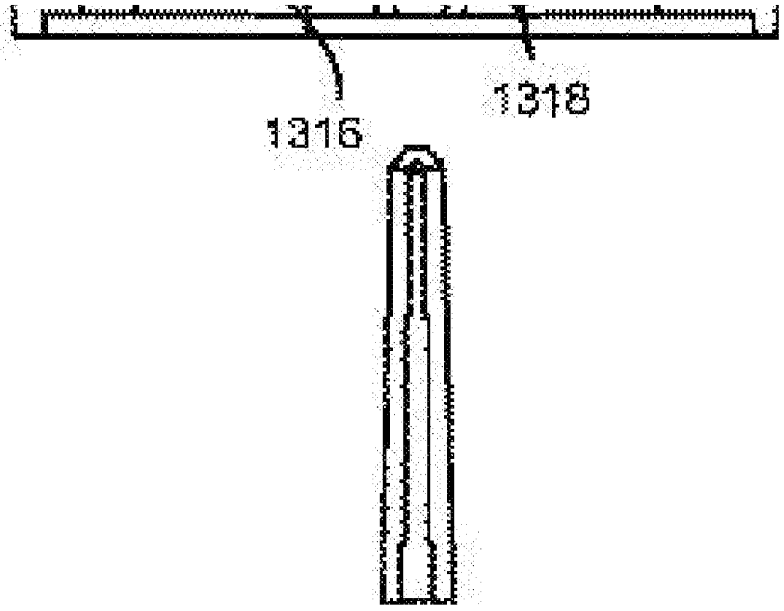
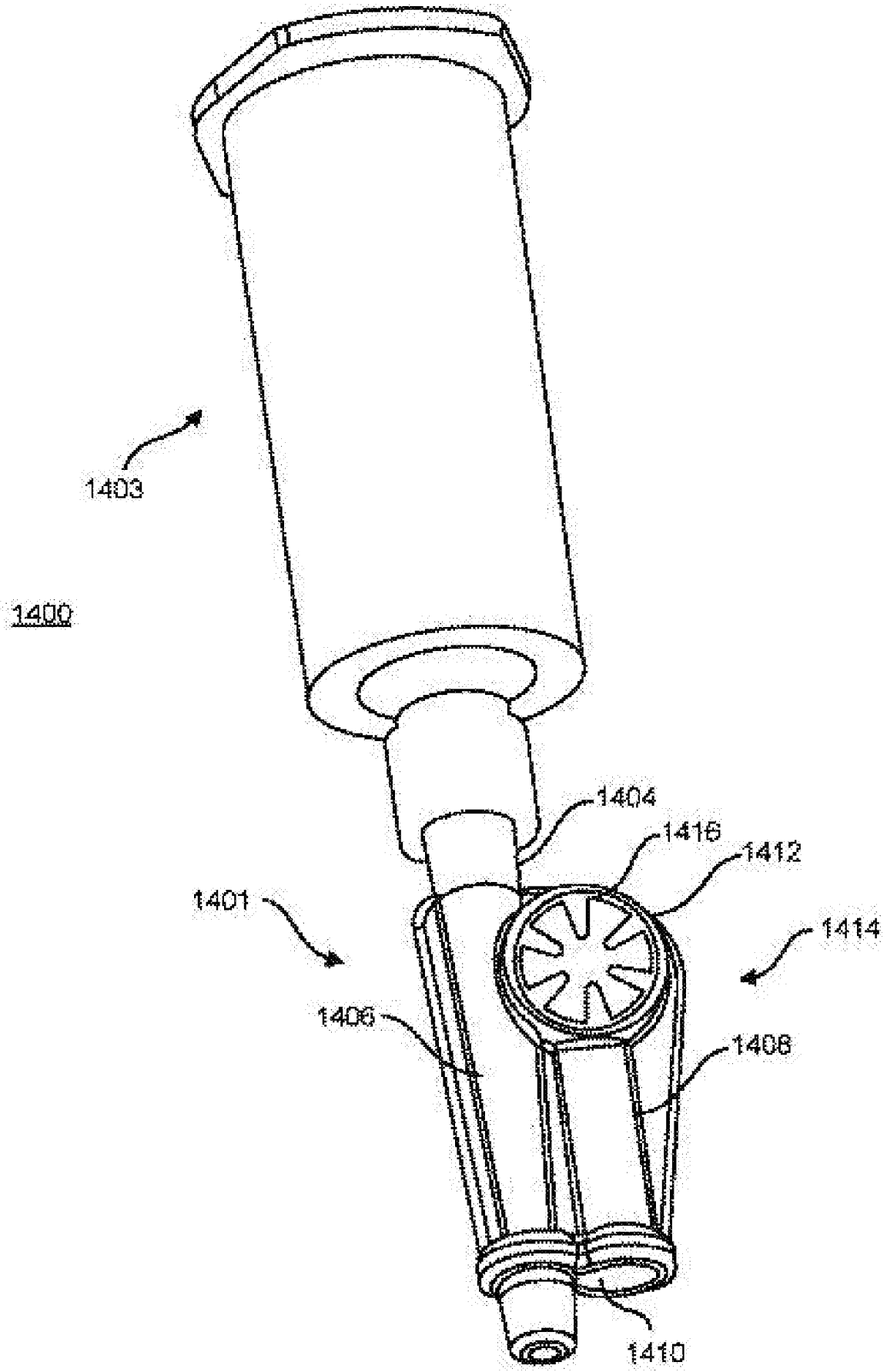


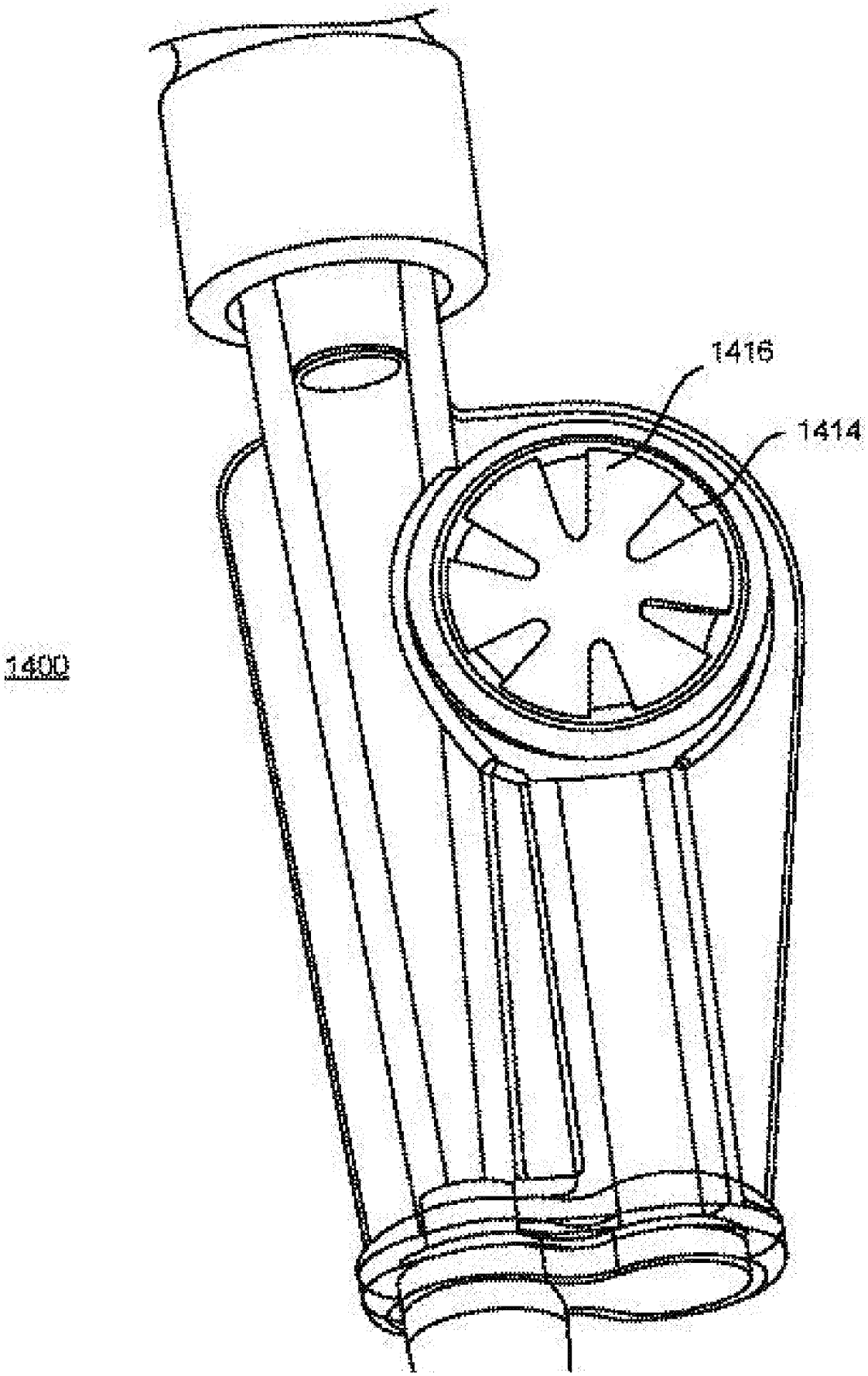
FIG. 13D


1403
1400
1404
1416
1412
1401
1414
1406
1408
1410

[Fig. 14B]



FIG. 14A


1416
1414
1400

[Fig. 14C]



FIG. 14B

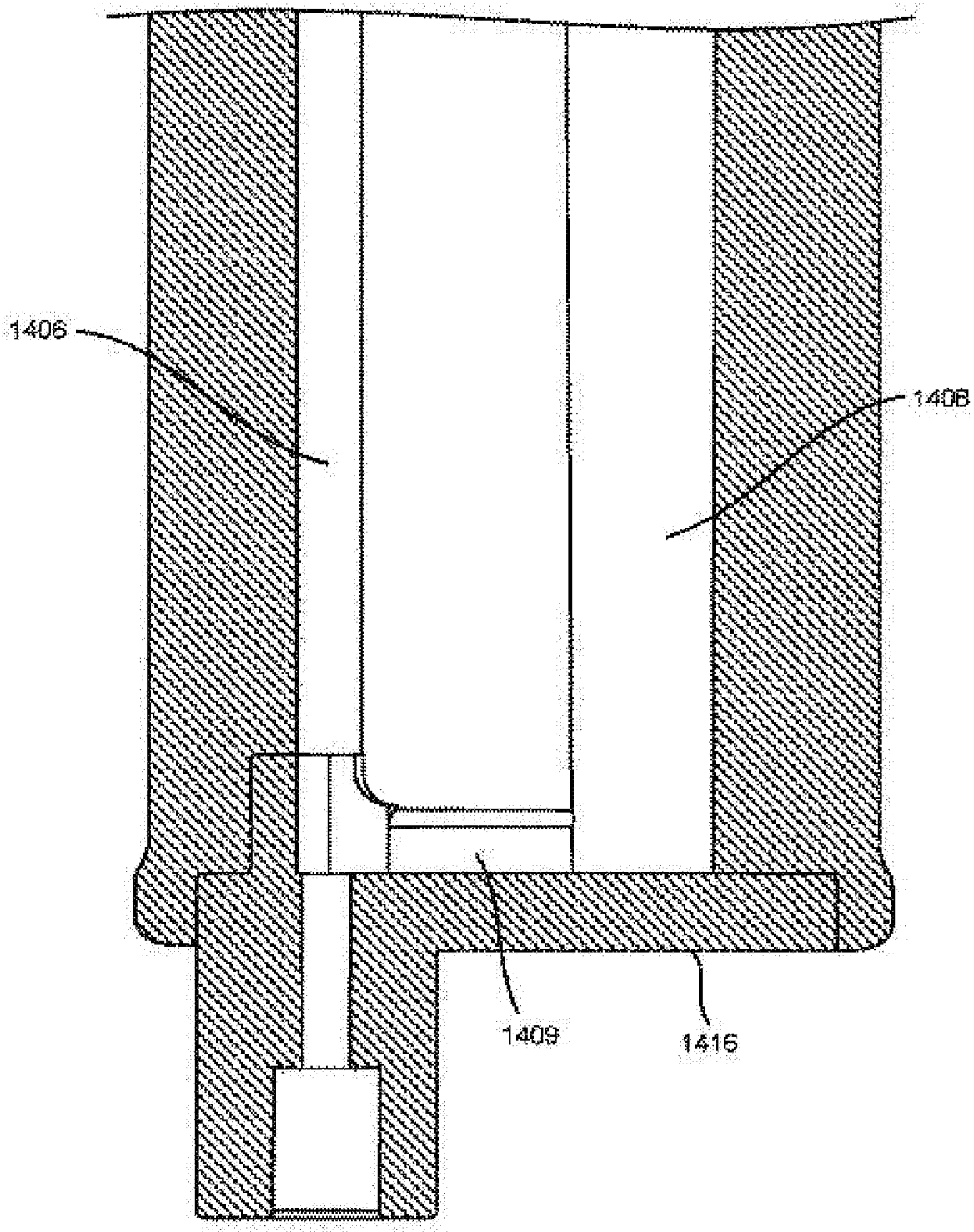
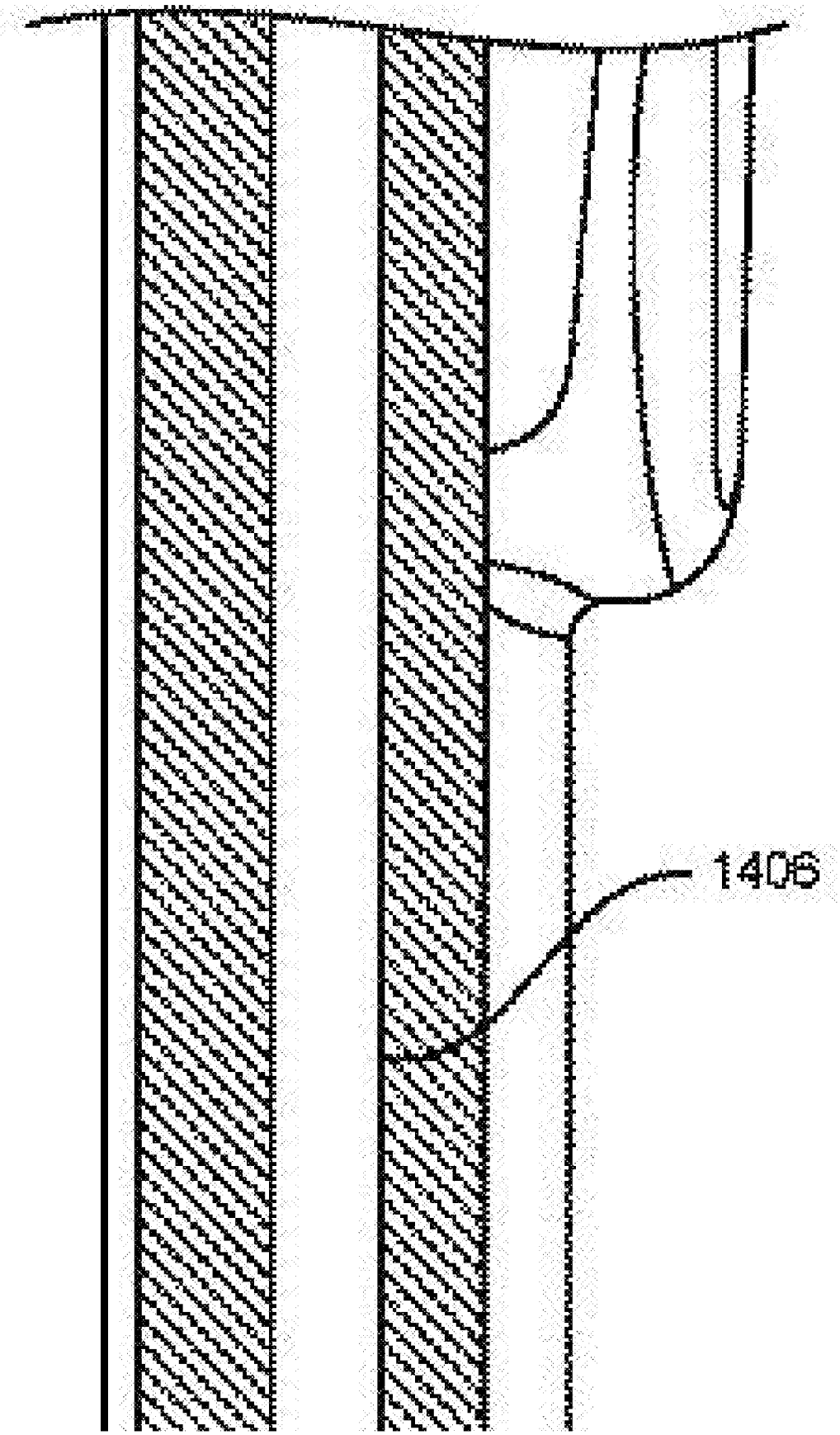


FIG. 14C

[Fig. 14D]


1406

[Fig. 14E]

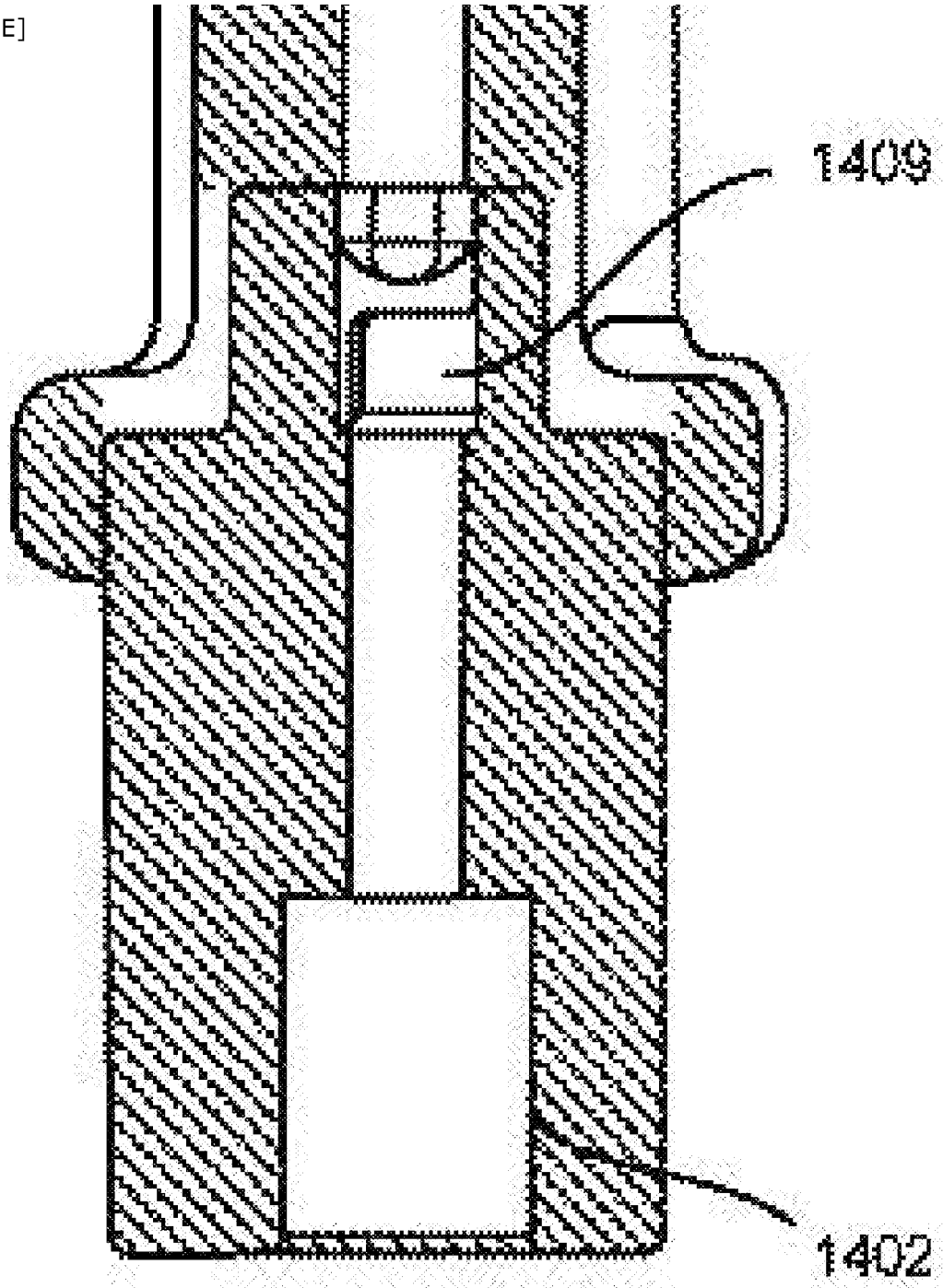


FIG. 14D

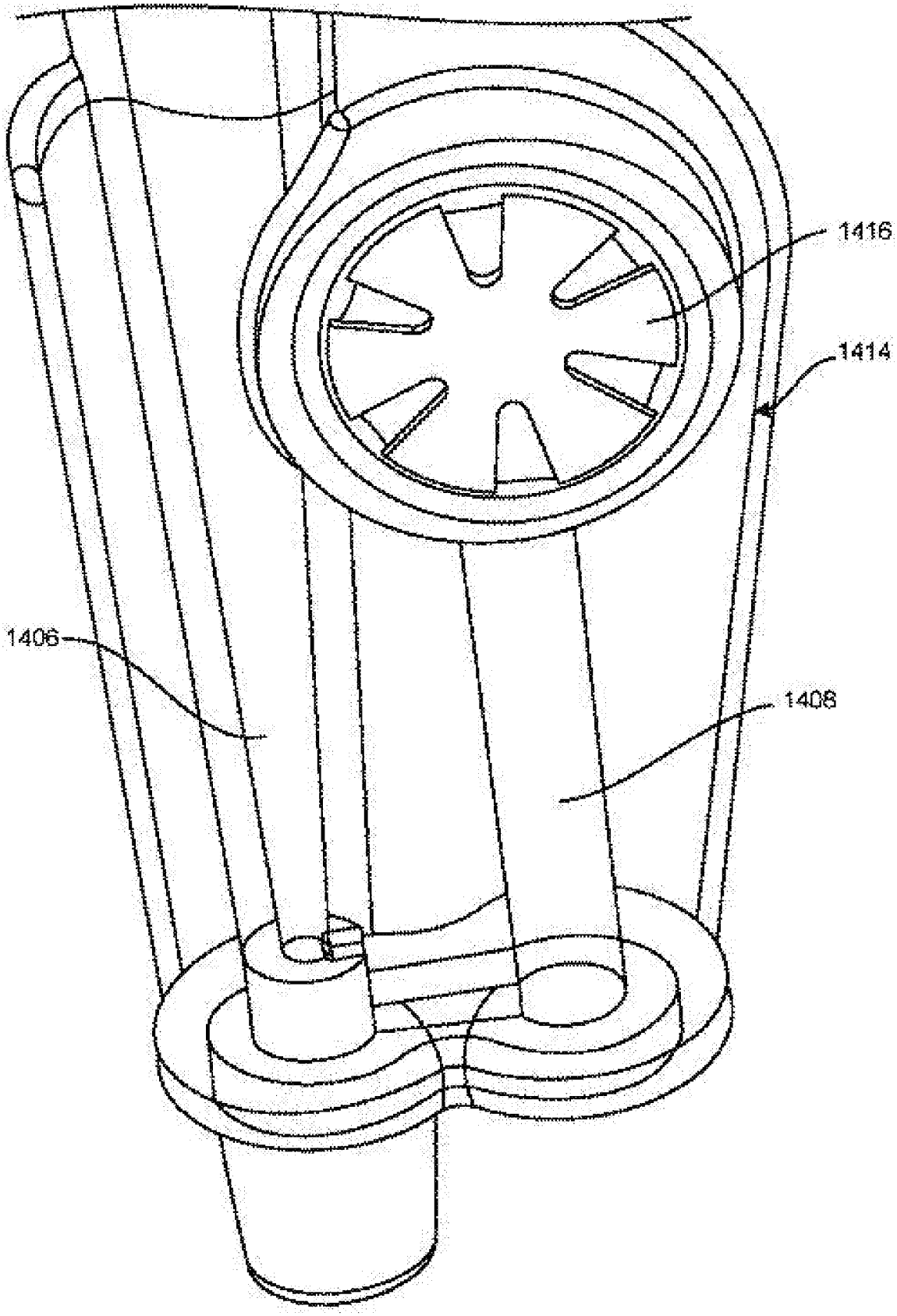


FIG. 14E

[Fig. 15A]

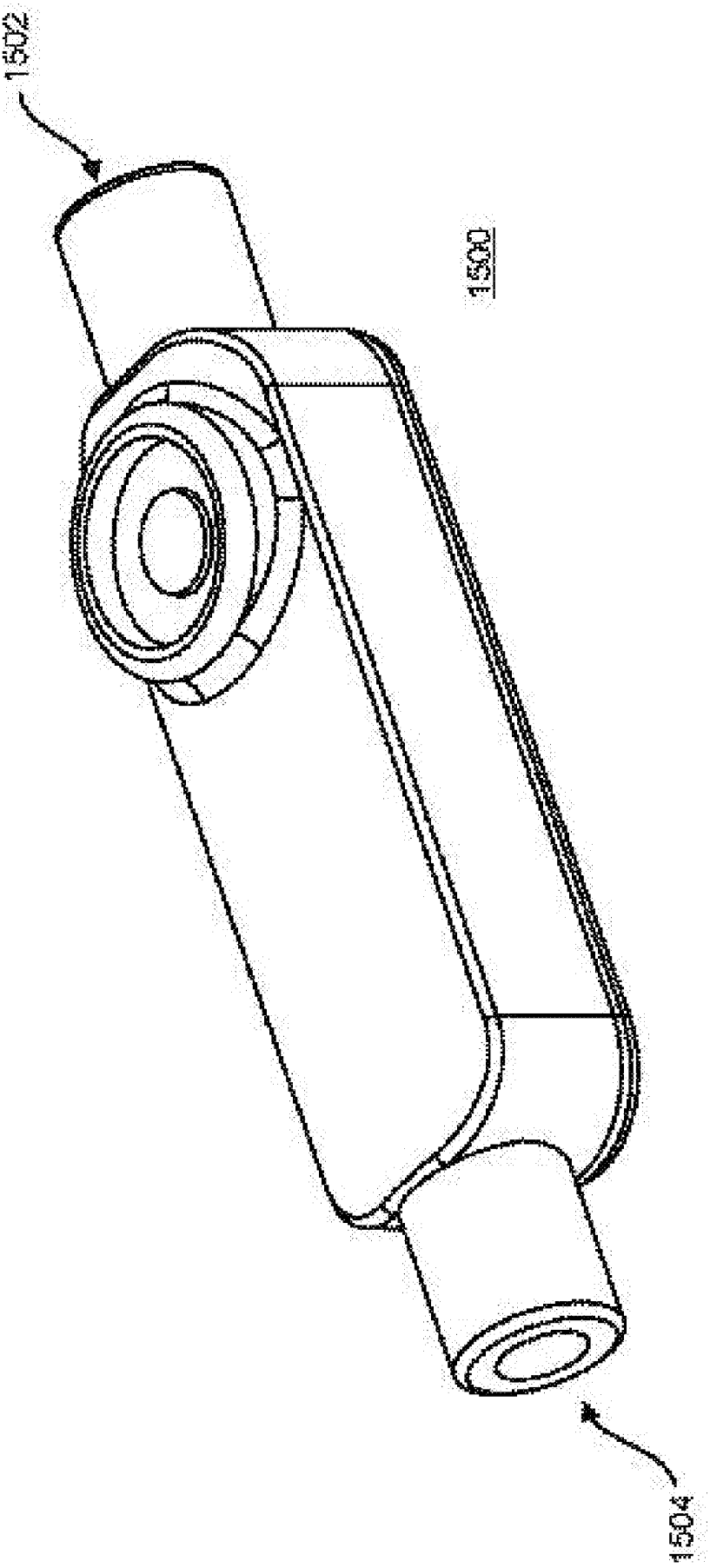


FIG. 15A

[Fig. 15B]

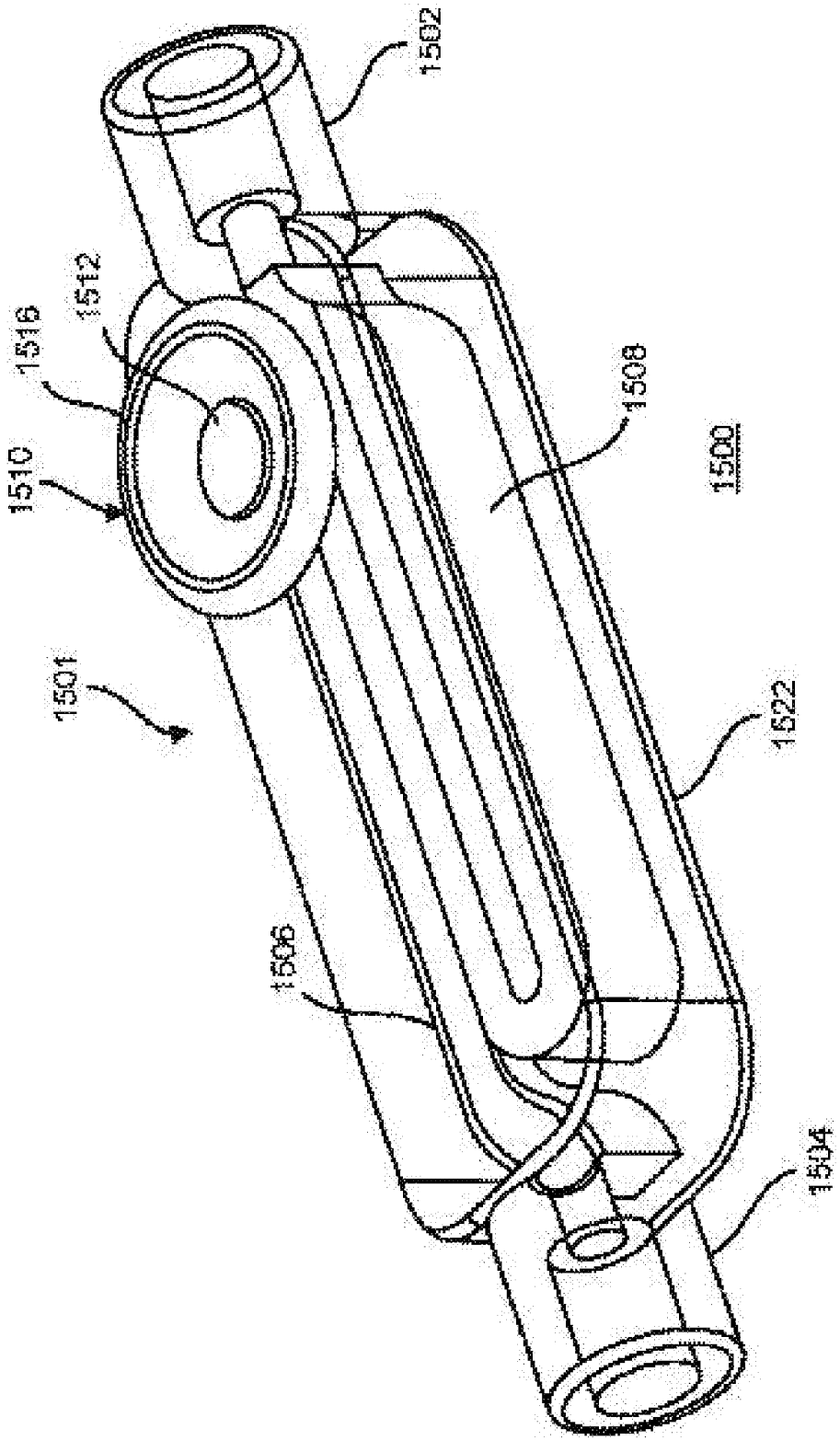


FIG. 15B

[Fig. 15C]

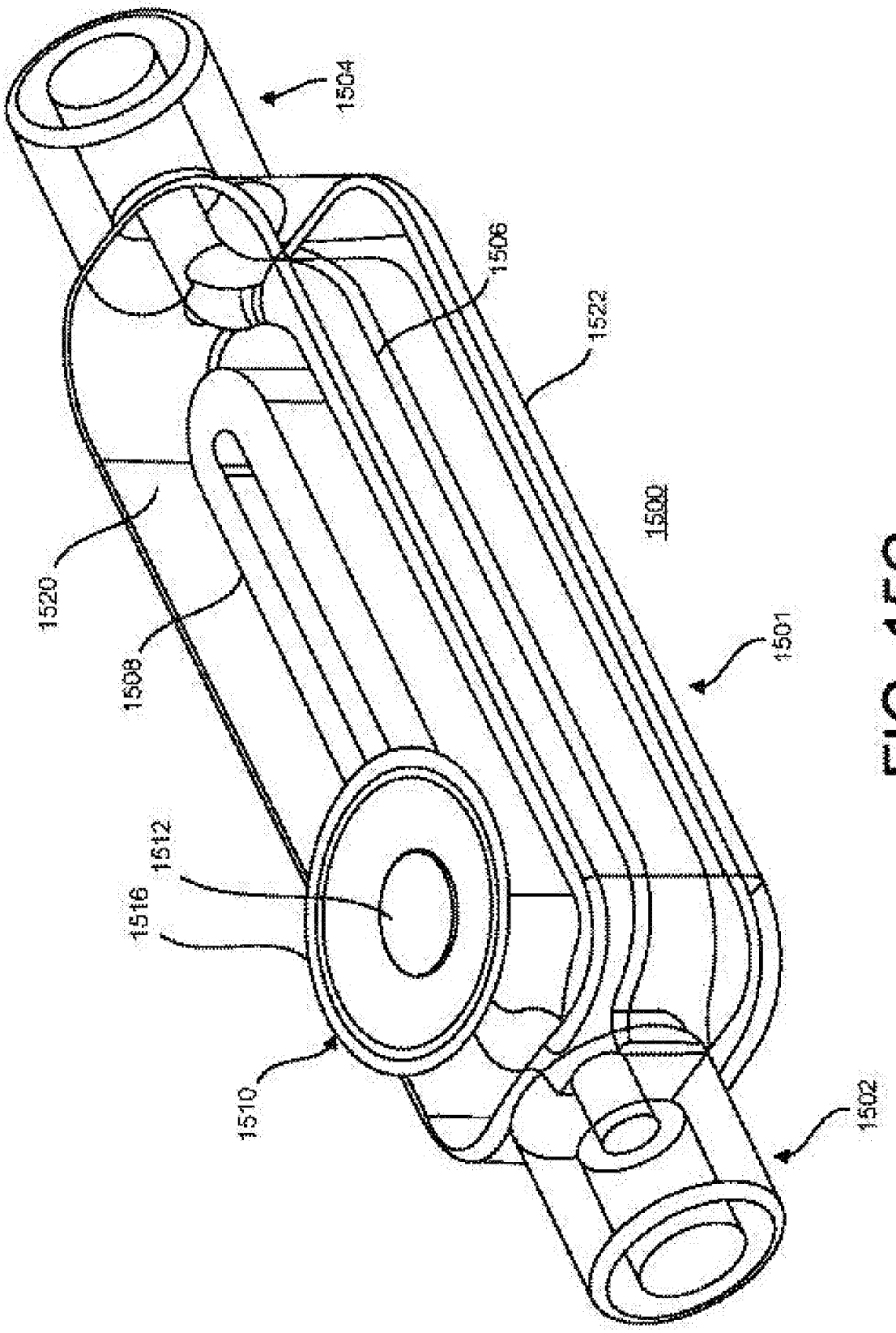


FIG. 15C

[Fig. 15D]

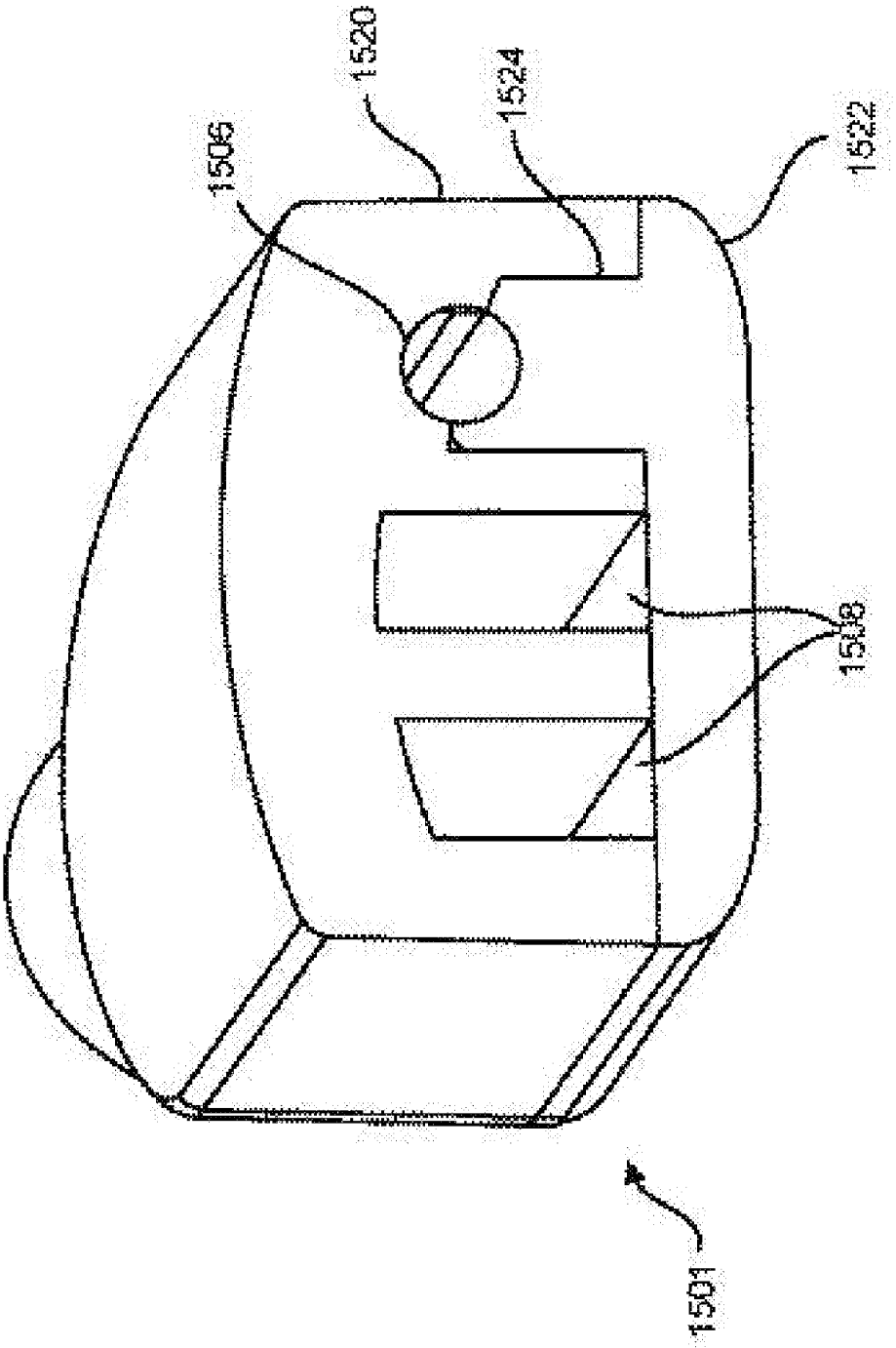


FIG. 15D

[Fig. 15E]

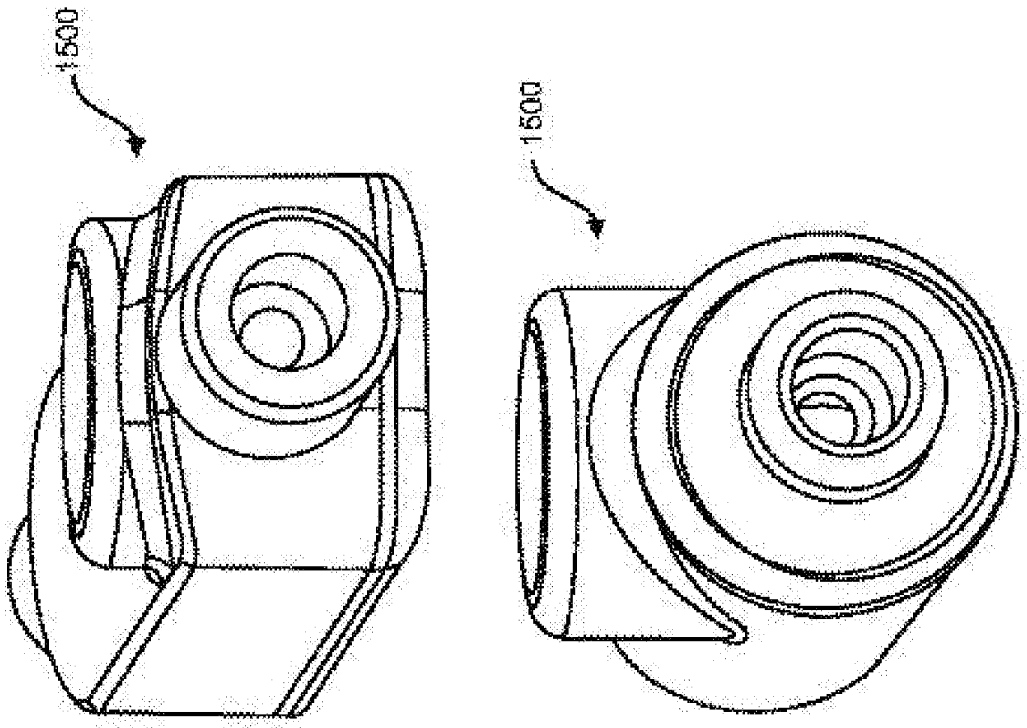


FIG. 15E

[Fig. 15F]

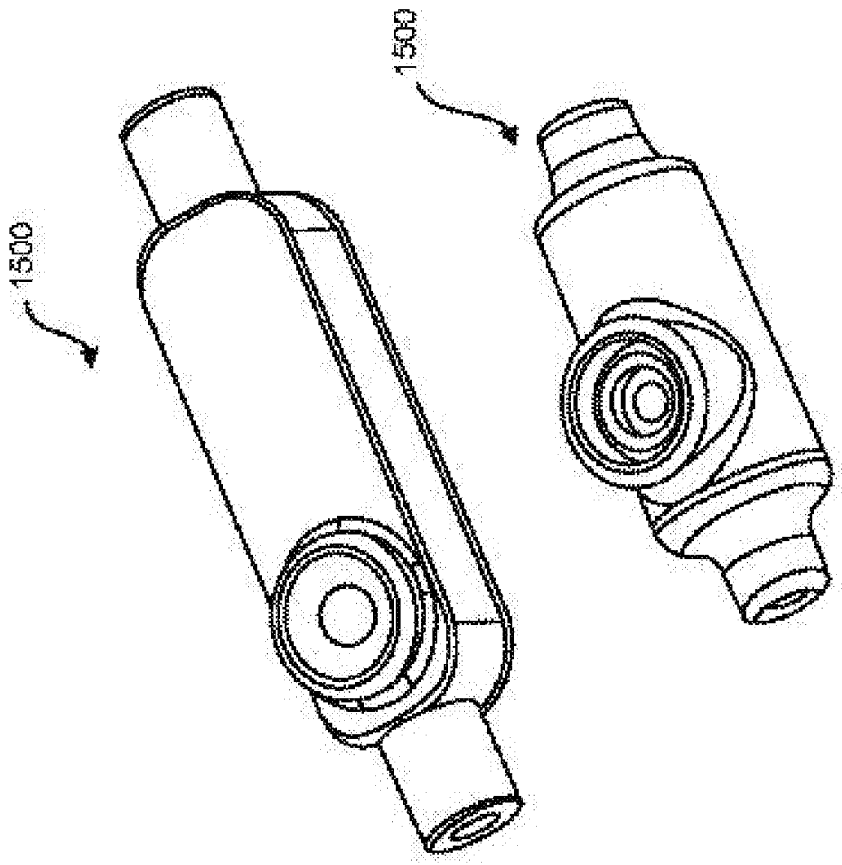


FIG. 15F

[Fig. 15G]

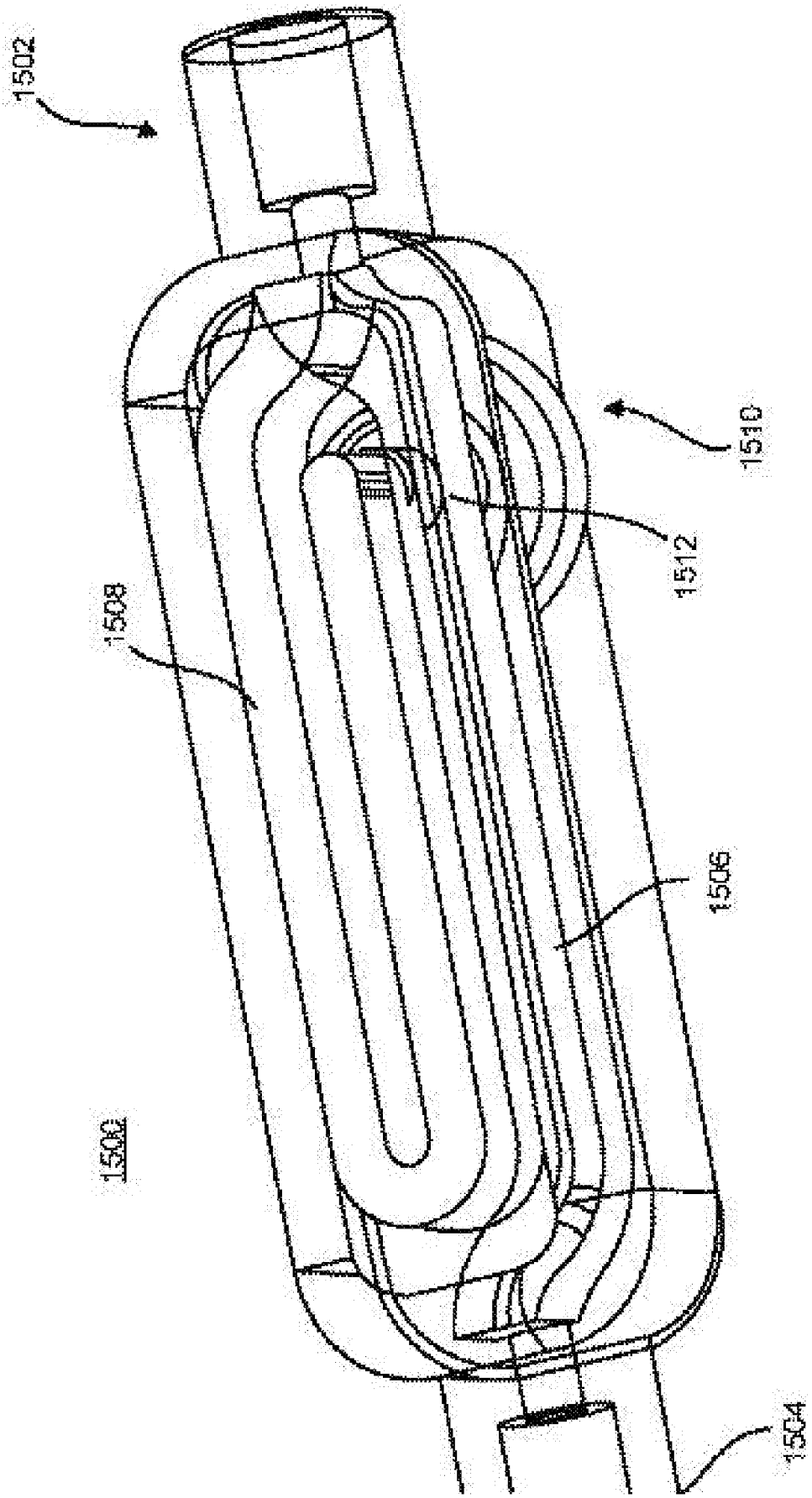


FIG. 15G

[Fig. 16A]



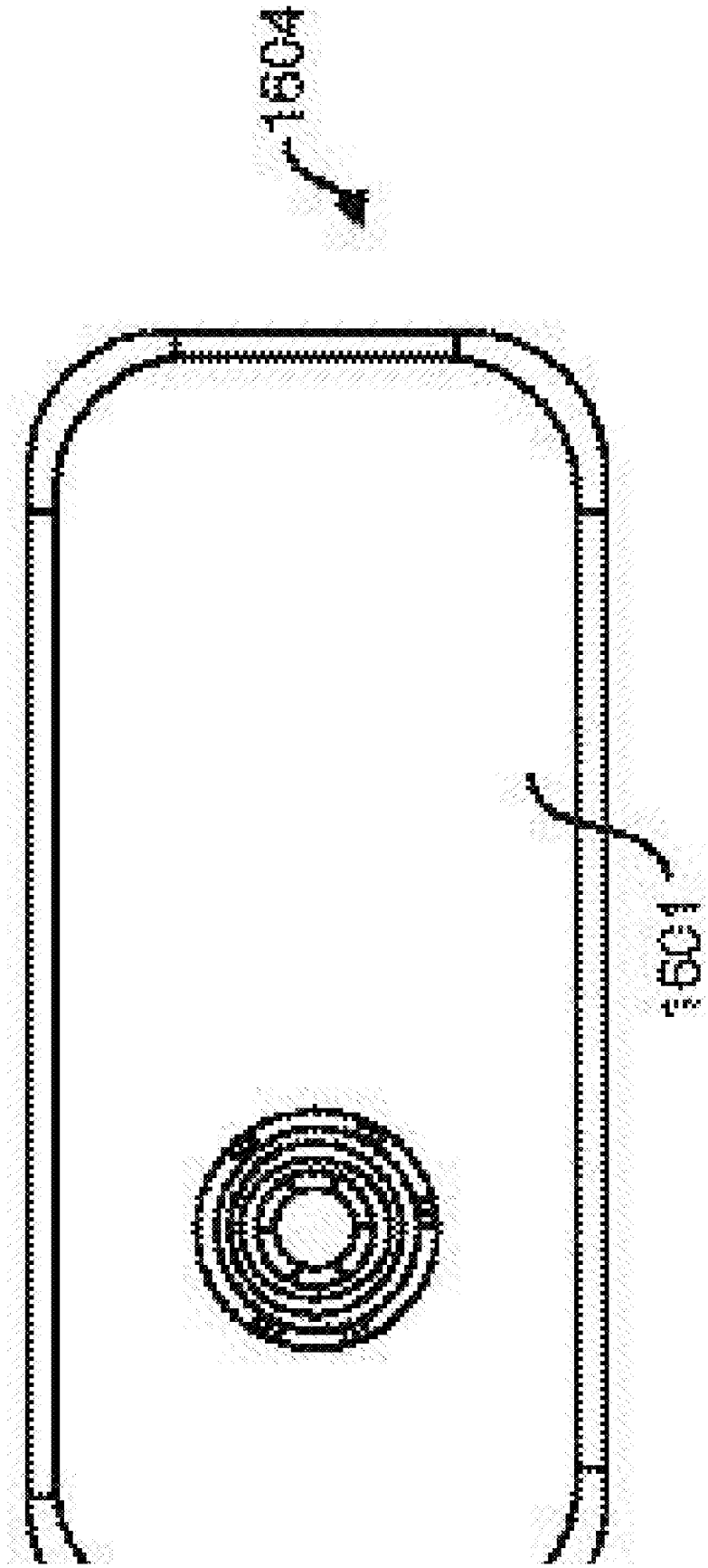
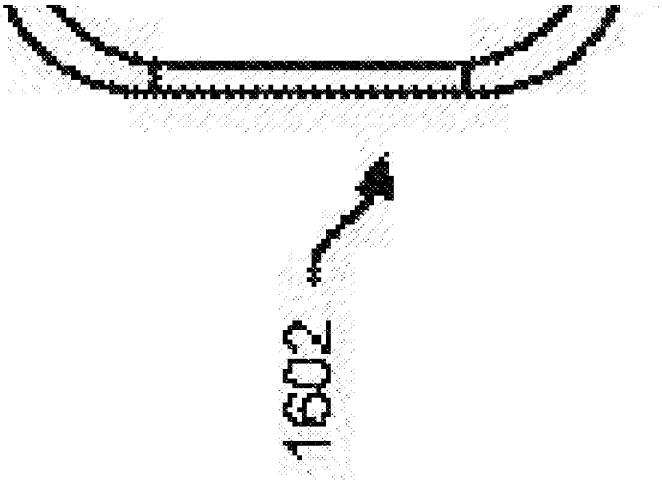
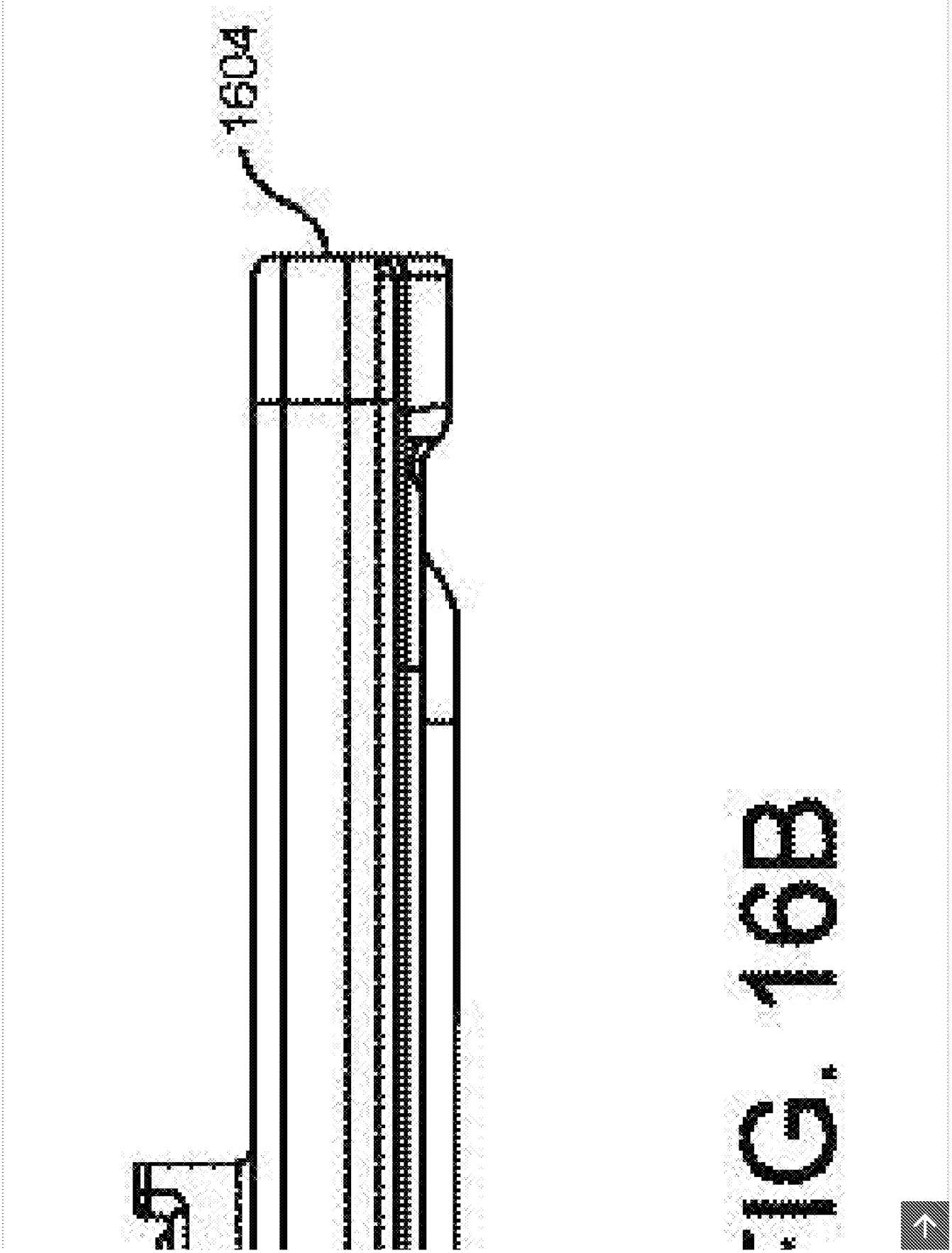


FIG. 16A

[Fig. 16B]




160a
160b

[Fig. 16C]

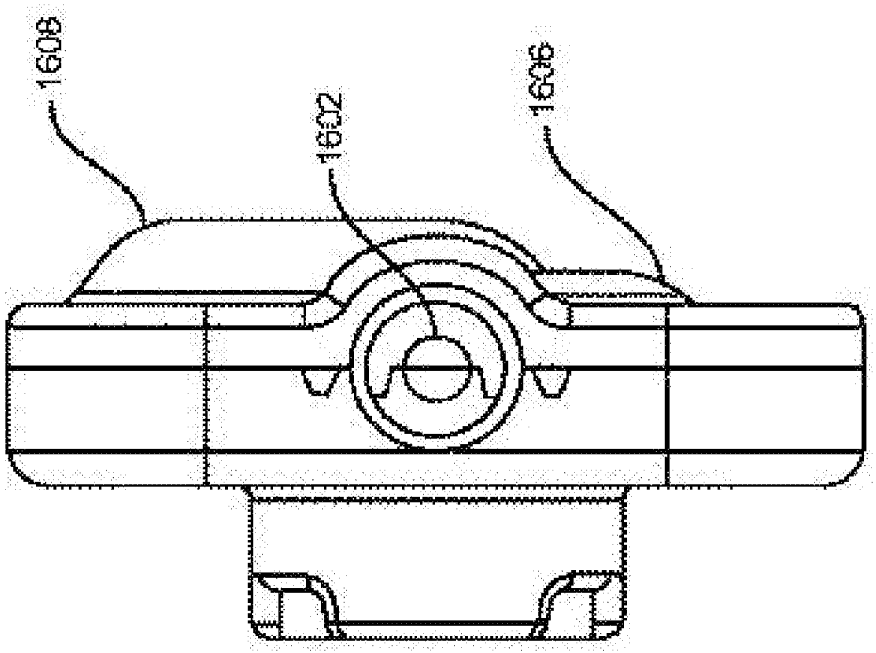
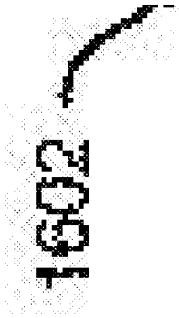


FIG. 16C

[Fig. 16D]



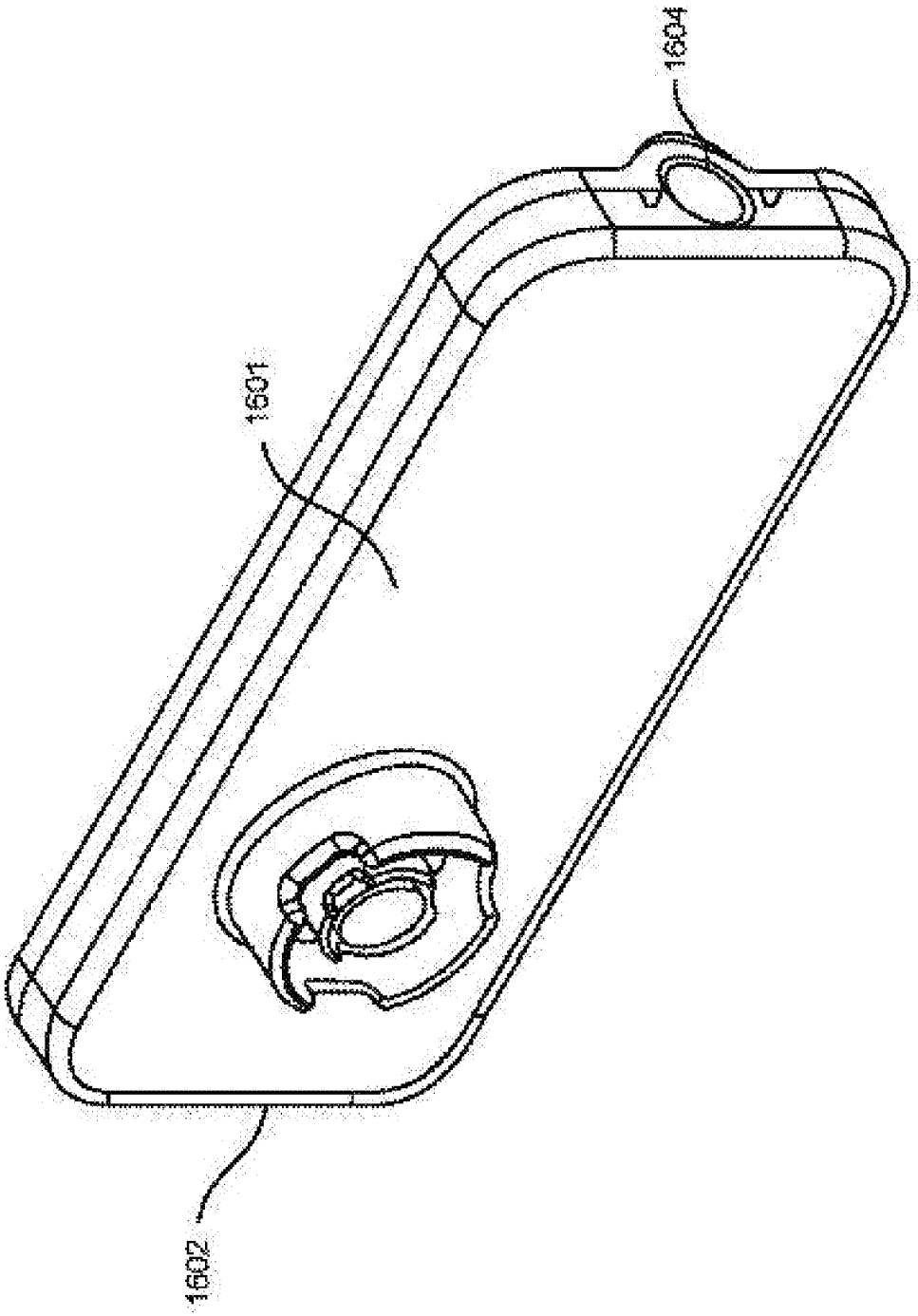


FIG. 16D

[Fig. 17A]

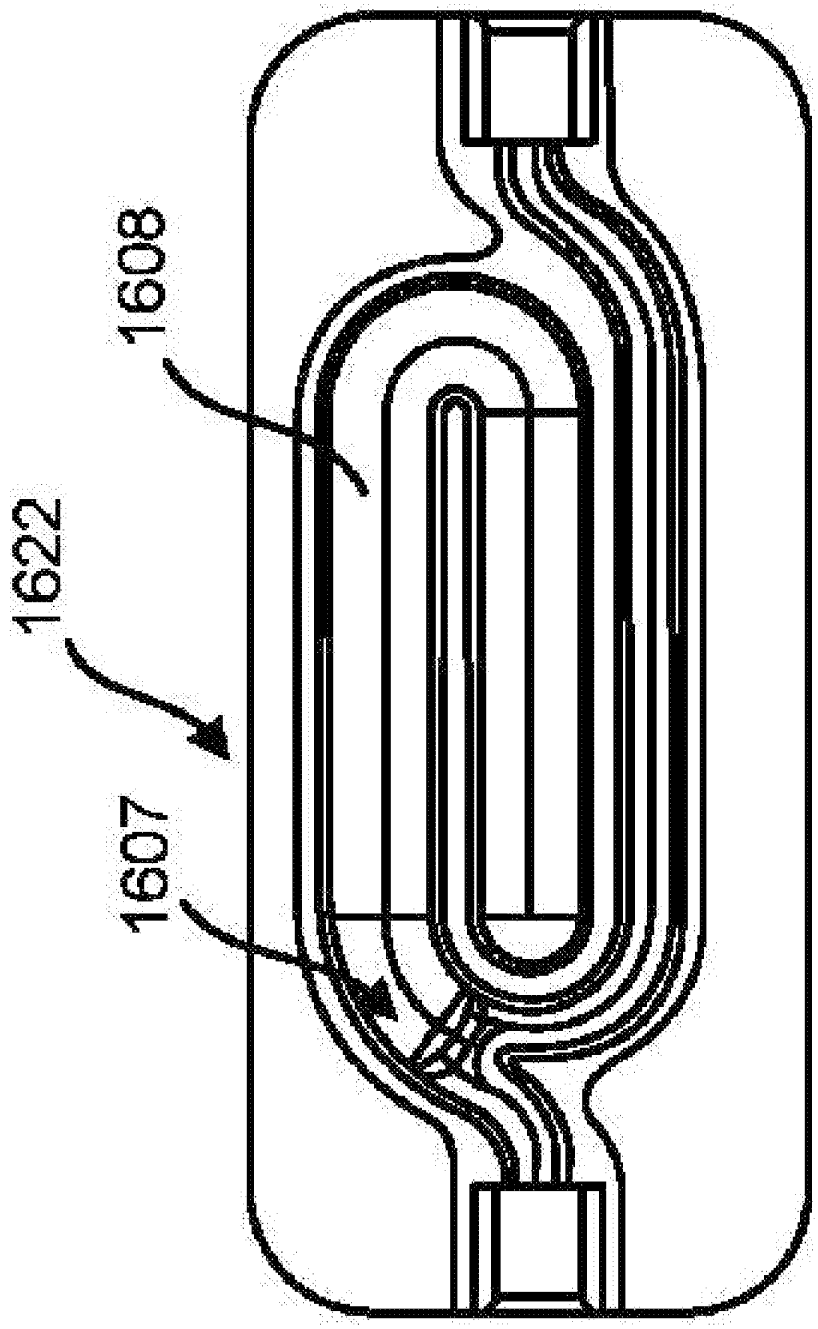


FIG. 17A

[Fig. 17B]

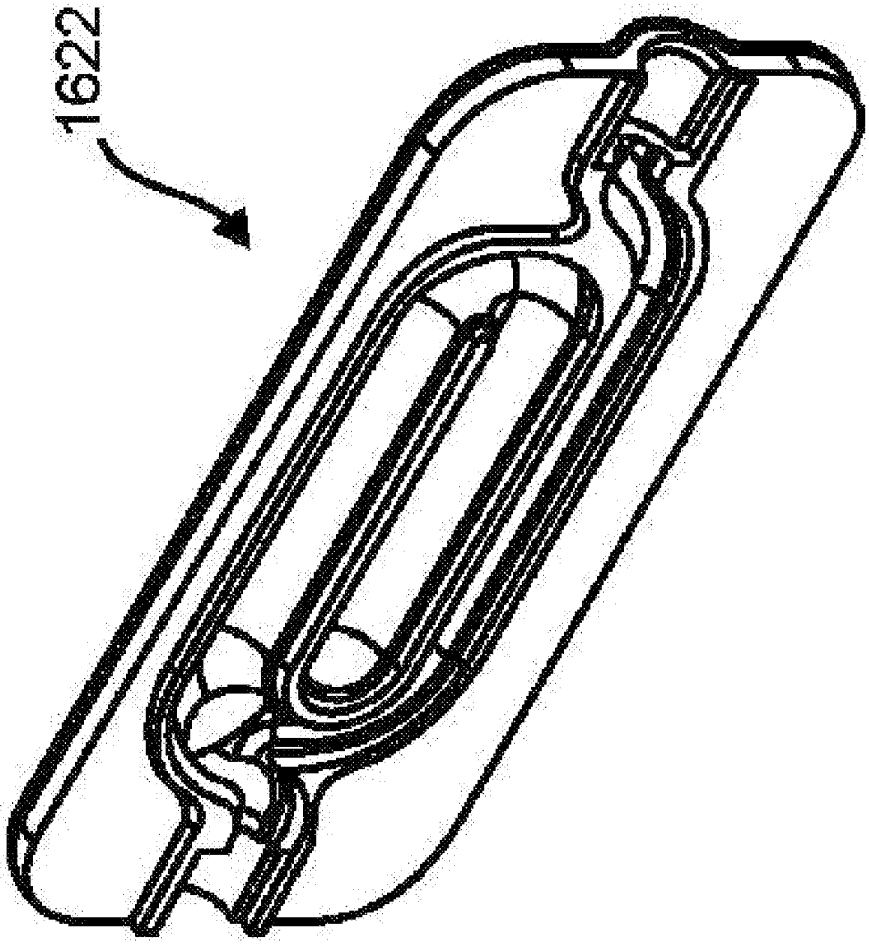


FIG. 17B

[Fig. 17C]

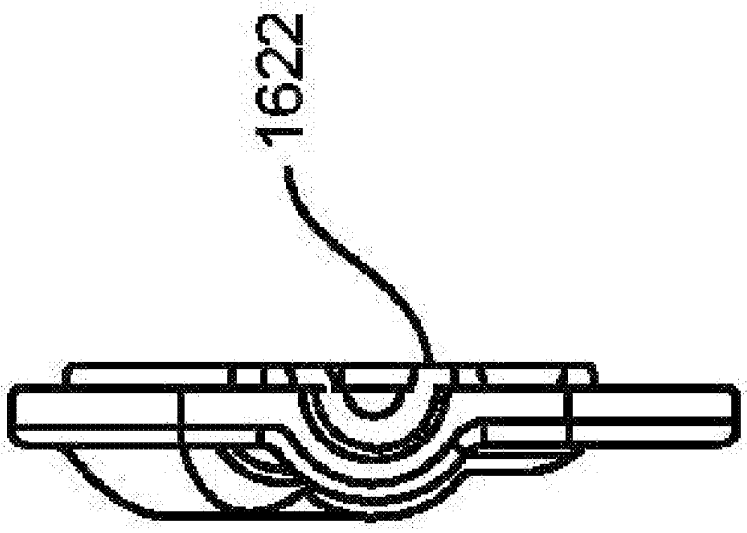


FIG. 17C

[Fig. 17D]

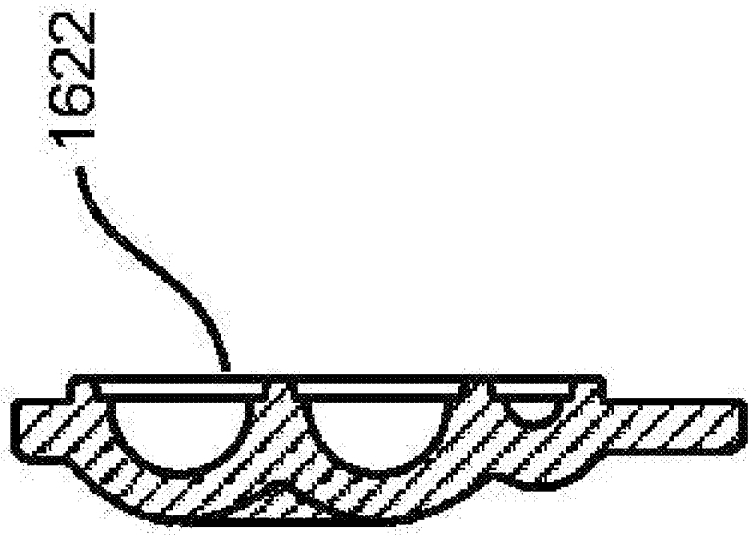


FIG. 17D

[Fig. 17E]



FIG. 17E

[Fig. 18A]

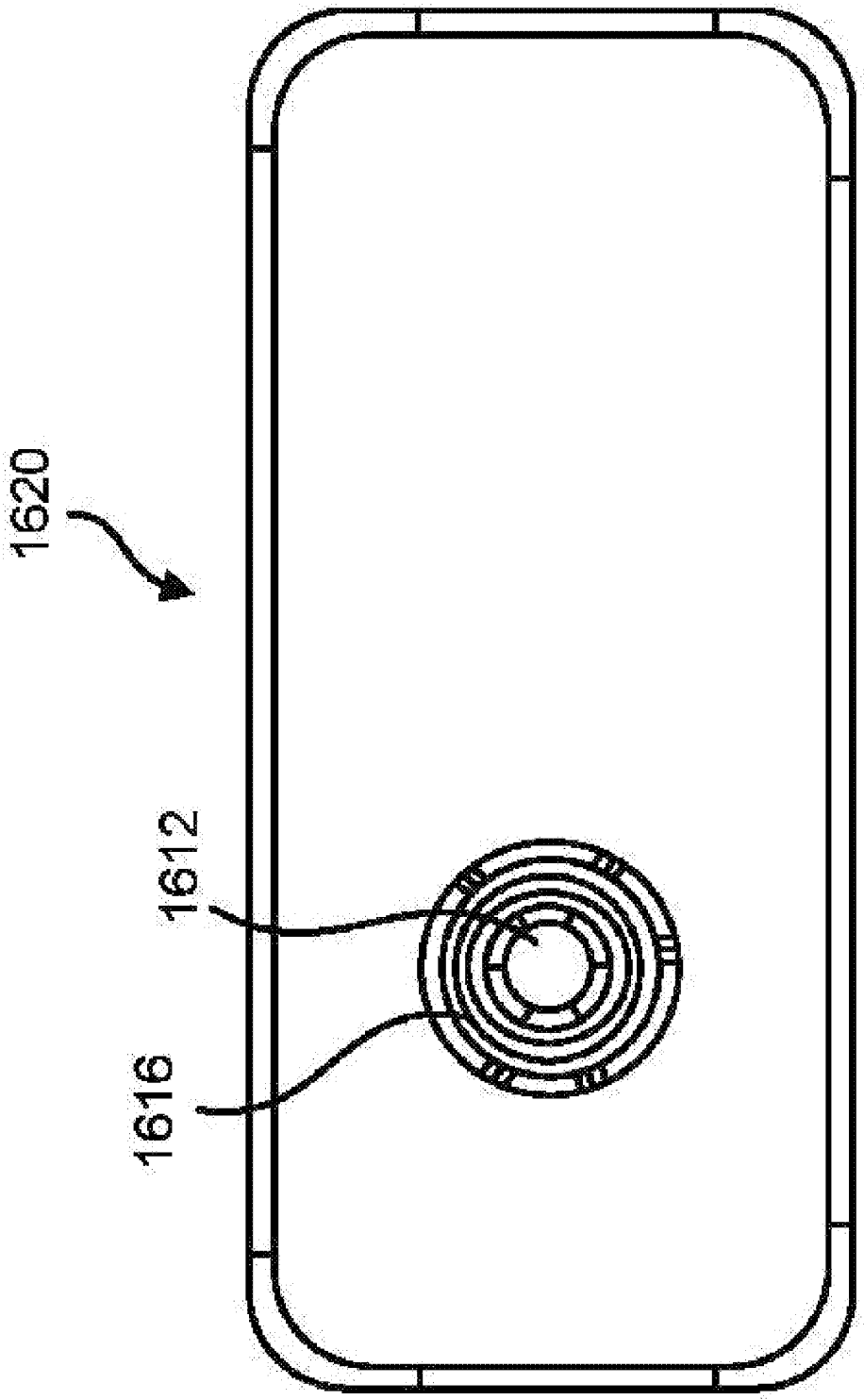


FIG. 18A

[Fig. 18B]

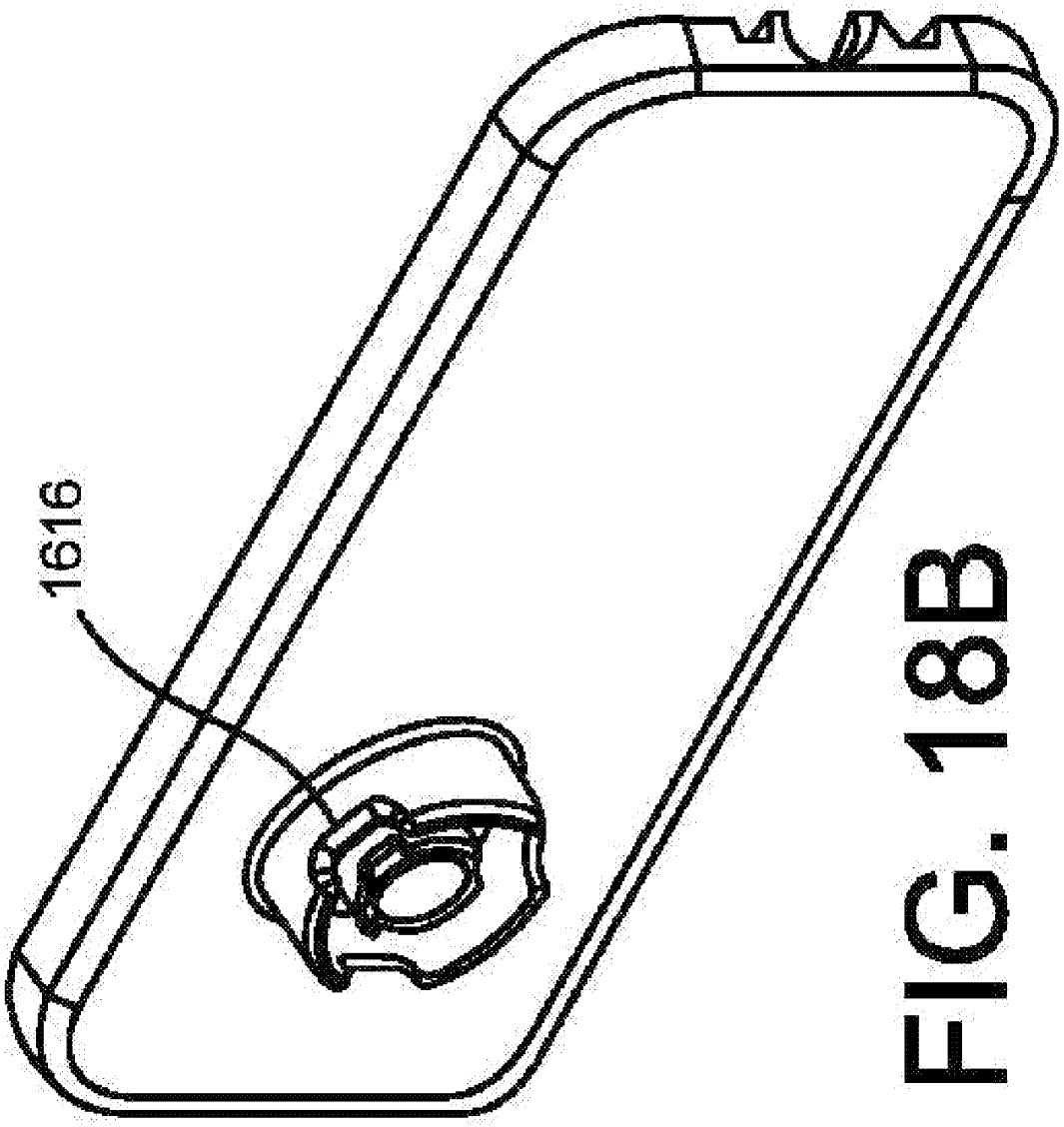


FIG. 18B

[Fig. 18C]

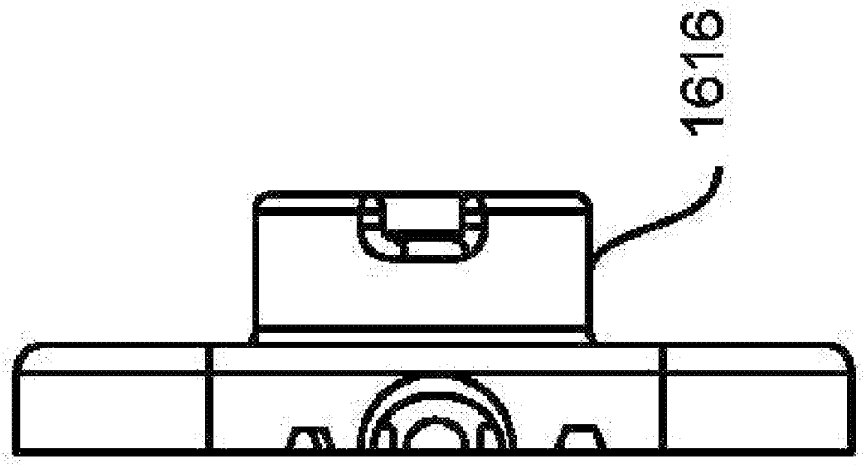


FIG. 18C

[Fig. 18D]

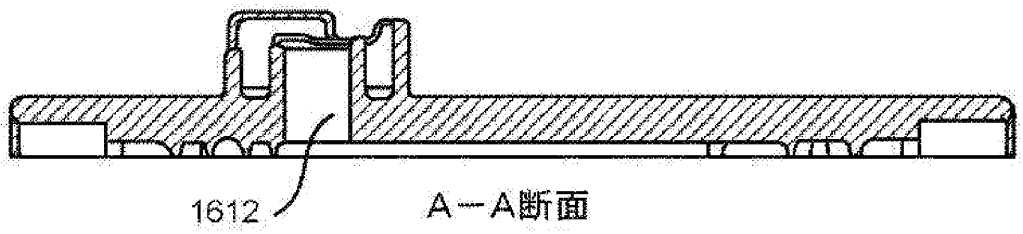


FIG. 18D

[Fig. 18E]

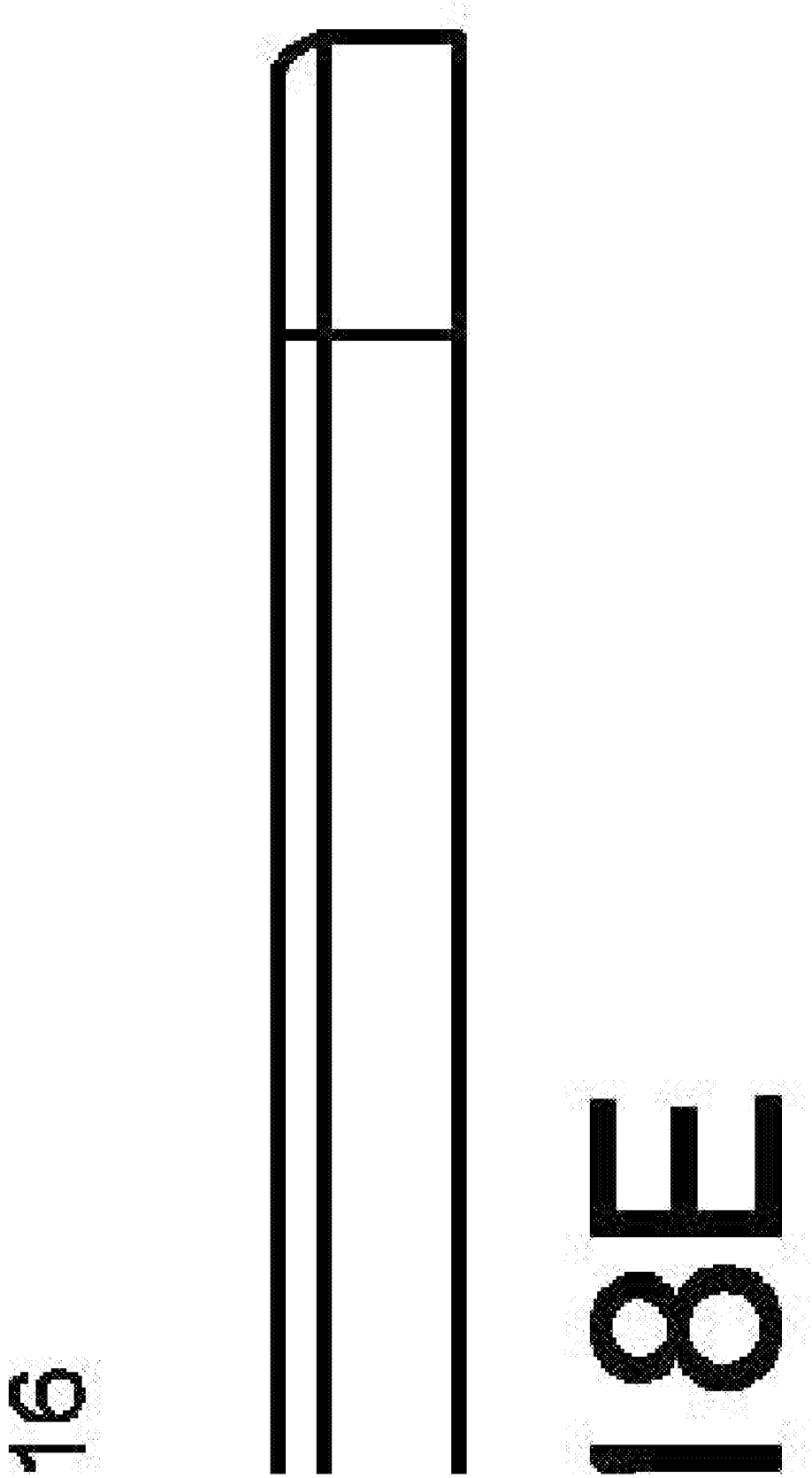
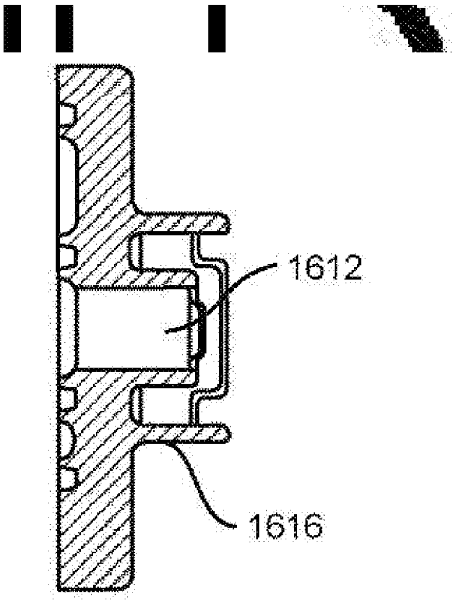


図18

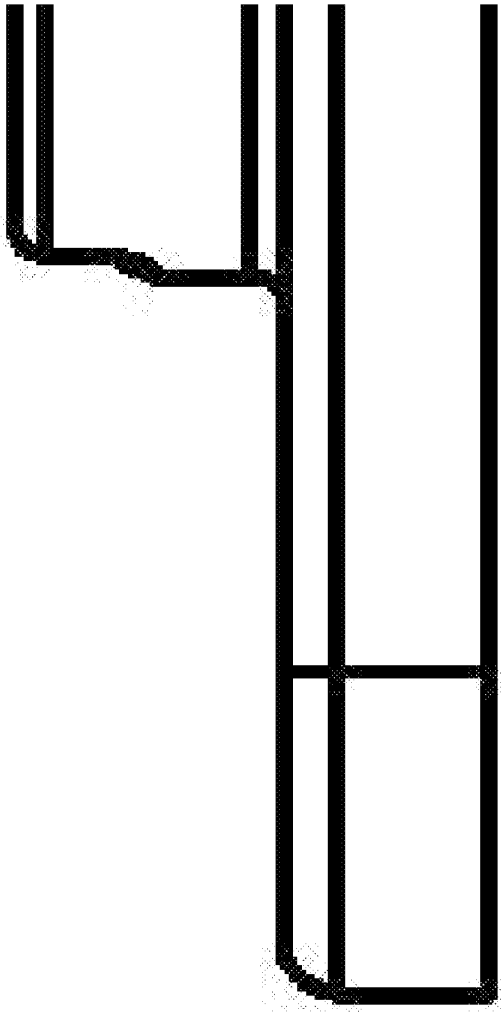
[Fig. 18F]



A－A断面

FIG. 18F

[Fig. 19A]



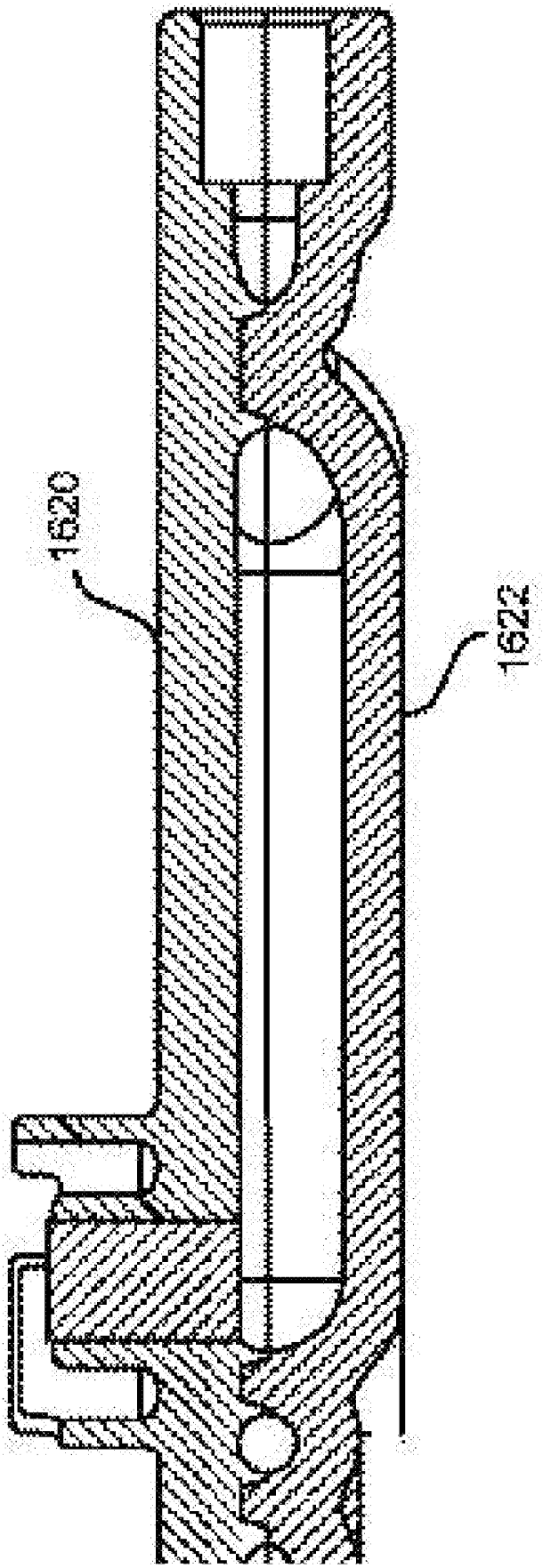


FIG. 19A

[Fig. 19B]

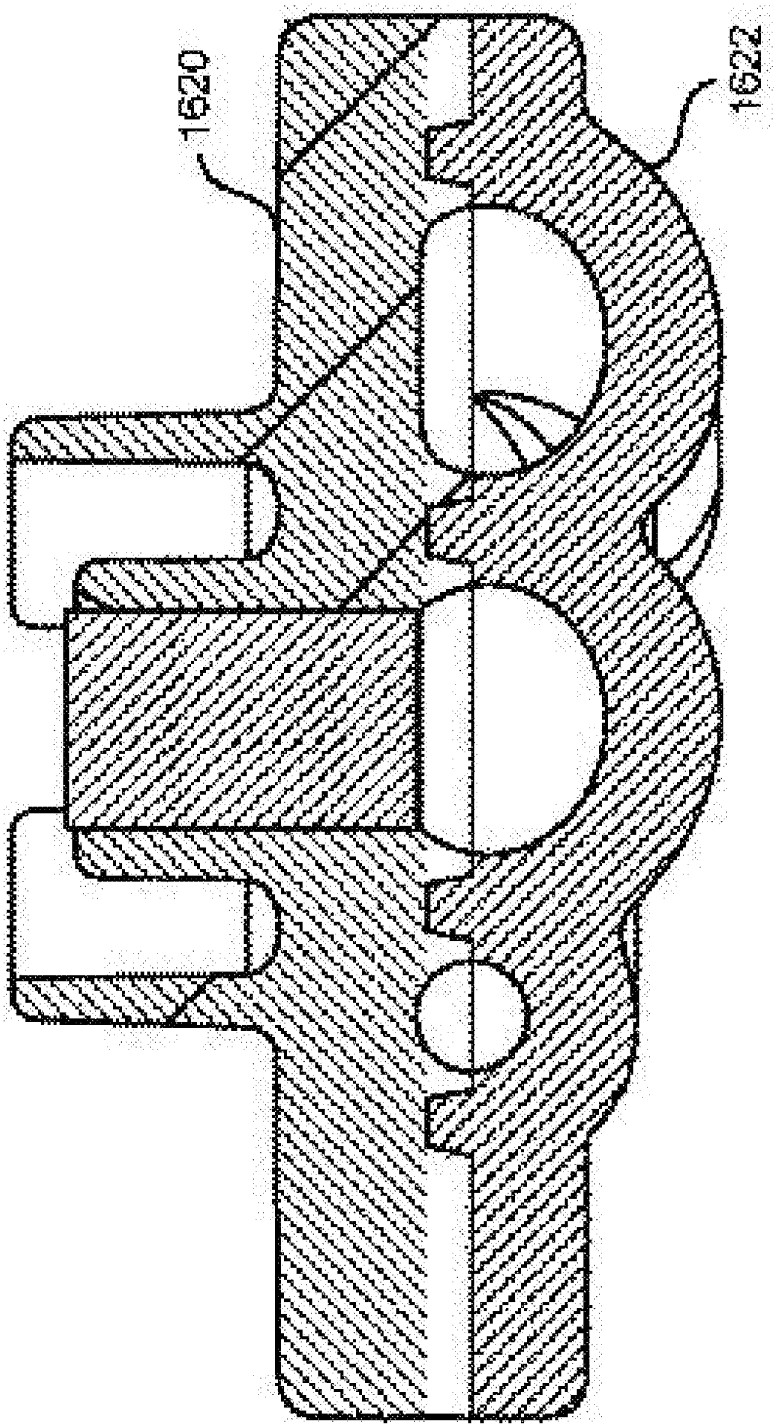


FIG. 19B

[Fig. 20]

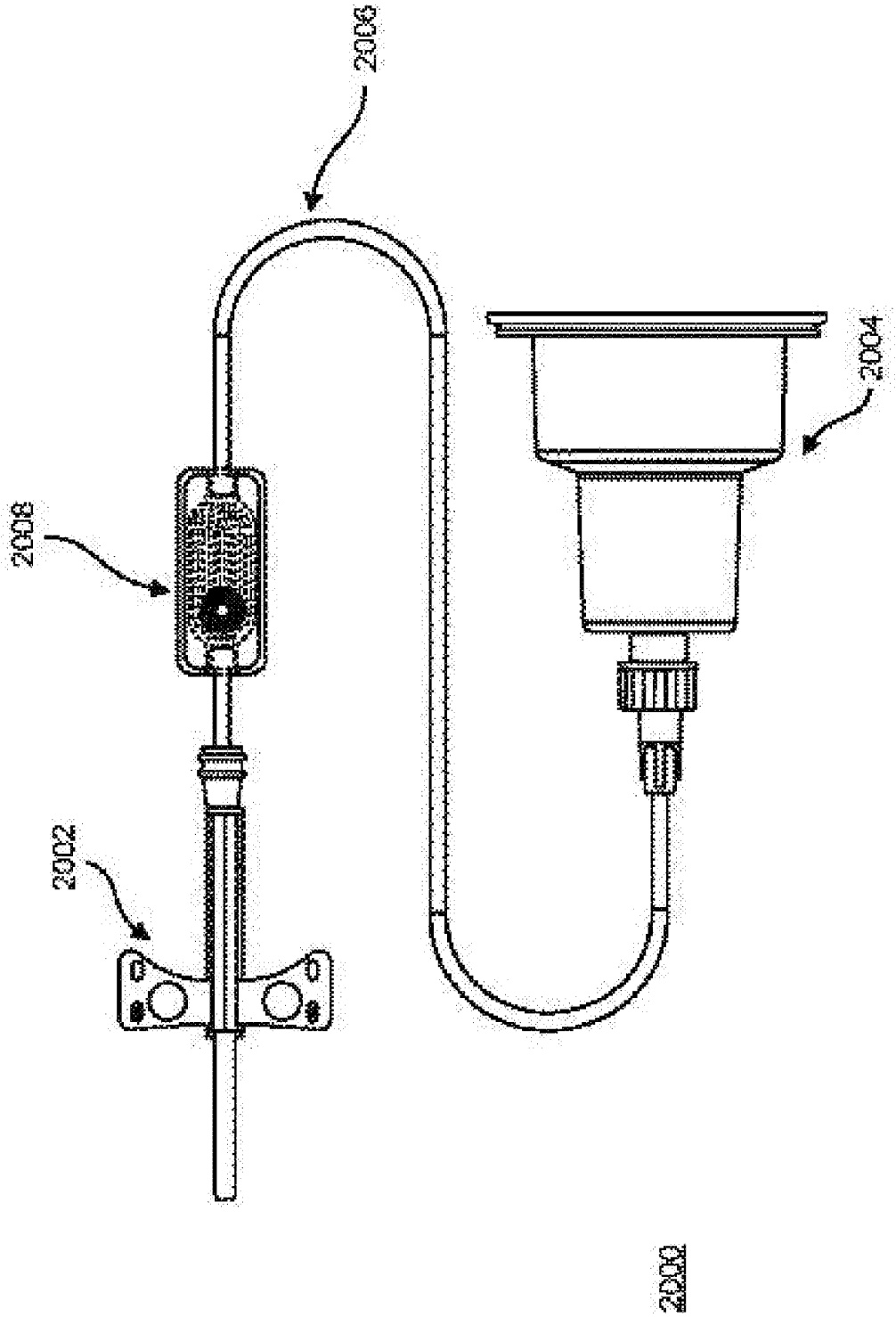


FIG. 20

[Fig. 21]

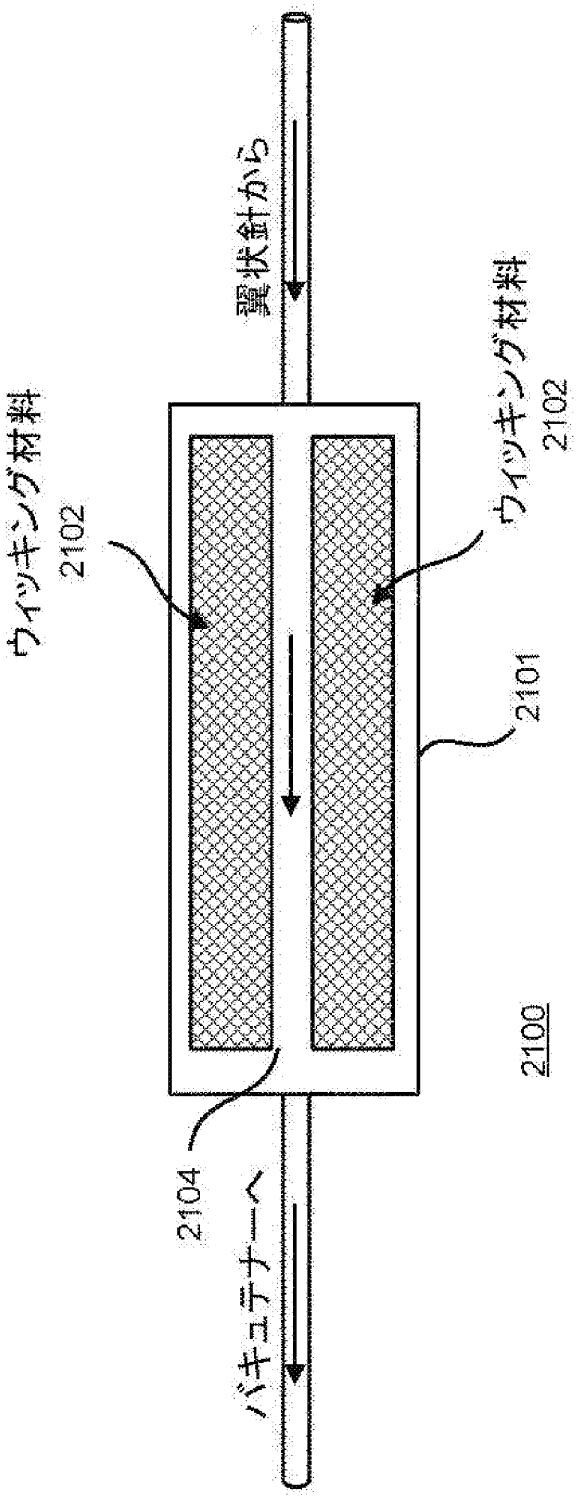


FIG. 21

[Fig. 22A]

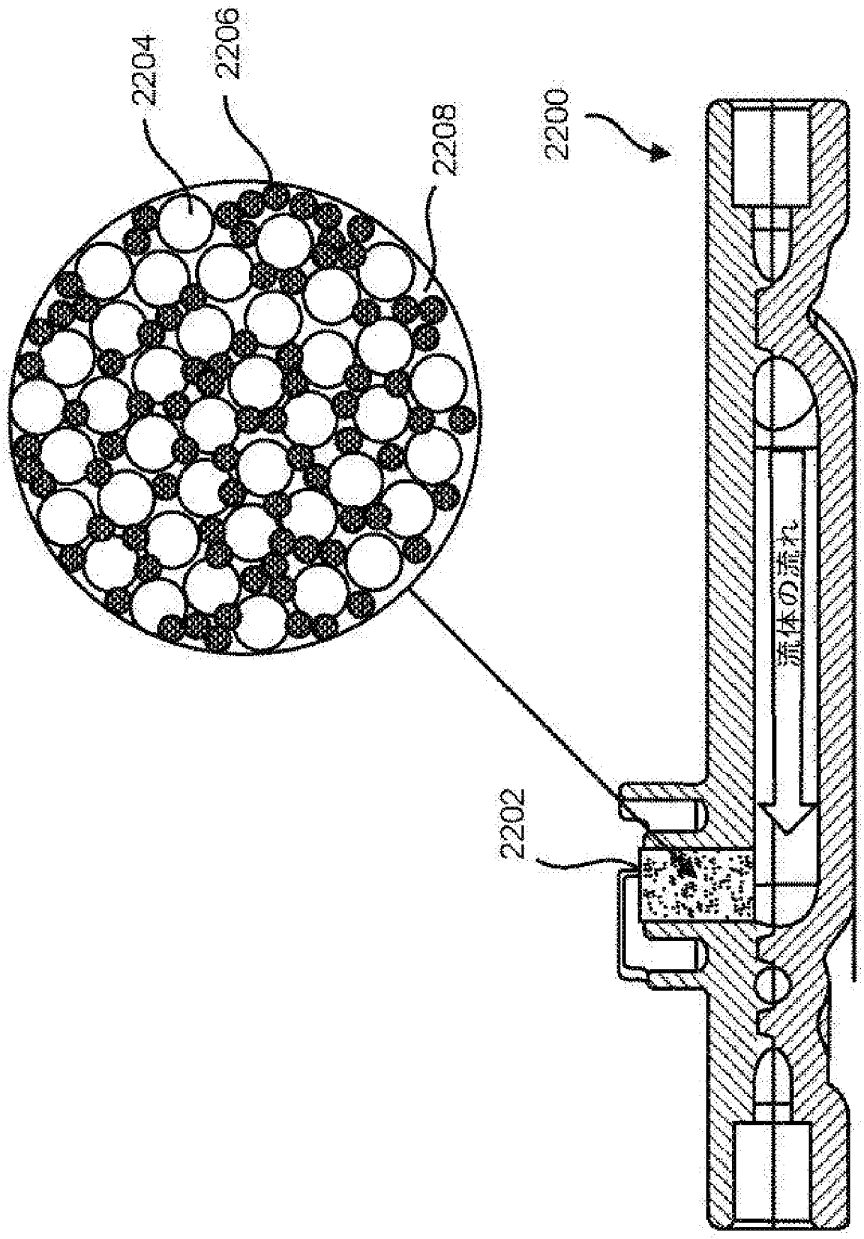


FIG. 22A

[Fig. 22B]

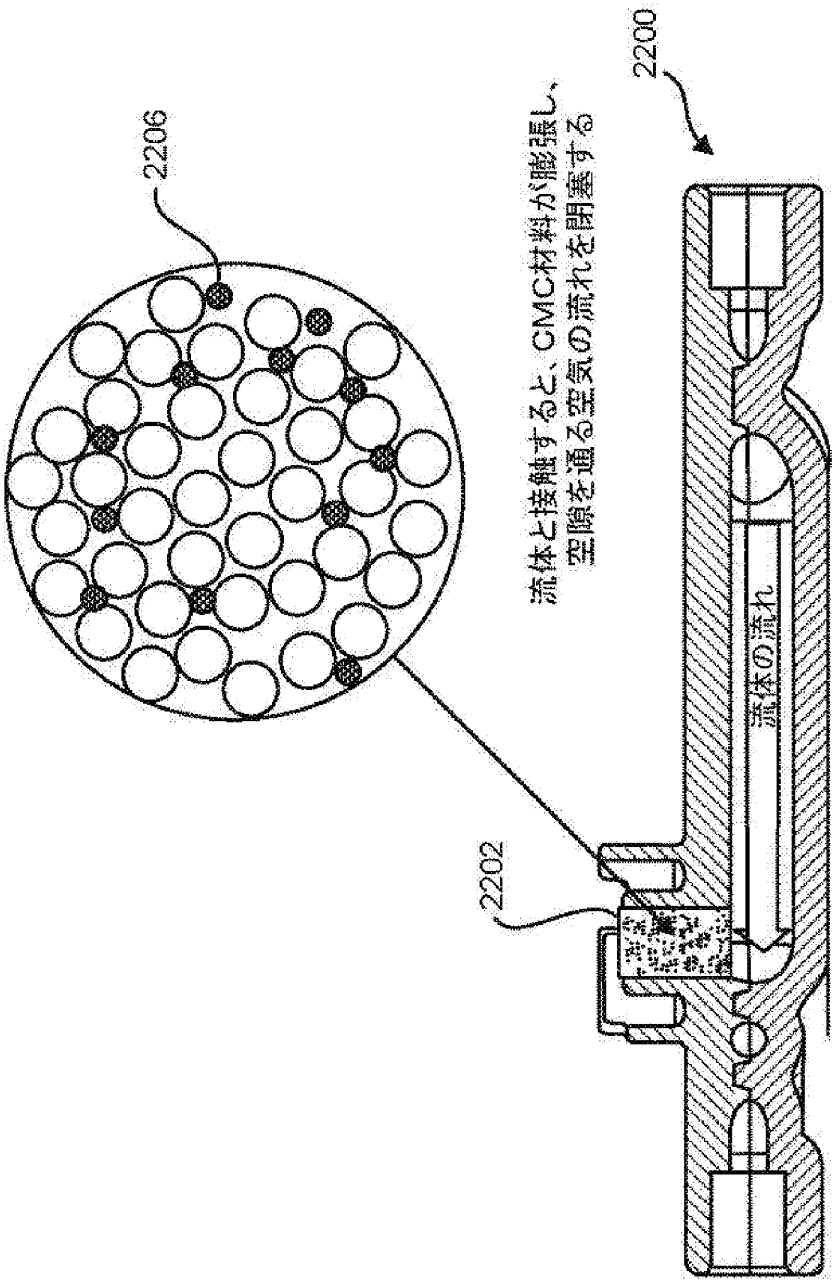


FIG. 22B

[Fig. 23A]

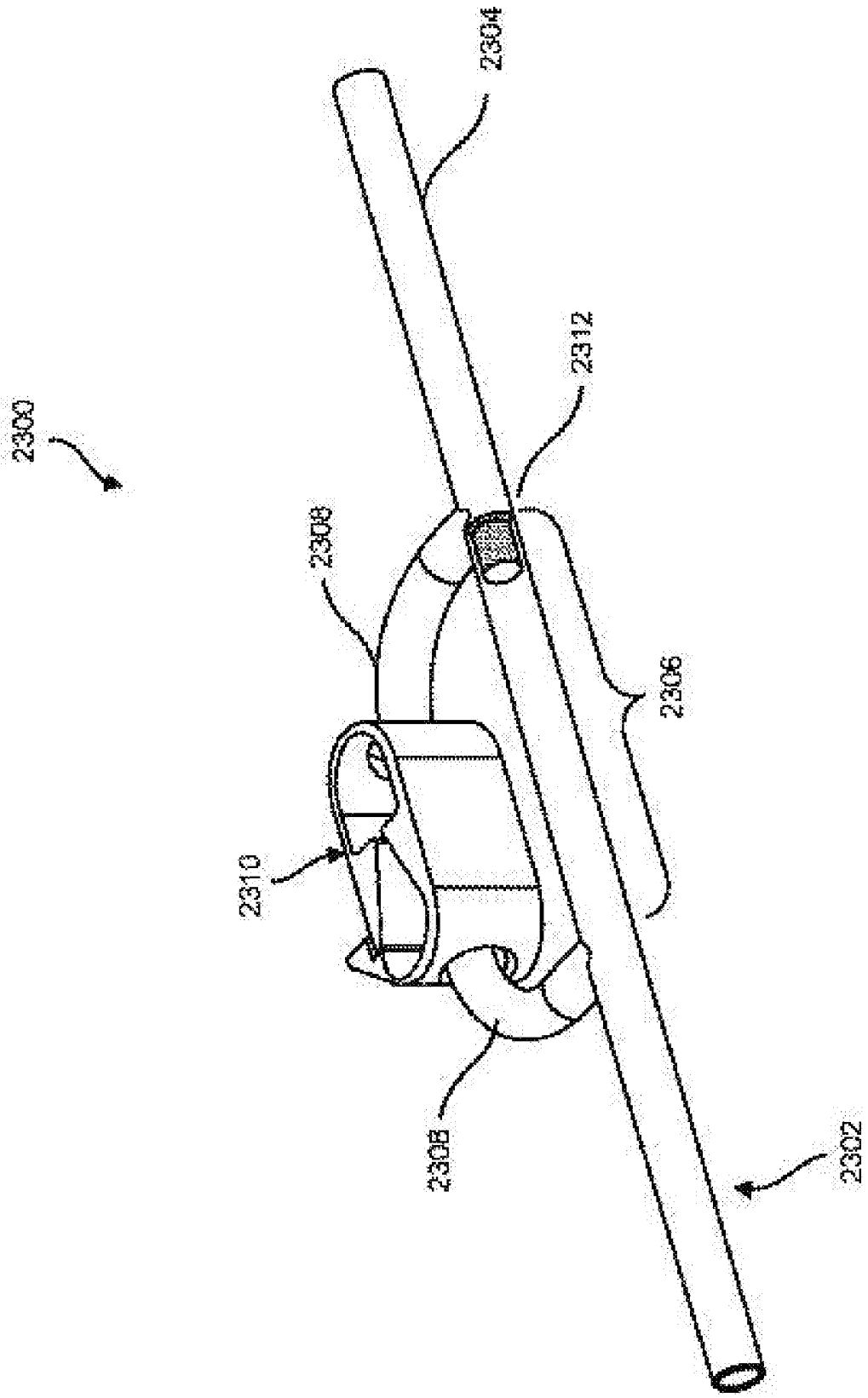


FIG. 23A

[Fig. 23B]

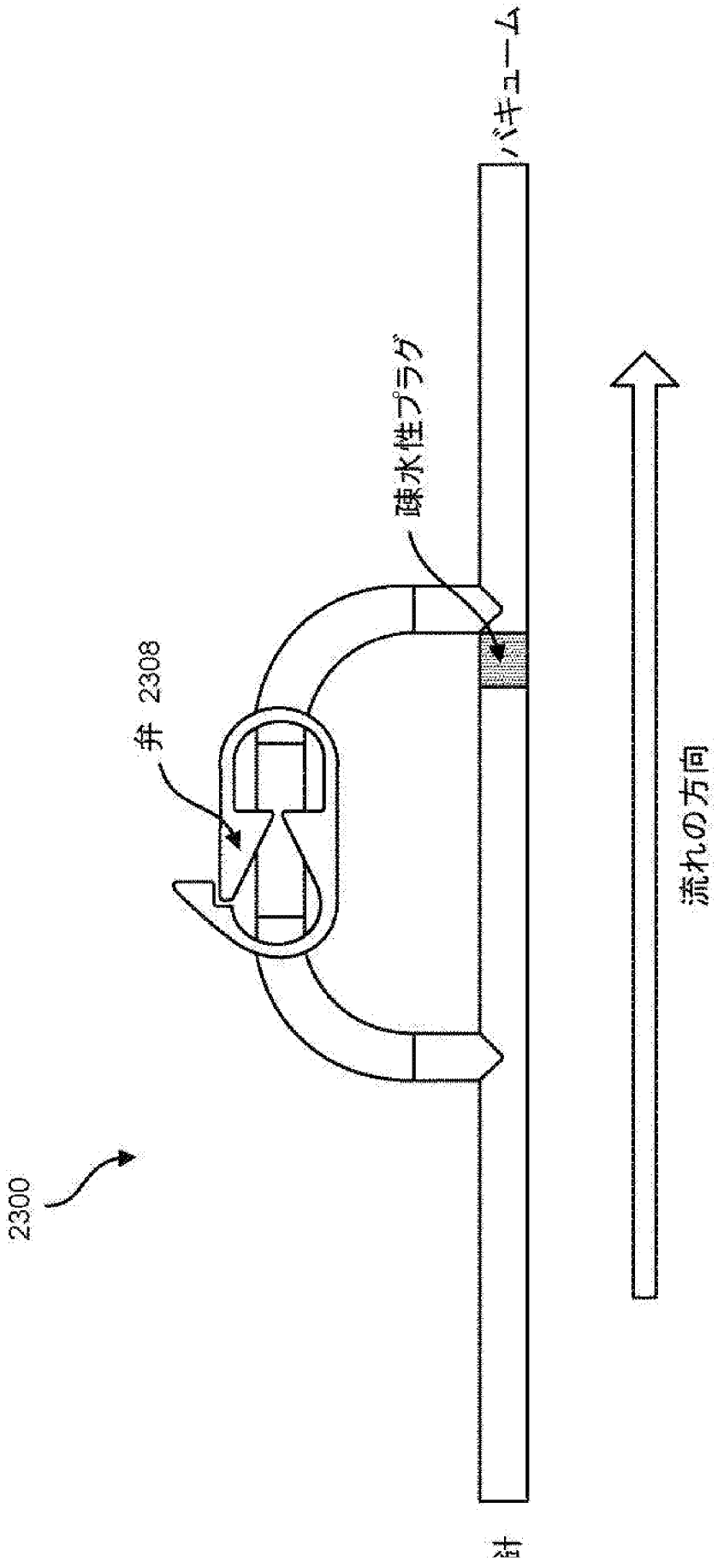


FIG. 23B

drawing open

1 2 3 Four Five 6 7 8A 8B 8C ...

Magnify and Rotate

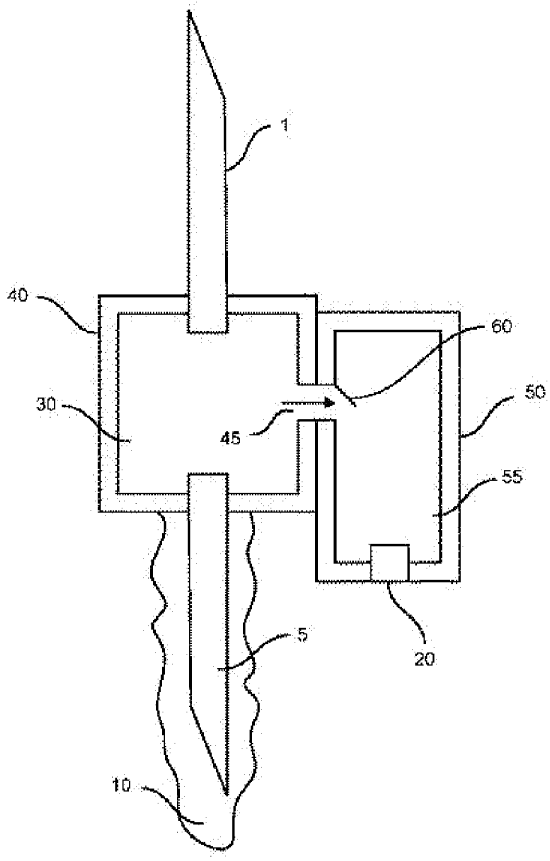


FIG. 1

Figure 1

1 / 1 display

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Bibliographic data: JP6643474 (B2) — 2020-02-12

BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE AND METHOD

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Applicant(s): クリン インコーポレイテッド

Classification: - international: ***A61B5/15; A61B5/154***
- cooperative: **A61B5/15003 (EP, US); A61B5/150213 (EP, US); A61B5/150221 (US); A61B5/150389 (EP, US); A61B5/150473 (EP, US); A61B5/150572 (EP, US); A61B5/150992 (US); A61B5/153 (EP, US); A61B5/154 (EP, US); A61M39/04 (US); A61M39/0693 (US);** A61M2039/0202 (US); A61M2039/0633 (US); A61M2039/068 (US)

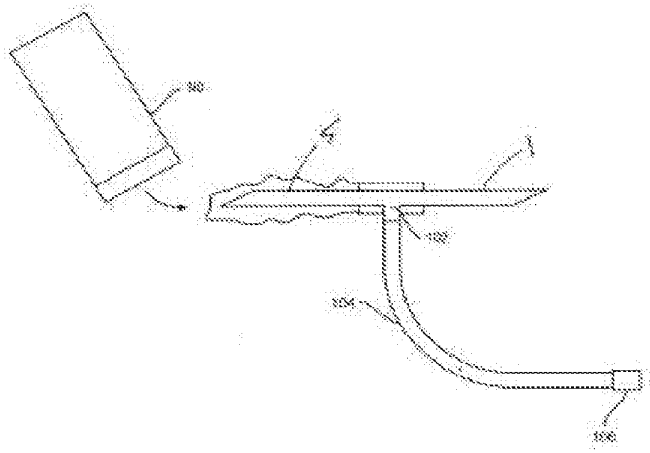
Application number: JP20180523384 20160722 Global Dossier

Priority number(s): US201562238636P 20151007 ; US201662318194P 20160404 ; US201562196797P 20150724 ; US201615140448 20160427 ; US201615140443 20160427 ; WO2016US43709 20160722

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Abstract not available for JP6643474 (B2)
Abstract of corresponding document: US2017020427 (A1)

Blood sample optimization systems and methods are described that reduce or eliminate contaminates in collected blood samples, which in turn reduces or eliminates false positive readings in blood cultures or other testing of collected blood samples. A blood sample optimization system can include a blood sequestration device located between a patient needle and a sample needle. The blood sequestration device can include a sequestration chamber for sequestering an initial, potentially contaminated aliquot of blood, and may further include a sampling channel that bypasses the sequestration chamber to convey likely uncontaminated blood between the patient needle and the sample needle after the initial aliquot of blood is sequestered in the sequestration chamber.



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A61B	5/154	(2006.01)	A61B	5/154	200

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最終頁に続く

(54)【発明の名称】血液サンプル最適化システム及び血液隔離装置

(57)【特許請求の範囲】
【請求項１】
血液サンプル最適化システムであって、
採血システムであって、
患者の血液サンプルを取り出せるようにするために患者の静脈穿刺用に構成された患者針と、
前記患者針に接続され、前記血液サンプルを運ぶように構成された採血経路と、
前記血液サンプルの後続の部分を採取しかつ収容するために真空採血管を受け入れるように構成されたサンプル針と
を含む採血システムと、
前記患者針と前記サンプル針との間に前記採血経路に沿って接続された血液隔離装置であって、
前記血液サンプルを受け入れるように構成された入口ポートと、
前記入口ポートに接続されかつ空気透過性血液バリアを含む通気口を有する隔離チャンバであって、前記血液サンプルの最初の量を受け入れかつ前記血液サンプルの最初の量の少なくとも最初の部分を隔離するように構成された隔離チャンバと、
前記入口ポートに接続された近位端を有し、前記血液サンプルの後続の部分を受け入れるように構成されたサンプリング流路と
を含み、
前記隔離チャンバ、前記サンプリング流路及び前記入口ポートは、前記血液サンプル

の後続の部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液サンプルの最初の部分を迂回することを可能にしかつ前記血液サンプルの後続の部分を前記サンプリング流路の遠位端に接続された出口ポートに向かわせるように構成され、前記出口ポートは、前記血液サンプルの後続の部分を前記真空採血管に排出するように構成され、

前記入口ポート、前記出口ポート、前記隔離チャンバ及び前記サンプリング流路を収容しかつ画定するハウジングをさらに含む、血液隔離装置と

を含む、血液サンプル最適化システム。

【請求項２】

前記血液隔離装置の前記隔離チャンバは周囲空気圧であり、前記隔離チャンバは患者の血圧が前記隔離チャンバ内の周囲空気圧に打ち勝つことによって前記血液サンプルの最初の部分を受け入れる、請求項１に記載の血液サンプル最適化システム。

【請求項３】

前記サンプル針は、前記採血経路及び前記サンプリング流路を介した前記患者針へのアクセスを開くために前記真空採血管によって穿孔されるシールを含む、請求項２に記載の血液サンプル最適化システム。

【請求項４】

前記血液隔離装置の前記サンプリング流路は、前記サンプル針を開封する前記真空採血管によって真空圧力下で前記血液サンプルの後続部分を前記入口ポートに進入させる、請求項３に記載の血液サンプル最適化システム。

【請求項５】

前記血液隔離装置の前記空気透過性血液バリアは、血液と接触すると密封する空気透過性材料を含む、請求項１に記載の血液サンプル最適化システム。

【請求項６】

前記採血システムの前記採血経路はチューブを含む、請求項１に記載の血液サンプル最適化システム。

【請求項７】

患者から血液サンプルを取り出せるようにするように構成された患者針と、密封されたサンプル針であって、前記サンプル針を開封しかつ取り出せるようにされた血液サンプルを患者から採取するために真空採血管を受け入れるように適合されたサンプル針とを含む血液採取システムに接続された血液隔離装置であって、

前記患者針に接続され、患者からの血液サンプルを受け入れるように構成されたた入口ポートと、

前記入口ポートに接続された出口ポートと、

前記入口ポートに接続されかつ空気透過性血液バリアを含む通気口を有する隔離チャンバであって、前記サンプル針が前記真空採血管によって開封される前に前記血液サンプルの最初の部分を受け入れかつ隔離するように構成された隔離チャンバと、

前記入口ポートに接続された近位端を有し、前記血液サンプルの後続の部分を受け入れるように構成されたサンプリング流路と

を含み、

前記隔離チャンバ、前記サンプリング流路及び前記入口ポートは、前記血液サンプルの後続の部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液サンプルの最初の部分を迂回することを可能にしかつ前記血液サンプルの後続の部分を前記サンプリング流路の遠位端に接続された前記出口ポートに向かわせるように構成され、

前記入口ポート、前記出口ポート、前記隔離チャンバ及び前記サンプリング流路を収容しかつ画定するハウジングをさらに含む、血液隔離装置。

【請求項８】

前記隔離チャンバは周囲空気圧であり、前記隔離チャンバは患者の血圧が前記隔離チャンバ内の周囲空気圧に打ち勝つことによって前記血液サンプルの最初の部分を受け入れる、請求項７に記載の血液隔離装置。

【請求項９】

前記空気透過性血液バリアは、血液と接触すると密封する空気透過性材料を含む、請求項７に記載の血液隔離装置。
【請求項１０】
前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項７に記載の血液隔離装置。
【請求項１１】
血液サンプル最適化システムであって、
採血システムであって、
患者の血液サンプルを取り出せるようにするために患者の静脈穿刺用に構成された患者針と、
前記患者針に接続され、前記血液サンプルを運ぶように構成された採血経路と、
前記血液サンプルの後続の部分を採取しかつ収容するために真空採血管を受け入れるように構成されたサンプル針と
を含む採血システムと、
前記患者針と前記サンプル針との間に前記採血経路に沿って接続された血液隔離装置であって、
前記血液サンプルを受け入れるように構成された入口ポートと、
前記入口ポート及び前記採血システムのサンプル針に接続された出口ポートと、
前記入口ポートに接続されかつ空気透過性血液バリアを含む通気口を有する隔離チャンバであって、前記血液サンプルの最初の量を受け入れかつ前記血液サンプルの最初の量の少なくとも最初の部分を隔離するように構成された隔離チャンバと、
前記入口ポートに接続された近位端を有し、前記血液サンプルの後続の部分を受け入れるように構成されたサンプリング流路と
を含み、
前記隔離チャンバ、前記サンプリング流路及び前記入口ポートは、前記血液サンプルの後続の部分が前記隔離チャンバ及び前記隔離チャンバ内に隔離された前記血液サンプルの最初の部分を迂回することを可能にしかつ前記血液サンプルの後続の部分を前記サンプリング流路の遠位端に接続された前記出口ポートに向かわせるように構成され、
前記入口ポート、前記出口ポート、前記隔離チャンバ及び前記サンプリング流路を収容しかつ画定するハウジングをさらに含む、血液隔離装置と
を含む、血液サンプル最適化システム。
【請求項１２】
前記血液隔離装置の前記隔離チャンバは周囲空気圧であり、前記隔離チャンバは患者の血圧が前記隔離チャンバ内の周囲空気圧に打ち勝つことによって前記血液サンプルの最初の部分を受け入れる、請求項１１に記載の血液サンプル最適化システム。
【請求項１３】
前記サンプル針は、前記採血経路を介した前記患者針へのアクセスを開くために前記真空採血管によって穿孔されるシールを含む、請求項１１に記載の血液サンプル最適化システム。
【請求項１４】
前記血液隔離装置の前記空気透過性血液バリアは、血液と接触すると密封する空気透過性材料を含む、請求項１１に記載の血液サンプル最適化システム。
【請求項１５】
前記隔離チャンバは、前記ハウジング内に画定された隔離流路を含む、請求項１１に記載の血液サンプル最適化システム。
【請求項１６】
前記採血システムの前記採血経路はチューブを含む、請求項１１に記載の血液サンプル最適化システム。
【発明の詳細な説明】
【背景技術】

【０００１】
関連出願との相互参照
本出願は、２０１６年４月２７日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国非仮出願第１５／１４０，４４３号及び２０１６年４月２７日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国非仮出願第１５／１４０，４４８号の優先権の利益を主張するものであり、これらの米国非仮出願の両方が２０１５年７月２４日に出願された「血液培養改良システム及び方法」と題する米国仮特許出願第６２／１９６，７９７号、２０１５年１０月７日に出願された「非汚染採血用の血液隔離システム」と題する米国仮出願第６２／２３８，６３６号、及び２０１６年４月４日に出願された「血液サンプル最適化システム及び血液汚染物質隔離装置及び方法」と題する米国仮特許出願第６２／３１８，１９４号の優先権を主張しており、これらの開示はその全体が参照により本明細書に含まれるものとする。
【０００２】
菌血症は、血液中に微生物が存在することである。一方、敗血症は、発熱、頻脈、頻呼吸及び低血圧などの臨床症状及び臨床兆候がある場合の菌血症である。菌血症及び敗血症は、高い死亡率、入院発生率及び入院期間と関連する費用の増加とを伴う。多くの菌血症、敗血症、真菌血症及び他の病原体が実際に病院又は他の医療施設内で発生し、カテーテル及び静脈穿刺がこれらの病原体の潜在的なキャリアとしての汚染源である。
【０００３】
血液培養は、患者の血液中の菌血症及び敗血症に関連する微生物病原体を検出するのに使用される標準検査である。血液培養という用語は、血液が１つ以上の血液培養ボトル又は容器に接種される、末梢部位又は中心ライン又は動脈ラインからの１回の静脈穿刺を指す。１つのボトルが１つの血液培養と見なされ、２つ以上がセットと見なされる。複数のセットは複数の静脈穿刺から得られ、患者の異なる部位に関連する。
【０００４】
これらの方法は、敗血症を管理する上で重要な要素である微生物同定及び感受性検査を可能にするが、迅速な結果が得られないことと厄介な病原体に対する感度が低いことが、改良されたシステムの開発及び補助的な分子検査又はプロテオミクス検査につながっている。
【０００５】
血液培養を行うための血液サンプルの採取は、現代の患者ケアの重要な要素であり、正確な診断を提供することによって患者の結果に良い影響を与えることも、不必要な抗菌療法を長引かせ、入院期間を長くし、コストを増加させることによって結果に悪影響を与えることもある。
【０００６】
血液培養の採取の１つの結果は、汚染である。血液培養の汚染は、偽陽性の培養結果及び／又は医療関連コストの著しい増加につながる可能性がある。血液培養の汚染の原因は、不適切な皮膚消毒、不適切な採取管の消毒、最初の採血の汚染を含み、これらは結果を歪める可能性がある。
【０００７】
血液培養採取キットは、一般に、ＢＤ、スミス、ビー・ブラウンなどの会社によって提供される「バタフライ」セット、輸液セット、又は他のタイプの静脈穿刺装置と、好気性血液培養ボトル及び嫌気性血液培養ボトルとで構成される。様々な異なるボトルも検査要件に応じて利用可能である。これらのボトルは、好気性生物と嫌気性生物の両方の回収を最適化するように特別に設計されている。従来のキットでは、使用されるボトルは一般に「バキュテナー（登録商標）」として知られており、これは、所定の量の血液などの液体の採取を容易にするべく管の内部に真空を作り出すために排気される蓋を備える滅菌ガラス管又は滅菌プラスチック管から形成される採血管である。
【０００８】

偽陽性の血液培養は、一般的に、不十分なサンプリング技術の結果である。それらは、必要でないときに抗生物質を使用させ、病院費及び患者の不安を増大させる。血液培養は、皮膚内への針刺しから採取され、その後で血液のサンプルを取り込むためにバキュテナー（登録商標）が取り付けられる。汚染は、穿刺部位及びその周辺の皮膚領域の不適切又は不完全な消毒によって生じ得る。それはまた、挿入中の針による皮膚のくりぬきから、くりぬかれた皮膚細胞と関連する汚染物質とがサンプル中に引き込まれることで生じることもある。

【０００９】

皮下注射針を通る血流は層流であり、このため、皮下注射針に圧力降下が加えられるときに流管にわたって流速勾配が発生する。血液を強く吸引するか又は非常に小さな皮下注射針を使用すると、溶解及び赤血球からのカリウムの放出が起こり、それにより血液サンプルが異常になる可能性がある。

【００１０】

他の例では、一部の患者は繊細な静脈を有し、繊細な静脈は、特に患者の状態に対してあまりにも急速に引き出される注射器のプランジャによって加えられるような圧力低下又は真空の下で崩壊し得る。このような状態は事前に知ることが不可能であるため、このような静脈崩壊は危険であり、制御することは非常に困難である。

【００１１】

血液培養の汚染率を低下させるために、例えば、無歯採取技術に関するスタッフの訓練、汚染率に関するフィードバック、及び血液培養採取キットの導入など、様々な戦略が実施されている。皮膚消毒は汚染の心配を減らすことができるが、２０％以上の皮膚の微生物は真皮の深部に位置し、消毒の影響を受けない。ボトル接種の前に針を交換することは、汚染率を低下させることなく針刺し損傷を受ける危険性を高めるので推奨されない。

【００１２】

血液培養の汚染を低減するための一部の従来のシステム及び技術は、中心静脈カテーテル、静脈穿刺及び他の血管アクセスシステムから採取された最初のアリコートの血液を捨てることを含む。しかしながら、これらのシステムは、ユーザーが血管内装置を機械的に操作することを必要とするか又は確実にすることが困難な複雑な一連のステップを踏むこと必要とする。

【発明の概要】

【発明が解決しようとする課題】

【００１３】

本明細書は、血液培養の汚染、細胞の溶解、及び静脈崩壊を低減するためのシステム及び方法を提示する。一部の実施では、システム及び方法は、ユーザーの消毒のばらつきをなくし、また皮膚細胞が血液培養サンプルに入り込む危険性をなくすこともできる。本明細書に開示されたシステム及び方法は、汚染物質のない血液サンプルを採取するためにバキュテナー（登録商標）又は他の採血装置（すなわち、注射器）をいつ取り付けるべきかを潜在的に示す以外は、既存の臨床プロセスの変更を必要としない。

【００１４】

本明細書に開示されたシステム及び方法の一部の実施では、採血は、患者自身の血圧の使用によって受動的に成し遂げられ、それによって静脈崩壊の危険性を低減し、現行の実務を超える更なるユーザーのステップを排除する。システム及び方法は、短経路の直接刺し又はバタフライ静脈穿刺システムに適合するように適用されることができる。カテーテルを通して採取されたサンプルと共に使用されることもできる。

【課題を解決するための手段】

【００１５】

一態様では、血液隔離装置が提示されている。血液隔離装置は、入口ポートと出口ポートとを含む。血液隔離装置は、入口ポートと接続される隔離チャンバであって、空気透過性血液バリアを含む通気口を有する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端と、出口ポートと接続される遠位端とを有する、サンプリング流路

を更に含む。

【００１６】

別の態様では、採血経路と接続される血液隔離装置が記載されている。採血経路は、患者針とサンプル採取装置とを有する。血液隔離装置は、患者針と接続される入口ポートと、入口ポートと接続される隔離チャンバであって、空気透過性血液バリアを含む通気口を有する隔離チャンバとを含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路と、サンプリング流路の遠位端及びサンプル採取装置と接続される出口ポートとを更に含む。

【００１７】

更に別の態様では、採血システムと接続される血液隔離装置が記載されている。採血システムは、患者から血液サンプルを取り出せるようにするための患者針と、密封され且つ真空採血管を受け入れるように適合されたサンプル針とを含む。血液隔離装置は、患者からの血液サンプルを受け入れるために患者針と接続される入口ポートを含む。血液隔離装置は、入口ポートと接続され且つ空気透過性血液バリアを含む通気口を有する隔離チャンバであって、サンプル針が真空採血管によって開封されるより前に血液サンプルの最初の部分を受け入れ且つ隔離する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路であって、真空採血管によってサンプル針が開封されると血液サンプルの後続の部分を運ぶサンプリング流路を更に含む。血液隔離装置は、血液サンプルの後続の部分をサンプル針に運ぶためにサンプリング流路の遠位端と接続される出口ポートを更に含む。

【００１８】

更に別の態様では、血液サンプル最適化システムが開示され、記載されている。血液サンプル最適化システムは、患者の血液の１つ以上のサンプルを取り出せるようにし且つ得るための採血システムと、静脈穿刺プロセスによって汚染されている恐れがあり且つ患者の血液中の病原体の偽陽性同定をもたらす可能性がある患者の血液の１つ以上のサンプルの最初の部分を受け入れ且つ隔離するための血液隔離装置とを含む。

【００１９】

採血システムは、患者の血液のサンプルを取り出せるようにするために患者の静脈穿刺用に構成された患者針と、血液サンプルを運ぶために患者針と接続される採血経路と、血液サンプルの後続の部分を採取し且つ収容するために真空採血容器を受け入れるように構成されたサンプル針とを含む。

【００２０】

更に別の態様では、血液隔離装置が開示され、記載されている。一部の実施では、血液隔離装置は、入口ポートと、入口ポートと接続される出口ポートと、入口ポートと接続される隔離チャンバとを含むことができる。隔離チャンバは、空気透過性血液バリアを含む通気口を有することができる。

【００２１】

血液隔離装置は、患者針とサンプル針との間で採血経路に沿って接続され、血液サンプルを受け入れるための入口ポートを含む。血液隔離装置は、血液サンプルの最初の量を受け入れるために入口ポートと接続される隔離チャンバであって、血液サンプルの最初の量の少なくとも最初の部分を隔離するために空気透過性血液バリアを含む通気口を有する隔離チャンバを更に含む。血液隔離装置は、入口ポートと接続される近位端を有するサンプリング流路であって、隔離チャンバが血液サンプルの最初の量の少なくとも最初の部分を隔離すると血液サンプルの後続の量を真空採血容器に運ぶサンプリング流路を更に含む。血液隔離装置は、サンプリング流路の遠位端と接続される出口ポートであって、血液サンプルの後続の量を出力する出口ポートを更に含む。

【００２２】

１つ以上の実施形態の詳細が、添付の図面及び以下の説明に記載されている。他の特徴及び利点は、明細書及び図面並びに特許請求の範囲から明らかになるであろう。

【図面の簡単な説明】

【００２３】
以下、これら及び他の態様について、以下の図面を参照して詳細に説明する。
【図１】血液サンプル最適化システムを示す。
【図２】代替的な実施に従う血液サンプル最適化システムを示す。
【図３】別の代替的な実施に従う血液サンプル最適化システムを示す。
【図４】別の代替的な実施に従う血液サンプル最適化システムを示す。
【図５】別の代替的な実施に従う血液サンプル最適化システムを示す。
【図６】代替的な実施に従う血液サンプル最適化システムを示す。
【図７】血液培養の質を最適化するための方法のフローチャートである。
【図８Ａ】一部の実施に従う非汚染採血用の血液隔離システムを示す。
【図８Ｂ】一部の実施に従う非汚染採血用の血液隔離システムを示す。
【図８Ｃ】一部の実施に従う非汚染採血用の血液隔離システムを示す。
【図８Ｄ】一部の実施に従う非汚染採血用の血液隔離システムを示す。
【図８Ｅ】一部の実施に従う非汚染採血用の血液隔離システムを示す。
【図９】血液隔離システムに用いる経路スプリッタを示す。
【図１０Ａ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１０Ｂ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１０Ｃ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１０Ｄ】代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１１Ａ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１１Ｂ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１１Ｃ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１１Ｄ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１１Ｅ】他の代替的な実施に従う非汚染採血用の血液隔離システムを示す。
【図１２Ａ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。
【図１２Ｂ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。
【図１２Ｃ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。
【図１２Ｄ】更に他の代替的な実施に従う血液隔離装置を含む血液サンプル最適化システムを示す。
【図１３Ａ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。
【図１３Ｂ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。
【図１３Ｃ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。
【図１３Ｄ】更に別の代替的な実施に従う血液サンプル最適化システム１３００を示す。
【図１４Ａ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｂ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｃ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｄ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に別の実施を示す。
【図１４Ｅ】患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システムの更に

別の実施を示す。
【図１５Ａ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｂ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｃ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｄ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｅ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｆ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１５Ｇ】更に別の実施に従う血液隔離装置及びそれを使用する方法を示す。
【図１６Ａ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｂ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｃ】更に別の実施に従う血液隔離装置を示す。
【図１６Ｄ】更に別の実施に従う血液隔離装置を示す。
【図１７Ａ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｂ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｃ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｄ】血液隔離装置用のハウジングの下部部材を示す。
【図１７Ｅ】血液隔離装置用のハウジングの下部部材を示す。
【図１８Ａ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｂ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｃ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｄ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｅ】血液隔離装置用のハウジングの上部部材を示す。
【図１８Ｆ】血液隔離装置用のハウジングの上部部材を示す。
【図１９Ａ】下部部材と嵌合する上部部材を有する血液隔離装置を示す。
【図１９Ｂ】下部部材と嵌合する上部部材を有する血液隔離装置を示す。
【図２０】血液隔離装置を含む血液サンプル最適化システムを示す。
【図２１】ウィッキング材料チャンバを使用する通気口付きでない血液隔離装置を示す。
【図２２Ａ】血液隔離装置の隔離チャンバ内の血液を隔離するためのフィルタの材料構成を示す。
【図２２Ｂ】血液隔離装置の隔離チャンバ内の血液を隔離するためのフィルタの材料構成を示す。
【図２３Ａ】採血装置による真空力を使用する血液隔離装置の別の実施を示す。
【図２３Ｂ】採血装置による真空力を使用する血液隔離装置の別の実施を示す。　様々な図面における同様の符号は同様の要素を示す。
【発明を実施するための形態】
【００２４】
本明細書は、採取される血液サンプル中の汚染物質を低減又は排除し、その結果、採取される血液サンプルの血液培養又は他の検査における偽陽性の判断を減少又は排除する血液サンプル最適化システム及び方法を記載している。一部の実施では、血液サンプル最適化システムは、患者の血流への血管アクセスのための患者針と、バキュテナー（登録商標）のような真空採血容器又は真空採血管などの採血容器か又は他のサンプリング装置に血液サンプルを供給するためのサンプル針と、患者針とサンプル針との間に位置する血液隔離装置とを含む。血液隔離装置は、汚染されている可能性のある最初のアリコートの血液を隔離するための隔離チャンバを含み、最初のアリコートの血液が隔離チャンバ内に隔離された後に患者針とサンプル針との間の汚染されていない可能性のある血液を運ぶために隔離チャンバを迂回するサンプリング流路を更に含むことができる。
【００２５】
図１は、一部の実施に従う血液サンプル最適化システムを示す。システムは、患者の皮膚を穿刺してその中の患者の静脈及び静脈内の血液にアクセスするための患者針１を含む。システムは、再密封可能なブーツ１０、ルアー作動弁、又は別の採取インターフェース

又は装置内に収容され且つ再密封可能なブーツ１０、ルアー作動弁、又は別の採取インターフェース又は装置によって当初は密封されていることができる、サンプル針（すなわち、バキュテナー（登録商標）などと共に使用するための再密封可能に密封された針）５を更に含む。再密封可能なブーツ１０は、患者の血液を採取するためのバキュテナー（登録商標）ボトル（図示せず）を用いることによって、サンプル針５のそばに又はサンプル針５の周りに押し付けることができる。システムは、サンプル針５に通じる低容量チャンバ３０を更に含むことができるが、ハウジング５０によって形成される隔離チャンバ５５に通じる穴又は１つ以上の流路４５も含む。

【００２６】

隔離チャンバ５５は、隔離チャンバ５５の容積に応じて、所定の又は測定された量であることができる、患者の血液の最初のアリコートを受け入れ且つ保持するためのチャンバ、流路、通路、ロック、又は他の構造である。最初の採血は、一般的に、後続の採血に比べて菌血症及び敗血症を引き起こす微生物又は他の病原体を含有しているか又はより含有の影響を受けやすい。隔離チャンバ５５は、硬いハウジング内に収容されるか、ハウジング自体に形成され又はハウジング自体によって画定された容器であることができ、或いはチューブ又は内腔として実現されることができる。隔離チャンバ５５は、どのように形成され且つ実施されるかにかかわらず、所定の容積を有することができる。一部の実施では、所定の容積は、患者針の容積に基づくこと、すなわち、患者針の容積よりも少ない容積から任意の容積から患者針の容積の２０倍以上大きい容積までの範囲であることができる。隔離チャンバ５５の所定の容積は、隔離され且つ処分される血液の量を節約又は最小化するように設定されることもできる。

【００２７】

隔離チャンバ５５は、チャンバハウジング５０内に形成、包含、又は収容されることができ、プラスチック、ゴム、鋼、アルミニウム又は他の適切な材料で作られることができる。例えば、隔離チャンバ５５は、可撓性チューブ又は他のエラストマー材料から形成されることができる。隔離チャンバ５５は、空気が隔離チャンバ５５から出ることを可能にする空気透過性血液バリア２０を更に含む。本明細書で使用される「空気透過性血液バリア」という用語は、空気透過性であるが実質的に血液不透過性の物質、材料又は構造体を意味する。代表的な例は、疎水性膜及び疎水性コーティング、疎水性膜又は疎水性コーティングと組み合わせた親水性膜又は親水性コーティング、メッシュ、フィルタ、機械的弁、抗菌性材料、又は隔離チャンバ５５が血液で満たされるときに隔離チャンバ５５から空気を追い出すことができる他の任意の手段を含むことができる。様々な例示的な実施形態において、空気透過性血液バリアは、空気が液体と接触するまで通過することを可能にする１つ以上の材料によって形成されることができ、このような材料は、空気及び／又は液体の通過を防止又は阻止するために完全に又は部分的に密封される。言い換えれば、液体との接触より前に、材料は空気透過性のバリアを形成している。液体との接触後、材料は、空気及び／又は液体の更なる通過を実質的に又は完全に防止する。

【００２８】

穴又は流路４５は、任意の所望の長さ、断面形状又はサイズであることができ、且つ／又は任意の所望の角度又は向きで低容量チャンバ３０から離れるように形成されることができる。穴又は流路４５はまた、最初のアリコートの血液サンプルを隔離チャンバ５５内に保持する一方向フラップ又は一方向弁６０を含むことができる。一部の特定の実施では、穴又は流路４５は、低容量チャンバ３０から隔離チャンバ５５への一方向の血液の流れのための「ダックビル」弁又はフラッパ弁６０などを含むことができる。空気透過性血液バリア２０は、空気が出ることを可能にするが血液と接触すると密封する材料で構成することもでき、それによって外気が隔離チャンバ５５に入ることを許容しない。この密封は弁を不要にする。

【００２９】

弁６０は、任意のタイプの弁又は開閉機構であることができる。チャンバ３０は、実質的に残留血液を保持しないように設計されており、特定の容積又は割合の血液を隔離チャ

ンバ５５に保持し又は通過させるように構成することができる。同様に、隔離チャンバ５５は、抗菌コーティングのような任意のタイプのコーティング、又は隔離された最初の採血の成分の同定及び／又は診断を支援するコーティングも含むことができる。

【００３０】

ハウジング５０及び４０は、アクリロニトリルブタジエンスチレン（ＡＢＳ）又は他の熱可塑性材料又はポリマー材料などのプラスチック、ゴム、鋼、又はアルミニウムを含む任意の適切な材料から形成されることができる。空気透過性血液バリア２０は、最初の採血による血液と接触すると又は空気の追い出しが停止されたときに、又は事象と隔離チャンバ５５内の血液との任意の組み合わせの場合に活性化される、色提供物質又は他の信号伝達機構を含むことができる。空気透過性のバリアはまた、外部流体源、しぶき等によるフィルタの不注意による又は早過ぎる密封を阻止又は防止する疎水性膜又はカバーなどの外層を含むことができる。隔離チャンバ５５はまた、チャンバが充填されたことをユーザーが視覚的に確認することを可能にするために半透明又は透明であることができる。

【００３１】

図２は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図２に示す実施では、隔離チャンバ５５又は廃棄チャンバが患者針１を取り囲み、端部が開放されたカフ又はハウジングが廃棄チャンバと接続され、サンプル針ハウジングベース及びハウジングを取り囲んでいる。患者針１とサンプル針５とは、ブーツ５６によって互いと接続されており、ブーツ５６は、それを貫通する連続的な採血流路を形成している。ブーツ５６は、採血流路から隔離チャンバ５５に通じる単一の穴又は流路を含む。装置は、他の実施では、複数の穴又は流路を含むことができる。各穴又は流路は、一方向弁を含むことができ、所定の量の血流のために寸法設定され且つ適合されることができる。

【００３２】

隔離チャンバ５５は、空気透過性血液バリアを含む。フィルタは、所定容積の血液が隔離チャンバ５５に集められたときに、それぞれ、感知及び／又は指示するためのセンサ又は指標を更に含むことができる。その指示は、バキュテナー（登録商標）などの真空採血管又はボトルをサンプル針５に取り付けるようにユーザーに警告する。隔離チャンバ５５用のハウジングは、任意のサイズ又は形状であることができ、ハウジング内の内部空間又は容積を画定するために任意のタイプの材料を含むことができる。内部空間は、最初は空気のみで満たされているが、汚染除去剤、凝固剤などの薬剤又は物質でコーティングされることもできる。真空採血管がサンプル針５に取り付けられると、血液は自動的に患者針１に、採血流路及びサンプル針５を通ってボトルに流入する。サンプル針５は、採血ボトルがサンプル針に取り付けられていないときにサンプル針を密封する再密封可能なブーツ、コーティング又は膜によって覆われている。

【００３３】

図３は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図示の実施では、サンプル針５は、再密封可能なブーツ又は膜によって取り囲まれ、更に患者針１と接続される。サンプル針及び患者針を通って血液流路が形成される。サンプル針と患者針との間の接続は、主血液流路から隔離チャンバ１０４へと導く流路、ポート又は開口部を含む「Ｔ」又は「Ｙ」コネクタ１０２を含む。

【００３４】

Ｔ又はＹコネクタ１０２は、フラップ又は一方向弁を含み、所定の流量の血液のために寸法設定され且つ適合された穴を有する。隔離チャンバ１０４は、チューブから形成され又は硬いハウジングによって形成されることができ、最初は空気で満たされている。隔離チャンバ１０４は、自動的に、すなわち、患者自身の血圧による圧力下で患者から流出する血液を受け入れる。隔離チャンバ１０４は、好ましくは隔離チャンバ１０４を形成し且つ近位端がＴ又はＹコネクタ１０２に接続されたチューブの遠位端に、空気透過性血液バリア１０６を含む。Ｔ又はＹコネクタ１０２は、最も効率的な血流のために任意の所望の角度で分岐することができ、最初のアリコートの血液と主要な採血サンプルとの混合を最小限に抑え又は排除するために、開口部及び流路と主血液流路との間の接合部分を最小化

するように形成されることができる。

【００３５】

一部の代替的な実施では、サンプル針は、図４に示すように、その反対側の端部がＴ又はＹコネクタ１０２と接続している任意の長さのチューブに取り付けられることができる。隔離チャンバ１０４は、最初のアリコートに所定量の血液サンプルを含む限り、任意の形状又は容積であることができる。Ｔ又はＹコネクタ１０２はまた、主血液流路に対して平行な開口部又は流路を含むことができる。空気透過性血液バリアは、所定量の血液が隔離チャンバに集められたとき、又は放出される空気が特定の閾値、すなわちゼロに達したときを示す指標１０７又は他の機構を更に含むことができる。チューブはまた、挟んでチューブを通る流体の流れを防止するのに使用することができるクリップ１０９を含むことができる。

【００３６】

空気透過性血液バリア及び一次チャンバが密封されると、最初のアリコートの血液が隔離チャンバ１０４に閉じ込められ、サンプルを得るためにバキュテナー（登録商標）ボトルのような真空採血管がサンプル針５に取り付けられる。採血管は取り外すことができ、サンプル針５は再密封される。更なる採血又はサンプルのために、任意の数の後続の採血管を取り付けることができる。全ての採血が完了すると、最初のアリコートの血液が隔離チャンバ１０４に閉じ込められたまま、システムは廃棄される。

【００３７】

図５は、一部の代替的な実施に従う血液サンプル最適化システムを示す。図示の実施では、サンプル針５が患者針とチューブによって接続されている。「Ｔ」又は「Ｙ」コネクタ１２０が、チューブに沿って任意の所望の位置に追加され、実質的に上記のように、隔離チャンバ２０４に通じる開口部、ポート又は流路を含む。

【００３８】

図６は、一次採取流路として形成された隔離チャンバ３０４が最初のアリコートの血液を受け入れ、採血流路に隣接して設けられている、一部の代替的な実施に従う血液サンプル最適化システムを示す。隔離チャンバ３０４は、採血流路、患者針１及び／又はサンプル針５を取り囲むことができる。一次採取流路は、Ｔ又はＹコネクタ１２０、又は他のタイプの開口部又は流路を含むことができる。隔離チャンバ３０４は空気透過性血液バリアを含み、上記のように、血液などの流体が接触したことの指標を含むこともできる。

【００３９】

一部の実施では、患者針１又はサンプル針５のいずれか又は両方をルアーロック雄コネクタ又はルアーロック雌コネクタで置き換えることができる。しかしながら、様々な実施で、血液サンプル最適化システムのサンプル針端部にあるコネクタを最初に密封し、周囲空気圧で加圧され且つ空気透過性血液バリアの空気出口を含む隔離チャンバへ最初のアリコートの血液をそらすことを可能にする。このようにして、システムは受動的且つ自動的に患者自身の血圧を用いて隔離チャンバの周囲空気圧に打ち勝ち、空気透過性血液バリアを通して空気を押し出し、隔離チャンバ内の空気を血液に置き換える。

【００４０】

図７は、血液培養の質を最適化するための例示的な方法のフローチャートである。７０２において、臨床医が患者の静脈に針を挿入する。７０４において、血液が隔離チャンバに流れ込み、隔離チャンバ内の空気を隔離チャンバから空気透過性血液バリアを通して押し出す。一部の実施では、隔離チャンバの容積は、０．１立方センチメートル（ｃｃ）未満から５立方センチメートル（ｃｃ）以上である。隔離チャンバは、血液サンプルの第２部分及び他の後続の部分又は後続の採取よりも汚染しやすい血液サンプルの第１部分を採取するように寸法設定され且つ適合されている。隔離チャンバは空気透過性血液バリアを有し、この血液バリアを通して空気を患者の静脈から押し出された血液で追い出すことができるので、このような血液は、血液サンプルを受け入れ且つ保管するためのバキュテナー（登録商標）又は他のボトルに引き込まれるか又は他の方法で入る前に、必然的に且つ自動的に隔離チャンバに流入する。

【００４１】
隔離チャンバがいっぱいになると、血液は、血液が通過するのを阻止又は防止する空気透過性血液バリアに集まるか、さもなければ接触する。７０６において、血液が空気透過性血液バリアの全内部表面積と接触すると、空気透過性血液バリアは閉じられ、空気はもはや流出又は流入しない。７０８において、臨床医は、バキュテナー（登録商標）などの真空採血管を取り付けることができることを示す指標を提供されるか又は満杯のチャンバを見ることができる。指標は、一次チャンバがいっぱいであるか否かを確認するための一次チャンバの可視性、例えば、色を変える血液バリア、又は他の指標を含むことができる。隔離チャンバの充填時間は、実質的に瞬間的であり得るので、このような指標は、存在する場合、隔離チャンバが満たされているというだけである可能性がある。

【００４２】
真空採血管が取り付けられる前、針、サンプリング流路、及び隔離チャンバの間の連通は、隔離チャンバの血液バリアの密封によって制限され、従って隔離によって空気がシステムに再び入ることを可能にしない。連通経路の密封は、機械的にねじること又は他の動作、小さな穴又は曲がりくねった経路によって達成され、臨床医による別個の弁又は機械的な動作又は操作の必要性をなくす。７１０において、真空採血管を取り外すと、自己密封式の膜がサンプル針を密封し、７１２で、更なる後続の真空採血管を取り付けることができる。７１４において、サンプルが採取されると、装置が患者から取り外され、廃棄される。

【００４３】
図８Ａ～８Ｅは、一部の実施に従う、非汚染採血用の例示的な血液サンプル最適化システム８００を示す。血液サンプル最適化システム８００は、チューブ、患者針（又は両方）、又は他の血管又は静脈アクセス装置に接続されることができる入口ポート８０２と、隔離チャンバチューブ８０６への第１出口とサンプル採取チューブ８０８への第２出口とを有する経路スプリッタ８０４とを含む。隔離チャンバチューブ８０６及びサンプル採取チューブ８０８の一方又は両方は、チューブから形成されることができる。一部の実施では、隔離チャンバチューブ８０６は、特定の量の当初血液サンプルを収容するように寸法設定される。サンプル採取チューブ８０８は、ひとたび隔離チャンバチューブ８０６が満たされると、血液サンプルを受け入れる。サンプル採取チューブ８０８は、バキュテナー（登録商標）ベース又はハウジング８１０、又は他の血液サンプル採取装置に接続されることができる。

【００４４】
血液隔離システム８００は血液隔離装置８１２を更に含み、血液隔離装置８１２は、図８Ｂ～８Ｄにより詳細に示すようにハウジング８１８を含み、ハウジング８１８は、非汚染サンプル採取チューブ８０８用の経路を画定するか又はいずれかの端部が非汚染サンプル採取チューブ８０８と接続されるサンプリング流路８２０を含む。サンプリング流路８２０は、非汚染サンプル採取チューブ８０８に沿った位置でハウジング８１８をより良好に固定し且つ安定させるように、ハウジング８１８を通って曲線状であることができる。

【００４５】
血液隔離装置８１２は、隔離チャンバチューブ８０６と接続される隔離チャンバ８２２又は他のチャンバを更に含む。隔離チャンバ８２２は、空気透過性血液バリア８２４で終端している。空気透過性血液バリア８２４はまた、血液サンプル（すなわち、非汚染血液サンプル）の正式な採取を開始することができる指標として、血液との完全な接触時に異なる色に変わる着色剤を含むことができる。小さい光、音発生機構などの他の指標を使用することができる。一部の実施では、空気透過性血液バリアは、隔離チャンバ８２２の方向から直角に配置されているが、ハウジング８１８に使用される空間及び材料を節約するために任意の距離又は向きに配置されることができる。ハウジング８１８及びその内容物は、任意の剛性材料又は半剛性材料又は一連の材料から形成されることができる。

【００４６】
図９は、例えば、図８Ａ～８Ｅに示すような血液隔離システムに用いる経路スプリッタ

９００を示す。経路スプリッタ９００は、入口ポート９０２と、主管路出口ポート９０４と、隔離流路出口ポート９０６とを含む。入口ポート９０２は、同様に患者針システムに接続される主チューブに、又は直接患者針に接続されることができる。主管路出口ポート９０４は、バキュテナー（登録商標）ベース又はハウジングなどの採血システムへの主管路チューブに、又は直接そのような採血システムに接続されることができる。隔離流路出口ポート９０６は、測定された量又は所定の閾値まで血液の第１サンプルを受け入れ且つ隔離するための隔離チューブに接続されることができる。代わりに、隔離流路出口ポート９０６は、隔離チャンバに接続することができる。隔離流路出口ポート９０６は、好ましくは、主管路出口ポート９０４から２０～７０度の角度に曲げられ、一方、主管路出口ポート９０４は、好ましくは、入口ポート９０２と一直線である。所定の量の最初の血液サンプルが、本明細書に記載された機構及び技術に従って隔離チューブ又は隔離チャンバ内に隔離されると、後続の血液サンプルは、入口ポート９０２に流入し、障害物なしで主管路出口ポート９０４から直接流出する。

【００４７】

図１０Ａ～１０Ｄは、別の実施に従う血液隔離装置１０００を示す。血液隔離装置１０００は、入口ポート１００２と、主出口ポート１００４と、隔離流路ポート１００６とを含む。入口ポート１００２は、患者針又は関連するチューブと接続されることができる。主出口ポート１００４は、バキュテナー（登録商標）、関連するチューブ、又はルアー作動弁などの血液サンプル採取装置に接続されることができる。隔離流路ポート１００６は、主出口ポート１００４から隔離チャンバ１００８に分離する。一部の実施では、隔離チャンバ１００８は、ハウジング又は他の容器１００１内に螺旋流路として形成される。

【００４８】

隔離チャンバ１００８は、実質的に上記のように、遠位端が空気透過性血液バリア１０１０に接続される。隔離チャンバ１００８内の空気は、空気透過性血液バリア１０１０を通して、隔離流路ポート１００６内に案内される最初のアリコートの血液によって追い出される。ひとたび隔離チャンバ１００８が満たされると、主出口ポート１００４を通る更なる採血が成し遂げられ、これらのサンプルは汚染されていない。

【００４９】

図１１Ａ～１１Ｅは、他の代替的な実施に従う血液隔離装置１１００を示す。血液隔離装置１１００は、上述の入口ポートと同様の入口ポート１１０２と、主出口ポート１１０４と、主出口ポート１１０４及び入口ポート１１０２から分離する隔離流路ポート１１０６とを含む。隔離流路ポートは、隔離チャンバ１１０８に接続されている。図１１Ａ～１１Ｅに示す実施では、血液隔離装置は、隔離チャンバ１１０８として機能する流路を内部に有するベース部材１１０１を含む。流路は、ベース部材１１０１を通る曲がりくねった経路として形成されることができ、一方、ベース部材１１０１は、患者の四肢に載るように成形され且つ形成される。

【００５０】

隔離チャンバ１１０８の一部は、血液隔離指標１１０９として機能するように、空気透過性血液バリア１１１０に出る直前に、ベース部材から又はベース部材の上面付近に突出することができる。指標１１０９は、透明な材料、又は血液と接触すると変色する材料で形成されることができる。

【００５１】

一部の実施では、血液隔離装置１１００は、常時閉じている針、バキュテナー（登録商標）シールド又は他の採取装置などの採血装置１１２０を含むことができる。採血装置１１２０は、患者針の挿入プロセスによって汚染される恐れがある最初のアリコートの血液を隔離することができるように、効率及び利便性のために血液隔離装置１１００と共に製造及び販売されることができる。従って、採血装置１１２０は、偽陽性の検査のリスクを低減するように非汚染血液サンプルを採取し且つ非汚染サンプルを確実にすることができる。

【００５２】

図１２Ａ～１２Ｄは、更に他の代替的な実施に従う血液サンプル最適化システム１２００を示す。システム１２００は、バキュテナー（登録商標）又は他の採取及びサンプリング装置のような採血装置１２０４に取り付けるための血液隔離装置１２０２を含む。血液隔離装置１２０２は、バキュテナー（登録商標）容器又はバイアルが採血装置１２０４の採取針に取り付けられる前に、最初のアリコート又は量の血液を受け入れ、且つその最初のアリコート又は量を血液隔離装置１２０２の隔離流路内に隔離するように、構成され且つ配置されている。

【００５３】

一部の実施では、血液隔離装置１２０２は、入口ポート１２１２と、主出口ポートと、隔離流路ポートとを含むことができる。入口ポート１２１２は、患者針又は関連するチューブに接続されることができる。主出口ポート１２１４は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁との接続を可能にするために、常時閉じている針又は装置に接続されることができる。隔離流路ポートは、主出口ポートから隔離チャンバ１２１８に分離する。

【００５４】

一部の実施では、隔離チャンバ１２１８は、隔離装置１２０２の本体内の流路として形成される。隔離チャンバ１２１８は、Ｕ字形流路、Ｓ字形流路、螺旋流路、又は任意の他の曲がりくねった流路などの曲がりくねった流路であることができる。隔離装置１２０２は、ハウジング又は他の収容体、及びその中に形成された１つ以上の流路を含むことができる。図１２Ａ及び１２Ｂに示すように、隔離装置１２０２は、本体１２０６とキャップ１２０８とを含む。本体１２０６には１つ以上の空洞又は流路が形成され、空洞又は流路にはキャップ１２０８から延びる１つ以上のアーム１２１０が更に形成され、１つ以上のアーム１２１０は、本体１２０６の空洞又は流路に当接して一次採取ポート及び主出口ポートを形成している。

【００５５】

図１３Ａ～１３Ｄは、更に他の代替的な実施に従う血液サンプル最適化システム１３００を示す。システム１３００は、バキュテナー（登録商標）又は他の体液採取及びサンプリング装置などの採血装置１３０４に取り付けるための血液隔離装置１３０２を含む。血液隔離装置１３０２は、バキュテナー（登録商標）容器又はバイアルが採血装置１３０４の採取針に取り付けられる前に、最初のアリコート又は量の血液を受け入れ、且つその最初のアリコート又は量の血液又は他の体液を血液隔離装置１３０２の隔離流路内に隔離するように、構成され且つ配置されている。

【００５６】

血液隔離装置１３０２は、入口ポート１３１４と、主出口ポート１３１２と、隔離流路ポート１３１６とを有するハウジング１３０１を含む。入口ポート１３１４は、患者針又は関連するチューブに接続されることができる。主出口ポート１３１２は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁との接続を可能にするために、常時閉じている針又は装置に接続されることができる。隔離流路ポート１３１６は、主入口ポート１３１４から隔離チャンバ１３１８に分離する。

【００５７】

図１３Ａ～１３Ｄに示す実施例では、隔離チャンバ１３１８は、ハウジング１３０１内の空洞又はチャンバとして形成され、又はハウジング１３０１を画定する壁によって形成される。隔離チャンバ１３１８は、Ｕ字形流路、Ｓ字形流路、螺旋流路などの曲がりくねった流路、又はハウジング１３０１とキャップ１３０７との協働及び接続によって画定される任意の他の曲がりくねった流路であることができ、キャップ１３０７は、隔離チャンバ１３１８内の曲がりくねった流路のための１つ以上の壁又はディレクタを提供する突出部１３０５を含むことができる。キャップ１３０７からの突出部１３０５は、真っ直ぐであるか湾曲していることができ、様々な流路、開口部又は溝が埋め込まれていることができ、キャップ１３０７から任意の角度又は向きで延びることができる。隔離チャンバ１３

１８の形成を完了するためにキャップ１３０７がハウジング１３０１と接続されると、突出部１３０５は曲がりくねった流路の少なくとも一部を形成し、隔離チャンバ１３１８内に曲がりくねった流路によって形成される隔離流路に最初のアリコート又は量の血液又は他の体液を隔離する。

【００５８】

隔離チャンバ１３１８は、実質的に上記のように空気透過性血液バリア１３１０を含む。隔離チャンバ１３１８内の空気は、患者の血圧によって隔離チャンバ１３１８内に供給される最初のアリコートの血液によって空気透過性血液バリア１３１０を通して追い出される。隔離チャンバ１３１８が満たされ、隔離チャンバ１３１８内の空気が追い出されると、バキュテナー（登録商標）のような血液サンプル採取装置によって提供されるような真空又は他の圧力のような力が次のアリコート又は量の血液又は体液を引き抜くために提供されるまで、患者の血圧は、血液隔離装置１３０２、特に、出口ポート１３１２に更なる血液を追い込み又は提供するのには不十分である。主出口ポート１３１２を通して更なる採血を行うことができ、あらゆる汚染物質が最初のアリコートの血液と共に隔離チャンバ１３１８内に隔離されているので、これらのサンプルは汚染されない。

【００５９】

図１４Ａ～１４Ｅは、患者の血液サンプルに対して実施される血液培養又は検査における偽陽性を低減するために最初のアリコート又はサンプルの汚染物質を隔離する採血システム１４００の更に別の実施を示す。採血システム１４００は、血液サンプル採取装置１４０３と患者針（図示せず）との間に接続されることができる血液隔離装置１４０１を含む。血液サンプル採取装置１４０３は、バキュテナー（登録商標）などであることができる。血液隔離装置１４０１は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１４０２を含む。入口ポート１４０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。

【００６０】

入口ポート１４０２は、血液隔離装置１４０１への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有する円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる。血液隔離装置１４０１は、血液隔離装置１４０１から及び血液サンプル採取装置１４０３への開口部を画定する出口ポート１４０４を更に含む。出口ポート１４０４は、同様に血液隔離装置１４０３と接続されるチューブ又は他の導管と接続されることもできる。出口ポート１４０４は、ねじ付きキャップ、ルアーコネクタ（雄型又は雌型）、チューブなどを含むがそれらに限定されない様々な装置の取り付け用のねじが切られていない締め代又は接着継手などのコネクタ装置を更に含むことができる。

【００６１】

血液隔離装置１４０１は、入口ポート１４０２と出口ポート１４０４との間にサンプリング流路１４０６を更に含み、サンプリング流路１４０６は、最初のアリコートの血液が隔離されると血液サンプル経路として機能する。サンプリング流路１４０６は、任意のサイズ、形状又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１４０６は、入口ポート１４０２の開口部と実質的に同様の断面積を有する。他の実施では、サンプリング流路１４０６は、入口ポート１４０２から出口ポート１４０４まで徐々に広がることができる。

【００６２】

血液隔離装置１４０１は隔離チャンバ１４０８を更に含み、隔離チャンバ１４０８は、入口ポート１４０２と出口ポート１４０４との間の任意の位置でサンプリング流路１４０６に接続され且つサンプリング流路１４０６から分離又は方向転換されるが、好ましくは入口ポート１４０２の近くのサンプリング流路１４０６の近位端に接続され且つ近位端か

ら分離又は方向転換される。隔離チャンバ１４０８は、最初は大気圧に維持され、サンプリング流路１４０６からの方向転換点と反対側の隔離チャンバ１４０８の遠位端又はその近傍に空気出口１４１２を含む。空気出口１４１２は、空気透過性血液バリア１４１２を含む。図１４Ｂに示すように、空気透過性血液バリア１４１２は、保護カバー１４１６で覆われていることができる。保護カバー１４１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１４１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも患者自身の血圧によって隔離チャンバ１４０８内に強制的に血液が供給されることによって空気が隔離チャンバから追い出されるときに空気が空気透過性血液バリア１４１２から出ることを可能にする。また、保護カバー１４１６は、空気透過性血液バリアが周囲の流体又は飛沫に偶発的に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００６３】

図１４Ｃ及び１４Ｄに示すように、サンプリング流路１４０６は、赤血球を溶解する可能性を最小限に抑えるために、より小さい直径からより大きい直径になる円筒形又は円錐台形であることができる。同様に、サンプリング流路１４０６は、赤血球を溶解する可能性がある急カーブ又は鋭角が最小限の量で又はなしで形成される。サンプリング流路１４０６は、方向転換経路１４０９を通して入口ポート１４０２の近くで隔離チャンバ１４０８へと分離する。方向転換経路１４０９は、任意の断面形状又はサイズを有することができるが、好ましくは、入口ポート１４０２の少なくとも一部の断面形状と同様である。

【００６４】

一部の実施では、サンプリング流路１４０６及び隔離チャンバ１４０８は、ハウジング１４１４に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１４１４は、プラスチック、金属又は他の剛性又は半剛性材料で作られることができる。ハウジング１４１４は、上部部材と密封可能に嵌合する下部部材を有することができる。下部部材及び上部部材の一方又は両方は、サンプリング流路１４０６及び隔離チャンバ１４０８、並びに方向転換経路１４０９、入口ポート１４０２、及び出口ポート１４０４を含むことができる。一部の他の実施態様では、方向転換経路１４０９、入口ポート１４０２、及び／又は出口ポート１４０４のうちの１つ以上が、ハウジング１４１４のいずれかの端部に接続されるキャップ部材によって少なくとも部分的に形成されることができる。一部の実施では、上部部材及び下部部材、並びにキャップ部材は、レーザ溶接、ヒートシール、接着、スナップ止め、ねじ止め、ボルト止めなどによって互いに連結されることができる。他の実施では、方向転換経路１４０９及び／又は隔離チャンバ１４０８の内面の一部又は全部が、汚染除去剤、凝固剤などの薬剤又は物質でコーティング又は充填されることができる。例えば、隔離チャンバ１４０８が満たされて最初のアリコートの血液が方向転換経路１４０９に戻るとき、隔離された血液の最後の量が凝固し、隔離チャンバ１４０８とサンプリング流路１４０６との間に障壁を作り出すように、方向転換経路１４０９に凝固剤を設けることができる。

【００６５】

図１５Ａ～１５Ｇは、血液隔離装置１５００を示す。血液隔離装置１５００は、真空採血容器又はバキュテナー（登録商標）などの他の採取装置、関連するチューブ、ルアーコネクタ、注射器、ルアー作動弁などとの接続を可能にするために常時閉じている針又は装置に接続されることができる。

【００６６】

血液隔離装置１５００は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１５０２を含む。入口ポート１５０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。入口ポート１５０２は、血液隔離装置１５００への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有す

る円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる。

【００６７】

入口ポート１５０２はまた、ねじ切り又はルアーフィッティングなどのような密封又は流体密封のコネクタ又は接続部を含むことができる。一部の実施では、患者針に結合されているチューブ又は他の導管は、部品同士の共成形、接着、レーザ溶接、又は熱接合などによって、入口ポート１５０２と一体化されることができる。これによって、血液隔離装置１５００は、患者針と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針を血液隔離装置１５００に接続する必要性をなくすことができる。

【００６８】

血液隔離装置１５００は、血液隔離装置１５００から及び血液サンプル採取装置への開口部を画定する出口ポート１５０４を更に含む。出口ポート１５０４は、同様に血液隔離装置と接続されるチューブ又は他の導管と接続されることもでき、ねじ切り又はルアーフィッティングなどの密封又は流体密封コネクタ又は接続部を含むことができる。したがって、上記のように、血液隔離装置１５００は、患者針及び／又はチューブ及び血液サンプル採取装置と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針及び血液サンプル採取装置を血液隔離装置１５００に接続する必要性をなくすことができる。

【００６９】

血液隔離装置１５００は、入口ポート１５０２と出口ポート１５０４との間にサンプリング流路１５０６を更に含み、サンプリング流路１５０６は、最初のアリコートの血液が隔離されると血液サンプル経路として機能する。サンプリング流路１５０６は、任意のサイズ、形状、又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１５０６は、入口ポート１５０２の開口部と実質的に同様の断面積を有する。他の実施では、サンプリング流路１５０６は、入口ポート１５０２から出口ポート１５０４まで徐々に広がることができる。

【００７０】

血液隔離装置１５００は隔離チャンバ１５０８を更に含み、隔離チャンバ１５０８は、入口ポート１５０２と出口ポート１５０４との間の任意の位置でサンプリング流路１５０６に接続され且つサンプリング流路１５０６から分離又は方向転換されるが、好ましくは入口ポート１５０２の近くのサンプリング流路１５０６の近位端に接続され且つ近位端から分離又は方向転換される。一部の実施では、分水路はＹ字路を含む。隔離チャンバ１５０８は、好ましくは大気圧に維持され、隔離チャンバ１５０８の遠位端又はその近傍に通気口１５１０を含む。通気口１５１０は、空気透過性血液バリア１５１２を含む。図１５Ｃは、隔離チャンバ１５０８が患者からの血液の最初のアリコート又はサンプルで満たされた血液隔離装置１５００を示す。

【００７１】

空気透過性血液バリア１５１２は、保護カバー１５１６で覆されていることができる。保護カバー１５１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１５１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも患者自身の血圧によって隔離チャンバ１５０８内に強制的に血液が供給されることによって空気が隔離チャンバから追い出されるときに空気が空気透過性血液バリア１５１２から出ることを可能にする。保護カバー１５１６は、フィルタが周囲の流体又は飛沫に偶発的に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００７２】

図１５Ｂは、血液隔離装置１５００の出口ポート１５０４及び通気口１５１０を含むハウジング１５０１の上面からの血液隔離装置１５００の斜視図であり、サンプル採取装置が起動される前、サンプリング流路１５０６が空である間に最初のアリコートの血液が隔

離チャンバ１５０８を満たすことを示す。図１５Ｇは、血液隔離装置１５００の出口ポート１５０４及びハウジング１５０１の底面からの血液隔離装置１５００の斜視図であり、サンプル採取装置が起動される前、サンプリング流路１５０６が空である間に最初のアリコートの血液が隔離チャンバ１５０８を満たすことを示す。図１５Ｃは、血液隔離装置１５００の入口ポート１５０２及び通気口１５１０を含むハウジング１５０１の上面からの血液隔離装置１５００の別の斜視図であり、隔離された血液は実質的に隔離チャンバ１５０８内にとどまっている間に血液がサンプリング流路１５０６を通って採取されることを示す。

【００７３】

図１５Ｄは、一部の実施に従う血液隔離装置１５００の断面図であり、サンプリング流路１５０６及び隔離チャンバ１５０８を画定するハウジング１５０１を示す。図１５Ｅ及び１５Ｆは、本明細書に記載される１つ以上の実施に従う血液隔離装置用のハウジングの様々なフォームファクタを示す。

【００７４】

隔離チャンバ１５０８は、サンプリング流路１５０６よりも大きい断面積を有することができ、断面積又は長さは、所定の又は特定の血液量が隔離又はロックされるように構成されることができる。サンプリング流路１５０６は、患者針のチューブ又は採血装置のチューブのいずれか又は両方のためのチューブに適合するように寸法設定されることができる。

【００７５】

ハウジング１５０１は、複数の部品又は単一の一体部品から形成されることができる。一部の実施では、図１５Ｄに示すように、ハウジング１５０１は、互いに嵌合する上部部材１５２０と下部部材１５２２とを含み、それらの一方又は両方は、例えば、射出成形プロセスによって又はエッチング、切削、穿孔などによって予め形成された溝、流路、ロック、導管又は他の経路を有する。上部部材１５２０は、レーザ溶接、熱接合、超音波溶接、接着、ねじ、リベット、ボルトなどを使用することなどの任意の嵌合又は接続機構によって、又はラッチ、溝、舌状部、ピン、フランジなどの他の嵌合機構によって、下部部材１５２２と接続されることができる。

【００７６】

一部の実施では、図１５Ｄに示すように、上部部材１５２０は、溝、流路、ロック、導管又は他の経路を含むことができ、一方、下部部材１５２２は、上部部材１５２０の溝、流路、ロック又は他の経路のうちの少なくとも１つに嵌合するように寸法設定され且つ適合された突出部１５２４を含むことができる。突出部１５２４は、例えば、サンプリング流路１５０６及び／又は隔離チャンバ１５０８のいずれかの形成を完了させるために、部分的な溝又は部分的な流路などの表面特徴を提供することができる。一部の実施では、突出部１５２４は、対応する溝、流路、ロック又は他の経路内によりぴったりと嵌合するために、１つ以上の傾斜した側面又は面を形成されることができる。更に他の実施では、上部部材１５２０と下部部材の両方が、溝、流路、ロック又は他の経路、並びに１つ以上の突出部１５２４を含むことができる。

【００７７】

一部の実施では、サンプリング流路１５０６及び隔離チャンバ１５０８は、ハウジング１５０１に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１５０１は、ゴム、プラスチック、金属又は他の材料を含む任意の適切な材料で作られることができる。ハウジング１５０１は、透明又は半透明の材料から、又は不透明又は非半透明の材料から形成されることができる。他の実施では、ハウジング１５０１は、大部分が不透明又は非透明であることができるが、サンプリング流路１５０６及び／又は隔離チャンバ１５０８に直接隣接するハウジング表面は、透明又は半透明であり、最初に隔離チャンバ１５０８が必要又は所望の程度まで満たされているという視覚的な合図又はサイン、及び／又は、次に汚染されていない血液サンプルがサンプリング流路１５０６を通して採取される間、隔離された血液が隔離されたままであるという視覚的な合図又はサインを施

術者に与える。隔離の他の視覚的な合図又はサインは、以下に限定されるものではないが、血液の接触、浸透、又は部分的な浸透で空気透過性血液バリア１５１２が異なる色に変わること、隔離チャンバに沿った又は隔離チャンバに隣接する任意の位置にある色分けされたタブ又は指標、可聴信号、振動信号、又は他の信号を含むことができる。

【００７８】

患者の皮膚から多数の病原体を集める可能性がある患者針（図示せず）による静脈穿刺の後、患者自身の血圧が隔離チャンバ１５０８内の大気圧に打ち勝って空気透過性血液バリア１５１２を通して隔離チャンバ１５０８内の空気を追い出すので、これらの病原体を有する患者の血液の最初の量が、血液隔離装置１５００入口ポート１５０２に入り、最も抵抗の少ない経路をたどることによって隔離チャンバ１５０８に流入する。患者の血圧は、密封されたサンプリング流路１５０６内で高まっている空気圧に打ち勝つのに十分ではない。最終的に、所定の容積を有する隔離チャンバ１５０８は、空気透過性血液バリア１５１２を通して空気を追い出す血液で満たされる。血液が空気透過性血液バリアに衝突すると、血液は空気透過性血液バリア１５１２の材料と相互作用して、通気口１５１０を完全に又は部分的に密封する。施術者がいまやバキュテナー（登録商標）カプセル又は他の血液サンプル採取装置を利用してサンプリングのために患者の血液の次の量を得ることができるという信号又は表示を提供することができる。隔離チャンバ１５０８内の血液は、このとき隔離チャンバ内で事実上隔離されている。

【００７９】

血液隔離経路１５０８を満たすと、バキュテナー（登録商標）又は他の血液サンプル採取装置の使用より前に、患者の血圧は、サンプリング流路１５０６内の空気の圧縮を引き起こし、場合によっては少量の血液が隔離チャンバ１５０８への方向転換点を過ぎてサンプリング流路１５０６に移動し、サンプリング流路１５０６を通して採取される汚染されていない血液を待ち行列に入れる。

【００８０】

図１６～１９は、血液隔離装置の更に別の実施を示す。図１６Ａ～１６Ｄは、バキュテナー（登録商標）（図示せず）のような真空採血容器のような血液サンプル採取装置と患者針（図示せず）及び／又は関連するチューブとの間に接続されることができる血液隔離装置１６００を示す。図１７は、血液隔離装置の下部部材を示し、図１８は、血液隔離装置の上部部材を示し、上部部材及び下部部材は、以下でより詳しく説明するように、相互に嵌合して、入口ポート、出口ポート、隔離チャンバ及びサンプリング流路を形成することができる。図１９Ａ及び１９Ｂは、互いに嵌合する上部部材及び下部部材を示す。図１６～１９は本明細書に記載される血液隔離装置を構成する１つの例示的な方法を示しており、他の形態の構成も可能であることを理解されたい。

【００８１】

図１６Ａ～１６Ｄを参照すると、血液隔離装置１６００は、血液サンプルへのアクセス及び血液サンプルの採取のために患者の血管系に挿入される患者針と接続されることができる入口ポート１６０２を含む。入口ポート１６０２は、同様に患者針と接続されるチューブ又は他の導管と接続されることもできる。入口ポート１６０２は、血液隔離装置１６００への開口部を画定し、この開口部は、患者針と接続されるチューブ又は他の導管又は患者針自体と同じ断面寸法であることができる。例えば、開口部は、約０．０４５インチ（１．１４３ｍｍ）の直径を有する円形であることができるが、０．０１インチ（０．２５４ｍｍ）から０．２インチ（５．０８ｍｍ）又はそれ以上の直径を有することができる。

【００８２】

入口ポート１６０２はまた、ねじ切り又はルアーフィッティングなどのような密封又は流体密封コネクタ又は接続部を含むことができる。一部の実施では、患者針に結合されているチューブ又は他の導管は、部品同士の共成形、接着、レーザー溶接、又は熱接合などによって、入口ポート１６０２と一体化されることができる。これによって、血液隔離装置１６００は、患者針及び／又はチューブと共に単一ユニットとして製造及び販売され、

採血又はサンプリングの際に患者針を血液隔離装置１６００に接続する必要性をなくすことができる。

【００８３】

血液隔離装置１６００は、血液隔離装置１６００から及び血液サンプル採取装置への開口部を画定する出口ポート１６０４を更に含む。出口ポート１６０４は、同様に血液隔離装置と接続されるチューブ又は他の導管と接続されることもでき、ねじ切り又はルアーフィッティングなどの密封又は流体密封コネクタ又は接続部を含むことができる。したがって、上記のように、血液隔離装置１６００は、患者針及び／又はチューブ及び血液サンプル採取装置と共に単一ユニットとして製造及び販売され、採血又はサンプリングの際に患者針及び血液サンプル採取装置を血液隔離装置１６００に接続する必要性をなくすことができる。

【００８４】

血液隔離装置１６００は、入口ポート１６０２と出口ポート１６０４との間のサンプリング流路１６０６と、入口ポート１６０２と出口ポート１６０４との間の任意の位置でサンプリング流路１６０６に接続され且つサンプリング流路１６０６から分離又は方向転換される隔離チャンバ１６０８とを更に含む。サンプリング流路１６０６は、最初のアリコートの血液が隔離チャンバ１６０８内に隔離されると、採血経路として機能する。サンプリング流路１６０６は、任意のサイズ、形状又は構成の流路又は導管であることができる。一部の実施では、サンプリング流路１６０６は、入口ポート１６０２の開口部と実質的に同様の断面積を有する。他の実施では、サンプリング流路１６０６は、入口ポート１６０２から出口ポート１６０４まで徐々に広がることができる。隔離チャンバ１６０８は、図１７及び１９により詳しく示すように、血液がサンプリング流路１６０６のより小さい直径に入るのに対して、まずリザーバに入ろうとするように、隔離流路の経路に向かって大きいリザーバを形成するべくより大きい断面を有することができる。

【００８５】

一部の例示的な実施では、サンプリング流路１６０６と隔離チャンバ１６０８との間の方向転換は、方向転換分岐点１６０７によって行われる。方向転換分岐点１６０７は、実質的にＹ字形、Ｔ字形、又はＵ字形であることができる。一部の好ましい例示的な実施では、図１７Ａ～１７Ｂに示すように、方向転換分岐点１６０７は、入口ポート１６０２からの流れが優先的に隔離チャンバ１６０８に向けられるように構成される。隔離チャンバ１６０８はまた、最初の血液流を隔離チャンバ１６０８に向かって且つ隔離チャンバ１６０８内に移動させるための湾曲部又は傾斜路を含むか又は形成することができる。

【００８６】

隔離チャンバ１６０８は、好ましくは大気圧に維持され、隔離チャンバ１６０８の遠位端又はその近傍に通気口１６１０を含む。通気口１６１０は、上記のように空気透過性血液バリア１６１２を含むことができる。

【００８７】

血液隔離装置１６００は、複数の部品又は単一の一体部品から形成されることができるハウジング１６０１を含むことができる。一部の実施では、図１７Ａ～１７Ｄ及び図１８Ａ～１８Ｆに示すように、ハウジング１６０１は、互いに嵌合する上部部材１６２０と下部部材１６２２とを含む。血液隔離装置１６００は、上部部材１６２０が下部部材１６２２に機械的に取り付けられたときに、両者の間の接合部分がガスケット又は密封部材によって密封されるように、ガスケット又は他の密封部材（図示せず）を含むこともできる。図１７Ａ～１７Ｄは、血液隔離装置１６００用のハウジングの下部部材１６２２を示す。下部部材１６２２は、サンプリング流路１６０６、隔離チャンバ１６０８、及び方向転換分岐点１６０７を形成するために、射出成形プロセスによって又はエッチング、切削、穿孔などによって予め形成された溝、流路、ロック、導管又は他の経路を含むことができる。

【００８８】

隔離チャンバ１６０８は、血液がサンプリング流路１６０６のより小さい直径に入るの

に対して、まず隔離チャンバ内に優先的に移動するように、サンプリング流路１６０６よりも大きい断面を有することができる。

【００８９】

図１８Ａ～１８Ｆは、レーザ溶接、熱接合、接着、ねじ、リベット、ボルトなどを使用することなどの任意の嵌合又は接続機構によって、又はラッチ、溝、舌状部、ピン、フランジなどの他の嵌合機構によって、下部部材１６２２と接続可能な上部部材１６２０を示す。上部部材１６２０は、サンプリング流路１６０６、隔離チャンバ１６０８、及び方向転換分岐点１６０７を形成するために、溝、流路、ロック、導管又は他の経路の一部又はすべてを含むことができる。更に他の実施では、上部部材１６２０と下部部材１６２２の両方が、溝、流路、ロック又は他の経路を含むことができる。

【００９０】

一部の実施では、サンプリング流路１６０６及び隔離チャンバ１６０８は、ハウジング１６０１に形成された溝、流路、ロック又は他の経路によって形成される。ハウジング１６０１は、ゴム、プラスチック、金属又は任意の他の適切な材料で作られることができる。ハウジング１６０１は、透明又は半透明の材料から、又は不透明又は非半透明の材料から形成されることができる。他の実施では、ハウジング１６０１は、大部分が不透明又は非半透明であることができるが、サンプリング流路１６０６及び／又は隔離チャンバ１６０８に直接隣接するハウジング表面は、透明又は半透明であることができ、最初に隔離チャンバ１６０８が必要又は所望の程度まで満たされているという視覚的な合図又はサイン、及び／又は、次に汚染されていない血液サンプルがサンプリング流路１６０６を通して採取される間、隔離された血液が隔離されたままであるという視覚的な合図又はサインを施術者に与える。隔離の他の視覚的な合図又はサインは、以下に限定されるものではないが、血液の接触、浸透、又は部分的な浸透で空気透過性血液バリア１６１２が異なる色に変わること、隔離チャンバに沿った又は隔離チャンバに隣接する任意の位置にある色分けされたタブ又は指標、可聴信号、振動信号、又は他の信号を含むことができる。

【００９１】

図１８Ａ～１８Ｆに示すように、空気透過性血液バリア１６１２は、保護部材１６１６で覆われているか又は保護部材１６１６によって包囲されていることができる。保護部材１６１６は、ユーザーが彼らの指又は他の外部器具で空気透過性血液バリア１６１２に触れるのを妨げるように寸法設定され且つ構成されることができ、一方それでも空気が隔離チャンバ１６０８から追い出されるときに空気が空気透過性血液バリア１６１２から出ることを可能にする。一部の実施では、保護部材１６１６は、上部部材１６２０の上面から上に空気透過性血液バリア１６１２の周りに延びる突出部を含む。保護カバー１６１６は、フィルタが周囲の流体又は飛沫に偶発的に曝されるのを阻止又は防止するように構成されることができる。これは、保護カバーに疎水性膜を追加することを含むがそれに限定されない、様々な機械的方法で行うことができる。

【００９２】

使用時、血液隔離装置１６００は、サンプリング流路１６０６と隔離チャンバ１６０８とを含む。両方の経路が、最初は大気圧で空気を充填されているが、サンプリング流路１６０６は、最初はバキュテナー（登録商標）又は他のこのような密封された採血装置によって密封されている出口ポート１６０４に向けられ、隔離チャンバ１６０８は、空気透過性血液バリア１６１２を含む大気への通気口１６１０で終端している。

【００９３】

患者の皮膚から多数の病原体を集める可能性がある患者針（図示せず）による静脈穿刺の後、これらの病原体を有する患者の血液の最初の量が、血液隔離装置１６００の入口ポート１６０２を通過する。この汚染されている可能性のある血液の最初の量は、最も抵抗の少ない経路を見出すことによって、隔離チャンバ１６０８に優先的に流入する。患者自身の血圧は、通気口付きの隔離チャンバ１６０８内の大気圧に打ち勝ち、空気透過性血液バリア１６１２を通して隔離チャンバ１６０８内の空気を追い出すが、密封されたサンプリング流路１６０６内で高まっている空気圧に打ち勝つには不十分である。様々な例示的

な実施形態では、隔離チャンバ１６０８及びサンプリング流路１６０６は、患者の血圧によって生じた力が、血液隔離装置の向きに関わらず、重力の影響に打ち勝つのに十分であるように構成されることができる。

【００９４】

最終的に、隔離チャンバ１６０８は、空気透過性血液バリア１６１２を通して空気を追い出す血液で満たされる。血液が空気透過性血液バリアと接触すると、血液は空気透過性血液バリア１６１２の材料と相互作用して通気口１６１０を完全に又は部分的に密封する。施術者がいまやバキュテナー（登録商標）又は他の採血装置を利用することができるという信号又は表示を提供することができる。

【００９５】

血液隔離経路１６０８を満たすと、バキュテナー（登録商標）又は他の血液サンプル採取装置の使用より前に、患者の血圧は、サンプリング流路１６０６内の空気の圧縮を引き起こし、場合によっては少量の血液が方向転換点を過ぎてサンプリング流路１６０６に移動しサンプリング流路１５０６を通して採取される汚染されていない血液を待ち行列に入れる。

【００９６】

図１９Ａは、血液隔離装置１６００の側面図であり、図１９Ｂは、血液隔離装置１６００の断面図であり、下部部材１６２２と嵌合する上部部材１６２０を示す。

【００９７】

図２０は、患者の血流への血管アクセスのための患者針２００２と、１つ以上の血液サンプルの採取を容易にする血液サンプル採取装置２００４と、患者針２００２と血液サンプル採取装置２００４との間の流体接続を提供する導管２００６とを含む血液サンプル最適化システム２０００を示す。一部の実施では、血液サンプル採取装置２００４は、密封された採取針を含む保護シールドを含み、採取針に密封された真空容器が置かれ、容器は採取針によって一度穿孔されると、患者針２００２から導管２００６を通して真空圧力又は真空力で血液サンプルを吸い込む。

【００９８】

血液サンプル最適化システム２０００は、本明細書で説明するように、患者針２００２と血液サンプル採取装置２００４との間の導管２００６上の任意の点に位置する血液隔離装置２００８を更に含む。

【００９９】

図２１は、ウィッキング材料チャンバを使用する通気口付きでない血液隔離装置２１００を示す。血液隔離装置２１００は、ウィッキング材料で満たされた隔離チャンバ２１０２によって少なくとも部分的に囲まれ又は当接されるサンプリング流路２１０４を有するハウジング２１０１を含む。最初のアリコートの血液が患者針からサンプリング流路２１０４に引き込まれ、サンプリング流路２１０４において隔離チャンバ２１０２のウィッキング材料の中に直ちに逃がされる。ウィッキング材料及び／又は隔離チャンバ２１０２は、後続の又はそれ以降の採血がウィッキング材料を通り過ぎ、サンプリング流路２１０４を通って直接バキュテナー（登録商標）などのサンプリング装置に流れるように、所定量の血液を受け入れ且つ保持するように寸法設定され且つ適合されている。ウィッキング材料は、固化剤、汚染除去剤、又は他の添加剤などの物質を含むことができる。

【０１００】

本明細書に記載されるように、空気透過性血液バリアは、多種多様な異なる構造及び材料を用いて作られることができる。図２２Ａ及び２２Ｂに示すように、血液隔離装置２２００の空気透過性血液バリア２２０２は、少なくとも一部のビーズが親水性になるように処理されたポリマービーズマトリックス２２０４を含むことができる。空気透過性血液バリア２２０２は、カルボキシメチルセルロース（ＣＭＣ）又はセルロースガムなどの自己密封材料２２０６、又は他の密封材料を更に含む。空気透過性血液バリア２２０２は、血液などの流体との接触前又は部分接触中の空気の流れを可能にする空隙２２０８を更に含むことができる。図２２Ｂに示すように、流体と接触すると、自己密封材料２２０６が膨

張して空隙２２０８を閉鎖し、空隙２２０８を通る空気の流れを閉塞し、完全に又は部分的に密封する。

【０１０１】

図２３Ａ及び２３Ｂは、患者針と接続するための入口ポート２３０２と、血液サンプル採取装置と接続するための出口ポート２３０４と、隔離チャンバ２３０６と、隔離チャンバ２３０６と、隔離するべき汚染されている可能性のある血液の最初のアリコートまで隔離チャンバが満たされると隔離チャンバ２３０６を迂回するサンプリング流路２３０８とを有する、血液隔離装置２３００の更に別の実施を示している。隔離チャンバ２３０６は、入口ポート２３０２から最も遠い隔離チャンバ２３０６の遠位端に疎水性プラグ２３１２を含む。バキュテナー（登録商標）などからのような、出口ポート２３０４から加えられる真空力又は他の吸引力は、血液を入口ポート２３０２内に、そして隔離チャンバ２３０６内に直接吸い込み、そこで最初のアリコートの血液が疎水性プラグ２３１２に接触し、最初のアリコートの血液を隔離チャンバ２３０６に戻してそこで隔離させる。少量の血液が、最初は弁２３０８によって閉鎖されているサンプリング流路２３０８に入ることができる。弁２３０８が解放されると、真空の更なる力又は他の力の下で、後続の量の血液が入口ポート２３０２に流れ、隔離チャンバ２３０６を迂回し、サンプリング流路２３０８を通り抜けて出口ポート２３０４に向かって流れ、採取装置に送られる。

【０１０２】

サンプリング流路２３０８は、任意の適切な幾何学的形状を有することができ、プラスチックチューブ又は任意の他の適切な材料から形成されることができる。弁２３０８は、最初のアリコートの血液が隔離チャンバ２３０６内に隔離される前にサンプリング流路を挟み、脇へそらし、曲げ、又は他の方法で閉じるためにクリップ又は他の包囲装置であることができる。

【０１０３】

様々な実施形態を上記で詳細に説明してきたが、他の変更も可能である。他の実施形態は、添付の特許請求の範囲内に含まれ得る。

【図１】

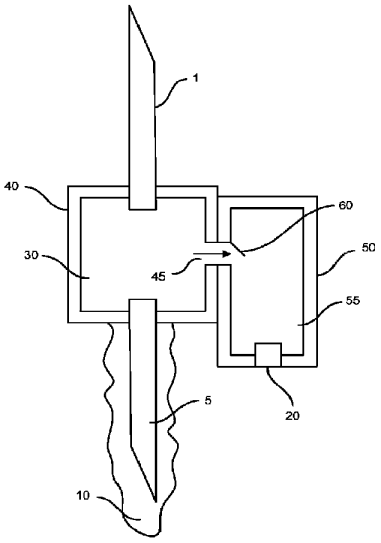


FIG. 1

【図２】

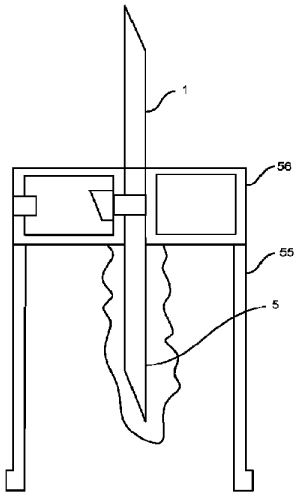


FIG. 2

【図３】

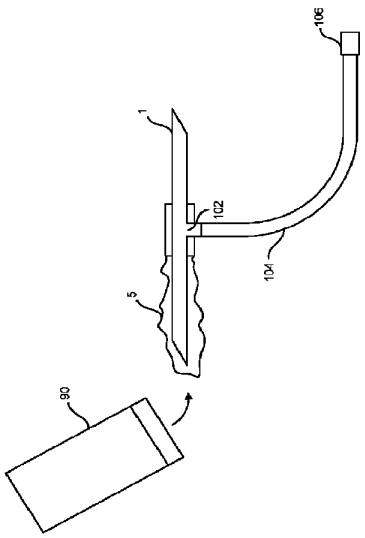


FIG. 3

【図４】

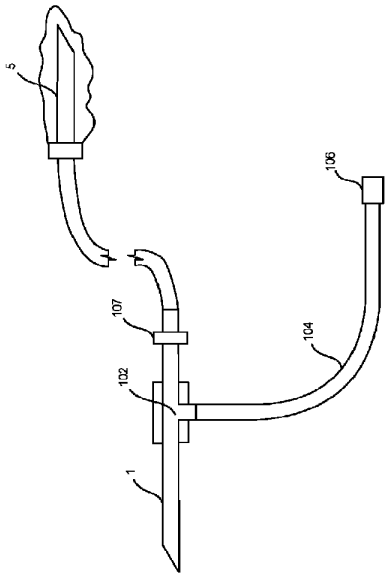


FIG. 4

【図５】

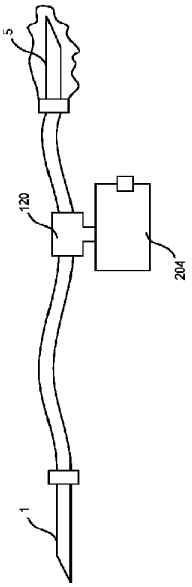


FIG. 5

【図６】

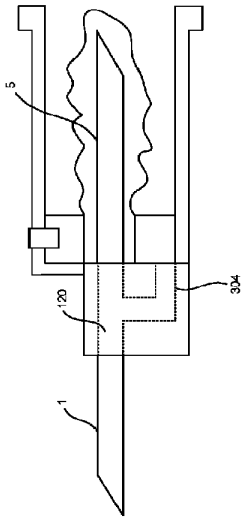


FIG. 6

【図７】

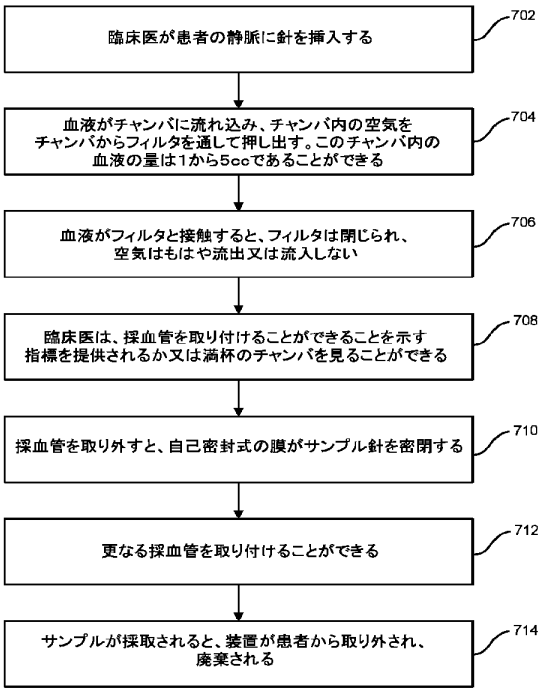


FIG. 7

【図８Ａ】

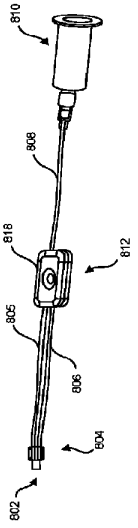


FIG. 8A

【図８Ｂ】

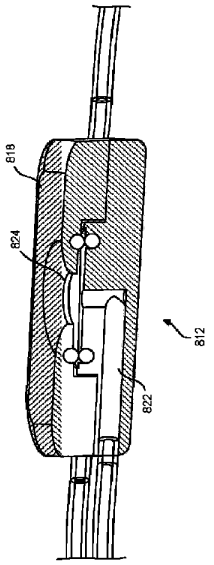


FIG. 8B

【図８Ｃ】

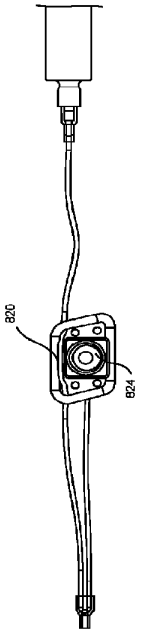


FIG. 8C

【図８Ｄ】

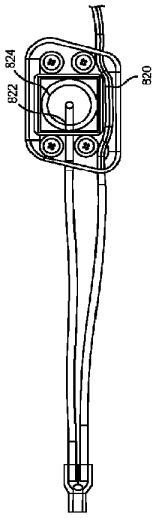


FIG. 8D

【図８Ｅ】

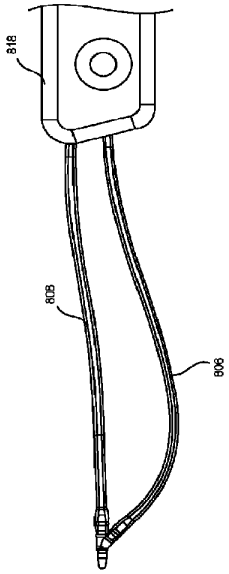


FIG. 8E

【図９】

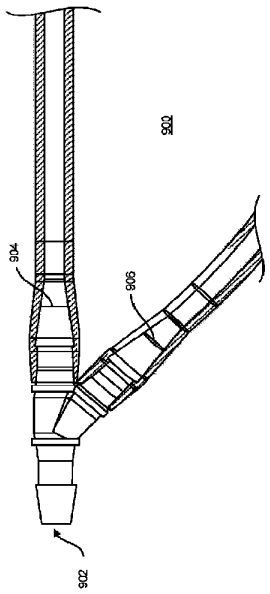


FIG. 9

【図１０Ａ】

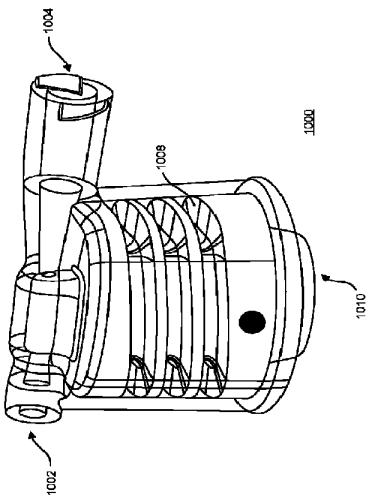


FIG. 10A

【図１０Ｂ】

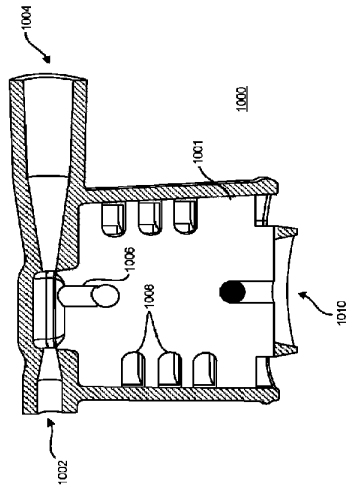


FIG. 10B

【図１０Ｃ】

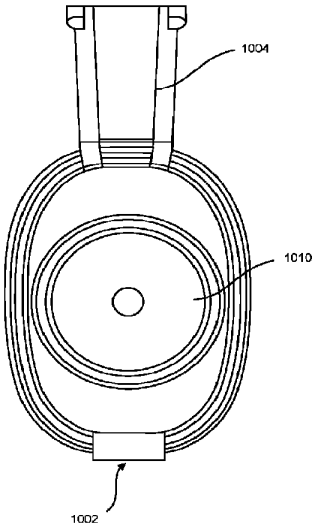


FIG. 10C

【図１０Ｄ】

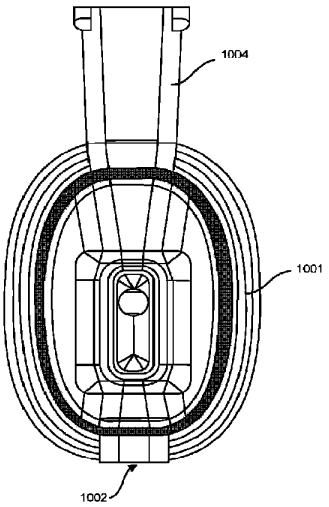


FIG. 10D

【図１１Ａ】

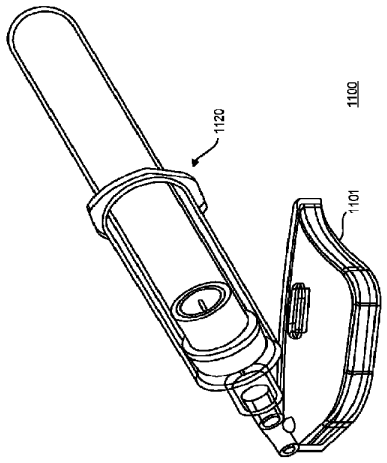


FIG. 11A

【図１１Ｂ】

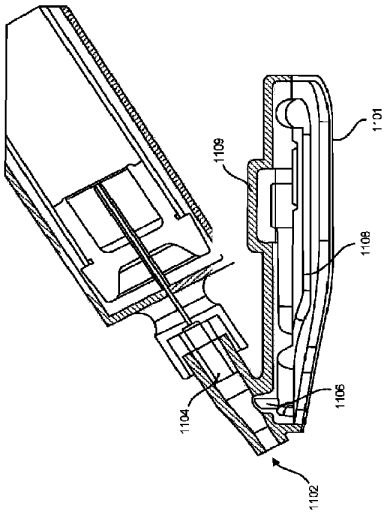


FIG. 11B

【図１１Ｃ】

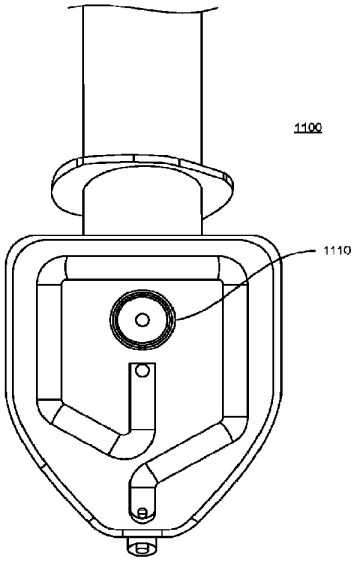


FIG. 11C

【図１１Ｄ】

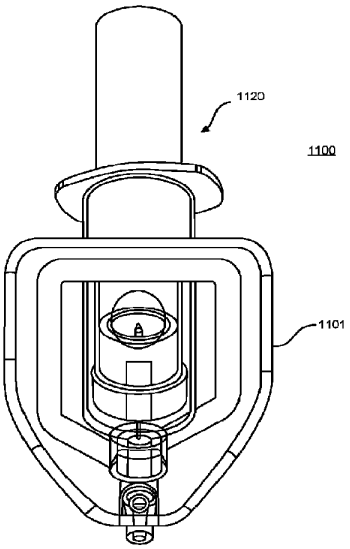


FIG. 11D

【図１１Ｅ】

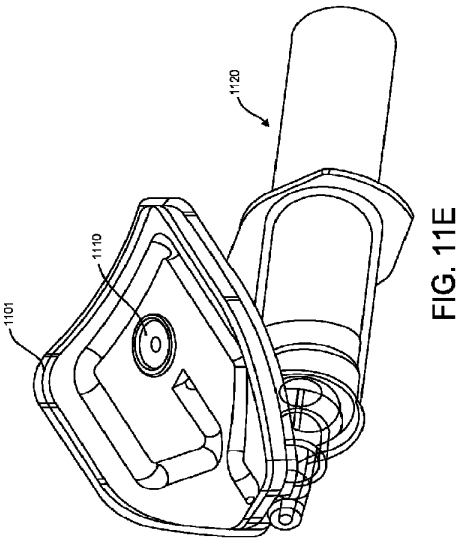


FIG. 11E

【図１２Ａ】

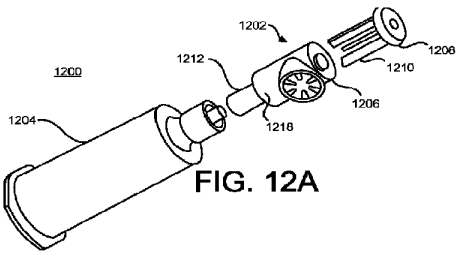


FIG. 12A

【図１２Ｂ】

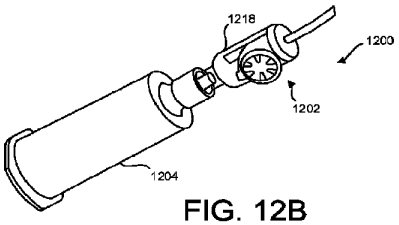


FIG. 12B

【図１２Ｃ】

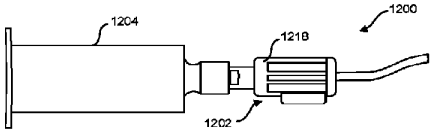


FIG. 12C

【図１２Ｄ】

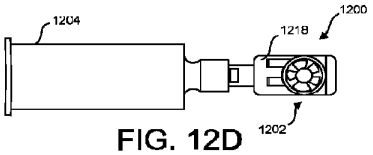


FIG. 12D

【図１３Ａ】

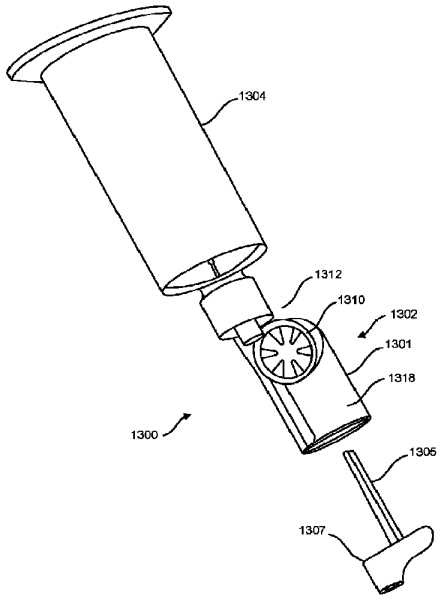


FIG. 13A

【図１３Ｂ】

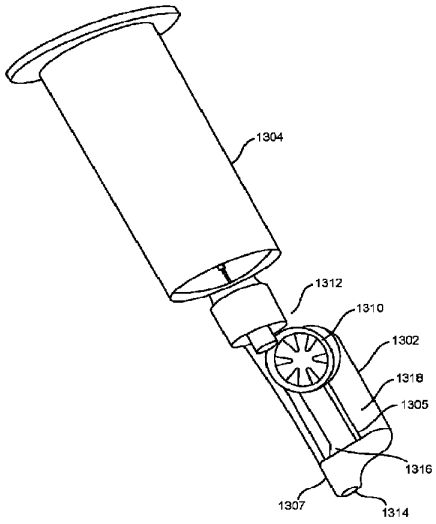


FIG. 13B

【図１３Ｃ】

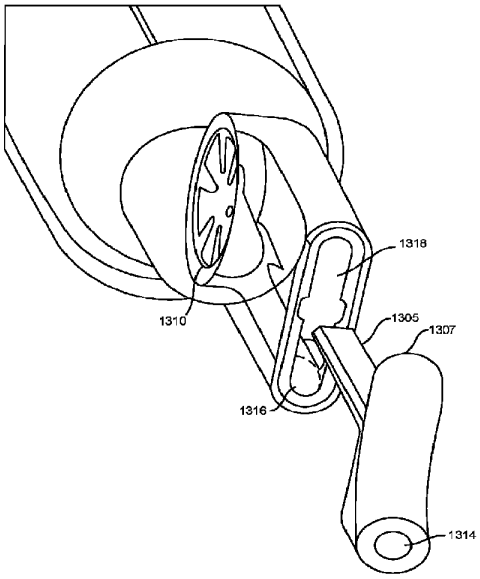


FIG. 13C

【図１３Ｄ】

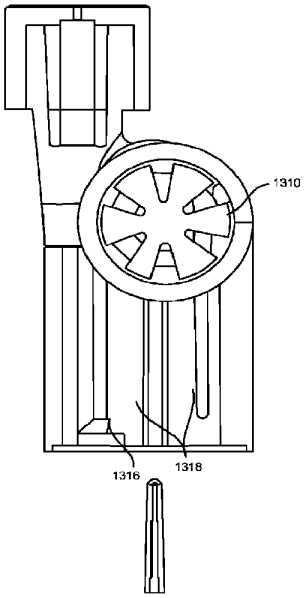


FIG. 13D

【図１４Ａ】

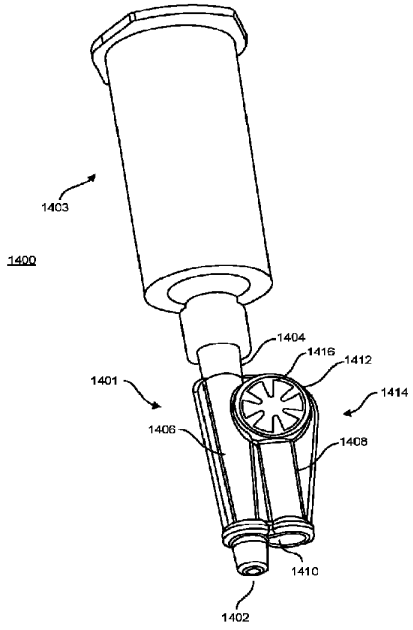


FIG. 14A

【図１４Ｂ】

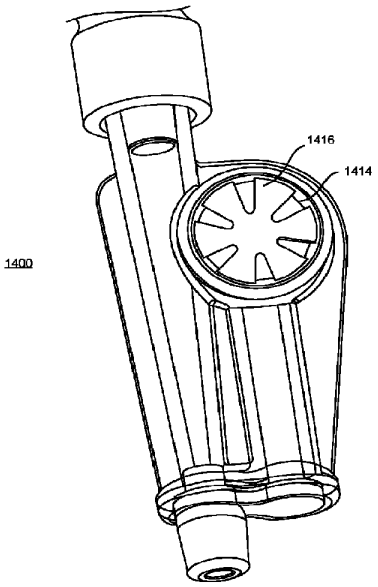


FIG. 14B

【図１４Ｃ】

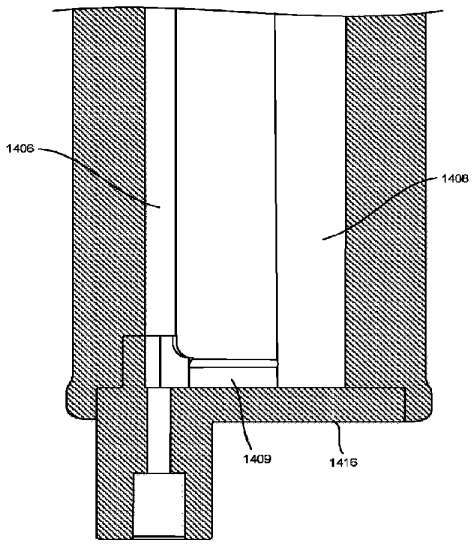


FIG. 14C

【図１４Ｄ】

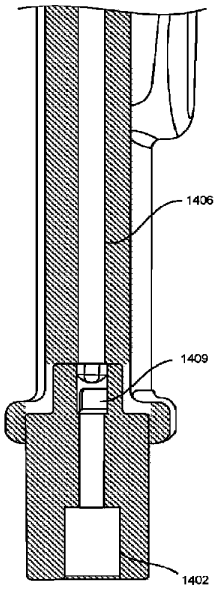


FIG. 14D

【図１４Ｅ】

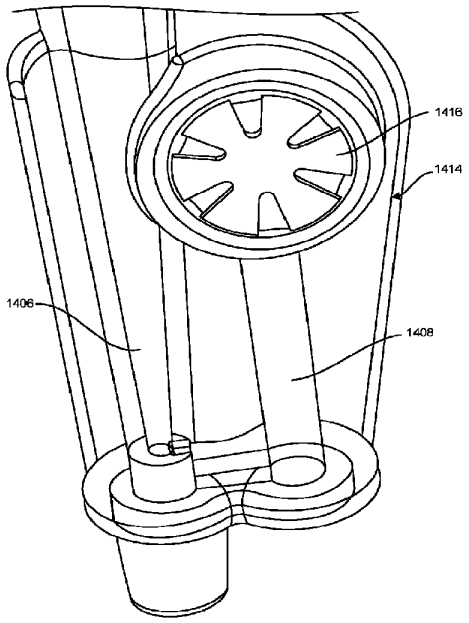


FIG. 14E

【図１５Ａ】

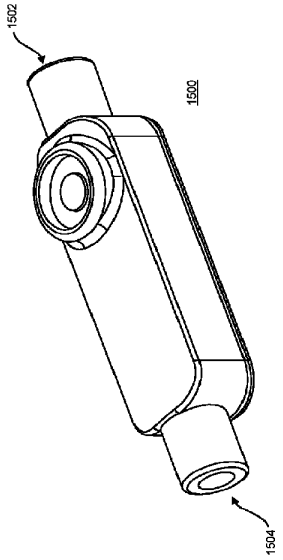


FIG. 15A

【図１５Ｂ】

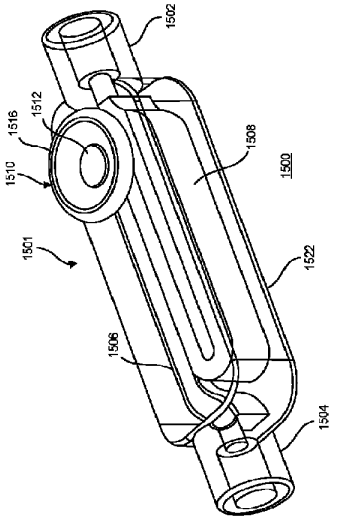


FIG. 15B

【図１５Ｃ】

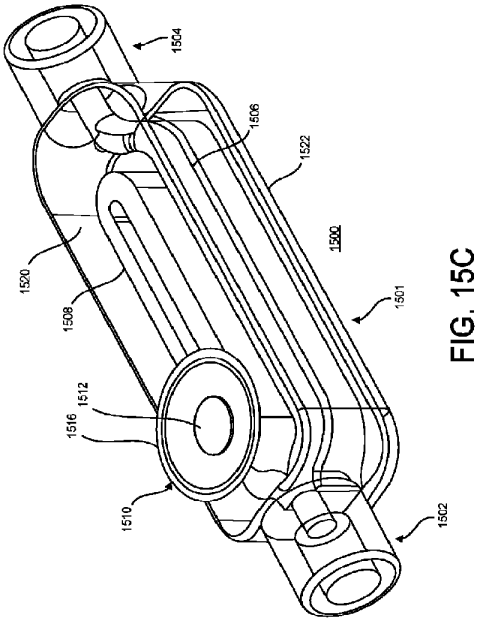


FIG. 15C

【図１５Ｄ】

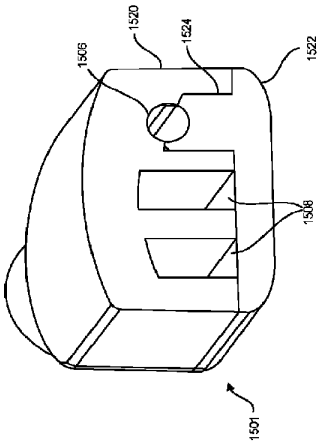


FIG. 15D

【図１５Ｅ】

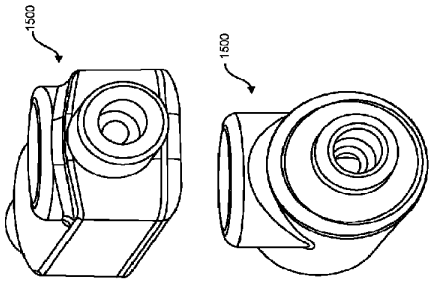


FIG. 15E

【図１５Ｆ】

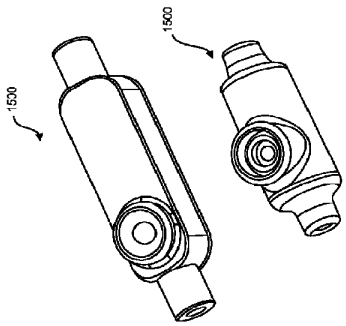


FIG. 15F

【図１５Ｇ】

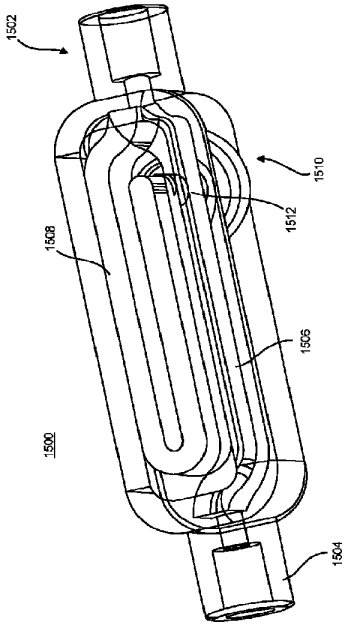


FIG. 15G

【図１６Ａ】

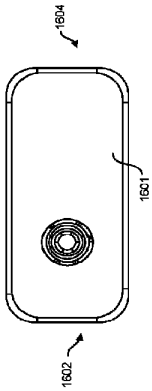


FIG. 16A

【図１６Ｂ】

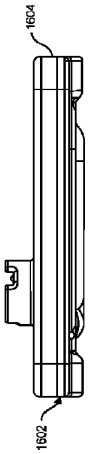


FIG. 16B

【図１６Ｃ】

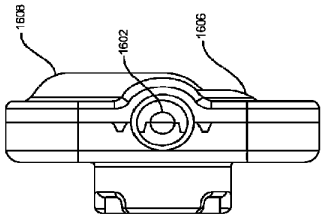


FIG. 16C

【図１６Ｄ】

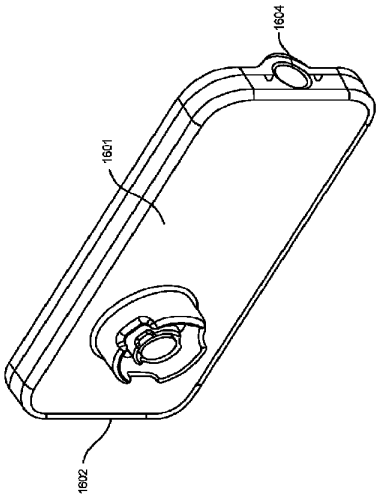


FIG. 16D

【図１７Ａ】

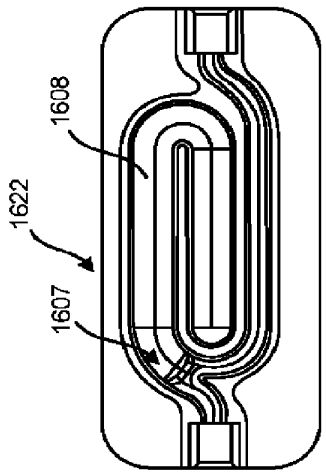


FIG. 17A

【図１７Ｂ】

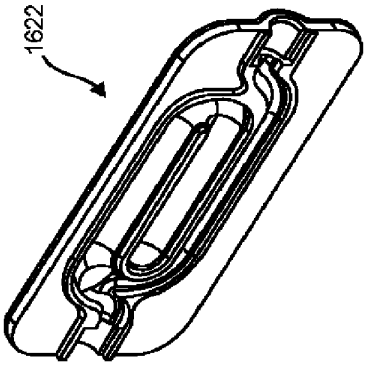


FIG. 17B

【図１７Ｃ】

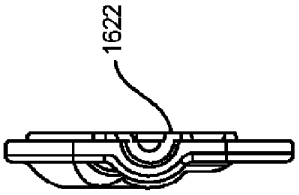


FIG. 17C

【図１７Ｄ】

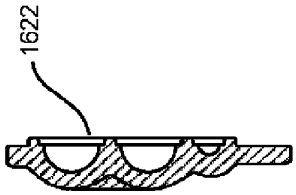


FIG. 17D

【図１７Ｅ】

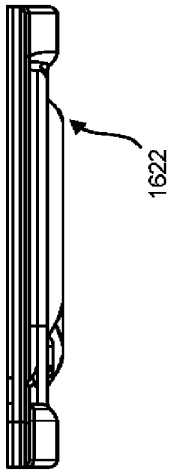


FIG. 17E

【図１８Ａ】

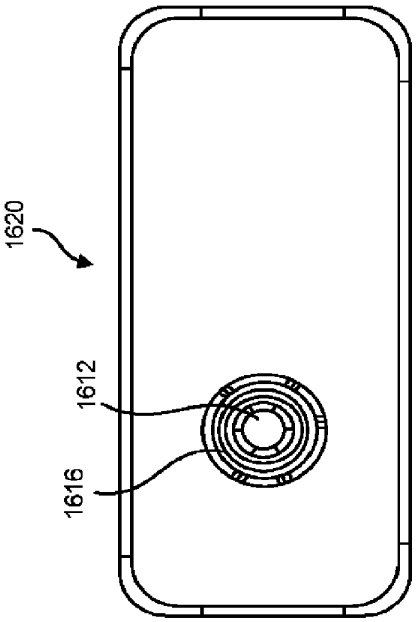


FIG. 18A

【図１８Ｂ】

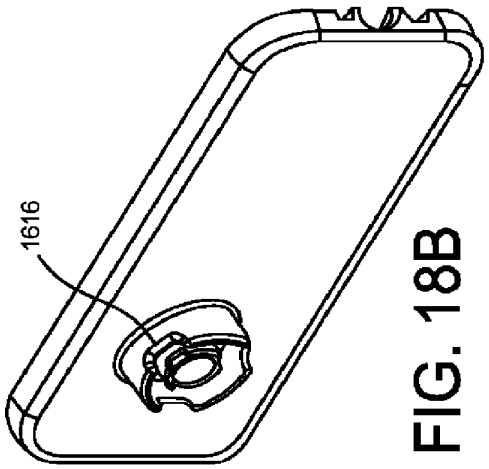


FIG. 18B

【図１８Ｃ】

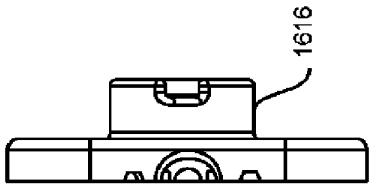


FIG. 18C

【図１８Ｄ】

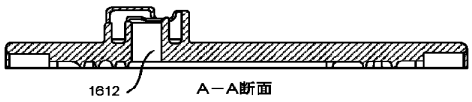


FIG. 18D

【図１８Ｅ】

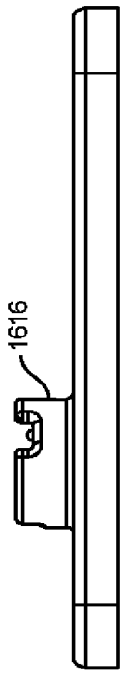


FIG. 18E

【図１８Ｆ】

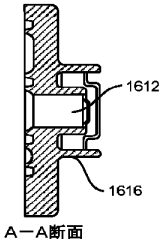


FIG. 18F

【図１９Ａ】

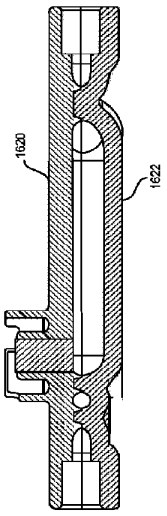


FIG. 19A

【図１９Ｂ】

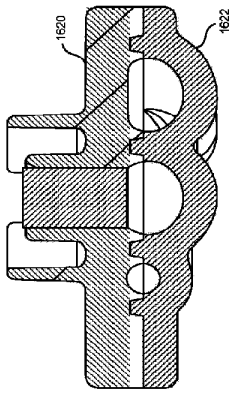


FIG. 19B

【図２０】

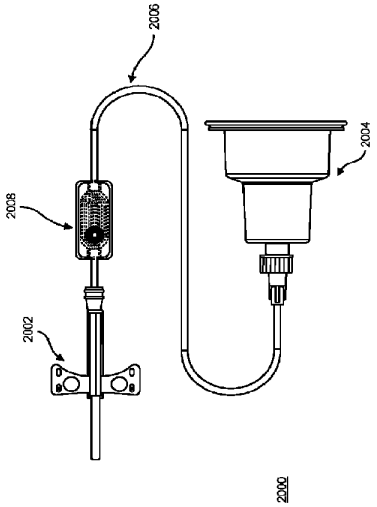


FIG. 20

【図２１】

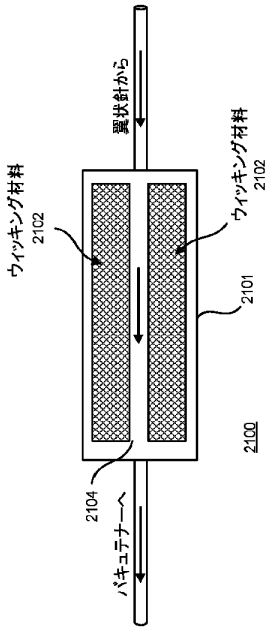


FIG. 21

【図２２Ａ】

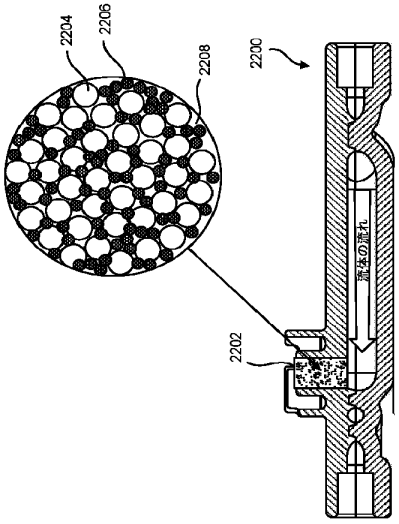


FIG. 22A

【図２２Ｂ】

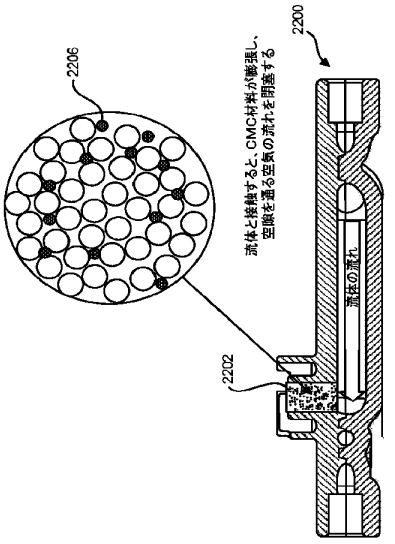


FIG. 22B

【図２３Ａ】

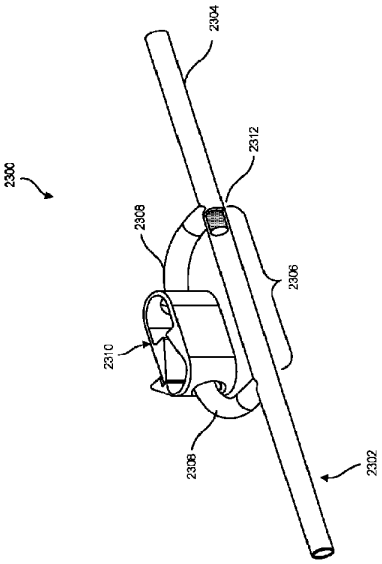


FIG. 23A

【図２３Ｂ】

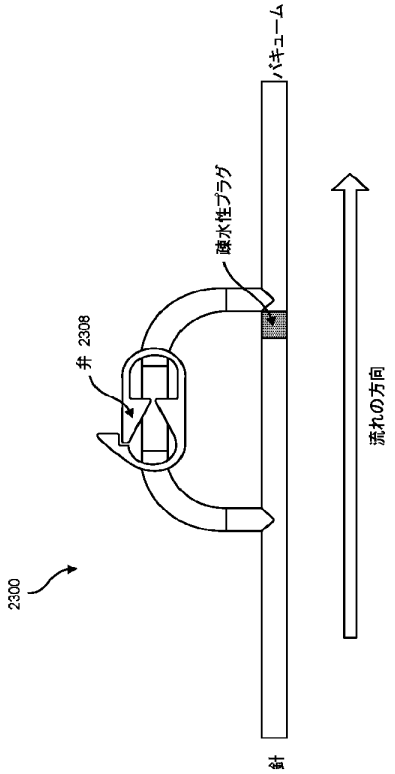


FIG. 23B

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審査官 清水 裕勝

(56)参考文献 特開昭５８－０２５１４６（ＪＰ，Ａ）
特開昭５８－０６７２３８（ＪＰ，Ａ）
特開２０１２－０１６４９６（ＪＰ，Ａ）
特開昭５７－０８９８６９（ＪＰ，Ａ）
特表平０９－５０４７２６（ＪＰ，Ａ）
特開平０２－２２４７４２（ＪＰ，Ａ）
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Ａ６１Ｂ ５／１５３－５／１５４

Current Blood Culture Methods and Systems: Clinical Concepts, Technology, and Interpretation of Results

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Since the mid-1970s there has been a number of advances in blood culture practices and technology; these advances have been based largely on well-designed controlled clinical evaluations of blood culture systems and media. Thus, a sound scientific basis for the fundamental principles of blood culturing now exists. In this article, I will address issues of clinical and technical importance with regard to blood culturing; these issues include skin antisepsis, the number and timing of blood cultures, the appropriate volume of blood for culture, culture media and additives, length and atmosphere of incubation, and interpretation of positive blood culture results. Finally, I will discuss the currently available blood culture systems, with an emphasis on the newer continuous-monitoring blood culture systems.

Detection of bacteremia and fungemia traditionally has been one of the most important functions of clinical microbiology laboratories. When blood cultures yield clinically important microorganisms, it is a sign that host defenses have failed to contain an infection at its primary site or that the clinician has failed to adequately eradicate the infectious process. During the past two decades, there has been a number of changes in blood culture practices; these changes have been based on clinical investigations that have established a stronger scientific basis for this diagnostic test. Moreover, manufacturers of blood culture systems and media have improved their products, and there has been a marked trend toward the use of automated systems—most recently, continuous-monitoring blood culture devices. In this review, I will focus on important clinical and technical issues related to blood culturing, as well as on the interpretation of positive blood cultures.

Clinical Issues

Skin antisepsis. The likelihood that a positive culture represents infection rather than contamination is, at least in part, a function of skin antisepsis at the time of culture. The recommended antiseptic preparations are 70% isopropyl alcohol, followed by an iodophor or iodine tincture [1]. Iodophors require 1.5–2 minutes of contact time for maximum antiseptic effect. Iodine tincture exerts its antiseptic effect more rapidly than do iodophors [2] and may lower contamination rates in institutions where these rates are high [3], including centers where house officers and medical students, who may not wait for the iodophor to exert its effect, obtain the blood samples for culture. In one study, a commercially available skin-preparation kit for blood cultures has been shown to reduce contamination [4].

Method of obtaining blood for culture. Venipuncture remains the method of choice for obtaining blood for culture; arterial blood cultures are not associated with higher diagnostic yields than are venous blood cultures [1]. Studies comparing contamination rates for blood cultures obtained from intravascular devices vs. those obtained by venipuncture have reported conflicting results [5–8]. My observations support those of Bryant and Strand [8], who noted significantly increased rates of contamination when blood for culture was obtained from intravenous catheters ($P < .001$).

Furthermore, the American College of Physicians guidelines also recommend that blood for culture not be obtained from intravascular devices [9]. Although blood may occasionally be obtained from intravenous lines, a culture of blood obtained from such a device should be paired with another culture of blood obtained by peripheral venipuncture. Finally, I am unaware of published data from systematic studies that support obtaining separate blood samples from different ports of triple-lumen catheters.

Several recent studies have documented that the two-needle technique, formerly recommended for blood cultures, is not associated with significantly lower contamination rates than is the single-needle technique [10–12]. Because the handling of any needle is associated with a small but finite risk of needlestick injury, the authors of these studies have recommended that the single-needle method become the standard. However, the results of a recently published meta-analysis have suggested that the two-needle method may reduce contamination rates slightly [13]. Nevertheless, pending further data, the single-needle method probably should continue to be the standard.

Number of blood cultures. Several studies have addressed the issue of the number of blood cultures needed to detect

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bacteremia and fungemia in adults. Washington [14] reported the cumulative yield from three 20-mL blood samples obtained in sequence and cultured with use of conventional manual methods; 64 (80%) of 80 bacteremic epidoses were detected with the first culture, 70 (88%) of 80 were detected with the first two cultures, and 79 (99%) of 80 were detected with three blood cultures. My colleagues and I also used conventional manual methods and found that the first blood culture detected 257 (91%) of 282 bacteremic episodes and that the first two blood cultures detected 281 (>99%) of 282 episodes [15].

More recently my colleagues and I used the BacT/Alert continuous-monitoring blood culture system (Organon Teknika, Durham, NC) and evaluated the yield of clinically important microorganisms from three consecutive 20-mL blood samples obtained and cultured during a 24-hour period [16]. During a 15-month period, three blood cultures were performed for 218 patients; the third blood culture was the only one positive on only six occasions, and only one of these positive cultures represented true sepsis. The conclusion that we drew from this small quality assurance study was that for the great majority of patients, two blood cultures should be sufficient to detect septicemia.

On the other hand, single blood cultures should be discouraged, if not forbidden altogether [9]. Not only will single blood cultures be insufficiently sensitive for detecting some bacteremias and fungemias, but they also may be difficult to interpret. For example, a single blood culture that yields a coagulase-negative staphylococcus may represent contamination or clinically important infection. However, if two samples obtained in sequence by separate venipunctures yield the same coagulase-negative staphylococcal species with the same antibiogram, the probability is high that the isolates represent true bacteremia.

On the basis of the concepts reviewed above, laboratories should recommend two blood cultures under routine circumstances. In institutions where phlebotomists or nurses obtain the blood for culture, two blood cultures should be performed automatically, even when the physician orders a single culture. On the other hand, ordering more than two blood cultures during any 24-hour period probably is unnecessary, except when the physician wishes to document the continuous bacteremia associated with an endovascular infection such as endocarditis. Therefore, it may be appropriate to require the approval of the laboratory director when more than two (or perhaps three) blood cultures are ordered during any 24-hour period.

Timing of blood cultures. Few studies have systematically evaluated the timing of blood cultures and the optimum interval between successive blood cultures. Strand [17] has arbitrarily recommended a 30- to 60-minute interval except for critically ill, septic patients, from whom specimens should be obtained minutes before initiating therapy. Li et al. [18] recently showed no difference in yield whether blood samples for cultures performed within a 24-hour period were drawn simultaneously or at spaced intervals [18]. However, drawing blood at intervals may be helpful if the clinician wishes to document continuous bacteremia in patients with suspected endovascular infections.

Technical Factors

Many technical factors affect the sensitivity of blood culture systems. Of these factors, the most important are probably the volume of blood cultured and the broth medium used for culture. Other important factors include the ratio of blood to broth, agitation during incubation, length of incubation, atmosphere of incubation, and additives to the media (e.g., those that neutralize the effect of antimicrobial agents present in the blood at the time the sample is drawn). These and other technical issues have been reviewed in detail elsewhere [1, 19, 20], and the reader is referred to those publications for additional discussion of these matters.

Volume of blood required for culture. During bloodstream infections, especially those in adults, there may be relatively few microorganisms present in a given volume of blood—often in the range of $<1-10$ cfu/mL. Moreover, in numerous studies of adult patients, a direct relationship between the diagnostic yield of blood cultures and the volume of blood cultured has been documented [21–24]. On the basis of this information, the recommended volume of blood per culture set for an adult is 10–30 mL [1], and the preferred volume is 20–30 mL. Blood volumes of >30 mL do not enhance the diagnostic yield and contribute to nosocomial anemia; as a practical matter, blood at these volumes may clot in the syringe, thereby making it impossible to inoculate the blood culture bottles.

The optimal volume of blood that should be obtained from children has not been defined with certainty [25]. However, for infants and small children, Szymczak et al. [26] concluded that the chance of failing to detect bacteremia was greater with blood volumes of <1 mL per culture than with blood volumes of ≥ 1 mL. On the basis of the available data, Paisley and Lauer [25] have recommended 1–2 mL of blood per culture for neonates, 2–3 mL for infants aged 1 month to 2 years, 3–5 mL for older children, and 10–20 mL for adolescents.

Culture media. All but one of the commercially available blood culture systems marketed in the United States are based on the inoculation of blood into broth culture media. No one medium or system is capable of detecting all microorganisms. Thus the results of innumerable clinical studies that evaluated different blood culture media and additives have been published. In general, most commercially marketed blood culture media perform well. However, many manufacturers supplement their base media with proprietary additives designed to enhance microbial growth, and it cannot be assumed that common generic media (e.g., supplemented soybean casein digest broth) from different manufacturers will perform in an equivalent manner. Decisions as to the choice of media formulations should be based on data from well-controlled field trials in which large numbers of cultures were assessed. The U.S. Food and Drug Administration has recently issued guidelines for

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manufacturers that sponsor such clinical field trials; these guidelines have been summarized by Wilson [27].

Blood-to-broth ratio. Human blood contains a number of substances (e.g., complement, lysozyme, and phagocytic WBCs) capable of inhibiting microbial growth. Moreover, nearly one-third of patients are receiving antimicrobial agents at the time blood for cultures is obtained (author's unpublished observations). Thus, to optimize the diagnostic yield, blood should be diluted adequately in the culture broth to minimize the effect of these substances. The results of studies that have addressed this issue have led to the recommendation that blood be diluted fivefold to tenfold [28–30]. Dilutions of <1:5 may result in a reduced yield; thus, filling blood culture bottles with more than the recommended amount of blood should be avoided. Dilutions of >1:10 may also be associated with a reduced yield that is not based on blood-to-broth ratio but rather on inadequate blood volume for culture.

Although commercially available blood culture bottles have a partial vacuum in the headspace, direct-draw techniques may result in overfilling and reduced blood-to-broth ratios. Collection of specimens with a needle and syringe provides greater control for inoculating blood culture bottles with the correct amount of blood and thus is preferred.

Neutralization and inactivation of antimicrobials. Given the frequency with which blood for cultures is obtained from patients already receiving antimicrobial agents, several manufacturers have marketed products designed to counteract the potential inhibitory effect on growth. These include the antimicrobial removal device (ARD; Becton Dickinson Microbiology Systems, Cockeysville, MD), BACTEC resin-containing media (Becton Dickinson Diagnostic Instrument Systems, Sparks, MD), and BacT/Alert FAN media (Organon Teknika).

The ARD, which was first introduced in 1980, has been the subject of many studies that have not defined a clear mandate for its use. By contrast, the results of studies of BACTEC resin media used with the semiautomated radiometric (BACTEC 460) and nonradiometric (BACTEC 660 and 730) systems generally were favorable [20]. In one study in which aerobic nonradiometric resin medium was used, the authors speculated that the improved yield of microorganisms might be due, at least in part, to factors other than the binding of antibiotics [31].

The resin medium is available for use in BACTEC continuous-monitoring blood culture devices (9240 and 9120). The manufacturer of the BacT/Alert continuous-monitoring blood culture instrument has recently marketed an aerobic medium, FAN, that uses activated charcoal in a proprietary substance (Ecosorb) to counter the potential inhibitory effects of antibiotics. Use of both the aerobic and the as yet unmarketed anaerobic formulations of the FAN media was associated with improved yields when they were compared with the standard BacT/Alert media [32–33]. The results of a comparative study of the FAN and BACTEC resin media suggest that the performance of these media is equivalent in the respective continuous-monitoring blood culture instruments [34].

Atmosphere of incubation. Traditional two-bottle blood culture systems have included one aerobic bottle and one anaerobic bottle, with the blood distributed equally between the two bottles. However, during the past two decades, the proportion of bacteremias due to obligate anaerobes has decreased substantially [35–37], leading some authorities to question the need for routine use of the anaerobic bottle. In fact, several recent studies of adults [35, 38, 39] and children [40] have concluded that the routine use of anaerobic blood culture bottles is not necessary and have recommended that these bottles be used only selectively for patients who are at high risk for bacteremia due to anaerobes.

Whether the data from these studies can be generalized to all institutions remains a subject of controversy for several reasons. Only a limited number of culture media and systems have been evaluated in these studies; for example, reports that assess the relative value of the BACTEC anaerobic resin or lytic media, the BacT/Alert anaerobic FAN medium, or the ESP anaerobic (80N) medium (Difco, Detroit) have not been published. Moreover, selective use of anaerobic bottles requires that certain logistic issues be addressed within each institution.

These issues include notifying physicians and staff of the change in procedure and the reasons the change was implemented; determining which, if any, nursing units (e.g., the gynecologic unit and the colon and rectal surgery unit) should be stocked routinely with anaerobic bottles; and, possibly, developing algorithms for the physicians ordering blood cultures or for the individuals obtaining the blood for culture (i.e., the phlebotomists, nurses, clinical care technicians, house officers, and medical students).

Indeed, an orderly and stepwise plan that includes both in-service education and postimplementation quality assurance evaluations to confirm that the recommended blood culture protocols are being followed should be developed at institutions where these changes are implemented.

Length of incubation of blood cultures. In routine circumstances, blood cultures need not be incubated for >7 days. Indeed, several recent studies in which instrumented blood culture systems were used have shown that 5-day incubation periods are sufficient for detecting the majority of pathogens [41–44]. Moreover, after 5 days most newly positive cultures represent contamination [44]. Incubation periods longer than 7 days may be useful when fungemia or bacteremia due to fastidious organisms such as the HACEK group of bacteria or species of *Legionella* or *Brucella* are suspected. Longer incubation periods may also be useful for patients with suspected endocarditis who have been treated with antimicrobial agents before blood cultures are performed. However, Washington [45] has noted that such extended incubation periods rarely increase yield. Mycobacterial blood cultures should be incubated for ≥4 weeks.

Microorganisms that Deserve Special Consideration

Yeasts and filamentous fungi. The incidence of fungemia has increased in recent decades because of the AIDS epidemic and

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because patients with malignancies survive longer, the number of patients with organ transplants has increased, and long-term indwelling intravascular devices are being used more frequently. The Isolator (Wampole Laboratories, Cranbury, NJ) lysis-centrifugation system continues to be the best system for detecting filamentous fungi. The Septi-Chek biphasic blood culture system (Becton Dickinson) also has performed well. Instrumented blood culture systems in which the newer media (e.g., the BACTEC aerobic resin, nonradiometric fungal media, and the BacT/Alert aerobic FAN medium) are used have performed well for the detection of yeasts other than *Cryptococcus neoformans* [32, 34, 46, 47].

Mycobacteria. Before the AIDS epidemic, blood cultures for detecting mycobacteria were rarely, if ever, performed. However, mycobacterial blood cultures are now commonly performed in many laboratories. The Isolator system and the BACTEC radiometric system with 13A media have excellent sensitivity and perform comparably [48, 49]. Manufacturers of continuous-monitoring blood culture systems are in various stages of evaluating these devices in terms of their utility for mycobacterial blood cultures, but no published data are yet available.

Blood Culture Systems that Are Currently Available

Manual blood culture systems. Conventional manual systems and media are available from many commercial sources. Aerobic blood culture bottles and (usually) anaerobic blood culture bottles are inoculated with blood and usually incubated for 7 days. Each bottle is examined daily for macroscopic evidence of microbial growth (e.g., hemolysis, turbidity of the media, gas production, or formation of discrete colonies). An aliquot of the contents of the aerobic bottle is gram stained and subcultured after the first overnight incubation. A terminal subculture is usually done at the end of the incubation period. Conventional manual systems are flexible and require no purchase of expensive instruments, but they are labor intensive.

The biphasic Septi-Chek system and the Opticult blood culture systems (Becton Dickinson) and the Oxoid Signal broth displacement blood culture system (Oxoid Unipath, Basingstoke, England) are labor-saving variations of the conventional manual method.

The Septi-Chek and Opticult systems utilize agar-coated paddles or slants attached to the broth-containing culture bottle and allow subcultures to be done daily or more frequently by inverting the blood-broth mixture so that it covers the agar. Microbial growth is often identified on the agar rather than in the broth, allowing for prompt preliminary identification and susceptibility testing. As mentioned earlier, comparative studies have shown that the Septi-Chek biphasic system performs well in detecting yeasts and other microorganisms [31, 50–52].

The Oxoid Signal system is a one-bottle system. After blood is inoculated into the bottle, a clear-plastic cylindrical signal device is attached to the top of the bottle; a long needle from the lower end of the device extends below the surface of the blood-broth mixture, creating a closed system. Gases produced as a by-product of microbial growth increase the pressure in the headspace and force some of the blood-broth mixture through the needle into the cylinder, thereby "signaling" a positive culture. Comparasons of this system with other manual systems and with the BACTEC radiometric system have yielded mixed results [53–56].

The Isolator is a unique manual blood culture system that is based on lysis of blood cells, centrifugation, and direct inoculation of the centrifugate into solid media. For children, from whom only small volumes of blood may be collected, the centrifugation step is deleted. Many studies that have compared the Isolator system with other systems have been reported (as reviewed by Doern [57]). Overall, the Isolator system performs well in the detection of most microorganisms—especially yeasts, filamentous fungi, mycobacteria, and opportunists such as *Bartonella (Rochalimaea) henselae.* Certain microorganisms, including *Streptococcus pneumoniae,* other streptococci, *Pseudomonas aeruginosa,* and anaerobic bacteria, may not be recovered optimally with this system. A potential advantage of the system is that it allows quantitation of the level of bacteremia or fungemia.

Disadvantages of the Isolator system include the following: the lysing solution is toxic for some microorganisms; specimens must be processed within 8 hours of blood collection (most microbiology laboratories are staffed for only one daily shift); substantial labor is required for the initial processing of Isolator cultures; and the contamination rates for this system are higher than those for conventional broth and automated systems.

Instrumented blood culture systems. Commercially available intsrumented blood culture methods were introduced in the 1970s. Until recently, the BACTEC instrumented systems were the only products commercially available in the United States; these systems were initially equipped with radiometric instruments and media, followed in the mid-1980s by the nonradiometric instruments and media. Both systems (as well as in the newer BACTEC and BacT/Alert continuous-monitoring devices) are based on the utilization of carbohydrate substrates in the culture media and subsequent production of CO_2 by growing microorganisms.

For the radiometric system, the instrument detects $^{14}CO_2$ in the bottle headspace, and for the nonradiometric system, CO_2 is detected by infrared spectrophotometry. For both systems, bottles are loaded onto the detection portion of the instrument, where needles perforate the bottle diaphragm and sample the gas contents of the headspace once or twice daily; a bottle is flagged as positive if the amount of CO_2 in the bottle exceeds a threshold value. The flagged bottle is then removed from the instrument, and an aliquot of its contents is gram-stained and subcultured for further testing. Numerous controlled clinical evaluations of the BACTEC radiometric and nonradiometric

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systems and media have been published; the advantages and disadvantages of these systems have been summarized recently by Wilson et al. [58].

Continuous-monitoring blood culture systems. With changes in health care financing, including the recognition that labor costs need to be better controlled, manufacturers are increasingly looking to the use of automation in clinical microbiology. The early-generation BACTEC instruments had the following disadvantages: culture bottles had to be manually manipulated, gas canisters were needed for every instrument; detection needles had to be changed periodically; sterilization of the needle devices occasionally failed, resulting in a false diagnosis of bacteremia (pseudobacteremia); cultures were sometimes instrument false-positive; and bottle throughput was relatively slow (35–60 seconds per bottle). Continuous-monitoring blood culture systems were developed in an effort to address these problems.

Three of these systems are currently available in the United States: the BACTEC 9000 series (Becton Dickinson), Difco ESP, and the BacT/Alert, which was the first to be marketed in 1991. All systems have several features in common including self-contained modular incubation; agitation; detection units, of which up to five or six can be controlled by a single computer; lack of the need for manual manipulation of culture bottles once they have been loaded into the instrument; instrument monitoring of microbial growth at 10- to 24-minute intervals; and culture bottles that each accept 10 mL of blood.

The BacT/Alert and BACTEC systems detect the production of CO_2 as change in pH; this is accomplished by means of colorimetry in the BacT/Alert system and by means of a fluorescent sensor in the BACTEC system. The ESP system detects changes in pressure, either as gases are used during early microbial growth or as they are produced later during growth. The BacT/Alert and BACTEC systems monitor every bottle at 10-minute intervals and gently rock all bottles 34 and 30 times a minute, respectively. The ESP system monitors aerobic bottles every 12 minutes and agitates them at 160 cycles per minute; anaerobic bottles are monitored every 24 minutes without agitation.

All comparative studies to date have shown that the three continuous-monitoring blood culture systems have detected growth sooner than earlier-generation BACTEC instruments and manual systems [46, 59–66]; these systems have been found to be comparable in terms of performance [66, 67]. All three systems have performed reliably in my laboratory.

Interpretation of Positive Blood Cultures

Since the presence of a bloodstream infection is important in terms of both diagnosis and prognosis, correct interpretation of the positive test result is crucial. Misinterpretation of positive results can be costly both to the institution and to the patient. Bates and colleagues [68] recently calculated that the excess cost associated with each blood culture contaminant was ~$4,500 [68]. Parameters that may be useful in interpreting results include the identity of the microorganism, the presence of more than one blood culture positive for the same microorganism, and the presence of the same microorganism as that found in the blood from another normally sterile site.

Microorganisms that almost always (>90% of isolates) represent true infection when isolated from the blood include *Staphylococcus aureus, Escherichia coli* and other Enterobacteriaceae, *P. aeruginosa, S. pneumoniae,* and *Candida albicans.* Isolates from blood that rarely (<5% of isolates) represent true infection include *Corynebacterium* species, *Bacillus* species, and *Propionibacterium acnes.*

Coagulase-negative staphylococci are particularly problematic, not only because they are so ubiquitous, but also because 12%–15% of the blood isolates are pathogens rather than contaminants [69]. Some authorities have suggested that the number of bottles positive in a culture set is a predictor of the clinical significance of an isolate. However, Mirrett and colleagues [70] and Peacock et al. [71] have found that this criterion is unreliable, at least for coagulase-negative staphylococci.

A useful interpretive concept is the number of culture sets found to be positive vs. the number obtained. If most or all cultures in a series are positive, regardless of the microorganism recovered, the probability that the organism is clinically important is high [15]. Of course, it is the physician who must ultimately make the final judgment, taking into account not only the laboratory findings but also the clinical presentation of the patient.

Limitations of Blood Cultures

Blood cultures, as described herein, currently represent the "gold standard" for diagnosis of septicemia. Nonetheless, they have limitations. Positive results require hours to days of incubation. No one culture medium or system in use has been shown to be best suited to the detection of all potential bloodstream pathogens. Some microorganisms grow poorly, or not at all, in conventional blood culture media and systems. Whether culture-based systems will remain the diagnostic methods of choice into the next century or be replaced by molecular techniques or other methods remains to be determined.

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wrap up close

(57) [Summary]

The present invention relates to a cooling device (7) for cooling the rolls (5) of the rolling sta nd (1). The cooling device (7) comprises cooling beams (13) for receiving and discharging coo lant. The cooling beam (13) has a plurality of full jet nozzles (21) arranged on the discharge si de (19) of said cooling beam (13), said side facing the roll (5).) extending parallel to the roll axis (17). A jet of coolant with a substantially constant jet diameter can be sprayed through e ach of the full jet nozzles from the cooling beam (13) towards the roll (5) in the discharge dire ction (23).

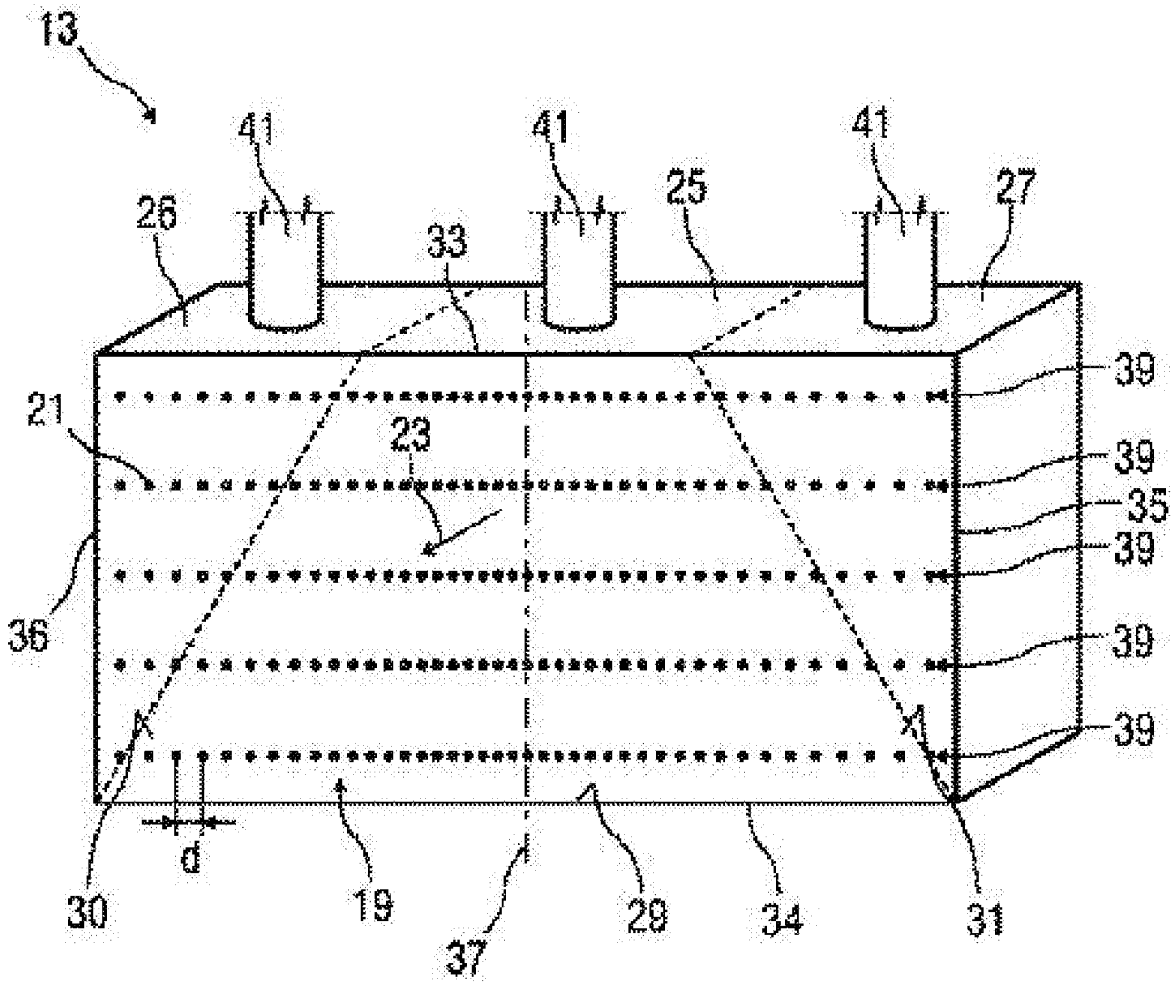


FIG 2

The scope of the claims open

We claim:

1.

A cooling device (7) for cooling rolls (5) of a rolling stand (1) comprising cooling bars (13) fo r receiving and discharging a coolant. wherein

said cooling rod (13) has a plurality of full jet nozzles (21) arranged on a discharge side (19) of said cooling rod (13), said discharge side facing a roll (5). , extending parallel to the roll axi s (17) of said roll (5) and sending coolant jets of substantially constant jet diameter through e ach of the full jet nozzles from said cooling rods (13) to said roll. A cooling device (7) capable of discharging in a discharge direction (23) towards (5).

2.

The cooling rod (13) is divided into at least two mutually separated coolant chambers (25-2 7) for receiving coolant, each coolant chamber (25-27) comprising: Corresponding sub-region s (29-31) of said discharge side (19) of said cooling rod (13) where a plurality of full-jet nozzl es (21) are arranged, through each of said full-jet nozzles (21), coolant Cooling device (7) acc ording to claim 1, characterized in that a jet can be discharged from the coolant chamber (25-27) towards the roll (5).

3.

A first coolant chamber (25) corresponds to a first partial area (29) of said discharge side (1 9) of said cooling rod (13), said first partial area (29)) is mirror symmetrical with respect to t he centerline (37) of the discharge side (19) of the cooling rod (13), the axis being perpendic ular to the roll axis (17). 3. Cooling device (7) according to claim 2.

[Claim 4]

characterized in that the extent of the first sub-region (29) parallel to the center line (37) va ries along the direction of said roll axis (17) and is greatest along said center line (37). A cooli ng device (7) according to claim 2 or 3, wherein

5.

A cooling device (7) according to any one of claims 2 to 4, characterized in that the first part ial area (29) is polygonal.

6.

Each coolant chamber (25-27) is connected to a coolant supply line (41) for supplying coola nt into said coolant chamber (25-27), said coolant supply line (41) opens into said coolant cha mber (25-27) substantially perpendicular to said discharge direction (23) of said coolant. A co oling device (7) according to claim 1.

7.

The amount of coolant supplied into the coolant chambers (25-27) is controlled independentl y of each other by respective control valves (43) and/or respective pumps (45). A cooling devi ce (7) according to any one of claims 2 to 6, characterized in that it is capable of

8. A

system according to any one of claims 2 to 7, characterized by an automated system for con trolling the amount of coolant fed into the coolant chamber (25-27). Cooling device (7).

9.

Characterized in that the nozzle spacing (d) of full jet nozzles (21) adjacent to each other al ong a direction parallel to said roll axis (17) varies along said direction. A cooling device (7) a ccording to any one of claims 1 to 8.

[Claim 10]

10. Cooling device (7) according to claim 9, characterized in that said nozzle spacing (d) is n arrowest in a central region of said discharge side (19) of said cooling rod (13).

11.

The nozzle spacing (d) is between about 25 mm and about 50 mm.

Cooling device (7) according to claim 9 or 10.

12. The method

according to any one of claims 1 to 11, characterized in that said full jet nozzles (21) are arr anged in a plurality of mutually parallel nozzle rows (39). A cooling device (7) as described.

13.

Characterized in that said cooling rod (13) has a nozzle opening for each full jet nozzle (21) to which said full jet nozzle (21) is detachably fixed. A cooling device (7) according to any one of claims 1 to 12.

14.

A wiper (15) for wiping coolant from said roll (5), characterized by a wiper (15) which can be pivoted together with said cooling rod (13). A cooling device (7) according to any one of claim s 1 to 13.

15. A

rolling stand (1) with rolls (5) and two cooling devices (7) each designed as claimed in any o ne of claims 1 to 13. A rolling stand (1), wherein said two cooling devices (7) are arranged on either side of said rolls (5).

detailed description open —

Description: BACKGROUND OF THE INVENTION 1.

Field of the Invention The present invention relates to a cooling device for cooling the rolls of a rolling stand. BACKGROUND OF THE INVENTION Rolling stands for rolling rolling stock hav e rolls which are cooled with a cooling liquid, generally cooling water. [0003] US Pat. No. 6,2 00,000 discloses a stiff, concave shell that allows low-pressure cooling liquid to be applied to t he rolls of a rolling stand. [0004] US Pat. No. 6,200,000 discloses fluid cooling of the work r

olls of a roll stand by means of movable, articulated cooling shells. In this case, the cooling liq uid is applied mainly at low pressure using the cooling shell, but in addition the cooling liquid i s applied at high pressure to produce a sufficient cooling effect. [0005] US Pat. No. 5,300,00 9 discloses a cooling device for cooling the work rolls of a rolling stand, which device comprise s a fixed spray that is slightly narrower than the narrowest strip produced using the relevant r olling stand. It has axially displaceable spray bars for cooling only those portions of the work r olls which have bars and which correspond to the width of the strip being rolled at the time. [0006] US Pat. No. 6,200,403 discloses a method for cooling the work rolls of a rolling stan d, in which cooling water is sprayed onto the work rolls at low pressure rather than high press ure, but at the same time, The range that can be used is widened. [0007]

US Pat. No. 5,300,003 discloses a spray bar for cooling rolled stock, the spray bar extending transversely to the direction of travel of the rolled stock and having a central region and two e dge regions. , the cooling medium can be supplied to each of them separately.
[0008]
[Patent Document 1] US Patent Application Publication No. 2010/0089112 [Patent Document 2] German Patent Application Publication No. 102009053074

[Patent Document 3] JP-A-6-170420 [Patent Document 4] JP-A-59-156506 [Patent Document 5] International Publication No. 2014/170139 [Outline of the Invention] [Problems to be Solve d by the Invention] [SUMMARY OF THE INVENTION It is a principal object of the present inv ention to identify an improved cooling device for cooling the rolls of a rolling stand. [0010] Ac cording to the invention , this object is achieved by the features of claim 1 . Advantageous embodiments of the invention form the subject matter of the dependent claims . A cooling de

vice according to the invention for cooling the rolls of a rolling stand comprises cooling rods f or receiving and discharging coolant. The cooling rod has a plurality of full jet nozzles located on the discharge side of the cooling rod, said side facing the roll and extending parallel to the roll axis of the roll. A coolant jet of coolant of substantially constant jet diameter can be disch arged through each full jet nozzle from the cooling rod toward the roll in the discharge directi on. [0013]

A full jet nozzle shall mean a nozzle capable of delivering a substantially straight jet of coola nt with a substantially constant jet diameter. By virtue of the concentrated coolant discharge, the full jet nozzle produces a higher roll impact pressure at the same coolant pressure at the c ooling rod than the conventionally used fan jet nozzle. Due to the large amount of coolant app lied throughout, there is always a specific coolant film, typically a few millimeters to a few cen timeters thick, by impinging coolant jets for good heat dissipation. Since this film should be p enetrated as completely as possible, a higher impact pressure has a direct positive effect on t he cooling action at the roll surface. Thanks to the high impact pressure of the coolant jets on the rolls produced by the full-jet nozzles, the coolant pressure in the cooling rods can be signif icantly reduced compared to when fan-jet nozzles are used, thereby increasing the cooling sys tem It is advantageous to be able to significantly reduce the energy consumption and operatin g costs of

[0014]

Since the coolant is discharged through a full-jet nozzle, the distance from the roll to the spr ay bar is also less critical over a wider range and therefore does not have to be adapted to the roll diameter. Thus, for example, a substantially straight coolant jet can cool the roll surface to be cooled at distances between 50 mm and 500 mm without any significant change in the coo ling effect of the coolant jet.

[0015]

Since the reduction in coolant pressure is also associated with reduced loading and conseque nt wear on the nozzles, this also results in reduced maintenance costs as a result of reduced c oolant pressure in the cooling rods, which Another advantage of using a full jet nozzle.

[0016]

In one embodiment of the invention, it is envisioned that the cooling rod is divided into at le ast two mutually separated coolant chambers for receiving coolant. Each coolant chamber cor responds to a sub-region of the discharge side of the cooling rod with a plurality of full-jet noz zles arranged through each of the full-jet nozzles to discharge a coolant jet from the coolant c hamber toward the roll. can. Dividing the cooling rod into a plurality of mutually separated co olant chambers corresponding to different subregions of the discharge side of the cooling rod controls the coolant pressure in the subregions independently of each other, resulting in It is a dvantageous to be able to control the cooling effect of the subregions independently of each o ther by controlling the coolant flow rate delivered by the . Thereby, depending on the position, the roll

It is advantageous to be able to influence the cooling and ensure that the more strongly heate d areas of the roll surface, for example the central area of the roll surface, are cooled more st rongly than the less intensely heated areas. . A development of the above-described embodi ment of the invention is that the first coolant chamber corresponds to a first partial area of th e discharge side of the cooling rod, the first partial area being the discharge side of the coolin g rod

.

is assumed to be mirror-symmetrical about the centerline of the roll, and its axis is perpendic ular to the roll axis. For example, the extent of the first subregion parallel to the centerline va ries along the direction of the roll axis and is greatest along the centerline. For example, the fi rst partial area is polygonal. Embodiments in which the first sub-region is mirror-symmetrical about the center line take into account the fact that the rolls are generally also heated symme trically about the center line. The fact that the extent of the first subregion parallel to the cent er line varies along the direction of the roll axis and has a maximum extent along the center li ne means that the roll is generally heated most strongly at the center and the heating of the r oll decreases towards the edge region. A corresponding configuration of the first subregion th us makes it possible to adapt the cooling of the rolls to the position-dependent thermal load o f the rolls by means of the first subregions.

[0018]

In another embodiment of the invention, each coolant chamber is connected to a coolant sup ply line for supplying coolant into the coolant chamber, the coolant supply line supplying coola nt into the coolant chamber. It is assumed that the opening is substantially perpendicular to t he ejection direction of the . The coolant supply lines opening into the cooling rods substantial ly perpendicular to the direction of discharge allow for a substantially uniform coolant pressur e distribution in each coolant chamber. Advantageously, the pressure gradient between the ful

l jet nozzle near the opening and the full jet nozzle away from the opening is thereby eliminat ed.

[0019]

Another embodiment of the invention envisions that the amount of coolant supplied into the coolant chambers can be controlled independently of each other by respective control valves a nd/or respective pumps. This allows the cooling effectiveness of the coolant jets discharged fr om the individual coolant chambers to be controlled independently of each other, as described above. If, for example, a conventional coolant supply system present at any given time can be used in the relevant rolling system, for example a water supply system that normally delivers cooling water at a pressure of 4 bar, the control It is particularly advantageous to control the amount of coolant by means of a valve. In this case, complex and expensive pressure boost s ystems can be dispensed with for roll cooling. By controlling the amount of coolant by the pu mps, if appropriate in conjunction with control valves, individual pumps can be turned off or t urned on during breaks between rolling or in the case of rolling operations requiring only a lo w cooling capacity. Power can be lowered, thereby reducing energy consumption. Another e mbodiment of the present invention contemplates an automated system for controlling the a mount of coolant supplied into the coolant chamber

.

Thereby, it is advantageous to be able to automatically control the volumetric flow rate of the coolant discharged from the coolant chamber onto the roll in order to adapt the volumetric flo w rate to the temperature distribution of the roll surface. In this case, the amount of coolant s upplied into the coolant chamber is preferably controlled by an automated system through co ntrolling the control valves and/or pumps mentioned above.

[0021]

In another embodiment of the invention, it is envisaged that the nozzle spacing of full jet no zzles adjacent to each other along a direction parallel to the roll axis varies along said directio n. In this case, the nozzle spacing is preferably the narrowest in the central region of the disc harge side of the cooling rod. For example, the nozzle spacing along the direction parallel to t he roll axis is between about 25mm and about 50mm. These embodiments of the present inve ntion also allow the nozzle spacing along the direction parallel to the roll axis to be varied acc ording to the position-dependent thermal load of the roll surface, so that the placement of the full-jet nozzles can also be adapted to this thermal load. can. The minimum nozzle spacing in the central region of the discharge side of the cooling rods takes into account the fact that the central region of the roll surface generally experiences the greatest heat load.

Another

embodiment of the present invention envisions that the full jet nozzles are arranged in parall el rows of nozzles. Advantageously, this allows the coolant to be applied to the roll over a wid er area and evenly as the roll rotates.

Another

embodiment of the invention envisions that the cooling rod has a nozzle opening for each ful l jet nozzle to which the full jet nozzle is removably secured. Advantageously, this embodimen t of the present invention allows for easy replacement of defective jet nozzles.

In another embodiment of the invention, a wiper is provided for wiping coolant from

the roll, and the wiper and cooling bar can be pivoted together. For example, wipers direct e xcess coolant to the rolled stock and/or to the roll nip where the rolled stock is guided betwee n two rolls to reduce friction between the rolled stock and the rolls. It is advantageous to be a ble to prevent the lubricant from washing away. Advantageously, the ability to pivot the wiper and cooling rods together obviates the need for additional equipment to move the cooling rod s. In this case, the advantages of using full-jet nozzles already mentioned above are also in ef fect here. That is, by using a full-jet nozzle, the distance between the spray bar and the roll b ecomes less critical over a wider range and therefore no longer needs to be adapted to the rol l diameter. Furthermore, the present invention is also particularly suitable as a retrofit to exist ing rolling systems with wipers, for example only conventional high pressure spray rods need to be replaced with cooling rods according to the invention.

[0025]

The rolling stand according to the invention comprises rolls and two cooling devices accordin g to the invention, the two cooling devices being arranged on opposite sides of the rolls. The a dvantages of the rolling stand according to the invention result from the advantages of the co oling device according to the invention already mentioned above.

The above-described properties, features, and advantages of the present invention, as well as the manner in which

they are achieved, will become clearer and will be clearly understood.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

FIG. 1 is a schematic view of a rolling stand with cooling device;

2 is a schematic perspective view of a first exemplary embodiment of a cooling rod; FIG.

3 shows the volumetric flow rate of coolant delivered by the cooling rods shown in FIG. 2 as a function of position; FIG.

FIG. 4 is a discharge side view of a second exemplary embodiment of a cooling rod;

FIG. 5 is a discharge side view of a third exemplary embodiment of a cooling rod;

FIG. 6 is a discharge side view of a fourth exemplary embodiment of a cooling rod;

FIG. 7 is a view of the discharge side of the fifth exemplary embodiment of the cooling rod;

FIG. 8 is a view of the discharge side of the sixth exemplary embodiment of the cooling rod;

FIG. 9 is a view of the discharge side of the seventh exemplary embodiment of the cooling ro d;

FIG. 10 is a discharge side view of an eighth exemplary embodiment of a cooling rod;

FIG. 11 is a discharge side view of a ninth exemplary embodiment of a cooling rod;

FIG. 12 is a discharge side view of a tenth exemplary embodiment of a cooling rod;

[Mode for carrying out the invention]

[0028]

In all drawings, the same parts are provided with the same reference numerals.

[0029]

FIG. 1 is a schematic diagram of a rolling stand 1 for rolling a rolling stock 3. FIG. The rolling stand 1 comprises two rolls 5 designed as work rolls and two cooling devices 7 for each roll 5 , said devices being arranged on either side of the rolls 5 . The rolls 5 are spaced apart by a r oll nip 9 and pass the rolling stock 3 through the roll nip 9 in the rolling direction 11 to form t he rolled stock 3 . Each cooling device 7 comprises cooling bars 13 and wipers 15 . Each cool ing rod 13 is designed to receive and discharge coolant

.

For discharging the coolant, the cooling rod 13 has a plurality of full jet nozzles 21 arranged o n the discharge side 19 of the cooling rod 13, said side facing the respective roll 5 and the roll of the roll 5. A coolant jet extending parallel to axis 17 and having a substantially constant jet diameter can be discharged in discharge direction 23 from cooling rod 13 towards roll 5 throu gh each of the full-jet nozzles. Coolant may be supplied into the cooling rods 13 via coolant su pply lines 41, the amount of coolant supplied into the cooling rods 13 being controlled by a co ntrol valve 43 and/or a frequency controlled pump 45, for example. can be controlled by A co olant is, for example, water. Each wiper 15 is designed to wipe coolant from the respective r oll 5 and can be pivoted toward and away from the roll 5

.

The cooling rods 13 and wipers 15 of each cooling device 7 are fixed to the pivoting device of the cooling device 7 , thus pivoting the cooling rods 13 and wipers 15 together toward and aw ay from the rolls 5 . Preferably, it can be moved.

[0032]

FIG. 2 is a schematic perspective view of a first exemplary embodiment of cooling rods 13 fo r delivering coolant to rolls 5. As shown in FIG. The cooling rod 13 is divided into three mutual ly separated coolant chambers 25-27 to receive coolant. Each coolant chamber 25-27 corresp onds to a sub-region 29-31 of the discharge side 19 in which a plurality of full jet nozzles 21 a re arranged to roll coolant jets from the coolant chambers 25-27 through each of the full jet n ozzles. 5 can be discharged in the discharge direction 23 . The discharge side 19 is rectangula r with two longitudinal sides 33 , 34 parallel to the roll axis 17 and two lateral sides 35 , 36 pe rpendicular to the roll axis 17 . The first coolant chamber 25 corresponds to a first partial ar ea 29 of the discharge side 19 of the cooling rod 13 forming the central area of the discharge side 19

.

The first partial region 29 is mirror-symmetrical to the centerline 37 of the discharge side 19 o f the cooling rod 13, said axis being perpendicular to the roll axis 17 and arranged on the first longitudinal side 33. It is a trapezoid with four vertices and two vertices each located at the e

ndpoint of the second longitudinal side 34 .

[0034]

The full jet nozzles 21 are arranged on the discharge side surface 19 in a plurality of nozzle r ows 39 each extending parallel to the roll axis 17 . In this case, the nozzle spacing d between the adjacent full jet nozzles 21 of each nozzle row 39 varies symmetrically with respect to the center line 37, so that the nozzle spacing d is is narrowest at and widens towards the edge re gion of the outlet side 19, for example parabolically. In the exemplary embodiment shown in F IG. 2, the nozzle spacing d is twice as large at the ends of each nozzle row 39 as it is at the c enter of the nozzle row 39 . The nozzle spacing d varies, for example, between 25mm and 50 mm. The nozzle rows 39 extend substantially evenly over the entire extent of the discharge si de 19 and thus produce a relatively uniform cooling effect on the roll surface of the roll 5 . A further development of the exemplary embodiment shown in FIG. 2 envisions arranging the n ozzle rows 39 staggered with respect to each other, so that the full jet nozzles 21 of the vario us nozzle rows 39 are arranged in

roll

It is not arranged along a direction perpendicular to the axis 17. A "cooling channel" extends perpendicular to the row of nozzles 39 where no coolant is ejected onto the roll 5, resulting in a reduced cooling effect, but this "cooling channel" can be avoided. so that the nozzle row 39 has a particularly uniform

Advantageously, a good cooling effect is achieved. Furthermore, the full jet nozzles 21 very c lose to or on the boundary between two adjacent sub-regions 29-31 in FIG

.

Displaced with respect to the arrangement, they are arranged to fall into one of the adjacent s ub-regions 29-31, which subdivide into the coolant chambers 25-27 inside the cooling tube 13 by the separating plate such a boundary line. because it extends along Each full jet nozzle 2 1 is removably attached to the nozzle opening of the cooling rod 13, for example by a threade d joint

.

Each full jet nozzle 21 has a minimum diameter nozzle cross-section of, for example, about 4 mm. Each coolant chamber 25-27 is connected to a coolant supply line 41 for supplying cool ant into the coolant chambers 25-27

.

, it is open substantially perpendicular to the discharge direction 23 of the coolant. The cross-sections of the coolant supply lines 41 each have a diameter of, for example, between 100 m m and 150 mm. The amount of coolant supplied into coolant chambers 25-27 via coolant su pply line 41 is controlled by respective control valves 43 (not shown in FIG. 2) and/or respecti ve pumps

.

can be controlled independently of each other by 45 (not shown in FIG. 2). Advantageously, t

his allows the amount of coolant discharged from the coolant chambers 25-27 to be adapted t o different heat loads in different regions of the roll surface.

FIG . 3 shows, by way of example, the volume flow rate V_1 of three coolants discharged from the cooling rod 13 shown in FIG. , V_2 , V_3 as a function o f the position y along the direction parallel to the roll axis 17 . Here, the volumetric flows V_1 , V_2 , V_3 are expressed as a percentage of the rated flow.

The rated flow is the first volumetric flow V_1 at the center position y_m . A first volumetric flow rate V_1 occur s when coolant is fed into all three coolant chambers 25-27 at the same specified pressure rat ing for all coolant chambers 25-27. The first volume flow rate V_1 has a parabolic shape with a maximum at the central position y_m and decreases from the central position y_m towards the two end regions to half the value of the central position y_m Become. The reason for this shap e of the first volumetric flow rate V1 is that from the center of the nozzle row 39 to the two en ds, the nozzle spacing d of the full jet nozzles 21 along the nozzle row 39 doubles . , a parabo lic increase in the nozzle spacing d is assumed. Second volumetric flow rate V_2 supplies coolant into the first coolant chamber 25 at a coolant pressure of approximately twic e the rated pressure and into the other two coolant chambers 26, at a coolant pressure of app roximately half the rated pressure. 27 when supplied to each of them. The third volume flow rate V3 supplies coolant into the first coolant chamber 25 at a coolant pressure approximately h alf the rated pressure and supplies coolant at a coolant pressure approximately twice the rate d pressure . into each of the other two coolant chambers 26, 27. FIG . 3 illustrates the volumetric flow ra tes V_1 , V_2 , V_3 with different patterns of dependence on position y along the direction par allel to the roll axis 17 at different coolant pressures in the coolant chambers 25-27. , so that the volume flows V_1 , V_2 , V_3 discharged from the cooling rods 13 can be adapted to the te mperature distribution of the roll surfaces. The coolant pressure in each coolant chamber 25 - 27 is set by a respective control valve 43 and/or a respective pump 45 . FIGS. 4-12 each sh ow the discharge side 19 of another exemplary embodiment of the cooling rod 13. FIG. these differs from the exemplary embodiment shown in FIG. 2 only in the shape and number of the coolant chambers 25-27 and the corresponding partial areas 29-31 of the discharge side 19. F IG. As in the exemplary embodiment shown in FIG. 2, the full jet nozzles 21 are each arrange d in a plurality of nozzle rows 39, with the nozzle spacing d in each case extending from the c enter along it to the two ends. increase towards the part. Therefore, the full jet nozzle 21 of Fi

gures 4-12 will not be described here again. Due to the distribution of the full jet nozzles 21 o n the discharge side 19 similar to the exemplary embodiment shown in FIG. 2, each of the ex emplary embodiments shown in FIGS. V_1 , V_2 , V_3 can be produced. Like the exemplary e mbodiment shown in FIG. 2, the exemplary embodiments shown in FIGS. 4-10 each correspo nd to three coolant chambers 25-27 and a discharge side 19

.

It has partial regions 29-31. Similar to the exemplary embodiment shown in FIG. 2, the first s ubregion 29 is mirror-symmetrical about the centerline 37 of the discharge side 19 of the cool ing rod 13, perpendicular to the roll axis 17, and the other The two partial areas 30 , 31 adjoi n the first partial area 29 and on different sides of the centerline 37 .

FIG.

4 shows that the first partial area 29 is trapezoidal with two vertices located on the first long itudinal side 33 and two vertices located on the second longitudinal side 34 . 1 illustrates an e xemplary embodiment;

[0048]

FIG. 5 shows that the first partial region 29 has one vertex arranged at the intersection of th e centerline 37 and the first longitudinal side 33 and two corners arranged at the end of the s econd longitudinal side 34 . 2 shows an exemplary embodiment that is a triangle with four ver tices.

FIG.

6 shows that the first partial area 29 has one vertex located at the intersection of the centerl ine 37 and the first longitudinal side 33 and two corners located at the second longitudinal sid e 34 . 2 shows an exemplary embodiment that is a triangle with four vertices.

FIG .

7 shows an exemplary embodiment in which the first partial area 29 is a rectangle with verti ces located on the longitudinal sides 33,34. In this exemplary embodiment, no coolant is disc harged via the two outer partial regions 30 , 31 , so that the discharge of coolant can only occ ur from the central region of the discharge side 19 . This exemplary embodiment is therefore particularly suitable for rolling rolling blanks 3 of different widths.

FIG .

8 shows that the second partial area 30 and the third partial area 31 each have a vertex on t he first longitudinal side 33 and a vertex located at one end of the first longitudinal side 33. , and vertices located on the lateral sides 35, 36. FIG.

FIG.

9 shows that the first partial region 29 has two vertices on the first longitudinal side 33 and t wo vertices located at the ends of the second longitudinal side 34, respectively. Figure 10 sho ws an exemplary embodiment that is a hexagon with vertices on its short sides 35,36.

[0053]

FIG. 10 shows that the first partial regions 29 are arranged at one vertex arranged at the int

ersection of the centerline 37 and the first longitudinal side 33 and at the end of the second lo ngitudinal side 34 respectively. An exemplary embodiment is shown that is a pentagon with t wo vertices and one vertex on each of the short sides 35,36. The exemplary embodiments s hown in FIGS. 11 and 12 each have two coolant chambers 25 , 26 and corresponding subregi ons 29 , 30 of the discharge side 19

.

Both partial regions 29 are mirror-symmetrical with respect to a centerline 37 of the discharg e side 19 of the cooling rod 13 perpendicular to the roll axis 17 .

FIG .

11 shows that the first partial area 29 is triangular with one vertex located at the centerline 37 and two vertices located at the ends of the second longitudinal sides 34 respectively. show s an exemplary embodiment

.

FIG.

12 shows that the first partial area 29 has one vertex located on the centerline 37 and two v ertices located respectively at the ends of the second longitudinal sides 34 and each short edg e. 4 shows an exemplary embodiment that is a pentagon with vertices on hand sides 35,36.

Although the present invention has been illustrated and described in more detail by way of p referred exemplary embodiments, the present invention is not limited to the disclosed exampl es, and a person skilled in the art can fully understand the scope of protection of the present i nvention

.

Other variations can be obtained from these without exceeding.

[Description of Symbols]

1

Rolling stand

3 Rolling material, rolling material

5 Roll

7 Cooling device

9 Roll gap

11 Rolling direction 13

Cooling bar

15 Wiper

17 Roll shaft

19 Discharge side surface

21 Full jet nozzle

23 Discharge direction

25-27 Cooling Agent chambers

29 to 31 Partial areas

33, 34 Longitudinal sides

35, 36 Short side

37 Center line

39 Nozzle row

41 Coolant supply line

43 Control valve

45 Pump

d Nozzle spacing

drawing open —

[Fig. 1]

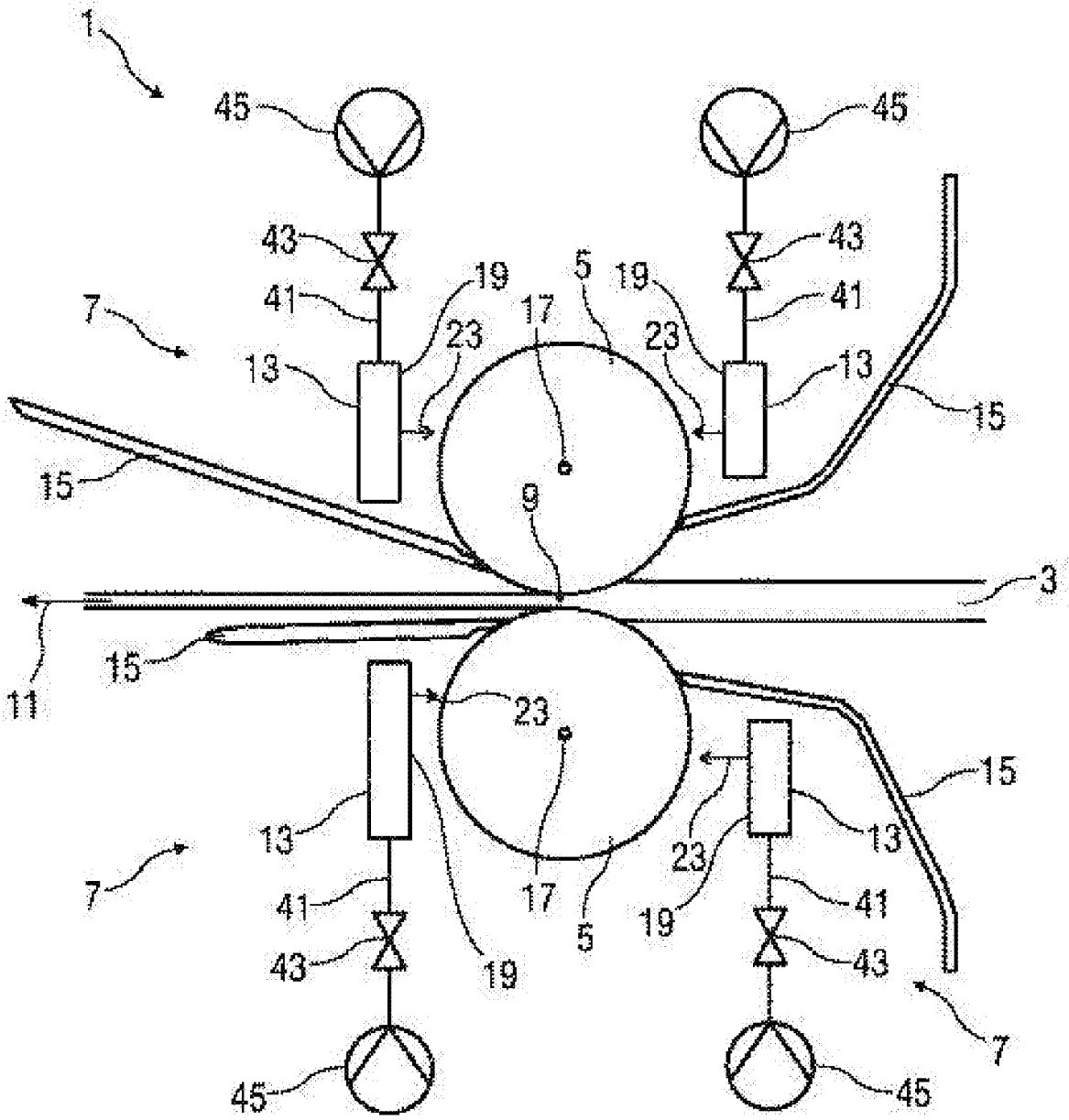


FIG 1

[Figure 2]

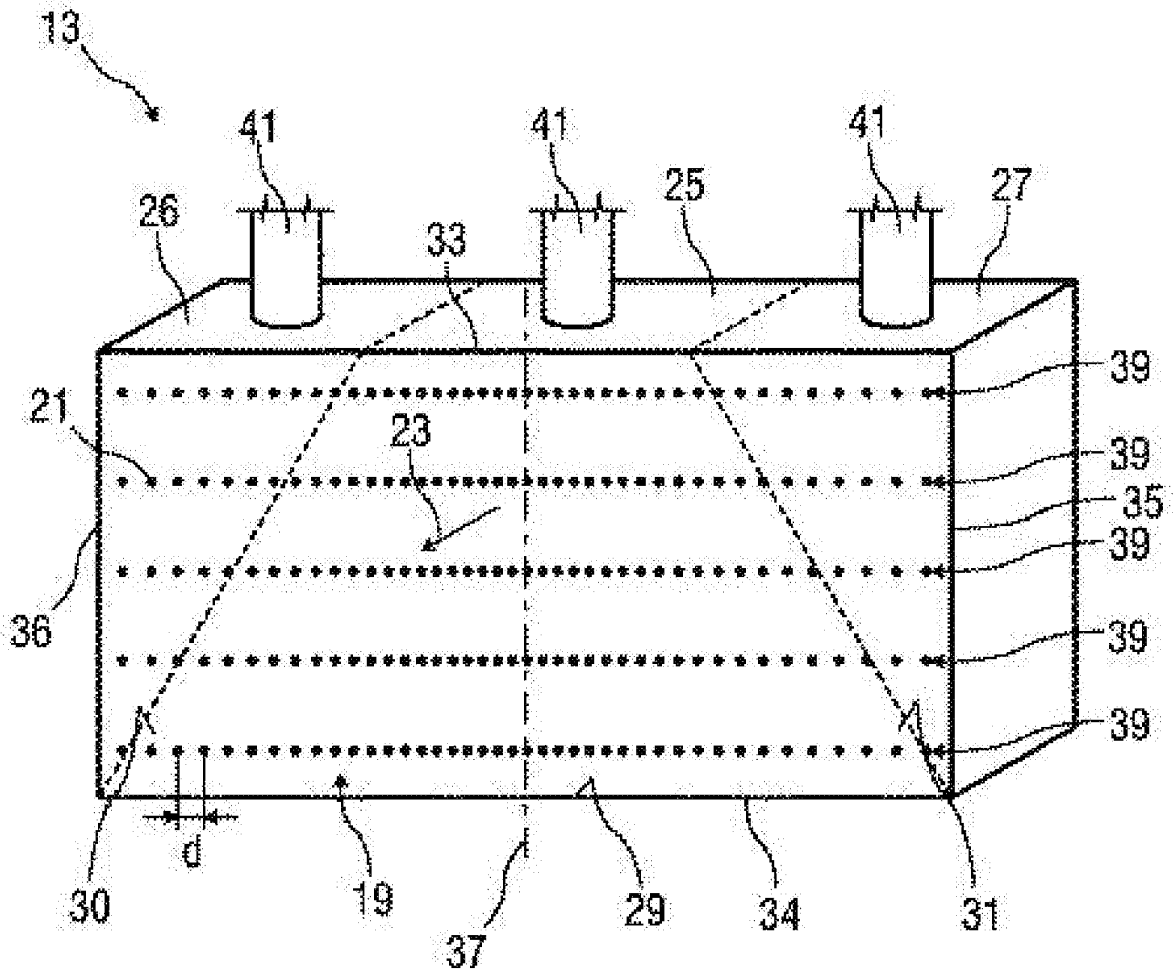


FIG 2

[Figure 3]

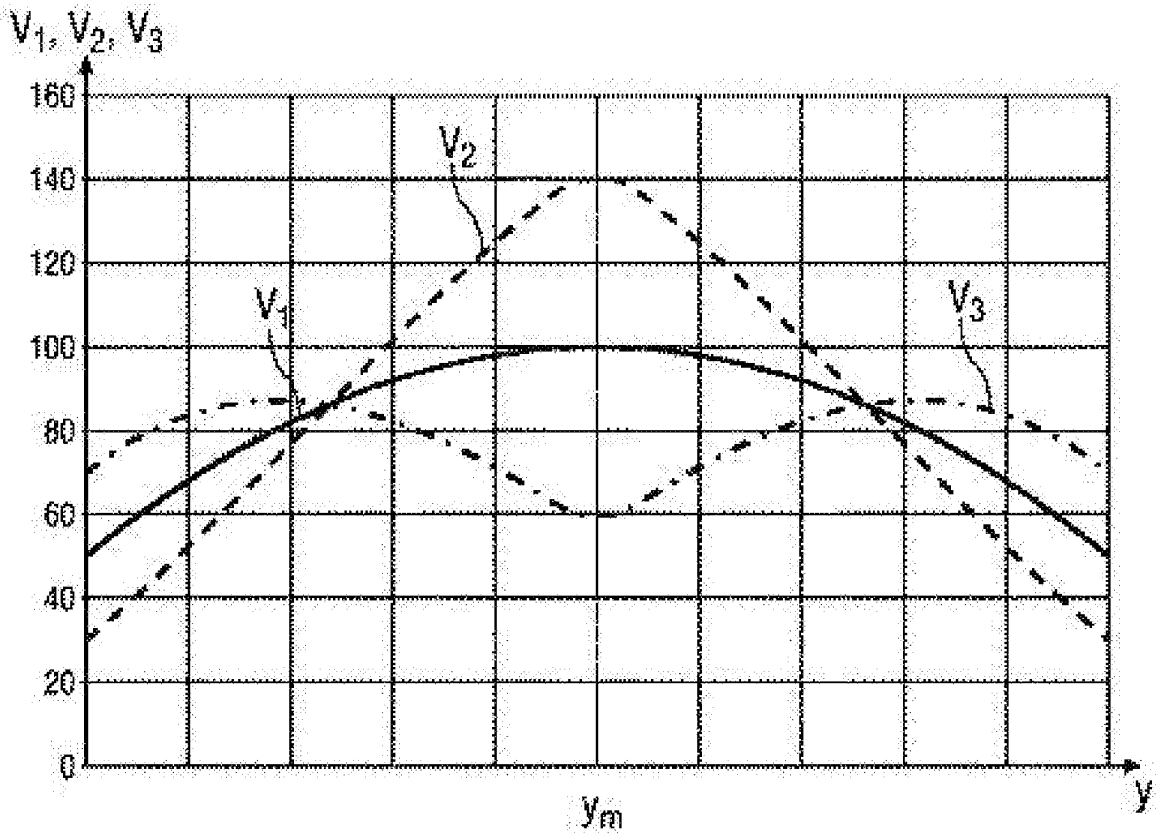


FIG 3

[Figure 4]

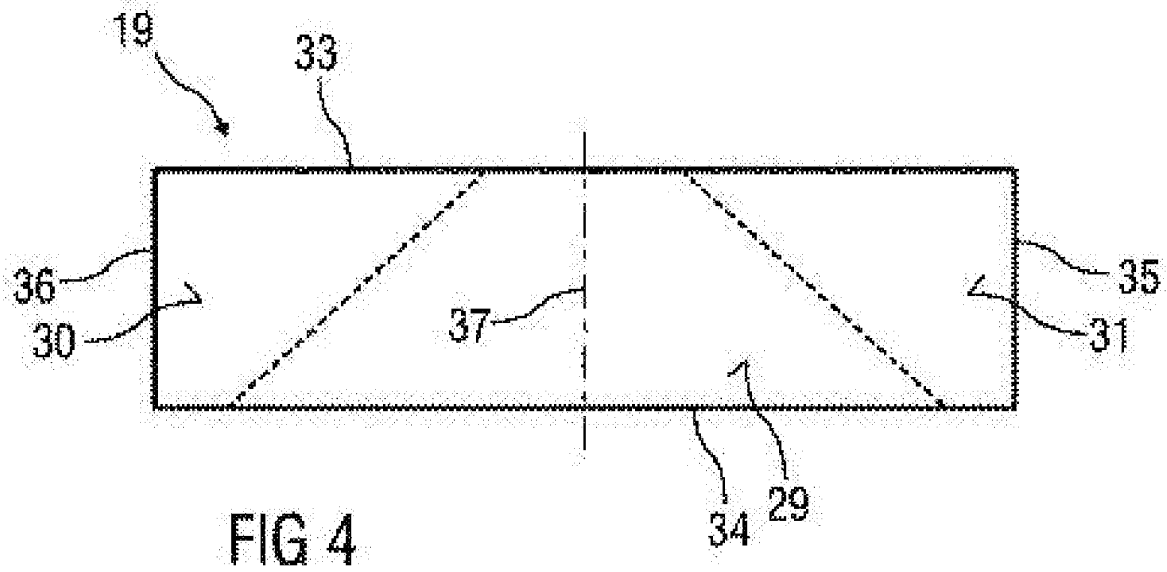


FIG 4

[Figure 5]

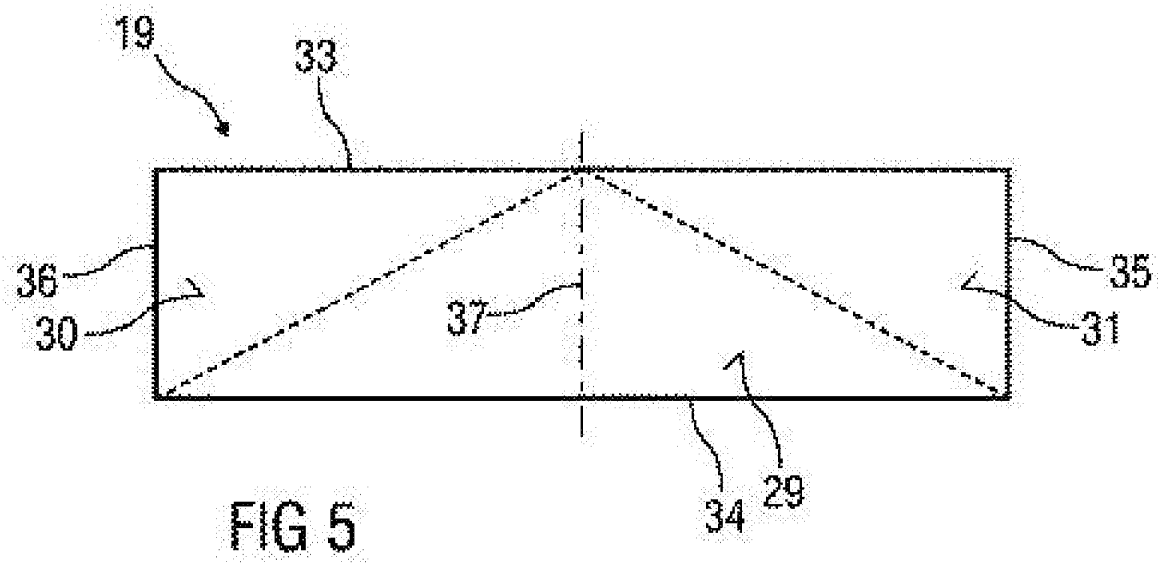


FIG 5

[Fig. 6]

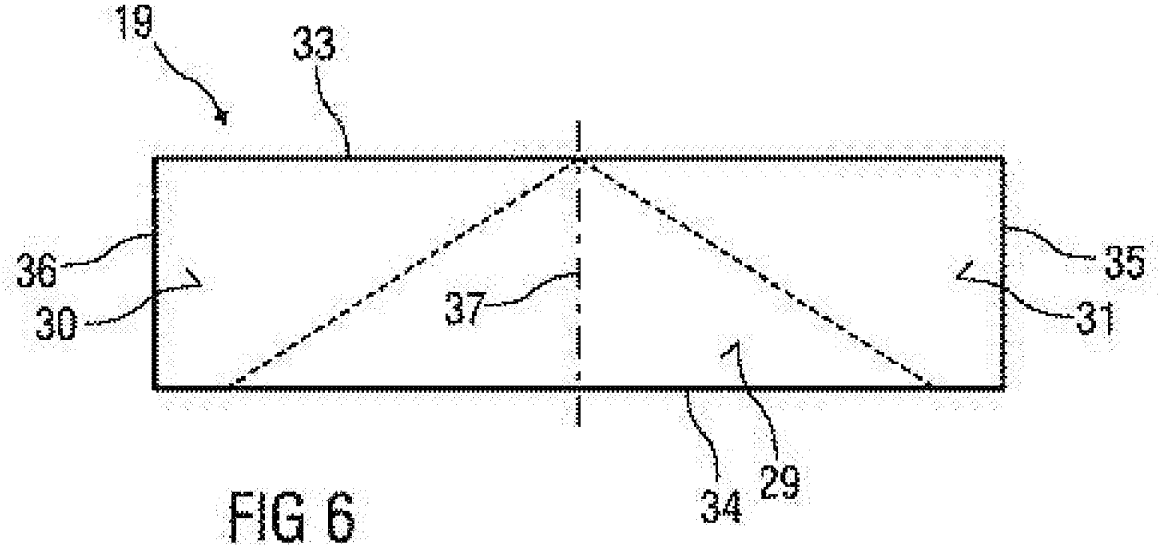


FIG 6

[Fig. 7]

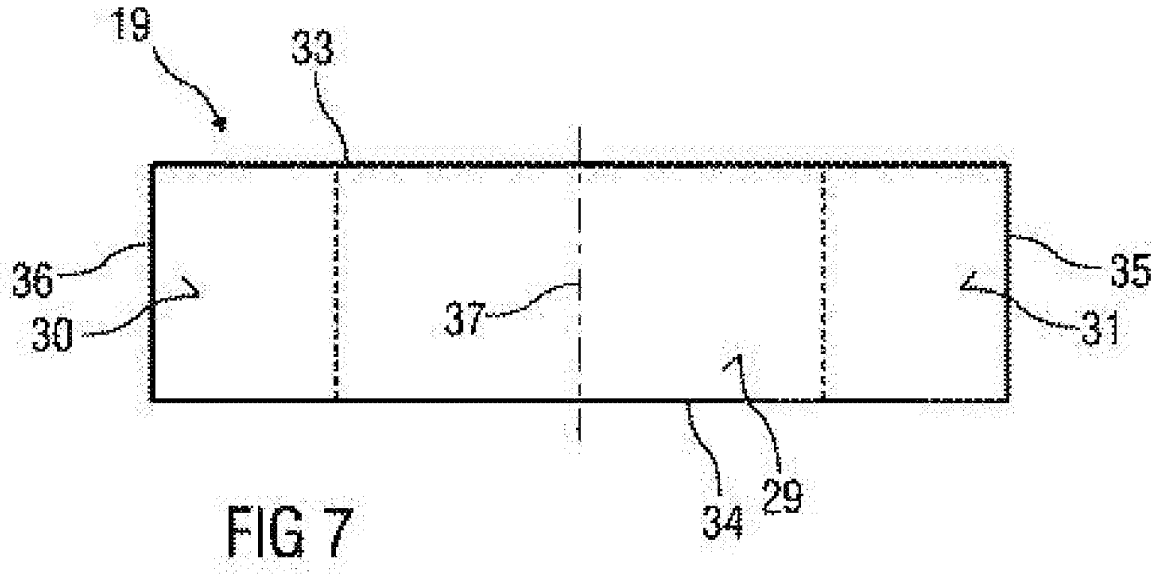


FIG 7

[Fig. 8]

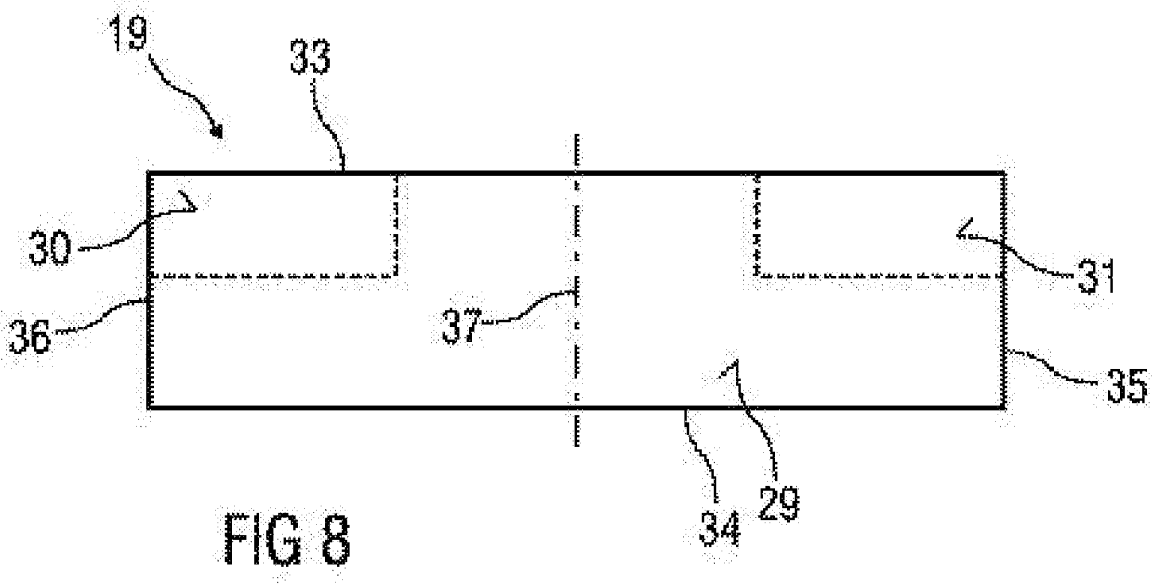


FIG 8

[Fig. 9]

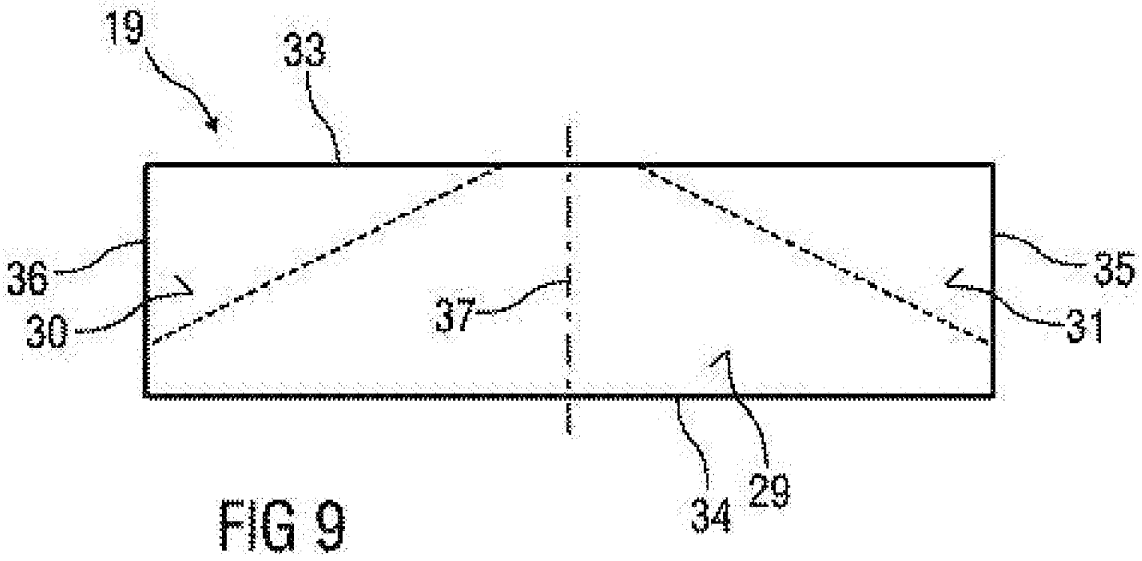


FIG 9

[Fig. 10]

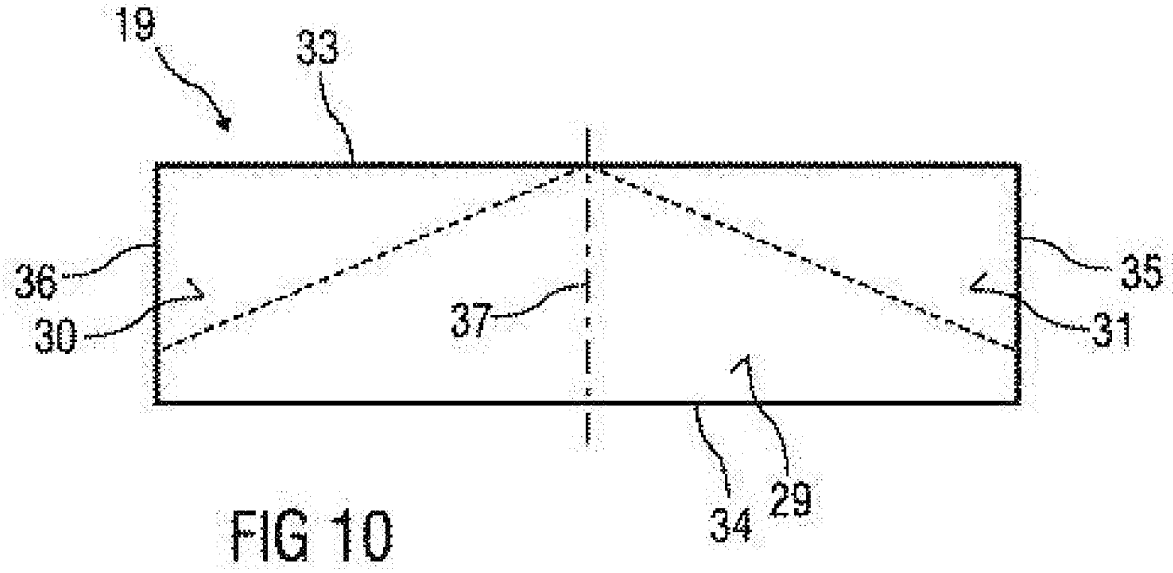


FIG 10

[Fig. 11]

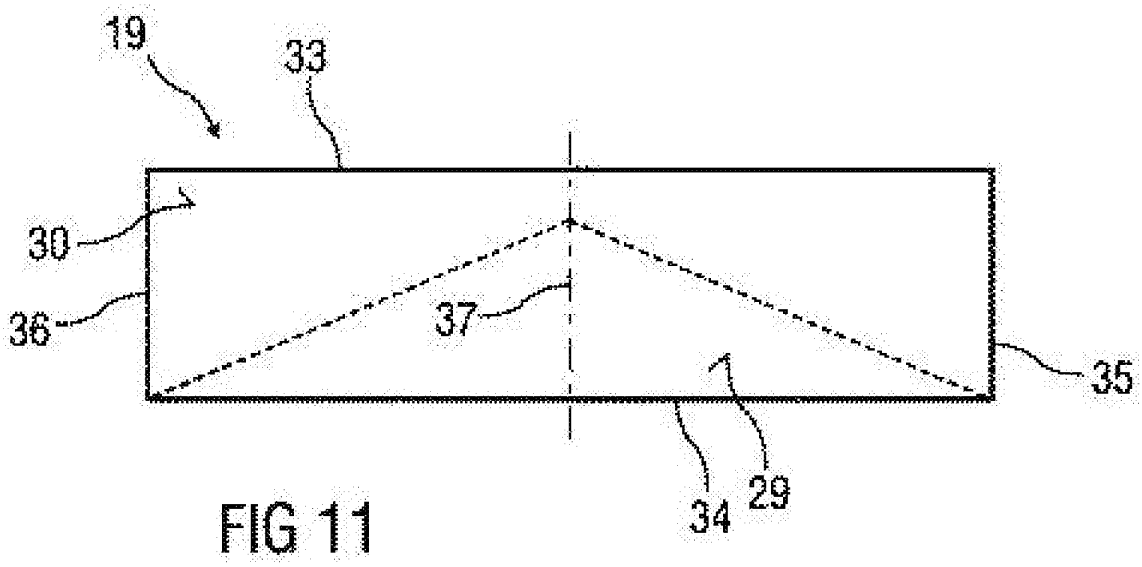


FIG 11

[Fig. 12]

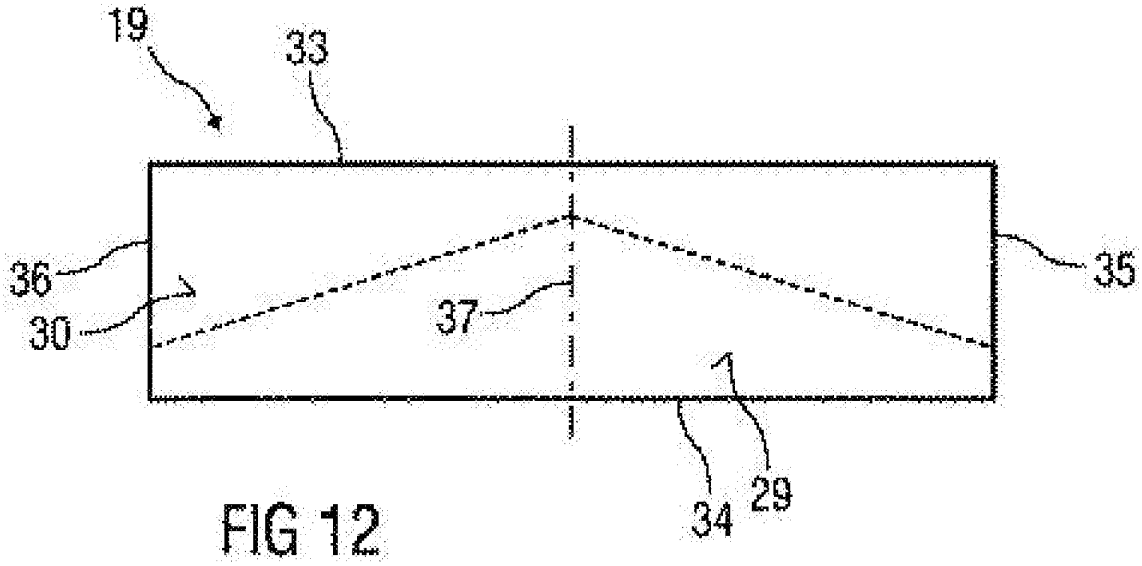


FIG 12

search report open

[International search report]

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/076000

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21B27/10
ADD.

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)
B21B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 200 06 508 U1 (ACHENBACH BUSCHHUETTEN GMBH [DE]) 31 August 2000 (2000-08-31)	1,15
Y	page 5, paragraph 3 - page 7, paragraph 3	2-5
X	WO 2008/149195 A1 (ARCELORMITTAL FRANCE [FR]; VANDERSCHUEREN DIRK [BE]; VAN POECKE PATRIC) 11 December 2008 (2008-12-11)	1,15
Y	page 3, line 20 - page 4, line 12; figures 1,2	2-5
Y	EP 2 792 428 A1 (SIEMENS VAI METALS TECH GMBH [AT]) 22 October 2014 (2014-10-22) paragraph [0017] - paragraph [0027]; figures 1-3	2-5
A	WO 2015/113832 A1 (LOI THERMPROCESS GMBH [DE]) 6 August 2015 (2015-08-06) page 4, line 8 - line 17	1

☐ 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

"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
11 January 2018	06/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Frisch, Ulrich

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/076000

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:

see additional sheet

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.:
1-5, 15

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.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/076000

The International Searching Authority has found that the international application contains multiple (groups of) inventions, as follows:

1. Claims 1-5, 15

Cooling device for cooling a roller, wherein two coolant chambers are provided which are separated from each other.

---

2. Claims 1, 6-8

Cooling device for cooling a roller, wherein the feed/control of the coolant is further defined.

---

3. Claims 1, 9-13

Cooling device for cooling a roller, wherein the distance of the nozzles is defined.

---

4. Claims 1, 14

Cooling device for cooling a roller, wherein an additional stripper is defined.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/076000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 20006508 U1	31-08-2000	DE 20006508 U1	31-08-2000
		EP 1142652 A2	10-10-2001
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		RU 2015141167 A	17-05-2017
		US 2016052033 A1	25-02-2016
		WO 2014170139 A1	23-10-2014
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		EP 3099829 A1	07-12-2016
		WO 2015113832 A1	06-08-2015

Form PCT/ISA/210 (patent family annex) (April 2005)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2017/076000

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B21B27/10
ADD.

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
B21B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	DE 200 06 508 U1 (ACHENBACH BUSCHHUETTEN GMBH [DE]) 31. August 2000 (2000-08-31)	1,15
Y	Seite 5, Absatz 3 - Seite 7, Absatz 3	2-5
X	WO 2008/149195 A1 (ARCELORMITTAL FRANCE [FR]; VANDERSCHUEREN DIRK [BE]; VAN POECKE PATRIC) 11. Dezember 2008 (2008-12-11)	1,15
Y	Seite 3, Zeile 20 - Seite 4, Zeile 12; Abbildungen 1,2	2-5
Y	EP 2 792 428 A1 (SIEMENS VAI METALS TECH GMBH [AT]) 22. Oktober 2014 (2014-10-22) Absatz [0017] - Absatz [0027]; Abbildungen 1-3	2-5
A	WO 2015/113832 A1 (LOI THERMPROCESS GMBH [DE]) 6. August 2015 (2015-08-06) Seite 4, Zeile 8 - Zeile 17	1

☐ Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen ☒ Siehe Anhang Patentfamilie

* Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" frühere Anmeldung oder Patent, die bzw. das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Rechercherenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)
"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist
"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist
"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
11. Januar 2018	06/03/2018

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Frisch, Ulrich

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Formblatt PCT/ISA/210 (Blatt 2) (April 2005)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2017/076000

Feld Nr. II Bemerkungen zu den Ansprüchen, die sich als nicht recherchierbar erwiesen haben (Fortsetzung von Punkt 2 auf Blatt 1)

Gemäß Artikel 17(2)a) wurde aus folgenden Gründen für bestimmte Ansprüche kein internationaler Recherchenbericht erstellt:

1. ☐ Ansprüche Nr.
weil sie sich auf Gegenstände beziehen, zu deren Recherche diese Behörde nicht verpflichtet ist, nämlich

2. ☐ Ansprüche Nr.
weil sie sich auf Teile der internationalen Anmeldung beziehen, die den vorgeschriebenen Anforderungen so wenig entsprechen, dass eine sinnvolle internationale Recherche nicht durchgeführt werden kann, nämlich

3. ☐ Ansprüche Nr.
weil es sich dabei um abhängige Ansprüche handelt, die nicht entsprechend Satz 2 und 3 der Regel 6.4 a) abgefasst sind.

Feld Nr. III Bemerkungen bei mangelnder Einheitlichkeit der Erfindung (Fortsetzung von Punkt 3 auf Blatt 1)

Diese Internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere Erfindungen enthält:

siehe Zusatzblatt

1. ☐ Da der Anmelder alle erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht auf alle recherchierbaren Ansprüche.

2. ☐ Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Behörde nicht zur Zahlung solcher Gebühren aufgefordert.

3. ☐ Da der Anmelder nur einige der erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht nur auf die Ansprüche, für die Gebühren entrichtet worden sind, nämlich auf die Ansprüche Nr.

4. ☒ Der Anmelder hat die erforderlichen zusätzlichen Recherchengebühren nicht rechtzeitig entrichtet. Dieser internationale Recherchenbericht beschränkt sich daher auf die in den Ansprüchen zuerst erwähnte Erfindung; diese ist in folgenden Ansprüchen erfasst:
1-5, 15

Bemerkungen hinsichtlich eines Widerspruchs

☐ Der Anmelder hat die zusätzlichen Recherchengebühren unter Widerspruch entrichtet und die gegebenenfalls erforderliche Widerspruchsgebühr gezahlt.

☐ Die zusätzlichen Recherchengebühren wurden vom Anmelder unter Widerspruch gezahlt, jedoch wurde die entsprechende Widerspruchsgebühr nicht innerhalb der in der Aufforderung angegebenen Frist entrichtet.

☐ Die Zahlung der zusätzlichen Recherchengebühren erfolgte ohne Widerspruch.

Formblatt PCT/ISA/210 (Fortsetzung von Blatt 1 (2)) (April 2005)

Internationales Aktenzeichen PCT/ EP2017/ 076000

WEITERE ANGABEN **PCT/ISA/** 210

Die internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere (Gruppen von) Erfindungen enthält, nämlich:

1. Ansprüche: 1-5, 15

   Kühlvorrichtung zur Kühlung einer Walze, wobei zwei voneinander getrennte Kühlmittelkammern vorgesehen sind.

   ---

2. Ansprüche: 1, 6-8

   Kühlvorrichtung zur Kühlung einer Walze, wobei die Zuleitung / Steuerung des Kühlmittels weiter definiert wird.

   ---

3. Ansprüche: 1, 9-13

   Kühlvorrichtung zur Kühlung einer Walze, wobei der Abstand der Düsen definiert wird.

   ---

4. Ansprüche: 1, 14

   Kühlvorrichtung zur Kühlung einer Walze, wobei ein zusätzlicher Abstreifer definiert wird

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INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2017/076000

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Formblatt PCT/ISA/210 (Anhang Patentfamilie) (April 2005)

drawing open

Representative drawing 1 2 3 Four Five 6 7 8 9 ...

Magnify and Rotate

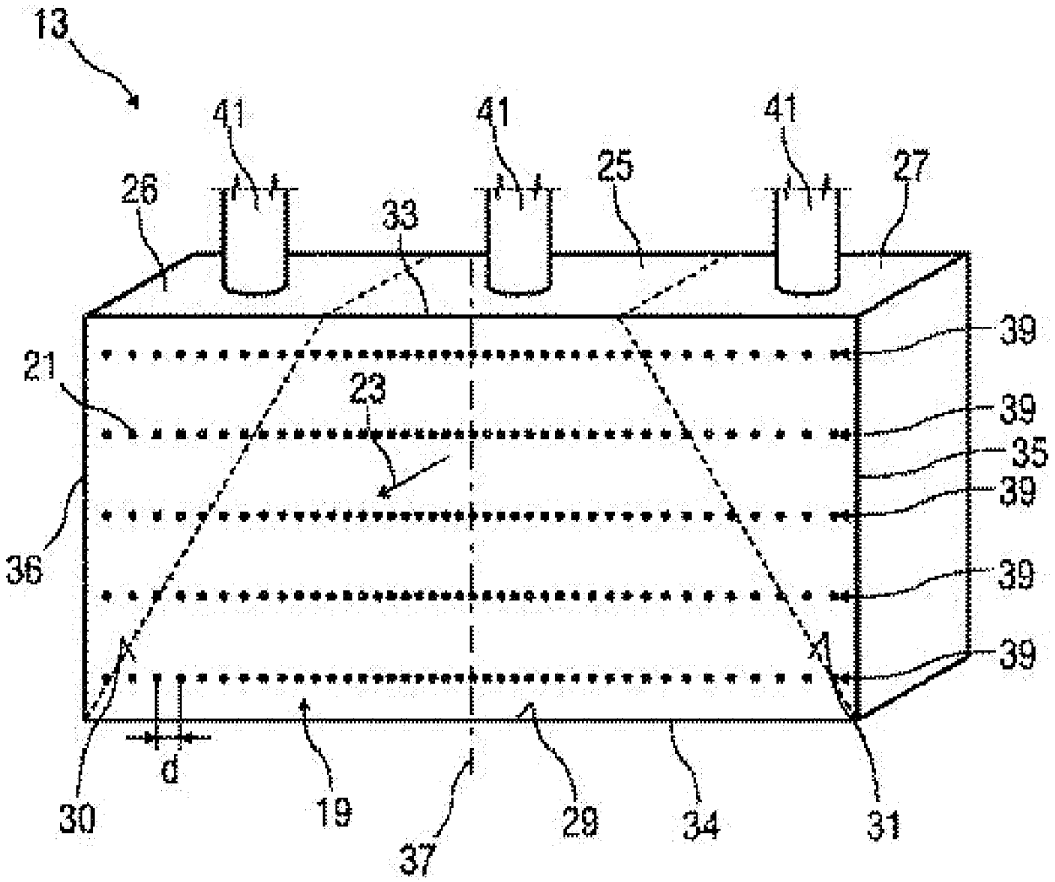


FIG 2

Representative drawing

1 / 1 display

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ABSTRACT JP2019534792A

[0001]

The present invention relates to a cooling device (7) for cooling the rolls (5) of the rolling stand (1). The cooling device (7) comprises cooling beams (13) for receiving and discharging coolant. The cooling beam (13) has a plurality of full jet nozzles (21) arranged on the discharge side (19) of said cooling beam (13), said side facing the roll (5).) parallel to the roll axis (17). A jet of coolant with a substantially constant jet diameter can be sprayed through each of the full jet nozzles from the cooling beam (13) towards the roll (5) in the discharge direction (23).



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最終頁に続く

(54)【発明の名称】圧延スタンドのロールの冷却

【要約】
本発明は、圧延スタンド　のロール　を冷却するための冷却装置　に関する。冷却装置　は、冷却剤を受け入れて吐出するための冷却ビーム　を備える。冷却ビーム　は、前記冷却ビーム　の吐出側面　に配置された複数のフルジェットノズル　を有し、前記側面は、ロール　に面してロール　のロール軸　に平行に延在する。ほぼ一定のジェット径を有する冷却剤のジェットを、フルジェットノズルのそれぞれを通して、冷却ビーム　からロール　に向けて吐出方向　に噴霧することができる。

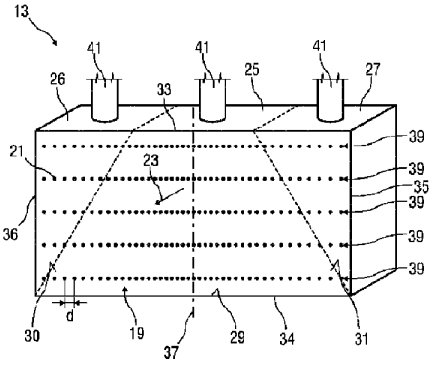


FIG 2

【特許請求の範囲】
【請求項１】
冷却剤を受け入れて吐出するための冷却棒（１３）を備えた、圧延スタンド（１）のロール（５）を冷却するための冷却装置（７）であって、
前記冷却棒（１３）が、前記冷却棒（１３）の吐出側面（１９）に配置された複数のフルジェットノズル（２１）を有し、前記吐出側面が、ロール（５）に面して前記ロール（５）のロール軸（１７）に平行に延在し、ほぼ一定のジェット径の冷却剤の冷却剤ジェットを、フルジェットノズルのそれぞれを通して、前記冷却棒（１３）から前記ロール（５）に向けて吐出方向（２３）に吐出することができる、冷却装置（７）。
【請求項２】
前記冷却棒（１３）が、冷却剤を受け入れるための、相互に分離した少なくとも２つの冷却剤室（２５～２７）に分割され、各冷却剤室（２５～２７）が、複数のフルジェットノズル（２１）が配置された前記冷却棒（１３）の前記吐出側面（１９）の部分領域（２９～３１）に対応し、前記フルジェットノズル（２１）のそれぞれを通して、冷却剤ジェットを前記冷却剤室（２５～２７）から前記ロール（５）に向けて吐出することができることを特徴とする、請求項１に記載の冷却装置（７）。
【請求項３】
第１の冷却剤室（２５）が、前記冷却棒（１３）の前記吐出側面（１９）の第１の部分領域（２９）に対応し、前記第１の部分領域（２９）が、前記冷却棒（１３）の前記吐出側面（１９）の中心線（３７）に対して鏡面対称であり、軸が前記ロール軸（１７）に垂直であることを特徴とする、請求項２に記載の冷却装置（７）。
【請求項４】
中心線（３７）に並行する第１の部分領域（２９）の範囲が、前記ロール軸（１７）の方向に沿って変化し、前記中心線（３７）に沿って最大であることを特徴とする、請求項２または３に記載の冷却装置（７）。
【請求項５】
第１の部分領域（２９）が多角形であることを特徴とする、請求項２から４のいずれか一項に記載の冷却装置（７）。
【請求項６】
各冷却剤室（２５～２７）が、前記冷却剤室（２５～２７）内に冷却剤を供給するための冷却剤供給ライン（４１）に接続され、前記冷却剤供給ライン（４１）が、前記冷却剤室（２５～２７）内に、前記冷却剤の前記吐出方向（２３）に実質的に垂直に開口していることを特徴とする、請求項２から５のいずれか一項に記載の冷却装置（７）。
【請求項７】
前記冷却剤室（２５～２７）内に供給される前記冷却剤の量を、それぞれの制御弁（４３）、および／または、それぞれのポンプ（４５）によって互いに独立して制御することができることを特徴とする、請求項２から６のいずれか一項に記載の冷却装置（７）。
【請求項８】
前記冷却剤室（２５～２７）内に供給される前記冷却剤の量を制御するための自動化システムによって特徴付けられた、請求項２から７のいずれか一項に記載の冷却装置（７）。
【請求項９】
前記ロール軸（１７）に平行な方向に沿って相互に隣り合うフルジェットノズル（２１）のノズル間隔（ｄ）が、前記方向に沿って変化していることを特徴とする、請求項１から８のいずれか一項に記載の冷却装置（７）。
【請求項１０】
前記ノズル間隔（ｄ）が、前記冷却棒（１３）の前記吐出側面（１９）の中央領域において最も狭いことを特徴とする、請求項９に記載の冷却装置（７）。
【請求項１１】
前記ノズル間隔（ｄ）が、約２５ｍｍから約５０ｍｍの間であることを特徴とする、請

求項９または１０に記載の冷却装置（７）。
【請求項１２】
前記フルジェットノズル（２１）が、相互に平行な複数のノズル列（３９）になるように配置されていることを特徴とする、請求項１から１１のいずれか一項に記載の冷却装置（７）。
【請求項１３】
前記冷却棒（１３）が、前記フルジェットノズル（２１）が取り外し可能に固定された、各フルジェットノズル（２１）のためのノズル開口を有していることを特徴とする、請求項１から１２のいずれか一項に記載の冷却装置（７）。
【請求項１４】
前記ロール（５）から冷却剤をぬぐい取るためのワイパ（１５）であって、前記冷却棒（１３）と一緒に枢動させることができるワイパ（１５）によって特徴付けられた、請求項１から１３のいずれか一項に記載の冷却装置（７）。
【請求項１５】
ロール（５）と、請求項１から１３のいずれか一項に記載されたようにそれぞれ設計された２つの冷却装置（７）と、を備えた圧延スタンド（１）であって、前記２つの冷却装置（７）が、前記ロール（５）の両側に配置されている、圧延スタンド（１）。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、圧延スタンドのロールを冷却するための冷却装置に関する。
【背景技術】
【０００２】
圧延素材を圧延するための圧延スタンドは、冷却液体、一般的には冷却水を用いて冷却されるロールを有する。
【０００３】
特許文献１には、低圧の冷却液体を圧延スタンドのロールにかけることができる、剛性の高い凹状のシェルが開示されている。
【０００４】
特許文献２には、移動可能な関節式冷却シェルによる圧延スタンドのワークロールの流動冷却が開示されている。この場合、冷却液体は、冷却シェルを用いて主として低圧でかけられるが、さらに、冷却液体は、高圧でかけられて十分な冷却効果を生じる。
【０００５】
特許文献３には、圧延スタンドのワークロールを冷却するための冷却装置が開示されており、この装置は、関係する圧延スタンドを用いて生産される最も狭い片よりもやや狭い固定スプレー棒を有し、そのときに圧延されている片の幅に対応するワークロールのこれらの部分のみを冷却するための、軸方向に移動可能なスプレー棒を有する。
【０００６】
特許文献４には、圧延スタンドのワークロールを冷却するための方法が開示されており、この方法では、冷却水が、高圧ではなく低圧でワークロールに噴霧されるが、同時に、かけられる範囲が広くされている。
【０００７】
特許文献５には、圧延材を冷却するためのスプレー棒が開示されており、このスプレー棒は、圧延材の移動方向に横断して延在し、中央領域および つの縁領域を有して、冷却媒体をそれらのそれぞれに別々に供給することができる。
【先行技術文献】
【特許文献】
【０００８】
【特許文献１】米国特許出願公開第　　号
【特許文献２】独国特許出願公開第　　号

【特許文献３】特開平　　号
【特許文献４】特開昭　　号
【特許文献５】国際公開第　　号
【発明の概要】
【発明が解決しようとする課題】
【０００９】
圧延スタンドのロールを冷却するための改善された冷却装置を特定することが本発明の基本的な目的である。
【課題を解決するための手段】
【００１０】
本発明によれば、この目的は、請求項　の特徴によって達成される。
【００１１】
本発明の有利な実施形態は、従属請求項の主題を形成する。
【００１２】
圧延スタンドのロールを冷却するための本発明による冷却装置は、冷却剤を受け入れて吐出するための冷却棒を備える。冷却棒は、冷却棒の吐出側面に配置された複数のフルジェットノズルを有し、前記側面は、ロールに面してロールのロール軸に平行に延在する。ほぼ一定のジェット径の冷却剤の冷却剤ジェットを、各フルジェットノズルを通して、冷却棒からロールに向けて吐出方向に吐出することができる。
【００１３】
フルジェットノズルとは、ほぼ一定のジェット径で実質的に直線状の冷却剤ジェットを吐出することができるノズルを意味するものとする。冷却剤を集中させて吐出するおかげで、フルジェットノズルは、従来使用されてきたファンジェットノズルよりも、冷却棒での同じ冷却剤圧力でより高いロールへの衝撃圧を生じる。全体にかけられた大量の冷却剤の量により、典型的には、数ミリメートルから数センチメートルの厚さの特定の冷却剤膜が常にあり、良好な放熱のために冷却剤ジェットを衝突させることによって、この膜はできるだけ完全に貫通されるべきであるので、より高い衝撃圧は、ロール表面での冷却作用に直接良い効果を生じる。フルジェットノズルによって生じた、ロールへの冷却剤ジェットの高い衝撃圧のおかげで、冷却棒の冷却剤圧力は、ファンジェットノズルを使用した場合に比べて大きく下げることができ、それによって、冷却装置のＴネルギー消費および運用コストを大きく下げることができることは有利である。
【００１４】
冷却剤はフルジェットノズルを通って吐出されるので、ロールからスプレー棒までの間隔はさらに、広い範囲にわたってそれほど重要ではなくなり、したがって、ロール直径に適合させる必要はない。したがって、例えば、実質的に直進する冷却剤ジェットによって、冷却剤ジェットの冷却効果に何ら大きな変化もなしに、　　から　　の間の距離で、冷却されるべきロール表面を冷却することができる。
【００１５】
冷却剤圧力の低下はまた、負荷の低減、その結果としてノズルの摩耗の低減に関係するので、これもまた、冷却棒の冷却剤圧力の低下の結果、保守費用が低減され、これがフルジェットノズルの使用の別の利点である。
【００１６】
本発明の一実施形態では、冷却棒が、冷却剤を受け入れるための、相互に分離した少なくとも　つの冷却剤室に分割されることが想定されている。各冷却剤室は、複数のフルジェットノズルが配置された冷却棒の吐出側面の部分領域に対応し、フルジェットノズルのそれぞれを通して、冷却剤ジェットを冷却剤室からロールに向けて吐出することができる。冷却棒の吐出側面の異なる部分領域に対応する、相互に分離した複数の冷却剤室に、冷却棒を分割すると、互いに独立して、部分領域の冷却剤圧力を制御し、その結果、部分領域によって吐出される冷却剤流量を制御することによって、部分領域の冷却効果を互いに独立して制御することができることは有利である。それによって、位置に応じてロールの

冷却に影響を与えることが可能となり、ロール表面のより強く加熱された領域、例えば、ロール表面の中央領域を、それほど強く加熱されていない領域よりも確実に強く冷却することができることは有利である。

【００１７】

本発明の上記の実施形態の展開としては、第 の冷却剤室が、冷却棒の吐出側面の第 の部分領域に対応し、第 の部分領域が、冷却棒の吐出側面の中心線に対して鏡面対称であり、その軸がロール軸に垂直であることが想定されている。例えば、中心線に並行する第 の部分領域の範囲は、ロール軸の方向に沿って変化し、中心線に沿って最大である。例えば、第 の部分領域は多角形である。第 の部分領域が中心線に対して鏡面対称の実施形態は、ロールが概ね同様に、中心線に対して対称的に加熱されるという事実を考慮している。中心線に並行する第 の部分領域の範囲がロール軸の方向に沿って変化し、中心線に沿って最大範囲を有することは、ロールが、一般に、中心において最も強く加熱され、ロールの加熱が縁領域に向けて減少するという事実を考慮している。したがって、これに対応した第 の部分領域の構成は、第 の部分領域によって、位置に依存したロールの熱負荷にロールの冷却を適合させることを可能にする。

【００１８】

本発明の別の実施形態では、各冷却剤室が、冷却剤室内に冷却剤を供給するための冷却剤供給ラインに接続され、冷却剤供給ラインが、冷却剤室内に、冷却剤の吐出方向に実質的に垂直に開口していることが想定されている。冷却剤供給ラインが、冷却棒内に、吐出方向に実質的に垂直に開口していることによって、各冷却剤室内の冷却剤の圧力分布をほとんど均一にすることができる。それによって、開口近くのフルジェットノズルと開口から離れたノルジェットノズルとの間の圧力勾配がなくなることは有利である。

【００１９】

本発明の別の実施形態では、冷却剤室内に供給される冷却剤の量を、それぞれの制御弁、および／または、それぞれのポンプによって互いに独立して制御することができることが想定されている。これによって、上記のように、個々の冷却剤室から吐出される冷却剤ジェットの冷却効果を互いに独立して制御することができる。例えば、通常、 の圧力で冷却水を送出する水供給システムなどの、例えば、いかなるときにも存在する従来の冷却剤供給システムを、関連する圧延システムにおいて使用することができる場合には、制御弁によって冷却剤の量を制御することが特に有利である。この場合、ロール冷却をするために複雑で高価な昇圧システム無しで済ますことができる。適当であれば、制御弁と共に、ポンプによって冷却剤の量を制御することによって、圧延間の休止時、または、低い冷却能力しか必要でない圧延作業の場合に、個々のポンプを止める、またはポンプの動力を下げることができ、それによって、エネルギー消費を低減することができる。

【００２０】

本発明の別の実施形態では、冷却剤室内に供給される冷却剤の量を制御するための自動化システムが想定されている。それによって、体積流量をロール表面の温度分布に適合させるために、冷却剤室からロールに吐出される冷却剤の体積流量を自動的に制御することができることは有利である。この場合、冷却剤室内に供給される冷却剤の量は、上記の制御弁および／またはポンプを制御することを通じて、自動化システムによって制御されることが好ましい。

【００２１】

本発明の別の実施形態では、ロール軸に平行な方向に沿って相互に隣り合うフルジェットノズルのノズル間隔が前記方向に沿って変化していることが想定されている。この場合、ノズル間隔は、冷却棒の吐出側面の中央領域において最も狭いことが好ましい。例えば、ロール軸に平行な方向に沿うノズル間隔は、約 から約 の間である。本発明のこれらの実施形態によって、また、ロール軸に平行な方向に沿うノズル間隔が位置に依存したロール表面の熱負荷に従って変えられるので、フルジェットノズルの配置をこの熱負荷に適合させることもできる。最小のノズル間隔が冷却棒の吐出側面の中央領域にあるのは、ロール表面の中央領域が一般に、最大の熱負荷を受けるという事実を考慮している。

【００２２】
本発明の別の実施形態では、フルジェットノズルが、相互に平行な複数のノズル列になるように配置されていることが想定されている。これによって、冷却剤をより広い範囲にわたって、かつ、ロールが回転することと併せて、均一にロールにかけることができることは有利である。
【００２３】
本発明の別の実施形態では、冷却棒が、フルジェットノズルが取り外し可能に固定された、各フルジェットノズルのためのノズル開口を有していることが想定されている。本発明のこの実施形態によって、不良なジェットノズルを容易に交換することができることは有利である。
【００２４】
本発明の別の実施形態では、ロールから冷却剤をぬぐい取るためのワイパが提供され、ワイパと冷却棒を一緒に枢動させることができる。例えば、ワイパによって、過剰な冷却剤が、圧延材に、および／または、圧延材が つのロール間を案内されるロール間隙に導かれて、圧延材とロールとの間の摩擦を低減するための潤滑剤を洗い流すことを防ぐことができることは有利である。ワイパと冷却棒が一緒に枢動することができることによって、冷却棒を動かすための追加の装置の必要が除かれることは有利である。この場合、上記ですでに言及したフルジェットノズルを使用する利点は、この場合にもまた効果がある。すなわち、フルジェットノズルを使用することによって、スプレー棒とロールとの間の距離は、広い範囲にわたってそれほど重要ではなくなり、したがって、ロール直径に適合させる必要がなくなる。さらに、本発明はまた、ワイパを有する既存の圧延システムに対しては改造策として特に適しており、例えば、従来の高圧スプレー棒のみを本発明による冷却棒に交換するだけでよい。
【００２５】
本発明による圧延スタンドは、ロール、および本発明による つの冷却装置を備え、 つの冷却装置は、ロールの反対側に配置される。本発明による圧延スタンドの利点は、上記ですでに言及した、本発明による冷却装置の利点から生じる。
【００２６】
この発明の上記の特性、特徴、および利点、ならびにこれらを達成する態様は、図面と併せてより詳細に説明される例示的な実施形態の以下の説明と関連して、より明確かつ明瞭に理解されるであろう。
【図面の簡単な説明】
【００２７】
【図１】冷却装置を有する圧延スタンドの概略図である。
【図２】冷却棒の第 の例示的な実施形態の概略斜視図である。
【図３】図 に示した冷却棒によって吐出される冷却剤の体積流量を位置の関数として示した図である。
【図４】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図５】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図６】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図７】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図８】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図９】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図１０】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図１１】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【図１２】冷却棒の第 の例示的な実施形態の吐出側面の図である。
【発明を実施するための形態】
【００２８】
すべての図面で、同じ部品には同じ参照符号が付けられている。
【００２９】

図 は、圧延素材 を圧延するための圧延スタンド の概略図である。圧延スタンド は、ワークロールとして設計された つのロール 、および各ロール に対して つの冷却装置 を備え、前記装置は、ロール の両側に配置されている。ロール は、ロール間隙 だけ間隔を置いて配置され、圧延材 を形成するために、圧延素材 をロール間隙 に圧延方向 に通す。各冷却装置 は、冷却棒 およびワイパ を備える。

【００３０】

各冷却棒 は、冷却剤を受け入れて吐出するように設計されている。冷却剤を吐出するために、冷却棒 は、冷却棒 の吐出側面 に配置された複数のフルジェットノズル を有し、前記側面は、それぞれのロール に面してロール のロール軸 に平行に延在し、ほぼ一定のジェット径の冷却剤ジェットを、フルジェットノズルのそれぞれを通して、冷却棒 からロール に向けて吐出方向 に吐出することができる。冷却剤は、冷却剤供給ライン を経て冷却棒 内に供給することができ、冷却棒 内に供給される冷却剤の量は、制御弁 、および／または、例えば周波数制御のポンプ によって制御することができる。冷却剤は、例えば、水である。

【００３１】

各ワイパ は、それぞれのロール から冷却剤をぬぐい取るように設計され、ロール に向かうように、またこれから離れるように枢動させることができる。各冷却装置 の冷却棒 およびワイパ は、冷却装置 の枢動装置に固定され、したがって、冷却棒 およびワイパ をロール に向かうように、またロール から離れるように一緒に枢動させることができることが好ましい。

【００３２】

図 は、ロール に冷却剤を吐出するための冷却棒 の第 の例示的な実施形態の概略斜視図である。冷却棒 は、相互に分離した つの冷却剤室 ～ に分割されて、冷却剤を受け入れる。各冷却剤室 ～ は、複数のフルジェットノズル が配置された吐出側面 の部分領域 ～ に対応し、冷却剤ジェットを冷却剤室 ～ からフルジェットノズルのそれぞれを通してロール に向けて吐出方向 に吐出することができる。吐出側面 は、ロール軸 に平行な つの長手方向辺 、 、およびロール軸 に垂直な つの短手方向辺 、 を有する長方形である。

【００３３】

第 の冷却剤室 は、吐出側面 の中央領域を形成する、冷却棒 の吐出側面 の第 の部分領域 に対応する。第 の部分領域 は、冷却棒 の吐出側面 の中心線 に対して鏡面対称であり、前記軸はロール軸 に垂直であり、第 の長手方向辺 に配置された つの頂点と、第 の長手方向辺 の端点にそれぞれ配置された つの頂点とを有する台形である。

【００３４】

フルジェットノズル は、それぞれがロール軸 に平行に延在する複数のノズル列 になって、吐出側面 に配置されている。この場合、各ノズル列 の相互に隣り合うフルジェットノズル のノズル間隔ｄは、中心線 に対して対称的に変化しており、その結果、ノズル間隔ｄは、吐出側面 の中央領域において最も狭く、吐出側面 の縁領域に向かって、例えば、放物線状に広くなっている。図 に示した例示的な実施形態では、ノズル間隔ｄは、各ノズル列 の端部ではノズル列 の中心での間隔の 倍大きくなっている。ノズル間隔ｄは、例えば、 から の間を変化する。ノズル列 は、吐出側面 の全範囲にわたって実質的に等間隔に延在し、したがって、ロール のロール表面に比較的均一な冷却効果を生じる。

【００３５】

図 に示した例示的な実施形態のさらなる展開としては、ノズル列 を互いに対してずらして配置することが想定され、したがって、様々なノズル列 のフルジェットノズル が、ロール軸 に垂直な方向に沿って配置されてはいない。「冷却チャネル」は、ノズル列 に垂直に延在して、そこでは、ロール に冷却剤が吐出されず、その結果、冷却効果が低下するが、この「冷却チャネル」を避けることができるので、ノズル列 の特に均一

な冷却効果が達成されることは有利である。
【００３６】
さらに、図 の隣り合う つの部分領域 ～ 間の境界線に非常に近い、または境界線上にあるフルジェットノズル は、完全に省かれるか、または、図 に示した配置に対してずらされて、隣接した部分領域 ～ の つに入るように配置され、それは分離板による冷却筒 の内部の冷却剤室 ～ への細分がこのような境界線に沿って延在するからである。
【００３７】
各フルジェットノズル は、冷却棒 のノズル開口に、例えば、ねじ込み継手によって取り外し可能に取り付けられる。フルジェットノズル はそれぞれ、例えば、約 の最小直径のノズル断面を有する。
【００３８】
各冷却剤室 ～ は、冷却剤室 ～ 内に冷却剤を供給するための冷却剤供給ライン に接続され、冷却剤供給ライン は、冷却剤室 ～ 内に、冷却剤の吐出方向 に実質的に垂直に開口している。冷却剤供給ライン の断面はそれぞれ、例えば、 からの間の直径を有する。
【００３９】
冷却剤供給ライン を経て冷却剤室 ～ 内に供給される冷却剤の量を、それぞれの制御弁 図 には示されていない 、および／または、それぞれのポンプ 図 には示されていない によって互いに独立して制御することができる。これによって、冷却剤室 ～ から吐出される冷却剤の量を、ロール表面の様々な領域の異なる熱負荷に対して適合させることができることは有利である。
【００４０】
図 は、一例として、図 に示した冷却棒 から吐出される つの冷却剤の体積流量 、 、 を、ロール軸 に平行な方向に沿う位置ｙの関数として示す。ここで、体積流量 、 、 は定格流量に対する比率で示されている。
【００４１】
定格流量は、中央位置ｙにおける第 の体積流量 である。第 の体積流量 は、冷却剤が、すべての冷却剤室 ～ に対して同じ与定の定格圧力で、すべての つの冷却剤室 ～ 内に供給された場合に生じる。第 の体積流量 は、中央位置ｙで最大となる放物線の形状を有し、中央位置ｙから つの端部領域に向かって減少して、中央位置ｙの値の半分になる。第 の体積流量 がこのような形状になる理由は、ノズル列 の中心から２つの端部へ、ノズル列 に沿うフルジェットノズル のノズル間隔ｄが 倍になるからであり、ノズル間隔ｄの放物線状の増大が仮定される。
【００４２】
第 の体積流量 は、定格圧力のほぼ 倍の冷却剤圧力で冷却剤を第 の冷却剤室 内に供給し、定格圧力のほぼ半分の冷却剤圧力で冷却剤を他の つの冷却剤室 、 内のそれぞれに供給した場合に生じる。
【００４３】
第 の体積流量 は、定格圧力のほぼ半分の冷却剤圧力で冷却剤を第 の冷却剤室 内に供給し、定格圧力のほぼ 倍の冷却剤圧力で冷却剤を他の つの冷却剤室 、 内のそれぞれに供給した場合に生じる。
【００４４】
図 は、ロール軸 に平行な方向に沿う位置ｙへの依存性が異なるパターンを有する体積流量 、 、 を、冷却剤室 ～ の異なる冷却剤圧力によって生じさせることができ、その結果、冷却棒 から吐出される体積流量 、 、 を、ロール表面の温度分布に適合させることができることを示している。各冷却剤室 ～ の冷却剤圧力は、それぞれの制御弁 および／またはそれぞれのポンプ によって設定される。
【００４５】
図 ～図 はそれぞれ、冷却棒 の別の例示的な実施形態の吐出側面 を示す。これら

の例示的な実施形態は、図 に示した例示的な実施形態とは、冷却剤室 ～ 、およびそれに対応する吐出側面 の部分領域 ～ の形状および数だけが異なる。図 に示した例示的な実施形態のように、フルジェットノズル はそれぞれ、複数のノズル列 になるように配置され、それぞれの場合のノズル間隔ｄは、それに沿って中央から つの端部に向かって増大する。したがって、図 ～図 のフルジェットノズル はここでまた説明することはしない。吐出側面 のフルジェットノズル の、図 に示した例示的な実施形態と同様な分布によって、図 ～図 に示される例示的な実施形態のそれぞれで、図 と同様な体積流量 、 、 を生じさせることができる。

【００４６】

図 に示した例示的な実施形態のように、図 ～図 に示した例示的な実施形態はそれぞれ、 つの冷却剤室 ～ 、および吐出側面 にそれに対応する部分領域 ～ を有する。図 に示した例示的な実施形態と同様に、第 の部分領域 は、冷却棒 の吐出側面 の、ロール軸 に垂直な中心線 に対して鏡面対称であり、他の つの部分領域 、 は、第 の部分領域 と中心線 の異なる側で隣接する。

【００４７】

図 は、第 の部分領域 が、第 の長手方向辺 に配置された つの頂点と、第 の長手方向辺 に配置された つの頂点とを有する台形である例示的な実施形態を示す。

【００４８】

図 は、第 の部分領域 が、中心線 と第 の長手方向辺 との交点に配置された つの頂点と、第 の長手方向辺 の端部に配置された つの頂点とを有する三角形である例示な実施形態を示す。

【００４９】

図 は、第 の部分領域 が、中心線 と第 の長手方向辺 との交点に配置された つの頂点と、第 の長手方向辺 に配置された つの頂点とを有する三角形である例示的な実形態を示す。

【００５０】

図 は、第 の部分領域 が、頂点が長手方向辺 、 に配置された長方形である例示的な実施形態を示す。この例示的な実施形態では、 つの外側の部分領域 、 を経て冷却剤を吐出しないので、冷却剤の吐出を吐出側面 の中央領域からのみ生じさせることができる。したがって、この例示的な実施形態は、異なる幅の圧延素材 を圧延するのに特に適している。

【００５１】

図 は、第 の部分領域 および第 の部分領域 がそれぞれ、第 の長手方向辺 上の頂点と、第 の長手方向辺 の一端に配置された頂点と、短手方向辺 、 に配置された頂点とを有する長方形である例示的な実施形態を示す。

【００５２】

図 は、第 の部分領域 が、第 の長手方向辺 上の つの頂点と、第 の長手方向辺 の端部にそれぞれ配置された つの頂点と、それぞれの短手方向辺 、 上の頂点とを有する六角形である例示的な実施形態を示す。

【００５３】

図 は、第 の部分領域 が、中心線 と第 の長手方向辺 との交点に配置された つの頂点と、第 の長手方向辺 の端部にそれぞれ配置された つの頂点と、それぞれの短手方向辺 、 上の つの頂点とを有する五角形である例示的な実施形態を示す。

【００５４】

図 および図 に示した例示的な実施形態はそれぞれ、 つの冷却剤室 、 、およびそれに対応する、吐出側面 の部分領域 、 を有する。両方の部分領域 は、冷却棒 の吐出側面 の、ロール軸 に垂直な中心線 に対して鏡面対称である。

【００５５】

図 は、第 の部分領域 が、中心線 に配置された つの頂点と、第 の長手方向辺 の端部にそれぞれ配置された つの頂点とを有する三角形である例示的な実施形態を示す

。
【００５６】
図　は、第　の部分領域　が、中心線　に配置された　つの頂点と、第　の長手方向辺　の端部にそれぞれ配置された　つの頂点と、それぞれの短手方向辺　、　上の頂点とを有する五角形である例示的な実施形態を示す。
【００５７】
本発明を、好ましい例示的な実施形態によって、より詳細に例示および説明したが、本発明は、開示した例に限定されるものではなく、当業者は、本発明の保護の範囲を超えずにこれらから他の変形を得ることができる。
【符号の説明】
【００５８】
圧延スタンド
圧延素材、圧延材
ロール
冷却装置
ロール間隙
圧延方向
冷却棒
ワイパ
ロール軸
吐出側面
ノルジェットノズル
吐出方向
～　冷却剤室
～　部分領域
、　長手方向辺
、　短手方向辺
中心線
ノズル列
冷却剤供給ライン
制御弁
ポンプ
ノズル間隔

【図１】

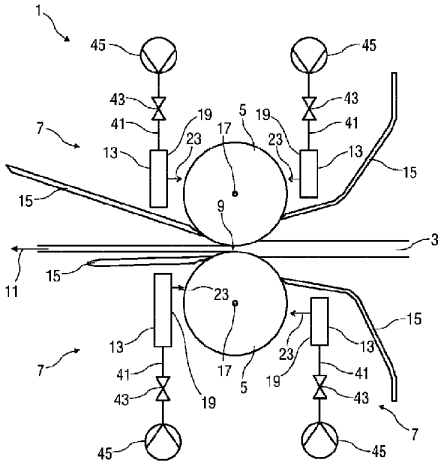


FIG 1

【図２】

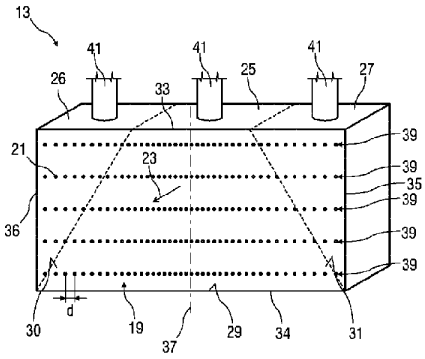


FIG 2

【図３】

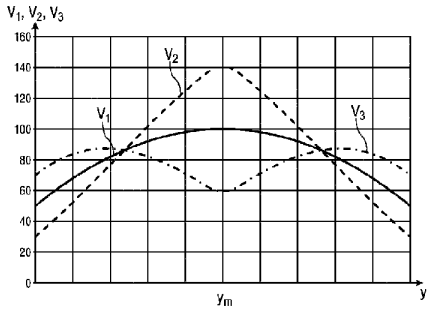


FIG 3

【図４】

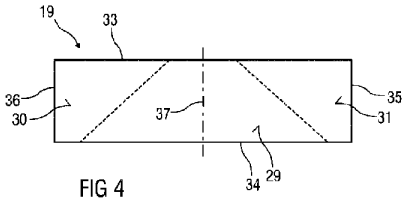


FIG 4

【図５】

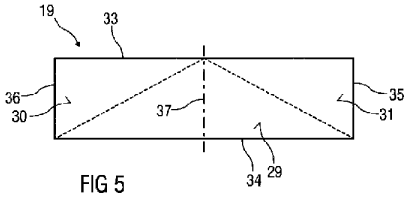


FIG 5

【図６】

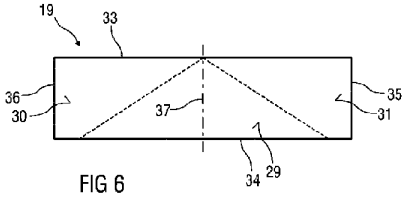


FIG 6

【図７】

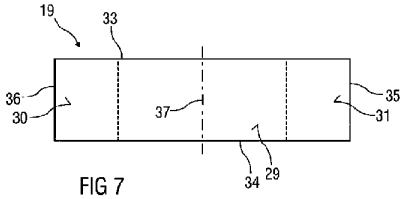


FIG 7

【図８】

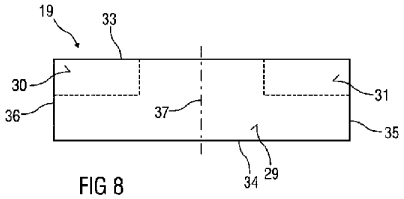


FIG 8

【図９】

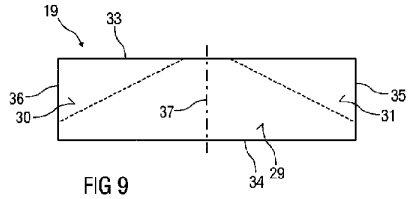


FIG 9

【図１０】

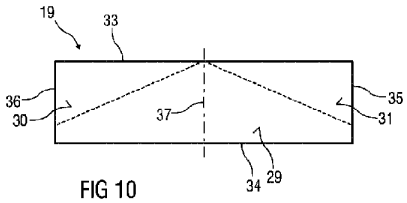


FIG 10

【図１１】

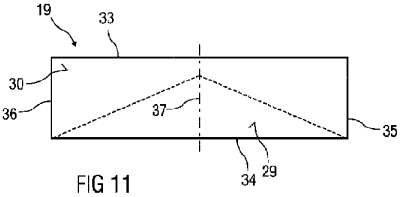


FIG 11

【図１２】

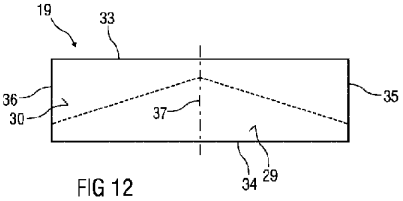


FIG 12

【国際調査報告】

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/076000

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21B27/10
ADD.

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)
B21B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 200 06 508 U1 (ACHENBACH BUSCHHUETTEN GMBH [DE]) 31 August 2000 (2000-08-31)	1,15
Y	page 5, paragraph 3 - page 7, paragraph 3	2-5

X	WO 2008/149195 A1 (ARCELORMITTAL FRANCE [FR]; VANDERSCHUEREN DIRK [BE]; VAN POECKE PATRIC) 11 December 2008 (2008-12-11)	1,15
Y	page 3, line 20 - page 4, line 12; figures 1,2	2-5

Y	EP 2 792 428 A1 (SIEMENS VAI METALS TECH GMBH [AT]) 22 October 2014 (2014-10-22) paragraph [0017] - paragraph [0027]; figures 1-3	2-5

A	WO 2015/113832 A1 (LOI THERMPROCESS GMBH [DE]) 6 August 2015 (2015-08-06) page 4, line 8 - line 17	1

☐ 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

"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
11 January 2018	06/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	Frisch, Ulrich

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/076000

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:

see additional sheet

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.:
1-5, 15

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.

The International Searching Authority has found that the international application contains multiple (groups of) inventions, as follows:

1. Claims 1-5, 15

Cooling device for cooling a roller, wherein two coolant chambers are provided which are separated from each other.

---

2. Claims 1, 6-8

Cooling device for cooling a roller, wherein the feed/control of the coolant is further defined.

---

3. Claims 1, 9-13

Cooling device for cooling a roller, wherein the distance of the nozzles is defined.

---

4. Claims 1, 14

Cooling device for cooling a roller, wherein an additional stripper is defined.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/076000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 20006508 U1	31-08-2000	DE 20006508 U1	31-08-2000
		EP 1142652 A2	10-10-2001
		JP 2001347307 A	18-12-2001
		US 2001027672 A1	11-10-2001
WO 2008149195 A1	11-12-2008	AU 2008259470 A1	11-12-2008
		BR PI0812201 A2	25-11-2014
		CA 2690098 A1	11-12-2008
		CN 101702888 A	05-05-2010
		EP 2014379 A1	14-01-2009
		EP 2164651 A1	24-03-2010
		JP 5380438 B2	08-01-2014
		JP 2010528870 A	26-08-2010
		KR 20100020462 A	22-02-2010
		RU 2009149178 A	20-07-2011
		SI 2164651 T1	30-08-2013
		UA 99295 C2	10-08-2012
		US 2010180657 A1	22-07-2010
		WO 2008149195 A1	11-12-2008
		ZA 200908405 B	28-07-2010
EP 2792428 A1	22-10-2014	CN 105188975 A	23-12-2015
		EP 2792428 A1	22-10-2014
		EP 2986400 A1	24-02-2016
		JP 6110015 B2	05-04-2017
		JP 2016515474 A	30-05-2016
		KR 20150143746 A	23-12-2015
		RU 2015141167 A	17-05-2017
		US 2016052033 A1	25-02-2016
		WO 2014170139 A1	23-10-2014
WO 2015113832 A1	06-08-2015	DE 102014001146 A1	06-08-2015
		EP 3099829 A1	07-12-2016
		WO 2015113832 A1	06-08-2015

Form PCT/ISA/210 (patent family annex) (April 2005)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2017/076000

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B21B27/10
ADD.

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
B21B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	DE 200 06 508 U1 (ACHENBACH BUSCHHUETTEN GMBH [DE]) 31. August 2000 (2000-08-31)	1,15
Y	Seite 5, Absatz 3 - Seite 7, Absatz 3	2-5

X	WO 2008/149195 A1 (ARCELORMITTAL FRANCE [FR]; VANDERSCHUEREN DIRK [BE]; VAN POECKE PATRIC) 11. Dezember 2008 (2008-12-11)	1,15
Y	Seite 3, Zeile 20 - Seite 4, Zeile 12; Abbildungen 1,2	2-5

Y	EP 2 792 428 A1 (SIEMENS VAI METALS TECH GMBH [AT]) 22. Oktober 2014 (2014-10-22) Absatz [0017] - Absatz [0027]; Abbildungen 1-3	2-5

A	WO 2015/113832 A1 (LOI THERMPROCESS GMBH [DE]) 6. August 2015 (2015-08-06) Seite 4, Zeile 8 - Zeile 17	1

☐ Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen ☒ Siehe Anhang Patentfamilie

* Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" frühere Anmeldung oder Patent, die bzw. das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)
"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist
"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist
"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
11. Januar 2018	06/03/2018

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Frisch, Ulrich

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Formblatt PCT/ISA/210 (Blatt 2) (April 2005)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2017/076000

Feld Nr. II Bemerkungen zu den Ansprüchen, die sich als nicht recherchierbar erwiesen haben (Fortsetzung von Punkt 2 auf Blatt 1)

Gemäß Artikel 17(2)a) wurde aus folgenden Gründen für bestimmte Ansprüche kein internationaler Recherchenbericht erstellt:

1. ☐ Ansprüche Nr.
weil sie sich auf Gegenstände beziehen, zu deren Recherche diese Behörde nicht verpflichtet ist, nämlich

2. ☐ Ansprüche Nr.
weil sie sich auf Teile der internationalen Anmeldung beziehen, die den vorgeschriebenen Anforderungen so wenig entsprechen, dass eine sinnvolle internationale Recherche nicht durchgeführt werden kann, nämlich

3. ☐ Ansprüche Nr.
weil es sich dabei um abhängige Ansprüche handelt, die nicht entsprechend Satz 2 und 3 der Regel 6.4 a) abgefasst sind.

Feld Nr. III Bemerkungen bei mangelnder Einheitlichkeit der Erfindung (Fortsetzung von Punkt 3 auf Blatt 1)

Diese Internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere Erfindungen enthält:

siehe Zusatzblatt

1. ☐ Da der Anmelder alle erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht auf alle recherchierbaren Ansprüche.

2. ☐ Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Behörde nicht zur Zahlung solcher Gebühren aufgefordert.

3. ☐ Da der Anmelder nur einige der erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht nur auf die Ansprüche, für die Gebühren entrichtet worden sind, nämlich auf die Ansprüche Nr.

4. ☒ Der Anmelder hat die erforderlichen zusätzlichen Recherchengebühren nicht rechtzeitig entrichtet. Dieser internationale Recherchenbericht beschränkt sich daher auf die in den Ansprüchen zuerst erwähnte Erfindung; diese ist in folgenden Ansprüchen erfasst:
1-5, 15

Bemerkungen hinsichtlich eines Widerspruchs

☐ Der Anmelder hat die zusätzlichen Recherchengebühren unter Widerspruch entrichtet und die gegebenenfalls erforderliche Widerspruchsgebühr gezahlt.

☐ Die zusätzlichen Recherchengebühren wurden vom Anmelder unter Widerspruch gezahlt, jedoch wurde die entsprechende Widerspruchsgebühr nicht innerhalb der in der Aufforderung angegebenen Frist entrichtet.

☐ Die Zahlung der zusätzlichen Recherchengebühren erfolgte ohne Widerspruch.

WEITERE ANGABEN PCT/ISA/ 210

Die internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere (Gruppen von) Erfindungen enthält, nämlich:

1. Ansprüche: 1-5, 15

   Kühlvorrichtung zur Kühlung einer Walze, wobei zwei voneinander getrennte Kühlmittelkammern vorgesehen sind.

   ---

2. Ansprüche: 1, 6-8

   Kühlvorrichtung zur Kühlung einer Walze, wobei die Zuleitung / Steuerung des Kühlmittels weiter definiert wird.

   ---

3. Ansprüche: 1, 9-13

   Kühlvorrichtung zur Kühlung einer Walze, wobei der Abstand der Düsen definiert wird.

   ---

4. Ansprüche: 1, 14

   Kühlvorrichtung zur Kühlung einer Walze, wobei ein zusätzlicher Abstreifer definiert wird

   ---

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2017/076000

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
DE 20006508 U1	31-08-2000	DE 20006508 U1	31-08-2000
		EP 1142652 A2	10-10-2001
		JP 2001347307 A	18-12-2001
		US 2001027672 A1	11-10-2001
WO 2008149195 A1	11-12-2008	AU 2008259470 A1	11-12-2008
		BR PI0812201 A2	25-11-2014
		CA 2690098 A1	11-12-2008
		CN 101702888 A	05-05-2010
		EP 2014379 A1	14-01-2009
		EP 2164651 A1	24-03-2010
		JP 5380438 B2	08-01-2014
		JP 2010528870 A	26-08-2010
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BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE AND METHOD

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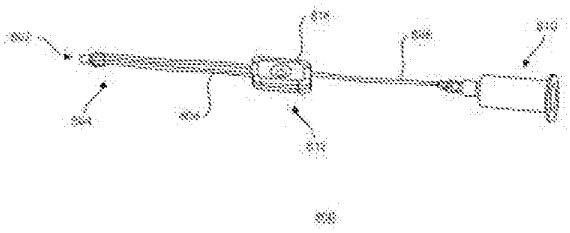
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Blood sample optimization systems and methods are described that reduce or eliminate contaminates in collected blood samples, which in turn reduces or eliminates false positive readings in blood cultures or other testing of collected blood samples. A blood sample optimization system can include a blood sequestration device located between a patient needle and a sample needle. The blood sequestration device can include a sequestration chamber for sequestering an initial, potentially contaminated aliquot of blood, and may further include a sampling channel that bypasses the sequestration chamber to convey likely uncontaminated blood between the patient needle and the sample needle after the initial aliquot of blood is sequestered in the sequestration chamber.

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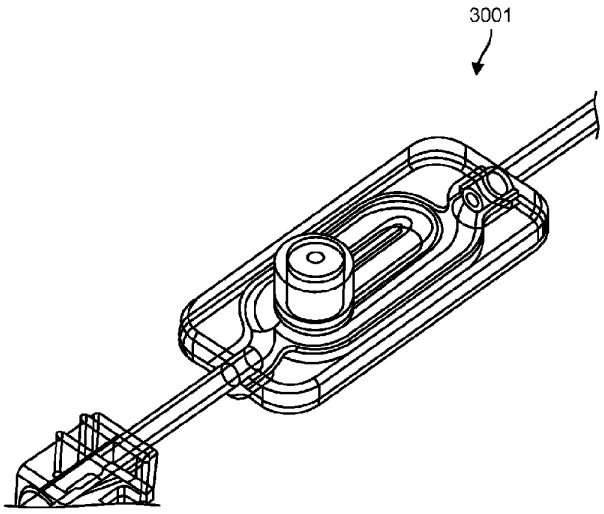


FIG. 30B

(57) Abstract: Blood sample optimization systems and methods are described that reduce or eliminate contaminates in collected blood samples, which in turn reduces or eliminates false positive readings in blood cultures or other testing of collected blood samples. A blood sample optimization system can include a blood sequestration device located between a patient needle and a sample needle. The blood sequestration device can include a sequestration chamber for sequestering an initial, potentially contaminated aliquot of blood, and may further include a sampling channel that bypasses the sequestration chamber to convey likely uncontaminated blood between the patient needle and the sample needle after the initial aliquot of blood is sequestered in the sequestration chamber.

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BLOOD SAMPLE OPTIMIZATION SYSTEM AND BLOOD CONTAMINANT SEQUESTRATION DEVICE AND METHOD

BACKGROUND

[0001] Bacteraemia is the presence of microorganisms in the blood. Sepsis, on the other hand, is bacteraemia in the presence of clinical symptoms and signs such as fever, tachycardia, tachypnea and hypotension. Bacteraemia and sepsis are associated with a high mortality and an increased incidence and duration of hospital stay and associated costs. Many bacteraemias, sepsis, fungaemias and other pathogens actually occur within a hospital or other healthcare settings with catheters and venipunctures being a source of contamination as potential carriers of these pathogens.

[0002] Blood cultures are the standard test used to detect microbial pathogens related to bacteraemia and sepsis in a patient's blood. The term blood culture refers to a single venipuncture, either from a peripheral site or central or arterial line, with the blood inoculated into one or more blood culture bottles or containers. One bottle is considered a blood culture where two or more are considered a set. Multiple sets may be obtained from multiple venipunctures and are associated with different sites on the patient.

[0003] These methods allow for microbial identification and susceptibility testing to be performed, which is a critical component to managing sepsis, however the lack of rapid results and decreased sensitivity for fastidious pathogens has led to the development of improved systems and adjunctive molecular or proteomic testing.

[0004] Collection of blood samples for conducting blood cultures is a critical component of modern patient care and can either positively affect the patient outcome by providing an accurate diagnosis, or can adversely affect the outcome by prolonging unnecessary antimicrobial therapy, the length of hospital stays, and increasing costs.

[0005] One outcome of collection of blood cultures is contamination. Blood culture contamination can lead to a false positive culture result and/or significant increase in healthcare related costs. Sources of blood culture contamination include improper skin antisepsis, improper collection tube disinfection, and contamination of the initial blood draw which may then skew results.

[0006] Blood culture collection kits generally consist of a "butterfly" set, infusion set, or other type of venipuncture device as offered by companies like BD, Smiths, B. Braun and others, and aerobic and anaerobic blood culture bottles. Various different bottles are also available depending on the test requirements. These bottles are specifically designed to optimize recovery of both aerobic and anaerobic organisms. In conventional kits, a bottle used is known generally as a "Vacutainer," which is a blood collection tube formed of a sterile glass or plastic tube with a closure that is evacuated to create a vacuum inside the tube to facilitate the draw of a predetermined volume of liquid such as blood.

[0007] False positive blood cultures are typically a result of poor sampling techniques. They cause the use of antibiotics when not needed, increasing hospital costs and patient anxiety. Blood cultures are drawn from a needlestick into the skin, and then a Vacutainer is attached to capture a sample of blood. Contamination may occur from improper or incomplete disinfection of the skin area in and around the puncture site. It may also occur from the coring of the skin by the needle during insertion, with the cored skin cells and any associated contamination being pulled into the sample.

[0008] Blood flow through a hypodermic needle is laminar, and as such, a velocity gradient can be developed over the flow tube as a pressure drop is applied to the hypodermic needle. Either forceful aspiration of blood, or using a very small hypodermic needle, can cause lysis and a release of potassium from the red blood cells, thereby rendering the blood samples abnormal.

[0009] In other instances, some patients have delicate veins that can collapse under a pressure drop or vacuum, particularly as applied by a syringe's plunger that is drawn too quickly for the patient's condition. Since such condition is impossible to know beforehand, such vein collapses are a risk and very difficult to control.

[0010] Various strategies have been implemented to decrease blood culture contamination rates, e.g. training staff with regard to aseptic collection technique, feedback with regard to contamination rates and implementation of blood culture collection kits. Although skin antisepsis can reduce the burden of contamination, 20% or more of skin organisms are located deep within the dermis and are unaffected by

antisepsis. Changing needles before bottle inoculation is not advisable as it increases the risk to acquire needle stick injuries without decreasing contamination rates.

[0011] Some conventional systems and techniques for reducing blood culture contamination include discarding the initial aliquot of blood taken from central venous catheters, venipunctures, and other vascular access systems. However, these systems require the user to mechanically manipulate an intravascular device, or require a complex series of steps that are difficult to ensure being followed.

SUMMARY

[0012] This document presents systems and methods for reducing blood culture contamination, lysing of cells, and vein collapse. In some implementations, a system and method can eliminate user variability in disinfection, and also eliminate the risk of skin cells getting into the blood culture sample. The systems and methods disclosed herein do not require a change in existing clinical processes, other than to potentially indicate when a vacutainer or other blood collection device (i.e., syringe) should be attached for drawing contaminant-free blood samples.

[0013] In some implementations of the systems and methods disclosed herein the withdrawal of blood is accomplished passively by use of the patient's own blood pressure, thereby reducing the risk of vein collapse and eliminating any additional user steps over current practice. The systems and methods can be applied to accommodate short-path direct stick or butterfly venipuncture systems. They can also be used with samples drawn through a catheter.

[0014] In one aspect, a blood sequestration device is presented. The blood sequestration device includes an inlet port and an outlet port. The blood sequestration device further includes a sequestration chamber connected with the inlet port, the sequestration chamber having a vent comprising an air permeable blood barrier. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port and a distal end connected with the outlet port.

[0015] In another aspect, a blood sequestration device connected with a blood sampling pathway is described. The blood sampling pathway has a patient needle and a sample collection device. The blood sequestration device includes an inlet port connected

with the patient needle, and a sequestration chamber connected with the inlet port, the sequestration chamber having a vent comprising an air permeable blood barrier. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port, and an outlet port connected with a distal end of the sampling channel and with the sample collection device.

[0016] In yet another aspect, a blood sequestration device connected with a blood sampling system is described. The blood sampling system includes a patient needle for accessing a blood sample from a patient, and a sample needle that is sealed and adapted for receiving an evacuated blood collection tube. The blood sequestration device includes an inlet port connected with the patient needle to receive the blood sample from the patient. The blood sequestration device further includes a sequestration chamber connected with the inlet port and having a vent comprising an air permeable blood barrier, the sequestration chamber for receiving and sequestering a first portion of the blood sample prior to the sample needle being unsealed by the evacuated blood collection tube. The blood sequestration device further includes a sampling channel having a proximal end connected with the inlet port, the sampling channel for conveying a subsequent portion of the blood sample once the sample needle is unsealed by the evacuated blood collection tube. The blood sequestration device further includes an outlet port connected with a distal end of the sampling channel for conveying the subsequent portion of the blood sample to the sample needle.

[0017] In yet another aspect, a blood sample optimization system is disclosed and described. The blood sample optimization system includes a blood sampling system for accessing and acquiring one or more samples of a patient's blood, and a blood sequestration device for receiving and sequestering a first portion of the one or more samples of the patient's blood which might be contaminated by a venipuncture process and which could result in a false positive identification of a pathogen in the patient's blood.

[0018] The blood sampling system includes a patient needle configured for a venipuncture of a patient to access a sample of blood of a patient, a blood sampling pathway connected with the patient needle for conveying the sample of blood, and a sample needle configured for receiving an evacuated blood collection container to collect and contain a subsequent portion of the sample of blood.

[0019] In yet another aspect, a blood sequestration device is disclosed and described. In some implementations, the blood sequestration device can include an inlet port, an outlet port connected with the inlet port, and a sequestration chamber connected with the inlet port. The sequestration chamber can have a vent comprising an air permeable blood barrier.

[0020] The blood sequestration device, in one aspect can include an inlet port, an outlet port, a sequestration chamber connected with the inlet port via a junction, the sequestration chamber having a vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further includes a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber, and a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port. In certain related aspects, the sequestration chamber, the sampling channel and the junction are sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0021] In another aspect, the sampling channel and the junction is sized and configured such that a first portion of blood flows into and fills the sequestration chamber to displace air therein through the vent, and such that a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0022] The blood sequestration and sampling system sequestration device, in certain aspects can include a blood sampling pathway having a patient needle on a proximal end and a sample collection device on a distal end; and a blood sequestration device attached on the blood sampling pathway between the proximal end and distal end of the blood sampling pathway. The blood sequestration device in one aspect can include an inlet port coupled with the blood sampling pathway toward the patient needle, an outlet port coupled with the blood sampling pathway toward the sample collection device, a sequestration chamber connected with the inlet port via a junction, which chamber has a

vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further including a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port. In a certain related aspect, the sequestration chamber, the sampling channel and the junction can be sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

[0023] The blood sequestration device is connected along the blood sampling pathway between the patient needle and the sample needle, and includes an inlet port for receiving the sample of blood. The blood sequestration device further includes a sequestration chamber connected with the inlet port for receiving a first amount of the sample of blood, the sequestration chamber having a vent comprising an air permeable blood barrier for sequestering at least a first portion of the first amount of the sample of blood. The blood sequestration device may further include a sampling channel having a proximal end connected with the inlet port, the sampling channel conveying a subsequent amount of the sample of blood to the evacuated blood collection container upon the sequestration chamber sequestering at least the first portion of the first amount of the sample of blood. The blood sequestration device further includes an outlet port connected with a distal end of the sampling channel, the outlet port for outputting the subsequent amount of the sample of blood.

[0024] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and other aspects will now be described in detail with reference to the following drawings.

[0026] FIG. 1 illustrates a blood sample optimization system.

[0027] FIG. 2 illustrates a blood sample optimization system in accordance with an alternative implementation.

[0028] FIG. 3 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0029] FIG. 4 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0030] FIG. 5 illustrates a blood sample optimization system in accordance with another alternative implementation.

[0031] FIG. 6 illustrates a blood sample optimization system in accordance with an alternative implementation.

[0032] FIG. 7 is a flowchart of a method for optimizing a quality of a blood culture.

[0033] FIGS. 8A – 8E illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with some implementations.

[0034] FIG. 9 illustrates a pathway splitter for use in a blood sequestrations system.

[0035] FIGS. 10A – 10D illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with alternative implementations.

[0036] FIGS. 11A – 11E illustrate a blood sequestration system for non-contaminated blood sampling, in accordance with other alternative implementations.

[0037] FIGS. 12A-12D illustrate a blood sample optimization system including a blood sequestration device in accordance with yet other alternative implementations.

[0038] FIGS. 13A-13D illustrate a blood sample optimization system 1300 in accordance with yet another alternative implementations.

[0039] FIGS. 14A-14E illustrate yet another implementation of a blood sampling system to sequester contaminates of an initial aliquot or sample to reduce false positives in blood cultures or tests performed on a patient's blood sample.

[0040] FIGS. 15A-15G illustrate a blood sequestration device and method of using the same, in accordance with yet another implementation.

[0041] FIGS. 16A-16D illustrate a blood sequestration device in accordance with yet another implementation.

[0042] FIGS. 17A – 17E illustrate a bottom member of a housing for a blood sequestration device.

[0043] FIGS. 18A – 18F illustrate a top member of a housing for a blood sequestration device.

[0044] FIGS. 19A and 19B illustrate a blood sequestration device having a top member mated with a bottom member.

[0045] FIG. 20 shows a blood sample optimization system including a blood sequestration device.

[0046] FIG. 21 illustrates a non-vented blood sequestration device using a wicking material chamber.

[0047] FIGS. 22A and 22B illustrate a material makeup of a filter for sequestering blood in a sequestration chamber of a blood sequestration device.

[0048] FIGS. 23A – 23E illustrate another implementation of a blood sequestration device that uses a vacuum force from a blood collection device.

[0049] FIGS. 24A – 24D illustrate another implementation of a blood optimization system and blood sequestration device.

[0050] FIGS. 25A – 25D illustrate another implementation of a blood optimization system and blood sequestration device.

[0051] FIGS. 26A – 26E illustrate another implementation of a blood optimization system and blood sequestration device.

[0052] FIGS. 27A – 27D illustrate another implementation of a blood optimization system and blood sequestration device.

[0053] FIGS. 28A – 28F illustrate another implementation of a blood optimization system and blood sequestration device.

[0054] FIGS. 29A – 29C illustrate another implementation of a blood optimization system and blood sequestration device.

[0055] FIGS. 30A – 30G illustrate another implementation of a blood optimization system and blood sequestration device.

[0056] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0057] This document describes blood sample optimization systems and methods for reducing or eliminating contaminates in collected blood samples, which in turn reduces or eliminates false positive readings in blood cultures or other testing of collected blood samples. In some implementations, a blood sample optimization system includes a patient needle for vascular access to a patient's bloodstream, a sample needle for providing a blood sample to a blood collection container, such as an evacuated blood collection container or tube like a Vacutainer™ or the like, or other sampling device, and a blood sequestration device located between the patient needle and the sample needle. The blood sequestration device includes a sequestration chamber for sequestering an initial, potentially contaminated aliquot of blood, and may further include a sampling channel that bypasses the sequestration chamber to convey likely uncontaminated blood between the patient needle and the sample needle after the initial aliquot of blood is sequestered in the sequestration chamber.

[0058] FIG. 1 illustrates a blood sample optimization system in accordance with some implementations. The system includes a patient needle 1 to puncture the skin of a patient to access the patient's vein and blood therein. The system further includes a sample needle (i.e., a resealably closed needle for use with Vacutainers™ or the like) 5, which may be contained within and initially sealed by a resealable boot 10, a Luer activated valve, or another collection interface or device. The resealable boot 10 can be

pushed aside or around the sample needle 5 by application of a Vacutainer™ bottle (not shown) for drawing the patient's blood. The system can further include a low volume chamber 30 that leads to the sample needle 5, but also includes an orifice or one or more channels 45 that lead to a sequestration chamber 55 formed by a housing 50.

[0059] The sequestration chamber 55 is a chamber, channel, pathway, lock, or other structure for receiving and holding a first aliquot of the patient's blood, which may be in a predetermined or measured amount, depending on a volume of the sequestration chamber 55. The first draw of blood typically contains or is more susceptible to containing organisms that cause bacteraemia and sepsis or other pathogens than subsequent blood draws. The sequestration chamber 55 can be a vessel encased in a solid housing, formed in or defined by the housing itself, or can be implemented as tubing or a lumen. The sequestration chamber 55, regardless how formed and implemented, may have a predetermined volume. In some implementations, the predetermined volume may be based on a volume of the patient needle, i.e. ranging from less than the volume of the patient needle to any volume up to or greater than 20 times or more of the volume of the patient needle. The predetermined volume of the sequestration chamber 55 may also be established to economize or minimize an amount of blood to be sequestered and disposed of.

[0060] The sequestration chamber 55 can be formed, contained or housed in a chamber housing 50, and can be made of plastic, rubber, steel, aluminum or other suitable material. For example, the sequestration chamber 55 could be formed of flexible tubing or other elastomeric materials. The sequestration chamber 55 further includes an air permeable blood barrier 20 that allows air to exit the sequestration chamber 55. As used herein the term "air permeable blood barrier" means an air permeable but substantially blood impermeable substance, material, or structure. Examples may include hydrophobic membranes and coatings, a hydrophilic membrane or coating combined with a hydrophobic membrane or coating, mesh, a filter, a mechanical valve, antimicrobial material, or any other means of allowing air to be displaced from the sequestration chamber 55 as it is filled with blood. In various exemplary embodiments, an air permeable blood barrier may be formed by one or more materials that allow air to pass through until contacted by a liquid, such material then becomes completely or partially sealed to prevent or inhibit the passage of air and/or liquid. In other words, prior to contact with liquid, the material forms a barrier that is air permeable. After contact with a

liquid, the material substantially or completely prevents the further passage of air and/or liquid.

[0061] The orifice or channel 45 can be any desired length, cross-sectional shape or size, and/or can be formed to depart from the low volume chamber 30 at any desired angle or orientation. The orifice or channel 45 may also include a one-way flap or valve 60 that maintains an initial aliquot of blood sample within the sequestration chamber 55. In some specific implementations, the orifice or channel 45 can include a "duck bill" or flapper valve 60, or the like, for one-way flow of blood from low volume chamber 30 to the sequestration chamber 55. The air permeable blood barrier 20 can also be constructed of a material that allows air to exit but then seals upon contact with blood, thereby not allowing external air to enter sequestration chamber 55. This sealing would eliminate the need for a valve.

[0062] Valve 60 can be any type of valve or closing mechanism. Chamber 30 is designed to hold virtually no residual blood, and can be designed to be adapted to hold or allow pass-through of a particular volume or rate of blood into sequestration chamber 55. Likewise, sequestration chamber 55 may also include any type of coating, such as an anti-microbial coating, or a coating that aids identification and/or diagnosis of components of the first, sequestered blood draw.

[0063] Housing 50 and 40 can be formed of any suitable material, including plastic, such as acrylonitrile butadiene styrene (ABS) or other thermoplastic or polymeric material, rubber, steel, or aluminum. The air permeable blood barrier 20 can include a color-providing substance, or other signaling mechanism, that is activated upon contact with blood from the initial blood draw, or when air displacement is stopped, or any combination of events with blood in the sequestration chamber 55. The air permeable barrier may also include an outer layer such as a hydrophobic membrane or cover that inhibits or prevents the inadvertent or premature sealing of the filter by an external fluid source, splash etc. Sequestration chamber 55 can also be translucent or clear to enable a user to visually confirm the chamber is filled.

[0064] FIG. 2 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown in FIG. 2, a sequestration chamber 55, or waste chamber, surrounds the patient needle 1, with an

open-ended cuff or housing connected with the waste chamber and encircling the sample needle housing base and housing. The patient needle 1 and sample needle 5 are connected together by a boot 56, which forms a continuous blood draw channel therethrough. The boot 56 includes a single orifice or channel leading from the blood draw channel into sequestration chamber 55. The device can include more than one single orifice or channel, in other implementations. Each orifice or channel can include a one-way valve, and can be sized and adapted for predetermined amount of blood flow.

[0065] The sequestration chamber 55 includes an air permeable blood barrier. The filter can further include a sensor or indicator to sense and/or indicate, respectively, when a predetermined volume of blood has been collected in the sequestration chamber 55. That indication will alert a user to attach an evacuated blood collection tube or bottle, such as a Vacutainer™ to the sample needle 5. The housing for the sequestration chamber 55 can be any size or shape, and can include any type of material to define an interior space or volume therein. The interior space is initially filled only with air, but can also be coated with an agent or substance, such as a decontaminate, solidifying agent, or the like. Once evacuated blood collection tube is attached to the sample needle 5, blood will flow automatically into the patient needle 1, through the blood draw channel and sample needle 5, and into the bottle. The sample needle 5 is covered by a resealable boot, coating or membrane that seals the sample needle when a blood collection bottle is not attached thereon or thereto.

[0066] FIG. 3 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown, a sample needle 5 is surrounded by a resealable boot or membrane, and is further connected with a patient needle 1. A blood flow channel is formed through the sample needle and the patient needle. The connection between the sample needle and patient needle includes a "T" or "Y" connector 102, which includes a channel, port or aperture leading out from the main blood flow channel to a sequestration chamber 104.

[0067] The T or Y connector 102 may include a flap or one-way valve, and have an opening that is sized and adapted for a predetermined rate of flow of blood. The sequestration chamber 104 can be formed from tubing, or be formed by a solid housing, and is initially filled with air. The sequestration chamber 104 will receive blood that flows out of a patient automatically, i.e. under pressure from the patient's own blood

pressure. The sequestration chamber 104 includes an air permeable blood barrier 106, preferably at the distal end of tubing that forms the sequestration chamber 104, and which is connected at the proximal end to the T or Y connector 102. The T or Y connector 102 can branch off at any desired angle for most efficient blood flow, and can be formed so as to minimize an interface between the aperture and channel and the main blood flow channel, so as to minimize or eliminate mixing of the initial aliquot of blood with main blood draw samples.

[0068] In some alternative implementations, the sample needle may be affixed to a tubing of any length, as shown in FIG. 4, connecting at its opposite end to the T or Y connector 102. The sequestration chamber 104 can be any shape or volume so long as it will contain a predetermined amount of blood sample in the initial aliquot. The T or Y connector 102 may also include an opening or channel that is parallel to the main blood flow channel. The air permeable blood barrier may further include an indicator 107 or other mechanism to indicate when a predetermined amount of blood has been collected in the sequestration chamber, or when air being expelled reaches a certain threshold, i.e. to zero. The tubing can also include a clip 109 that can be used to pinch off and prevent fluid flow therethrough.

[0069] Once the air permeable blood barrier and primary chamber are sealed the initial aliquot of blood is trapped in the sequestration chamber 104, an evacuated blood collection tube, such as a Vacutainer™ bottle may be attached to the sample needle 5 to obtain the sample. The blood collection tube can be removed, and the sample needle 5 will be resealed. Any number of follow-on blood collection tubes can then be attached for further blood draws or samples. Upon completion of all blood draws, the system can be discarded, with the initial aliquot of blood remaining trapped in the sequestration chamber 104.

[0070] FIG. 5 illustrates a blood sample optimization system in accordance with some alternative implementations. In the implementation shown, a sample needle 5 is connected with a patient needle by tubing. A "T" or "Y" connector 120 is added along the tubing at any desired location, and includes an aperture, port or channel leading to a sequestration chamber 204, substantially as described above.

[0071] FIG. 6 illustrates a blood sample optimization system in accordance with some alternative implementations, in which a sequestration chamber 304, formed as a primary collection channel, receives an initial aliquot of blood, and is provided adjacent to the blood sampling channel. The sequestration chamber 304 can encircle the blood sampling channel, the patient needle 1, and/or the sample needle 5. The primary collection channel can include a T or Y connector 120, or other type of aperture or channel. The sequestration chamber 304 includes an air permeable blood barrier, which can also include an indicator of being contacted by a fluid such as blood, as described above.

[0072] In some implementations, either the patient needle 1 or the sample needle 5, or both, can be replaced by a Luer lock male or female connector. However, in various implementations, the connector at a sample needle end of the blood sample optimization system is initially sealed to permit the diversion of the initial aliquot of blood to the sequestration chamber, which is pressured at ambient air pressure and includes the air outlet of the air permeable blood barrier. In this way, the system passively and automatically uses a patient's own blood pressure to overcome the ambient air pressure of the sequestration chamber to push out air through the air permeable blood barrier and displace air in the sequestration chamber with blood.

[0073] FIG. 7 is a flowchart of an exemplary method for optimizing the quality of a blood culture. At 702, a clinician places a needle into a patient's vein. At 704, blood then flows into a sequestration chamber, pushing the air in the sequestration chamber out of the sequestration chamber through an air permeable blood barrier. In some implementations, the volume of the sequestration chamber is less than 0.1 to more than 5 cubic centimeters (cc's), or more. The sequestration chamber is sized and adapted to collect a first portion of a blood sample, which is more prone to contamination than secondary and other subsequent portion of the blood sample or subsequent draws. Since the sequestration chamber has an air-permeable blood barrier through which air can be displaced by blood pushed from the patient's vein, such blood will naturally and automatically flow into the sequestration chamber before it is drawn into or otherwise enters into a Vacutainer or other bottle for receiving and storing a blood sample.

[0074] When the sequestration chamber fills, the blood will gather at or otherwise make contact with the air permeable blood barrier, which will inhibit or prevent blood

from passing therethrough. At 706, when the blood comes into contact with the entire internal surface area of the air permeable blood barrier, the air permeable blood barrier is then closed and air no longer flows out or in. At 708, the clinician may be provided an indictor or can see the full chamber, to indicate the evacuated blood collection tube, such as a Vacutainer™ can be attached. The indicator can include visibility into the primary chamber to see whether it is full, the blood barrier changing color, for example, or other indicator. The fill time of the sequestration chamber may be substantially instantaneous, so such indicator, if present, may be only that the sequestration chamber is filled.

[0075] Prior to an evacuated blood collection tube being attached, communication between the needle, sampling channel, and the sequestration chamber is restricted by the sealing of the sequestration chamber blood barrier thereby not permitting air to reenter the system through the sequestration. Sealing the communication path could also be accomplished with a mechanical twist or other movement, a small orifice or tortuous pathway, eliminating the need for a separate valve or mechanical movement or operation by the clinician. At 710, once the evacuated blood collection tube is removed, the self-sealing membrane closes the sample needle, and at 712, additional subsequent evacuated blood collection tubes may be attached. Once samples have been taken, at 714 the device is removed from the patient and discarded.

[0076] FIGS. 8A – 8E illustrate an exemplary blood sample optimization system 800 for non-contaminated blood sampling, in accordance with some implementations. The blood sample optimization system 800 includes an inlet port 802 that can be connected to tubing, a patient needle (or both), or other vascular or venous access device, and a pathway splitter 804 having a first outlet to a sequestration chamber tubing 806 and a second outlet to sample collection tubing 808. One or both of the sequestration chamber tubing 806 and the sample collection tubing 808 can be formed of tubing. In some implementations, the sequestration chamber tubing 806 is sized so as to contain a particular volume of initial blood sample. The sample collection tubing 808 will receive a blood sample once the sequestration chamber tubing 806 is filled. The sample collection tubing 808 can be connected to a Vacutainer™ base or housing 810, or other blood sample collection device.

[0077] The blood sequestration system 800 further includes a blood sequestration device 812 which, as shown in more detail in FIGS. 8B – 8D, includes a housing 818 that

includes a sampling channel 820 defining a pathway for the non-contaminated sample collection tubing 808 or connected at either end to the non-contaminated sample collection tubing 808. The sampling channel 820 can be curved through the housing 818 so as to better affix and stabilize the housing 818 at a location along the non-contaminated sample collection tubing 808.

[0078] The blood sequestration device 812 further includes a sequestration chamber 822 connected with the sequestration chamber tubing 806 or other chamber. The sequestration chamber 822 terminates at an air permeable blood barrier 824. The air permeable blood barrier 824 can also include a coloring agent that turns a different color upon full contact with blood, as an indicator that the regular collection of blood samples (i.e. the non-contaminated blood samples) can be initiated. Other indicators may be used, such as a small light, a sound generation mechanism, or the like. In some implementations, the air permeable blood barrier is positioned at a right angle from the direction of sequestration chamber 822, but can be positioned at any distance or orientation in order to conserve space and materials used for the housing 818. The housing 818 and its contents can be formed of any rigid or semi-rigid material or set of materials.

[0079] FIG. 9 illustrates a pathway splitter 900 for use in a blood sequestrations system, such as those shown in FIGS. 8A – 8E, for example. The pathway splitter 900 includes an inlet port 902, a main line outlet port 904, and a sequestration channel outlet port 906. The inlet port 902 can be connected to main tubing that is in turn connected to a patient needle system, or directly to a patient needle. The main line outlet port 904 can be connected to main line tubing to a blood sampling system, such as a vacutainer base or housing, or directly to such blood sampling system. The sequestration channel outlet port 906 can be connected to sequestration tubing for receiving and sequestering a first sample of blood, up to a measured amount or predetermined threshold. Alternatively, the sequestration channel outlet port 906 can be connected to a sequestration chamber. The sequestration channel outlet port 906 is preferably 20-70 degrees angled from the main line outlet port 904, which in turn is preferably in-line with the inlet port 902. Once the predetermined amount of initial blood sample is sequestered in the sequestration tubing or chamber, in accordance with mechanisms and techniques described herein, follow-on blood samples will flow into the inlet port 902 and directly out the main line outlet port 904, without impedance.

[0080] FIGS. 10A – 10D illustrate a blood sequestration device 1000 in accordance with alternative implementations. The blood sequestration device 1000 includes an inlet port 1002, a main outlet port 1004, and a sequestration channel port 1006. The inlet port 1002 can be connected to a patient needle or related tubing. The main outlet port 1004 can be connected to a blood sample collection device such as a Vacutainer, associated tubing, or a Luer activated valve, or the like. The sequestration channel port 1006 splits off from the main outlet port 1004 to a sequestration chamber 1008. In some implementations, the sequestration chamber 1008 is formed as a helical channel within a housing or other container 1001.

[0081] The sequestration chamber 1008 is connected at the distal end to an air permeable blood barrier 1010, substantially as described above. Air in the sequestration chamber 1008 is displaced through the air permeable blood barrier 1010 by an initial aliquot of blood that is guided into the sequestration channel port 1006. Once the sequestration chamber 1008 is filled, further blood draws through the main outlet port 1004 can be accomplished, where these samples will be non-contaminated.

[0082] FIGS. 11A – 11E illustrate a blood sequestration device 1100 in accordance with other alternative implementations. The blood sequestration device 1100 includes an inlet port 1102, similar to the inlet ports described above, a main outlet port 1104, and a sequestration channel port 1106 that splits off from the main outlet port 1104 and inlet port 1102. The sequestration channel port is connected to a sequestration chamber 1108. In the implementation shown in FIGS. 11A – 11E, the blood sequestration device includes a base member 1101 having a channel therein, which functions as the sequestration chamber 1108. The channel can be formed as a tortuous path through the base member 1101, which is in turn shaped and formed to rest on a limb of a patient.

[0083] A portion of the sequestration chamber 1108 can protrude from the base member or near a top surface of the base member, just before exiting to an air permeable blood barrier 1110, to serve as a blood sequestration indicator 1109. The indicator 1109 can be formed of a clear material, or a material that changes color when in contact with blood.

[0084] In some implementations, the blood sequestration device 1100 can include a blood sampling device 1120 such as a normally closed needle, Vacutainer™ shield or other collection device. The blood sampling device 1120 can be manufactured and sold with the blood sequestration device 1100 for efficiency and convenience, so that a first aliquot of blood that may be contaminated by a patient needle insertion process can be sequestered. Thereafter, the blood sampling device 1120 can draw non-contaminated blood samples to reduce the risk of false positive testing and ensure a non-contaminated sample.

[0085] FIGS. 12A-12D illustrate a blood sample optimization system 1200 in accordance with yet other alternative implementations. The system 1200 includes a blood sequestration device 1202 for attaching to a blood sampling device 1204, such as a Vacutainer™ or other collection and sampling device. The blood sequestration device 1202 is configured and arranged to receive, prior to a Vacutainer™ container or vial being attached to a collection needle of the blood sampling device 1204, a first aliquot or amount of blood, and sequester that first aliquot or amount in a sequestration channel of the blood sequestration device 1202.

[0086] In some implementations, the blood sequestration device 1202 can include an inlet port 1212, a main outlet port, and a sequestration channel port. The inlet port 1212 can be connected to a patient needle or related tubing. The main outlet port 1214 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like. The sequestration channel port splits off from the main outlet port to a sequestration chamber 1218.

[0087] In some implementations, the sequestration chamber 1218 is formed as a channel within the body of a sequestration device 1202. The sequestration chamber 1218 can be a winding channel, such as a U-shaped channel, an S-shaped channel, a helical channel, or any other winding channel. The sequestration device 1202 can include a housing or other containing body, and one or more channels formed therein. As shown in FIGS. 12A and 12B, the sequestration device 1202 includes a main body 1206 and a cap 1208. The main body 1206 is formed with one or more cavities or channels, which are further formed with one or more arms 1210 that extend from the cap 1208, and which

abut the cavities or channels in the main body 1206 to form the primary collection port and main outlet port.

[0088] FIGS. 13A-13D illustrate a blood sample optimization system 1300 in accordance with yet other alternative implementations. The system 1300 includes a blood sequestration device 1302 for attaching to a blood sampling device 1304, such as a Vacutainer or other bodily fluid collection and sampling device. The blood sequestration device 1302 is configured and arranged to receive, prior to a Vacutainer container or vial being attached to a collection needle of the blood sampling device 1304, a first aliquot or amount of blood, and to sequester that first aliquot or amount of blood or other bodily fluid in a sequestration channel of the blood sequestration device 1302.

[0089] The blood sequestration device 1302 includes a housing 1301 having an inlet port 1314, a main outlet port 1312, and a sequestration channel port 1316. The inlet port 1314 can be connected to a patient needle or associated tubing. The main outlet port 1312 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like. The sequestration channel port 1316 splits off from the main inlet port 1314 to a sequestration chamber 1318.

[0090] In the implementation shown in FIGS. 13A-D, the sequestration chamber 1318 is formed as a cavity or chamber within housing 1301 or formed by walls that define housing 1301. The sequestration chamber 1318 can be a winding channel, such as a U-shaped channel, an S-shaped channel, a helical channel, or any other winding channel, that is defined by the cooperation and connection of housing 1301 with cap 1307 which cap 1307 can include a protrusion 1305 that provides one or more walls or directors for the winding channel in the sequestration chamber 1318. The protrusion 1305 from the cap 1307 can be straight or curved, and may have various channels, apertures or grooves embedded therein, and can extend from the cap 1307 any angle or orientation. When the cap 1307 is connected with the housing 1301 to complete the formation of the sequestration chamber 1318, the protrusion 1305 forms at least part of the winding channel to sequester a first aliquot or amount of blood or other bodily fluid in a sequestration channel formed in the sequestration chamber 1318 and by the winding channel.

[0091] The sequestration chamber 1318 includes an air permeable blood barrier 1310, substantially as described above. Air in the sequestration chamber 1318 is displaced through the air permeable blood barrier 1310 by an initial aliquot of blood that is provided into the sequestration chamber 1318 by the blood pressure of the patient. Once the sequestration chamber 1318 is filled and the air in the sequestration chamber 1318 displaced, the blood pressure of the patient will be insufficient to drive or provide further blood into the blood sequestration device 1302, and in particular the outlet port 1312, until a force such as a vacuum or other pressure, such as provided by the blood sample collection device like Vacutainer is provided to draw out a next aliquot or amount of blood or bodily fluid. Further blood draws through the main outlet port 1312 can be accomplished, where these samples will be non-contaminated since any contaminants would be sequestered in the sequestration chamber 1318 with the first aliquot of blood.

[0092] FIGS. 14A-14E illustrate yet another implementation of a blood sampling system 1400 to sequester contaminates of an initial aliquot or sample to reduce false positives in blood cultures or tests performed on a patient's blood sample. The blood sampling system 1400 includes a blood sequestration device 1401 that can be connected between a blood sample collection device 1403 and a patient needle (not shown). The blood sample collection device 1403 can be a Vacutainer or the like. The blood sequestration device 1401 includes an inlet port 1402 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1402 may also be connected with tubing or other conduit that is in turn connected with the patient needle.

[0093] The inlet port 1402 defines an opening into the blood sequestration device 1401, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately 0.045 inches, but can have a diameter of between 0.01 inches or less to 0.2 inches or more. The blood sequestration device 1401 further includes an outlet port 1404, which defines an opening out of the blood sequestration device 1401 and to the blood sample collection device 1403. The outlet port 1404 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device 1403. The outlet port 1404 can further include a connector device such as a threaded cap, a Luer connector (male or female), a

non threaded interference or glue joint fitting for attachment of various devices including but not limited to tubing, or the like.

[0094] The blood sequestration device 1401 further includes a sampling channel 1406 between the inlet port 1402 and the outlet port 1404, and which functions as a blood sample pathway once a first aliquot of blood has been sequestered. The sampling channel 1406 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 1406 has a substantially similar cross sectional area as the opening of the inlet port 1402. In other implementations, the sampling channel 1406 can gradually widen from the inlet port 1402 to the outlet port 1404.

[0095] The blood sequestration device 1401 further includes a sequestration chamber 1408 that is connected to and split off or diverted from the sampling channel 1406 at any point between the inlet port 1402 and the outlet port 1404, but preferably from a proximal end of the sampling channel 1406 near the inlet port 1402. The sequestration chamber 1408 is at first maintained at atmospheric pressure, and includes an air outlet 1412 at or near a distal end of the sequestration chamber 1408 opposite the diversion point from the sampling channel 1406. The air outlet 1412 includes an air permeable blood barrier 1412. As shown in FIG. 14B, the air permeable blood barrier 1412 can be overlaid with a protective cover 1416. The protective cover 1416 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1412 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1412 as the air is displaced from the sequestration chamber 1408 by blood being forced into the sequestration chamber 1408 by a patient's own blood pressure. In addition the protective cover 1416 can be constructed to inhibit or prevent accidental exposure of the air permeable blood barrier to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[0096] As shown in FIGS. 14C and 14D, the sampling channel 1406 can be cylindrical or frusto-conical in shape, going from a smaller diameter to a larger diameter, to minimize a potential to lyse red blood cells. Likewise, the sampling channel 1406 is formed with a minimal amount of or no sharp turns or edges, which can also lyse red blood cells. The sampling channel 1406 splits off to the sequestration chamber 1408 near the inlet port 1402 via a diversion pathway 1409. The diversion pathway 1409 can have

any cross-sectional shape or size, but is preferably similar to the cross-sectional shape of at least part of the inlet port 1402.

[0097] In some implementations, the sampling channel 1406 and the sequestration chamber 1408 are formed by grooves, channels, locks or other pathways formed in housing 1414. The housing 1414 can be made of plastic, metal or other rigid or semi-rigid material. The housing 1414 can have a bottom member that sealably mates with a top member. One or both of the bottom member and the top member can include the sampling channel 1406 and the sequestration chamber 1408, as well as the diversion pathway 1409, the inlet port 1402, and the outlet port 1404. In some other implementations, one or more of the diversion pathway 1409, the inlet port 1402, and/or the outlet port 1404 can be at least partially formed by a cap member that is connected to either end of the housing 1414. In some implementations, the top member and the bottom member, as well as the cap member(s), can be coupled together by laser welding, heat sealing, gluing, snapping, screwing, bolting, or the like. In other implementations, some or all of the interior surface of the diversion pathway 1409 and/or sequestration chamber 1408 can be coated or loaded with an agent or substance, such as a decontaminate, solidifying agent, or the like. For instance, a solidifying agent can be provided at the diversion pathway 1409 such that when the sequestration chamber 1408 is filled and the initial aliquot of blood backs up to the diversion pathway 1409, that last amount of sequestered blood could solidify, creating a barrier between the sequestration chamber 1408 and the sampling channel 1406.

[0098] FIGS. 15A-15G illustrate a blood sequestration device 1500. The blood sequestration device 1500 can be connected to a normally closed needle or device to enable connection with an evacuated blood collection container or other collection device such as a Vacutainer™, associated tubing, luer connectors, syringe, a Luer activated valve, or the like.

[0099] The blood sequestration device 1500 includes an inlet port 1502 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1502 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 1502 defines an opening into the blood sequestration device 1500, which opening may be the same cross sectional dimensions as tubing or other conduit connected with the

patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately 0.045 inches, but can have a diameter of between 0.01 inches or less to 0.2 inches or more.

[00100] The inlet port 1502 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 1502, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 1500 can be fabricated and sold with the patient needle as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 1500 at the time of blood draw or sampling.

[00101] The blood sequestration device 1500 further includes an outlet port 1504, which defines an opening out of the blood sequestration device 1500 and to the blood sample collection device. The outlet port 1504 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 1500 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 1500 at the time of blood draw or sampling.

[00102] The blood sequestration device 1500 further includes a sampling channel 1506 between the inlet port 1502 and the outlet port 1504, and which functions as a blood sample pathway once a first aliquot of blood has been sequestered. The sampling channel 1506 can be any sized, shaped or configured channel or conduit. In some implementations, the sampling channel 1506 has a substantially similar cross sectional area as the opening of the inlet port 1502. In other implementations, the sampling channel 1506 can gradually widen from the inlet port 1502 to the outlet port 1504.

[00103] The blood sequestration device 1500 further includes a sequestration chamber 1508 that is connected to and split off or diverted from the sampling channel 1506 at any point between the inlet port 1502 and the outlet port 1504, but preferably from a proximal end of the sampling channel 1506 near the inlet port 1502. In some

implementations, the diversion includes a Y-shaped junction. The sequestration chamber 1508 is preferably maintained at atmospheric pressure, and includes a vent 1510 at or near a distal end of the sequestration chamber 1508. The vent 1510 includes an air permeable blood barrier 1512. FIG. 15C illustrates the blood sequestration device 1500 with the sequestration chamber 1508 filled with a first aliquot or sample of blood from the patient.

[00104] The air permeable blood barrier 1512 can be covered with a protective cover 1516. The protective cover 1516 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1512 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1512 as the air is displaced from the sequestration chamber 1508 by blood being forced into the sequestration chamber 1508 by a patient's own blood pressure. The protective cover 1516 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00105] FIG. 15B is a perspective view of the blood sequestration device 1500 from the outlet port 1504 and top side of a housing 1501 of the blood sequestration device 1500 that includes the vent 1510, and illustrating an initial aliquot of blood filling sequestration chamber 1508 while the sampling channel 1506 is empty, before a sample collection device is activated. FIG. 15G is a perspective view of the blood sequestration device 1500 from the outlet port 1504 and bottom side of the housing 1501 of the blood sequestration device 1500, and illustrating the initial aliquot of blood filling sequestration chamber 1508 while the sampling channel 1506 is empty, before the sample collection device is activated. FIG. 15C is another perspective view of the blood sequestration device 1500 from the inlet port 1502 and top side of a housing 1501 of the blood sequestration device 1500 that includes the vent 1510, and illustrating blood now being drawn through sampling channel 1506 while the sequestered blood remains substantially in the sequestration chamber 1508.

[00106] FIG. 15D is a cross section of the blood sequestration device 1500 in accordance with some implementations, showing the housing 1501 that defines the sampling channel 1506 and the sequestration chamber 1508. FIGS. 15E and 15F

illustrate various form factors of a housing for a blood sequestration device, in accordance with one or more implementations described herein.

[00107] The sequestration chamber 1508 can have a larger cross-sectional area than the sampling channel 1506, and the cross-sectional area and length can be configured for a predetermined or specific volume of blood to be sequestered or locked. The sampling channel 1506 can be sized to be compatible with tubing for either or both of the patient needle tubing or the blood collection device tubing.

[00108] The housing 1501 can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated in FIG. 15D, the housing 1501 includes a top member 1520 and a bottom member 1522 that are mated together, one or both of which having grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc. The top member 1520 can be connected with the bottom member 1522 by any mating or connection mechanism, such as by laser welding, thermal bonding, ultrasonic welding, gluing, using screws, rivets, bolts, or the like, or by other mating mechanisms such as latches, grooves, tongues, pins, flanges, or the like.

[00109] In some implementations, such as shown in FIG. 15D, the top member 1520 can include the grooves, channels, locks, conduits or other pathways, while the bottom member 1522 can include a protrusion 1524 that is sized and adapted to fit into at least one of the grooves, channels, locks or other pathways of the top member 1520. The protrusion 1524 can provide a surface feature, such as a partial groove or channel, for instance, to complete the formation of either the sampling channel 1506 and/or the sequestration chamber 1508. In some implementations, the protrusion 1524 can be formed with one or more angled sides or surfaces for a tighter fit within the corresponding groove, channel, lock or other pathway. In yet other implementations, both the top member 1520 and the bottom member can include grooves, channels, locks or other pathways, as well as one or more protrusions 1524.

[00110] In some implementations, the sampling channel 1506 and the sequestration chamber 1508 are formed by grooves, channels, locks or other pathways formed in housing 1501. The housing 1501 can be made of any suitable material, including rubber, plastic, metal or other material. The housing 1501 can be formed of a clear or translucent

material, or of an opaque or non-translucent material. In other implementations, the housing 1501 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 1506 and/or the sequestration chamber 1508 is clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 1508 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 1506. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 1512 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00111] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will make its way into the inlet port 1502 blood sequestration device 1500 and flow into the sequestration chamber 1508 by following the path of least resistance, as the patient's own blood pressure overcomes the atmospheric pressure in the sequestration chamber 1508 to displace air therein through the air permeable blood barrier 1512. The patient's blood pressure will not be sufficient to overcome the air pressure that builds up in the sealed sampling channel 1506. Eventually, the sequestration chamber 1508, which has a predetermined volume, is filled with blood that displaces air through the air permeable blood barrier 1512. Once the blood hits the air permeable blood barrier, the blood interacts with the air permeable blood barrier 1512 material to completely or partially seal the vent 1510. A signal or indication may be provided that the practitioner can now utilize the Vacutainer capsule or other blood sample collection device to acquire a next amount of the patient's blood for sampling. The blood in the sequestration chamber 1508 is now effectively sequestered in the sequestration chamber.

[00112] Upon filling the blood sequestration pathway 1508 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 1506, possibly resulting in a small amount of blood moving past the diversion point to the sequestration chamber 1508 and into the sampling channel 1506, queuing up the uncontaminated blood to be drawn through the sampling channel 1506.

[00113] In some instances, as shown in FIG. 15H, an inlet port 1532 can include a male luer connector for connecting to a removable patient needle, and an outlet port 11534 can include a female luer connector for connecting with a syringe. This implementation of the inlet port and outlet port can be used with any device described herein, for avoiding a propensity of a Vacutainer-type device collapsing a patient's vein. In this implementation, a clinician can use the syringe in a modulated fashion to obtain a blood sample. In operation, the syringe is attached to the outlet port 1004, and the needle is attached to the inlet port 1002. A venipuncture is performed with the needle, and without the clinician pulling on the syringe. An initial aliquot of blood fills a sequestration chamber, and then the syringe can be used to draw a sample of blood through the collection channel, bypassing the sequestered blood in the sequestration chamber.

[00114] FIGS. 16-19 illustrate yet another implementation of a blood sequestration device. FIGS. 16A-16D illustrate a blood sequestration device 1600 that can be connected between a blood sample collection device, such as an evacuated blood collection container like a Vacutainer™ (not shown), and a patient needle (not shown) and/or associated tubing. FIG. 17 illustrates a bottom member of the blood sequestration device, and FIG. 18 illustrates a top member of the blood sequestration device, which top member and bottom member can be mated together to form an inlet port, and outlet port, a sequestration chamber and a sampling channel, as explained more fully below. FIGS. 19A and B show the top member and bottom member mated together. It should be understood that FIGS. 16-19 illustrate one exemplary manner of constructing a blood sequestration device as described herein, and other forms of construction are possible.

[00115] Referring to FIGS. 16A – D, the blood sequestration device 1600 includes an inlet port 1602 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 1602 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 1602 defines an opening into the blood sequestration device 1600, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the opening can be circular with a diameter of approximately 0.045 inches, but can have a diameter of between 0.01 inches or less to 0.2 inches or more.

[00116] The inlet port 1602 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 1602, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 1600 can be fabricated and sold with the patient needle and/or tubing as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 1600 at the time of blood draw or sampling.

[00117] The blood sequestration device 1600 further includes an outlet port 1604, which defines an opening out of the blood sequestration device 1600 and to the blood sample collection device. The outlet port 1604 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 1600 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 1600 at the time of blood draw or sampling.

[00118] The blood sequestration device 1600 further includes a sampling channel 1606 between the inlet port 1602 and the outlet port 1604, and a sequestration chamber 1608 that is connected to and split off or diverted from the sampling channel 1606 at any point between the inlet port 1602 and the outlet port 1604. The sampling channel 1606 functions as a blood sampling pathway once a first aliquot of blood has been sequestered in the sequestration chamber 1608. The sampling channel 1606 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 1606 has a substantially similar cross sectional area as the opening of the inlet port 1602. In other implementations, the sampling channel 1606 can gradually widen from the inlet port 1602 to the outlet port 1604. The sequestration chamber 1608 may have a larger cross section to form a big reservoir toward the sequestration channel path so that the blood will want to enter the reservoir first versus entering a smaller diameter on the sampling channel 1606, as is shown more fully in FIGS. 17 and 19.

[00119] In some exemplary implementations, the diversion between the sampling channel 1606 and the sequestration chamber 1608 is by diverter junction 1607. Diverter junction 1607 may be a substantially Y-shaped, T-shaped, or U-shaped. In some preferred exemplary implementations, and as shown in FIG. 17A – 17B, the diverter junction 1607 is configured such that the flow out of the inlet port 1602 is preferentially directed toward the sequestration chamber 1608. The sequestration chamber 1608 may also include or form a curve or ramp to direct the initial blood flow toward and into the sequestration chamber 1608.

[00120] The sequestration chamber 1608 is preferably maintained at atmospheric pressure, and includes a vent 1610 at or near a distal end of the sequestration chamber 1608. The vent 1610 may include an air permeable blood barrier 1612 as described above.

[00121] The blood sequestration device 1600 can include a housing 1601 that can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated in FIGS. 17A – 17E and FIGS. 18A – 18F, the housing 1601 includes a top member 1620 and a bottom member 1622 that are mated together. The blood sequestration device 1600 can also include a gasket or other sealing member (not shown) so that when the top member 1620 is mechanically attached with the bottom member 1622, the interface between the two is sealed by the gasket or sealing member. The FIGS. 17A – 17E illustrate a bottom member 1622 of a housing for a blood sequestration device 1600. The bottom member 1622 can include grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc., to form the sampling channel 1606, the sequestration chamber 1608, and diverter junction 1607.

[00122] The sequestration chamber 1608 may have a larger cross section than the sampling channel 1606 so that the blood will preferentially move into the sequestration chamber first versus entering a smaller diameter on the sampling channel 1606.

[00123] FIGS. 18A – 18F illustrate the top member 1620, which can be connected with the bottom member 1622 by any mating or connection mechanism, such as by laser welding, thermal bonding, gluing, using screws, rivets, bolts, or the like, or by other mating mechanisms such as latches, grooves, tongues, pins, flanges, or the like. The top

member 1620 can include some or all of the grooves, channels, locks, conduits or other pathways to form the sampling channel 1606, the sequestration chamber 1608, and the diverter junction 1607. In yet other implementations, both the top member 1620 and the bottom member 1622 can include the grooves, channels, locks or other pathways.

[00124] In some implementations, the sampling channel 1606 and the sequestration chamber 1608 are formed by grooves, channels, locks or other pathways formed in housing 1601. The housing 1601 can be made of rubber, plastic, metal or any other suitable material. The housing 1601 can be formed of a clear or translucent material, or of an opaque or non-translucent material. In other implementations, the housing 1601 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 1606 and/or the sequestration chamber 1608 may be clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 1608 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 1606. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 1612 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00125] As shown in FIGS. 18A – 18F, the air permeable blood barrier 1612 can be covered with, or surrounded by, a protective member 1616. The protective member 1616 can be sized and configured to inhibit a user from touching the air permeable blood barrier 1612 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 1612 as the air is displaced from the sequestration chamber 1608. In some implementations, the protective member 1616 includes a protrusion that extends up from a top surface of the top member 1620 and around the air permeable blood barrier 1612. The protective member 1616 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00126] In use, the blood sequestration device 1600 includes a sampling channel 1606 and a sequestration chamber 1608. Both pathways are initially air-filled at

atmospheric pressure, but the sampling channel 1606 is directed to an outlet port 1604 that will be initially sealed by a Vacutainer or other such sealed blood sampling device, and the sequestration chamber 1608 terminates at a vent 1610 to atmosphere that includes an air permeable blood barrier 1612.

[00127] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will pass through inlet port 1602 of blood sequestration device 1600. This initial volume of potentially contaminated blood will preferentially flow into the sequestration chamber 1608 by finding the path of least resistance. The patient's own blood pressure overcomes the atmospheric pressure in the vented sequestration chamber 1608 to displace air therein through the air permeable blood barrier 1612, but is not sufficient to overcome the air pressure that builds up in the sealed sampling channel 1606. In various exemplary embodiments, the sequestration chamber 1608 and sampling channel 1606 can be configured such that the force generated by the patient's blood pressure is sufficient to overcome any effect of gravity, regardless of the blood sequestration device's orientation.

[00128] Eventually, the sequestration chamber 1608 fills with blood that displaces air through the air permeable blood barrier 1612. Once the blood contacts the air permeable blood barrier, the blood interacts with the air permeable blood barrier 1612 material to completely or partially seal the vent 1610. A signal or indication may be provided that the practitioner can now utilize the Vacutainer or other blood sampling device.

[00129] Upon filling the blood sequestration pathway 1608 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 1606, possibly resulting in a small amount of blood moving past the diversion point into the sampling channel 1606, queuing up the uncontaminated blood to be drawn through the sampling channel 1606.

[00130] FIG. 19A is a side view, and FIG. 19B is a cross-sectional view, of the blood sequestration device 1600, illustrating the top member 1620 mated with the bottom member 1622.

[00131] FIG. 20 shows a blood sample optimization system 2000 that includes a patient needle 2002 for vascular access to a patient's bloodstream, a blood sample collection device 2004 to facilitate the collecting of one or more blood samples, and a conduit 2006 providing a fluid connection between the patient needle 2002 and the blood sample collection device 2004. In some implementations, the blood sample collection device 2004 includes a protective shield that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2002.

[00132] The blood sample optimization system 2000 further includes a blood sequestration device 2008, located at any point on the conduit 2006 between the patient needle 2002 and the blood sample collection device 2004 as described herein.

[00133] FIG. 21 illustrates a non-vented blood sequestration device 2100 using a wicking material chamber. The blood sequestration device 2100 includes a housing 2101 that has a sampling channel 2104 that is at least partially surrounded or abutted by a sequestration chamber 2102 that is filled with a wicking material. An initial aliquot of blood is drawn in from the patient needle into the sampling channel 2104 where it is immediately wicked into the wicking material of the sequestration chamber 2102. The wicking material and/or sequestration chamber 2102 is sized and adapted to receive and hold a predetermined amount of blood, such that follow-on or later blood draws pass by the wicking material and flow straight through the sampling channel 2104 to a sampling device such as a Vacutainer. The wicking material can include a substance such as a solidifier, a decontaminate, or other additive.

[00134] As described herein, an air permeable blood barrier may be created using a wide variety of different structures and materials. As shown in FIGS. 22A and B, an air permeable blood barrier 2202 of a blood sequestration device 2200 can include a polymer bead matrix 2204, in which at least some beads are treated to make them hydrophilic. The air permeable blood barrier 2202 further includes a self-sealing material 2206, such as carboxymethyl cellulose (CMC) or cellulose gum, or other sealing material. The air permeable blood barrier 2202 can further include voids 2208 that permit air flow before contact or during partial contact with a fluid such as blood. As shown in FIG. 22B,

contact with a fluid causes the self-sealing material 2206 to swell and close off the voids 2208, occluding air flow through the voids 2208 and creating a complete or partial seal.

[00135] FIGS. 23A and B illustrate yet another implementation of a blood sequestration device 2300, having an inlet port 2302 to connect with a patient needle, an outlet port 2304 to connect with a blood sample collection device, a sequestration chamber 2306, and a sampling channel 2308 that bypasses the sequestration chamber 2306 once the sequestration chamber is filled to an initial aliquot of potentially contaminated blood to be sequestered. The sequestration chamber 2306 includes a hydrophobic plug 2312 at a distal end of the sequestration chamber 2306 that is farthest from the inlet port 2302. A vacuum or other drawing force applied from the outlet port 2304, such as from a Vacutainer or the like, draws in blood into the inlet port 2302 and directly into the sequestration chamber 2306, where the initial aliquot of blood will contact the hydrophobic plug 2312 and cause the initial aliquot of blood to back up into the sequestration chamber 2306 and be sequestered there. A small amount of blood may make its way into the sampling channel 2308, which is initially closed off by valve 2308. Upon release of the valve 2308, and under further force of the vacuum or other force, follow-on amounts of blood will flow into inlet port 2302, bypass the sequestration chamber 2306, and flow into and through sampling channel 2308 toward the outlet port 2304 and to the collection device.

[00136] The sampling channel 2308 can have any suitable geometry and can be formed of plastic tubing or any other suitable material. Valve 2308 can be a clip or other enclosing device to pinch, shunt, bend or otherwise close off the sampling channel 2308 before the initial aliquot of blood is sequestered in the sequestration chamber 2306. For instance, valve 2308 can also be formed as a flap, door or closable window or barrier within the sampling channel 2308.

[00137] FIGS. 23C – 23E illustrate an alternative implementation of the blood sequestration device 2300', in which a sequestration chamber 2320 branches off from a main collection channel 2322 between an inlet port 2316 to connect with a patient needle and an outlet port 2318 to connect with a blood sample collection device, such as a Vacutainer, a syringe, or the like. The sequestration chamber 2320 includes an air-permeable, blood impermeable blood barrier 2324, such as a hydrophobic plug of material, or a filter formed of one or more layers, for example. A valve 2324 closes off

and opens the collection channel 2322, and the device 2300' can be used similarly as described above.

[00138] FIG. 24A – 24D illustrate a blood sample optimization system 2400 that includes a patient needle 2402 for vascular access to a patient's bloodstream, a blood sample collection device 2404 to facilitate the collecting of one or more blood samples for blood testing or blood cultures, and a conduit 2406 providing a fluid connection between the patient needle 2402 and the blood sample collection device 2404. In some implementations, the blood sample collection device 2404 includes a protective shield that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2402.

[00139] The blood sample optimization system 2400 further includes a blood sequestration device 2408, located at any point on the conduit 2406 between the patient needle 2402 and the blood sample collection device 2404. The location of the blood sequestration device 2408 can be based on a length of the conduit between the blood sequestration device 2408 and the patient needle 2402, and the associated volume that length provides.

[00140] The blood sequestration device 2408 includes an inlet port 2412 for being connected to the conduit 2406 toward the patient needle 2402, and an outlet port 2414 for being connected to the conduit 2406 toward the blood sample collection device 2404, and a housing 2416. The housing 2416 can be any shape, although it is shown in FIGS. 24A – D as being substantially cylindrical, and includes the inlet port 2412 and outlet port 2414, which can be located anywhere on the housing although shown as being located on opposite ends of the housing 2416.

[00141] The blood sequestration device 2408 further includes a blood sequestration chamber 2418 connected with the inlet port 2412. The blood sequestration chamber 2418 is defined by an inner chamber housing 2419 that is movable from a first position to receive and sequester a first aliquot of blood, to a second position to expose one or more apertures 2424 at a proximal end of the inner chamber housing 2419 to allow blood to bypass and/or flow around the inner chamber housing 2419 and through a blood sample channel 2422 defined by the outer surface of the inner chamber housing 2419 and the

inner surface of the housing 2416. The blood sequestration chamber 2418 includes an air permeable blood barrier 2420 at a distal end of the blood sequestration chamber 2418.

[00142] In operation, the inner chamber housing 2419 is in the first position toward the inlet port 2412, such that the one or more apertures 2424 are closed, and the blood sequestration chamber 2418 is in a direct path from the patient needle. Upon venipuncture of a patient, and drawing of blood by way of a syringe or Vacutainer, or other blood collection device 2404, the initial aliquot of blood flows into the blood sequestration chamber 2418. As the initial aliquot of blood flows into the blood sequestration chamber, it displaces air therein and eventually the blood contacts the blood barrier 2420, forcing the inner chamber housing to the second position. The inner chamber housing 2419 and/or housing 2416 can include a locking mechanism of one or more small tabs, grooves, detents, bumps, ridges, or the like, to maintain the inner chamber housing 2419 in the first position until the blood sequestration chamber 2418 is filled, providing force to overcome the locking mechanism to enable movement of the inner chamber housing 2419 to the second position. Once in the second position, the initial aliquot of blood is sequestered in the blood sequestration chamber 2418 and the one or more apertures 2424 are opened to create a pathway from the inlet port 2412 to the blood sampling channel 2422, bypassing and/or flowing around the blood sequestration chamber 2418.

[00143] As described above, the housing 2416 and/or inner chamber housing 2419 can be formed as cylindrical and concentric, but can be any shape, such as squared, rectangular, elliptical, oval, or other cross-sectional shape. The outer surface of the distal end of the inner chamber housing 2419 can have one or more outwardly projecting tangs 2421with gaps therebetween. The tangs 2421 contact the inner surface of the housing 2416 to help define the blood sampling channel 2422 therebetween, and to help stop the inner chamber housing 2419 in the second position. The gaps between the tangs 2421 enable blood to flow through the blood sampling channel 2422 and to the outlet port 2414. When the inner chamber housing 2419 is in the second position and the blood sequestration chamber 2418 is filled with the first aliquot of blood, further blood samples will automatically flow through the inlet port 2412, through the one or more apertures 2424, through the blood sampling channel 2422, through the gaps between the tangs 2421, and ultimately through the outlet port 2414 to be collected by a blood sampling device 2404.

[00144] FIGS. 25A – D show a blood optimization system 2500 and blood sequestration device 2502, formed substantially as described in FIGS. 15, 16, 17, 18 and 19, but being formed to inhibit a user or other object from touching or blocking an air venting mechanism from a blood sequestration chamber 2520. Air initially in the blood sequestration chamber 2520 is displaced by an initial aliquot of blood upon venipuncture, where a patient's blood pressure overcomes the ambient air pressure in the blood sequestration chamber 2520. The air venting mechanism includes an air permeable blood barrier 2506, such as a porous material or set of materials that allows air to escape but blocks blood from leaving the blood sequestration chamber 2520.

[00145] The air venting mechanism includes an inner wall 2516 that at least partially circumscribes or surrounds the air permeable blood barrier 2506, and an outer wall 2504 spaced apart from the inner wall 2516. The outer wall 2504 can have one or more air vents 2514 formed therein. The outer wall 2504 extends higher upward than the inner wall 2516, such that a lid 2510, such as a cap, plug, cover, etc., can be attached to the outer wall 2504 and be displaced by a small distance from the top of the inner wall 2516. A seal 2508 in the form of a silicone wafer, or other elastomeric material, fits within the outer wall 2504 to cover the air permeable blood barrier 2506 and abut the top of the inner wall 2516. The seal 2508 covers and seals the air permeable blood barrier 2506 and inhibits air from entering the blood sequestration chamber 2520 through the air permeable blood barrier 2506. A fulcrum 2512 on an underside of the lid 2510 allows the seal 2508 to flexibly disconnect from the top of the inner wall 2516 when pushed by air displaced from the blood sequestration chamber 2520, to allow air to vent from the air permeable blood barrier 2506 and through the one or more air vents 2514 in the outer wall 2504.

[00146] FIG. 26A – E illustrate a blood sample optimization system 2600 that includes a patient needle 2602 for vascular access to a patient's bloodstream, a blood sample collection device 2604 to facilitate the collecting of one or more blood samples for blood testing or blood cultures, and a conduit 2606 providing a fluid connection between the patient needle 2602 and the blood sample collection device 2604. The conduit 2606 can include flexible tubing. In preferred implementations, the blood sample collection device 2604 includes a protective shield 2605 that includes a sealed collection needle on which a sealed vacuum-loaded container is placed, which, once pierced by the

collection needle, draws in a blood sample under vacuum pressure or force through the conduit 2006 from the patient needle 2602.

[00147] The blood sample optimization system 2600 further includes a blood sequestration device 2608, located at any point on the conduit 2606 between the patient needle 2602 and the blood sample collection device 2604. The location of the blood sequestration device 2608 can be based on a length of the conduit between the blood sequestration device 2608 and the patient needle 2602, and the associated volume that length provides.

[00148] The blood sequestration device 2608 includes an inlet port 2612 for being connected to the conduit 2606 toward the patient needle 2602, and an outlet port 2614 for being connected to the conduit 2606 toward the blood sample collection device 2604. The blood sequestration device 2608 includes an outer housing 2616 and an inner housing 2617, both having a cylindrical form, and being connected concentrically. The outer housing 2616 includes an outer wall 2618 and an inner conduit 2620 that defines a blood sampling channel 2622 to convey blood through the conduit 2606 to the blood sampling device 2604. The inner housing 2617 fits snugly between the inner conduit 2620 and the outer wall 2618 of the outer housing, and is rotatable in relation to the outer housing 2616. The fit between the outer housing 2616 and the inner housing 2617 can be a friction fit that maintains the housings in a particular position. The inner housing 2617 defines a blood sequestration chamber 2624, preferably a helical or corkscrew channel around the outer surface of inner conduit 2620 of the outer housing 2616, and which terminates at an air vent 2628 having an air permeable blood barrier, as shown in FIG. 26E.

[00149] The blood sequestration chamber 2624 is connected with the blood sampling channel 2622 via diversion junction 2624 formed in the inner conduit 2620, when the blood sequestration device in a first state, illustrated in FIG. 26C. The protective shield 2606 on the collection needle 2604 provides a block for air or blood, enabling a diversion of an initial aliquot of blood into the blood sequestration chamber 2624 as the patient's blood pressure overcomes the ambient air pressure in the blood sequestration channel 2624 to displace air therefrom through air vent 2628.

[00150] When the inner housing 2617 is rotated relative to the outer housing 2616, or vice versa, to a second state, as illustrated in FIG. 26D, the blood sequestration chamber 2624 is shut off from diversion junction 2624, enabling a direct path from the patient needle through the conduit 2606 to the collection needle 2604, via blood sampling channel 2622. The outer housing 2616 and/or inner housing 2617 can include ridges or grooves formed within a portion of their surfaces, to facilitate relative rotation from the first state to the second state.

[00151] FIGS. 27A – D illustrate a blood optimization system 2700 and blood sequestration device 2702, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, and 25, but being formed to inhibit a user or other object from touching or blocking an air venting mechanism from a blood sequestration chamber 2720. Air initially in the blood sequestration chamber 2720 is displaced by an initial aliquot of blood upon venipuncture, where a patient's blood pressure overcomes the ambient air pressure in the blood sequestration chamber 2720. The air venting mechanism includes an air permeable blood barrier 2706, such as a porous material or set of materials that allows air to escape but blocks blood from leaving the blood sequestration chamber 2720.

[00152] The air venting mechanism includes an inner wall 2716 that at least partially circumscribes or surrounds the air permeable blood barrier 2706, and an outer wall 2704 spaced apart from the inner wall 2716. A cap 2722 is positioned on the air venting mechanism, preferably by having a lower cap wall 2728 that fits between the inner wall 2716 and the outer wall 2704 of the air venting mechanism, and frictionally abutting either the the inner wall 2716 or the outer wall 2704 or both. The cap 2722 further includes one or more vent holes 2724 or slits, apertures, openings, or the like, which extend through an upper surface of the cap 2722 around a downwardly extending plug 2726. The plug 2726 is sized and adapted to fit snugly within the space defined by inner wall 2716.

[00153] In a first position, as illustrated in FIG. 27C, the cap 2722 is extended from the air venting mechanism to allow air from the blood sequestration chamber 2720 to exit through the air permeable blood barrier 2706 and through the one or more vent holes 2724. Once the air from the blood sequestration chamber 2720 has been displaced, i.e., when the blood sequestration chamber 2720 is filled with the first aliquot of potentially tainted blood from the patient, then the cap 2722 can be pushed down on the air venting

mechanism in a second position as shown in FIG. 27D, so that the plug 2726 fits within the inner wall 2716 over the air permeable blood barrier 2706 to seal the air venting mechanism. In either the first position or the second position, the cap 2722 protects the air permeable blood barrier 2706 from outside air or from being touched by a user.

[00154] FIGS. 28A – F illustrate a blood optimization system 2800 and blood sequestration device 2802, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26, but utilizing a multi-layered filter, and in some implementations, a filter with trapped reactive material, for an air permeable blood barrier. As shown in FIGS. 28C and D, an air permeable blood barrier 2803 includes a first layer 2804 of an air permeable but blood impermeable material, and a second layer 2806 that includes a reactive material, such as a hydrophobic material, for repelling blood while still allowing air to pass through both layers. As shown in FIGS. 28E and F, the air permeable blood barrier 2803 can include any number of layers, such as a third layer 2808 formed of the same air permeable but blood impermeable material as first layer 2804, while a second layer 2806 includes trapped or embedded blood reactive material.

[00155] FIGS. 29A – C illustrate a blood optimization system 2900 and blood sequestration device 2902, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26, but in which a blood sequestration chamber 2904 is at least partially filled with a blood-absorptive material 2906. The blood-absorptive material 2906 can act as a wicking material to further draw in blood to be sequestered upon venipuncture of the patient, and prior to use of a blood drawing device such as a Vacutainer™ or a syringe, or the like.

[00156] FIGS. 30A – G illustrate a blood optimization system 3000 and blood sequestration device 3002, formed substantially as described with reference to at least FIGS. 15, 16, 17, 18, 19, 25 and 26. The blood sequestration device 3000 includes an inlet port 3002 that can be connected with a patient needle that is inserted into a patient's vascular system for access to and withdrawing of a blood sample. The inlet port 3002 may also be connected with tubing or other conduit that is in turn connected with the patient needle. The inlet port 3002 defines an opening into the blood sequestration device 3000, which opening can be the same cross sectional dimensions as tubing or other conduit connected with the patient needle or the patient needle itself. For instance, the

opening can be circular with a diameter of approximately 0.045 inches, but can have a diameter of between 0.01 inches or less to 0.2 inches or more.

[00157] The inlet port 3002 can also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. In some implementations, tubing or other conduit associated with the patient needle can be integral with the inlet port 3002, such as by co-molding, gluing, laser weld, or thermally bonding the parts together. In this manner, the blood sequestration device 3000 can be fabricated and sold with the patient needle and/or tubing as a single unit, eliminating the need for connecting the patient needle to the blood sequestration device 3000 at the time of blood draw or sampling.

[00158] The blood sequestration device 3000 further includes an outlet port 3004, which defines an opening out of the blood sequestration device 3000 and to the blood sample collection device. The outlet port 3004 may also be connected with tubing or other conduit that is in turn connected with the blood sequestration device, and may also include a sealing or fluid-tight connector or connection, such as threading or Luer fitting, or the like. Accordingly, as discussed above, the blood sequestration device 3000 can be fabricated and sold with the patient needle and/or tubing and the blood sample collection device as a single unit, eliminating the need for connecting the patient needle and the blood sample collection device to the blood sequestration device 3000 at the time of blood draw or sampling.

[00159] The blood sequestration device 3000 further includes a sampling channel 3006 between the inlet port 3002 and the outlet port 3004, and a sequestration chamber 3008 that is connected to and split off or diverted from the sampling channel 3006 at any point between the inlet port 3002 and the outlet port 3004. The sampling channel 3006 functions as a blood sampling pathway once a first aliquot of blood has been sequestered in the sequestration chamber 3008. The sampling channel 3006 can be any sized, shaped or configured channel, or conduit. In some implementations, the sampling channel 3006 has a substantially similar cross sectional area as the opening of the inlet port 3002. In other implementations, the sampling channel 3006 can gradually widen from the inlet port 3002 to the outlet port 3004. The sequestration chamber 3008 may have a larger cross section to form a big reservoir toward the sequestration channel path so that the

blood will want to enter the reservoir first versus entering a smaller diameter on the sampling channel 3006.

[00160] In some exemplary implementations, the diversion between the sampling channel 3006 and the sequestration chamber 3008 is by diverter junction 3007. Diverter junction 3007 may be a substantially Y-shaped, T-shaped, or U-shaped. In some preferred exemplary implementations, and as shown in FIG. 17A – 17B, the diverter junction 3007 is configured such that the flow out of the inlet port 3002 is preferentially directed toward the sequestration chamber 3008. The sequestration chamber 3008 may also include or form a curve or ramp to direct the initial blood flow toward and into the sequestration chamber 3008.

[00161] The sequestration chamber 3008 is preferably maintained at atmospheric pressure, and includes a vent 3010 at or near a distal end of the sequestration chamber 3008. The vent 3010 may include an air permeable blood barrier 3012 as described above.

[00162] The blood sequestration device 3000 can include a housing 3001 that can be formed of multiple parts or a single, unitary part. In some implementations, and as illustrated FIG. 30F, the housing 3001 includes a top member 3020 and a bottom member 3022 that are mated together. The blood sequestration device 3000 can also include a gasket or other sealing member (not shown) so that when the top member 3020 is mechanically attached with the bottom member 3022, the interface between the two is sealed by the gasket or sealing member. The bottom member 3022 can include grooves, channels, locks, conduits or other pathways pre-formed therein, such as by an injection molding process or by etching, cutting, drilling, etc., to form the sampling channel 3006, the sequestration chamber 3008, and diverter junction 3007.

[00163] The sequestration chamber 3008 may have a larger cross section than the sampling channel 3006 so that the blood will preferentially move into the sequestration chamber first versus entering a smaller diameter on the sampling channel 3006.

[00164] In some implementations, the sampling channel 3006 and the sequestration chamber 3008 are formed by grooves, channels, locks or other pathways formed in housing 3001. The housing 3001 can be made of rubber, plastic, metal or any other suitable material. The housing 3001 can be formed of a clear or translucent material, or

of an opaque or non-translucent material. In other implementations, the housing 3001 can be mostly opaque or non-translucent, while the housing surface directly adjacent to the sampling channel 3006 and/or the sequestration chamber 3008 may be clear or translucent, giving a practitioner a visual cue or sign that the sequestration chamber 3008 is first filled to the extent necessary or desired, and/or then a visual cue or sign that the sequestered blood remains sequestered while a clean sample of blood is drawn through the sampling channel 3006. Other visual cues or signs of the sequestration can include, without limitation: the air permeable blood barrier 3012 turning a different color upon contact, saturation, or partial saturation with blood; a color-coded tab or indicator at any point along or adjacent to the sequestration chamber; an audible signal; a vibratory signal; or other signal.

[00165] The air permeable blood barrier 3012 can be covered with, or surrounded by, a cap 3032. The cap 3032 can be sized and configured to inhibit a user from touching the air permeable blood barrier 3012 with their finger or other external implement, while still allowing air to exit the air permeable blood barrier 3012 as the air is displaced from the sequestration chamber 3008. The cap 3032 can be constructed to inhibit or prevent accidental exposure of the filter to environmental fluids or splashes. This can be accomplished in a variety of mechanical ways including but not limited to the addition of a hydrophobic membrane to the protective cover.

[00166] The air venting mechanism includes a wall 3030 that at least partially circumscribes or surrounds the air permeable blood barrier 3012. The wall 3030 can have one or more air vents formed therein. The cap 3032 covers wall 3030 and can be snapped, glued, or otherwise attached in place. A seal 3017 in the form of a silicone wafer, or other elastomeric material, fits within the wall 3030 to cover the air permeable blood barrier 3012 and abut the top of the wall 3030. The seal 3017 covers and seals the air permeable blood barrier 3012 and inhibits air from entering the blood sequestration chamber 3008 through the air permeable blood barrier 3012. A fulcrum 3012 on an underside of the cap 3032 allows the seal 3008 to flexibly disconnect from the top of the inner wall 3016 when pushed by air displaced from the blood sequestration chamber 3008, to allow air to vent from the air permeable blood barrier 3012 and through the one or more air vents in the wall 3030 and/or cap 3032.

[00167] In use, the blood sequestration device 3000 includes a sampling channel 3006 and a sequestration chamber 3008. Both pathways are initially air-filled at atmospheric pressure, but the sampling channel 3006 is directed to an outlet port 3004 that will be initially sealed by a Vacutainer or other such sealed blood sampling device, and the sequestration chamber 3008 terminates at a vent 3010 to atmosphere that includes an air permeable blood barrier 3012.

[00168] After a venipuncture by a patient needle of a patient (not shown), which could gather a number of pathogens from the patient's skin, a first amount of the patient's blood with those pathogens will pass through inlet port 3002 of blood sequestration device 3000. This initial volume of potentially contaminated blood will preferentially flow into the sequestration chamber 3008 by finding the path of least resistance. The patient's own blood pressure overcomes the atmospheric pressure in the vented sequestration chamber 3008 to displace air therein through the air permeable blood barrier 3012, but is not sufficient to overcome the air pressure that builds up in the sealed sampling channel 3006. In various exemplary embodiments, the sequestration chamber 3008 and sampling channel 3006 can be configured such that the force generated by the patient's blood pressure is sufficient to overcome any effect of gravity, regardless of the blood sequestration device's orientation.

[00169] Eventually, the sequestration chamber 3008 fills with blood that displaces air through the air permeable blood barrier 3012. Once the blood contacts the air permeable blood barrier, the blood interacts with the air permeable blood barrier 3012 material to completely or partially seal the vent 3010. A signal or indication may be provided that the practitioner can now utilize the Vacutainer or other blood sampling device.

[00170] Upon filling the blood sequestration pathway 3008 but prior to use of the Vacutainer or other blood sample collection device, the patient's blood pressure may drive compression of the air in the sampling channel 3006, possibly resulting in a small amount of blood moving past the diversion point into the sampling channel 3006, queuing up the uncontaminated blood to be drawn through the sampling channel 3006.

[00171] In yet another aspect, the blood sequestration chamber and/or blood sampling channel, or other component, of any of the implementations described herein,

can provide a visually discernable warning or result in a component adapted for operative fluid communication with the flash chamber of an introducer for an intravenous catheter into a blood vessel of a patient. The device and method provides a visually discernable alert when blood from the patient communicates with a test component reactive to communicated blood plasma, to visually change. The reaction with the blood or the plasma occurs depending on one or a plurality of reagents positioned therein configured to test for blood contents, substances or threshold high or low levels thereof, to visually change in appearance upon a result.

[00172] In yet other aspects, the blood sequestration chamber and/or blood sampling channel can be sized and adapted to provide a particular volumetric flow of blood, either during the sequestration process and/or the sampling process.

[00173] Although a variety of embodiments have been described in detail above, other modifications are possible. Other embodiments may be within the scope of the following claims.

CLAIMS

1. A blood sequestration device comprising;

an inlet port;

an outlet port;

a sequestration chamber connected with the inlet port via a junction, the sequestration chamber having a vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further including a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and

a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port;

the sequestration chamber, the sampling channel and the junction being sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

2. The blood sequestration device in accordance with claim 1, further comprising a housing that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel.

3. The blood sequestration device in accordance with claim 1, wherein the vent further includes an inner wall within the outer wall and that contains the air permeable blood barrier.

4. The blood sequestration device in accordance with claim 1, wherein the one-way seal is positioned over the inner wall and within the outer wall of the vent.

5. The blood sequestration device in accordance with claim 4, wherein the cap includes an inner surface that faces the air permeable blood barrier, the

inner surface of the cap including a fulcrum against which the seal can flexibly unseal from the air permeable blood barrier to allow air to escape the sequestration chamber.

6. The blood sequestration device in accordance with claim 1, wherein the air permeable blood barrier includes a sealing material that seals the vent upon contact with blood.

7. The blood sequestration device in accordance with claim 1, wherein the air permeable blood barrier includes a filter having a first layer and a second layer, the second layer of the filter having a hydrophobic material to repel blood.

8. A blood sequestration and sampling system comprising;

a blood sampling pathway having a patient needle on a proximal end and a sample collection device on a distal end; and

a blood sequestration device attached on the blood sampling pathway between the proximal end and distal end of the blood sampling pathway, the blood sequestration device comprising:

an inlet port coupled with the blood sampling pathway toward the patient needle;

an outlet port coupled with the blood sampling pathway toward the sample collection device;

a sequestration chamber connected with the inlet port via a junction, the sequestration chamber having a vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further including a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and

a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port;

the sequestration chamber, the sampling channel and the junction being sized and configured such that a first portion of blood flows into the sequestration chamber toward the air permeable blood barrier for sequestration therein, and a second portion of blood bypasses the sequestration chamber and the

first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

9. The blood sequestration system in accordance with claim 8, wherein the blood sequestration device further comprises a housing that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel.

10. The blood sequestration system in accordance with claim 8, wherein the vent of the blood sequestration device further includes an inner wall within the outer wall and that contains the air permeable blood barrier.

11. The blood sequestration system in accordance with claim 8, wherein the one-way seal of the vent is positioned over the inner wall and within the outer wall of the vent.

12. The blood sequestration system in accordance with claim 11, wherein the cap includes an inner surface that faces the air permeable blood barrier, the inner surface of the cap including a fulcrum against which the seal can flexibly unseal from the air permeable blood barrier to allow air to escape the sequestration chamber.

13. The blood sequestration system in accordance with claim 8, wherein the air permeable blood barrier of the blood sequestration device includes a sealing material that seals the vent upon contact with blood.

14. The blood sequestration system in accordance with claim 8, wherein the air permeable blood barrier of the blood sequestration device includes a filter having a first layer and a second layer, the second layer of the filter having a hydrophobic material to repel blood.

15. A blood sequestration device comprising;

an inlet port;

an outlet port;

a sequestration chamber connected with the inlet port via a junction, the sequestration chamber having a vent that includes an air permeable blood barrier, the vent being defined by an outer wall that at least partially circumscribes the air permeable blood barrier and includes one or more air vents, the vent further including a cap that at least partially covers the wall and a one-way seal abutting the air permeable blood barrier that inhibits air from entering the sequestration chamber; and

a sampling channel having a proximal end connected with the inlet port via the junction, and a distal end connected with the outlet port;

the sequestration chamber, the sampling channel and the junction being sized and configured such that a first portion of blood flows into and fills the sequestration chamber to displace air therein through the vent, and such that a second portion of blood bypasses the sequestration chamber and the first portion of blood sequestered therein and is directed into the sampling channel toward the outlet port.

16. The blood sequestration device in accordance with claim 15, further comprising a housing that houses and defines the inlet port, the outlet port, the sequestration chamber, and the sampling channel.

17. The blood sequestration device in accordance with claim 15, wherein the vent further includes an inner wall within the outer wall and that contains the air permeable blood barrier.

18. The blood sequestration device in accordance with claim 15, wherein the one-way seal is positioned over the inner wall and within the outer wall of the vent.

19. The blood sequestration device in accordance with claim 18, wherein the cap includes an inner surface that faces the air permeable blood barrier, the inner surface of the cap including a fulcrum against which the seal can flexibly unseal from the air permeable blood barrier to allow air to escape the sequestration chamber.

20. The blood sequestration device in accordance with claim 15, wherein the air permeable blood barrier includes a sealing material that seals the vent upon contact with blood.

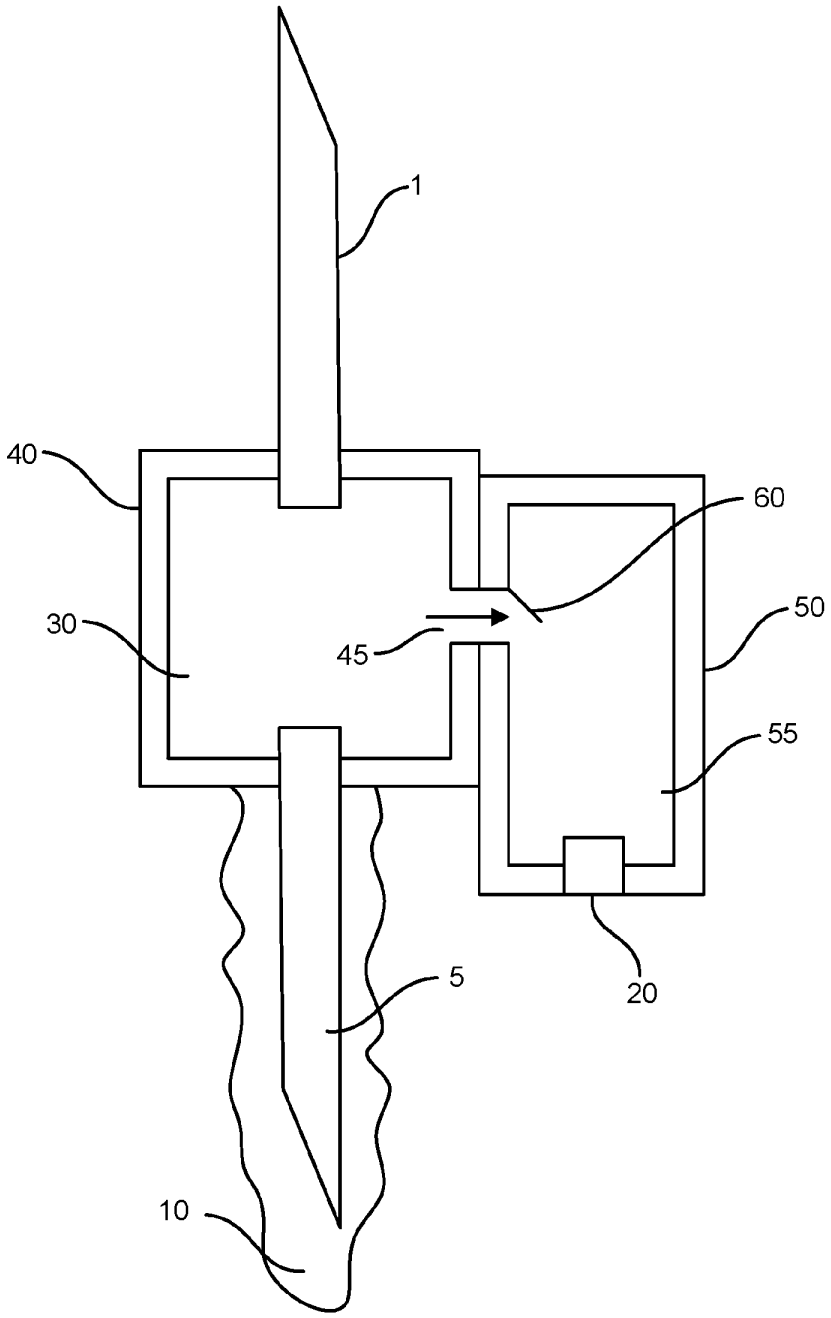


FIG. 1

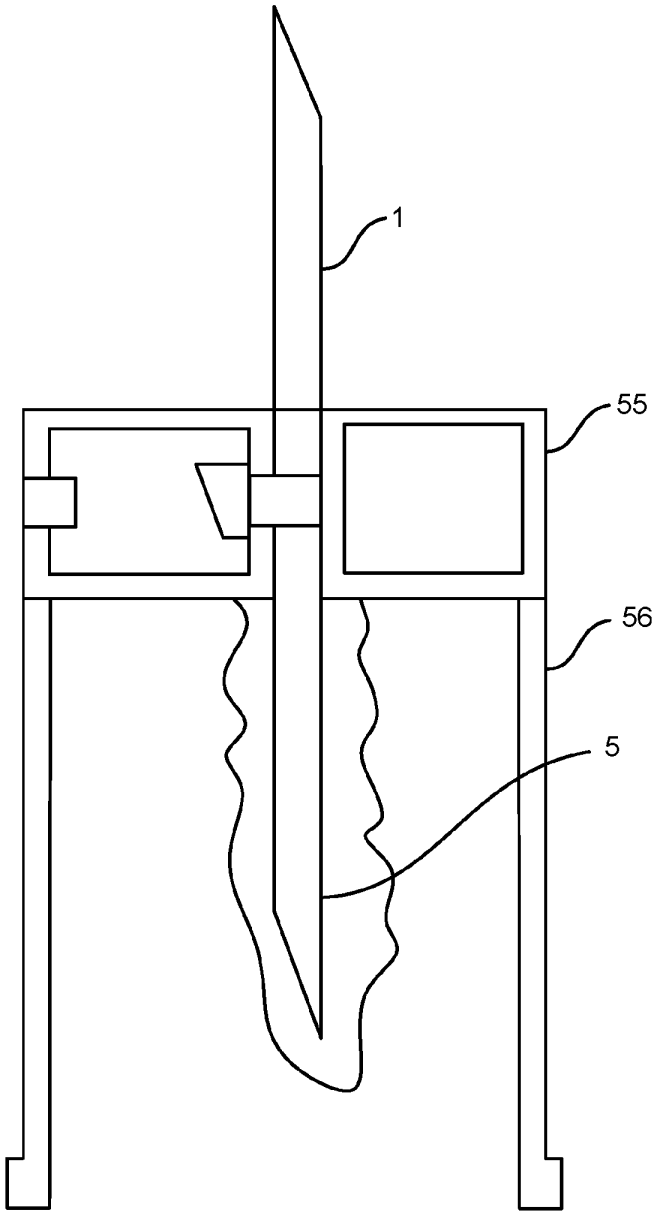


FIG. 2

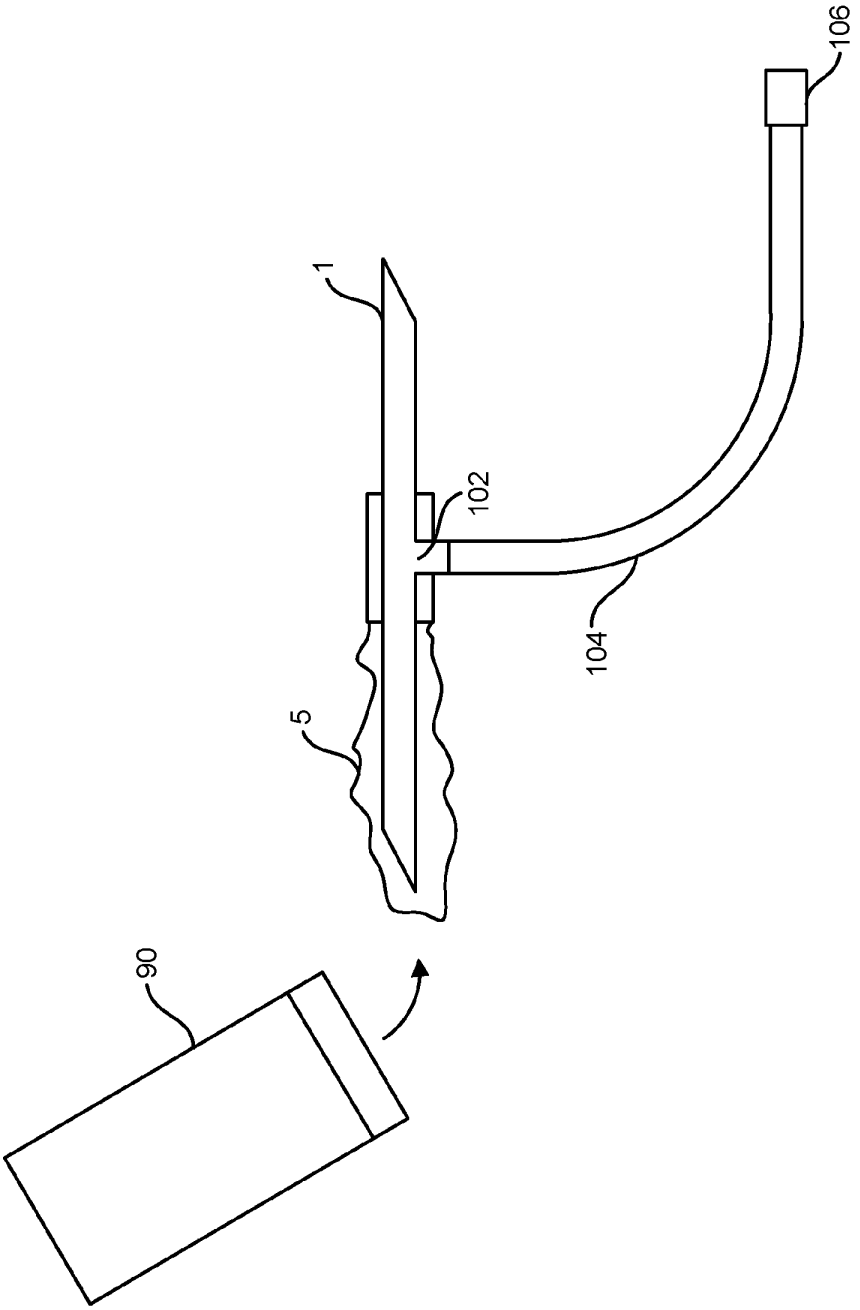


FIG. 3

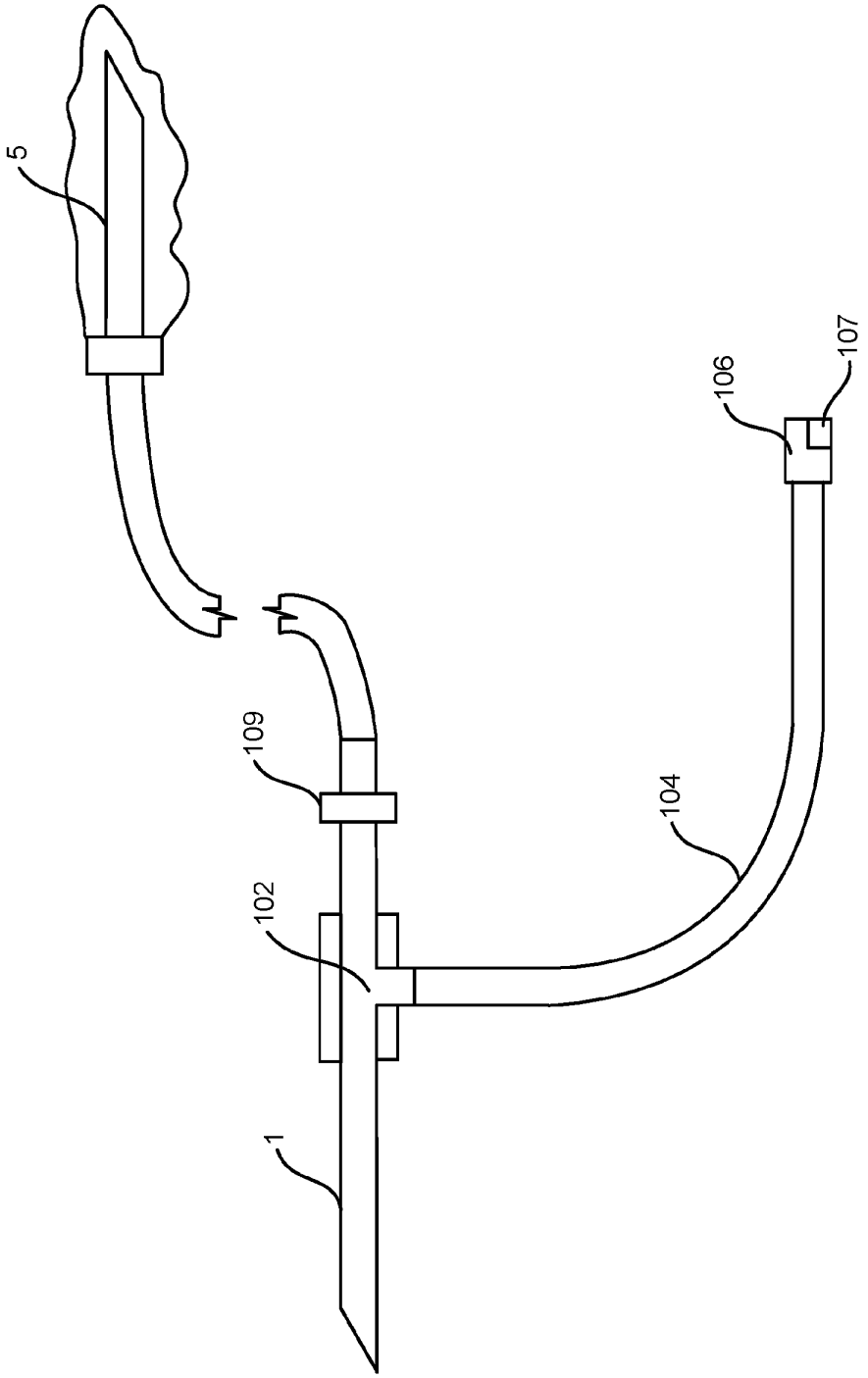


FIG. 4

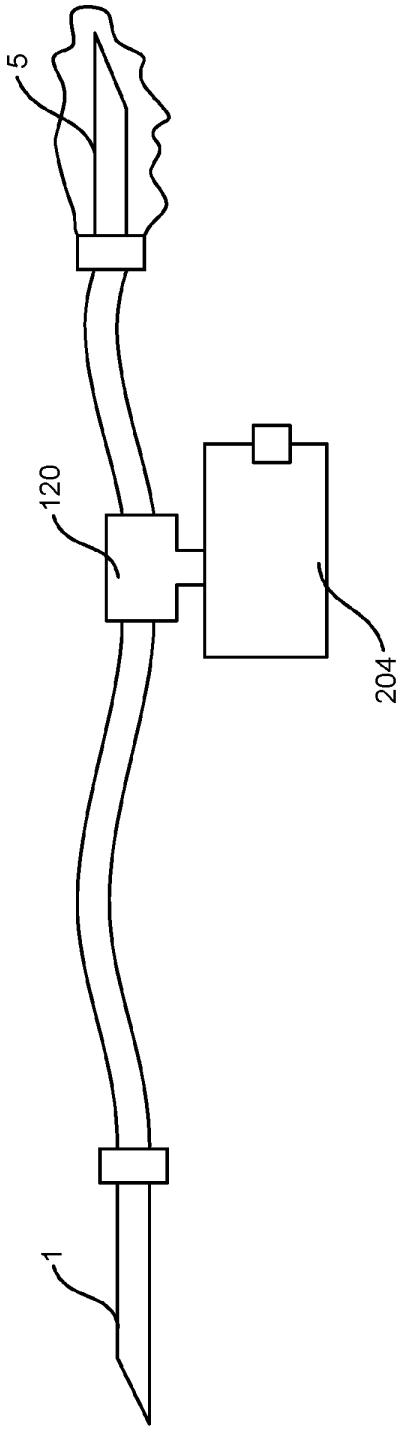


FIG. 5

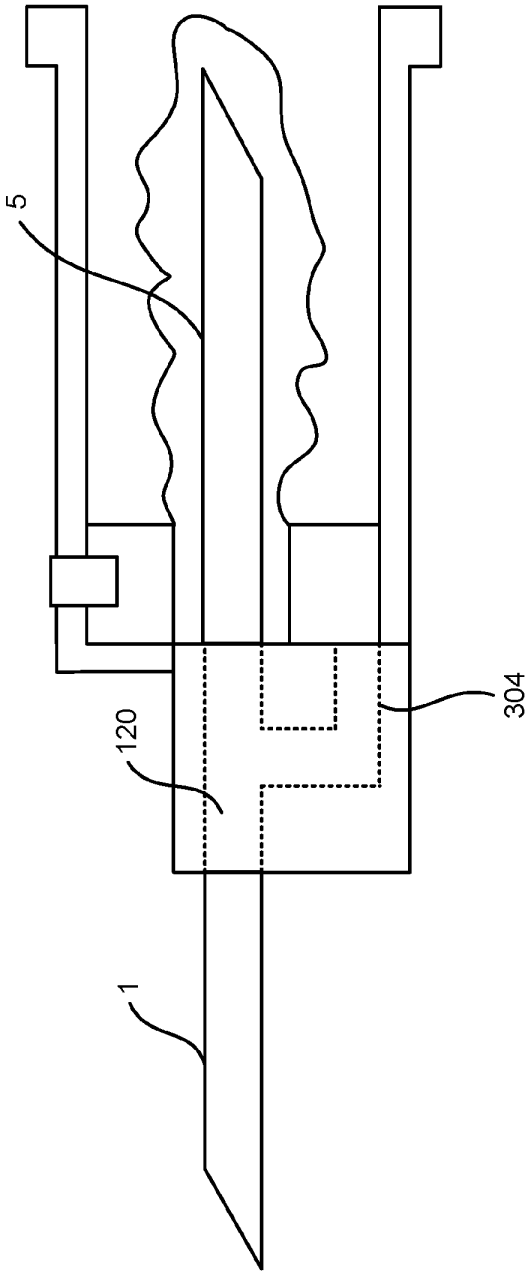


FIG. 6

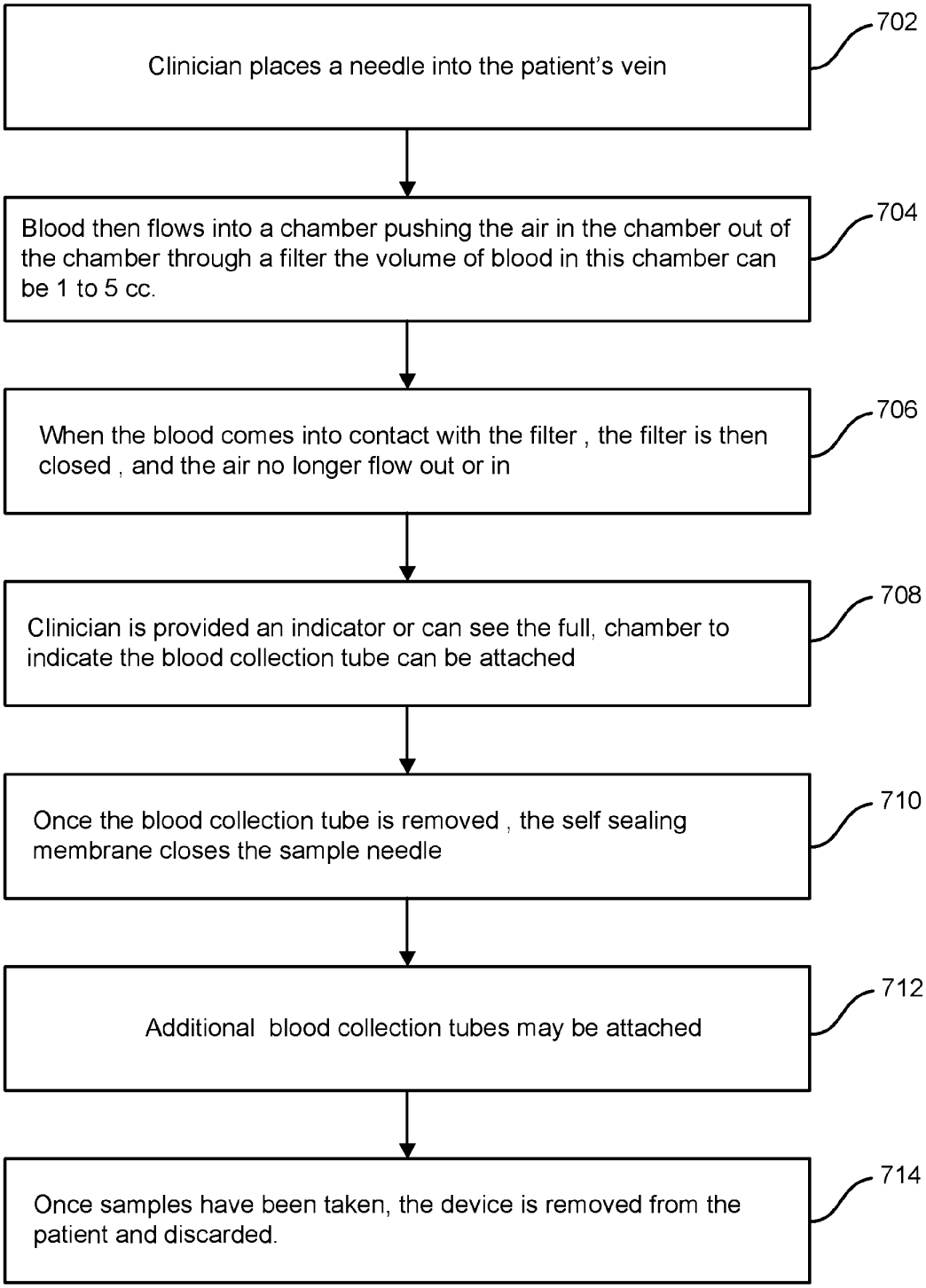

Clinician places a needle into the patient's vein
702
Blood then flows into a chamber pushing the air in the chamber out of the chamber through a filter the volume of blood in this chamber can be 1 to 5 cc.
704
When the blood comes into contact with the filter , the filter is then closed , and the air no longer flow out or in
706
Clinician is provided an indicator or can see the full, chamber to indicate the blood collection tube can be attached
708
Once the blood collection tube is removed , the self sealing membrane closes the sample needle
710
Additional blood collection tubes may be attached
712
Once samples have been taken, the device is removed from the patient and discarded.
714

FIG. 7

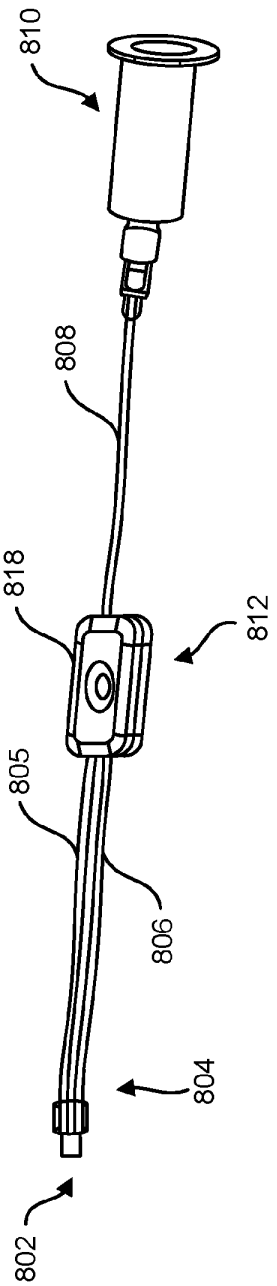


FIG. 8A

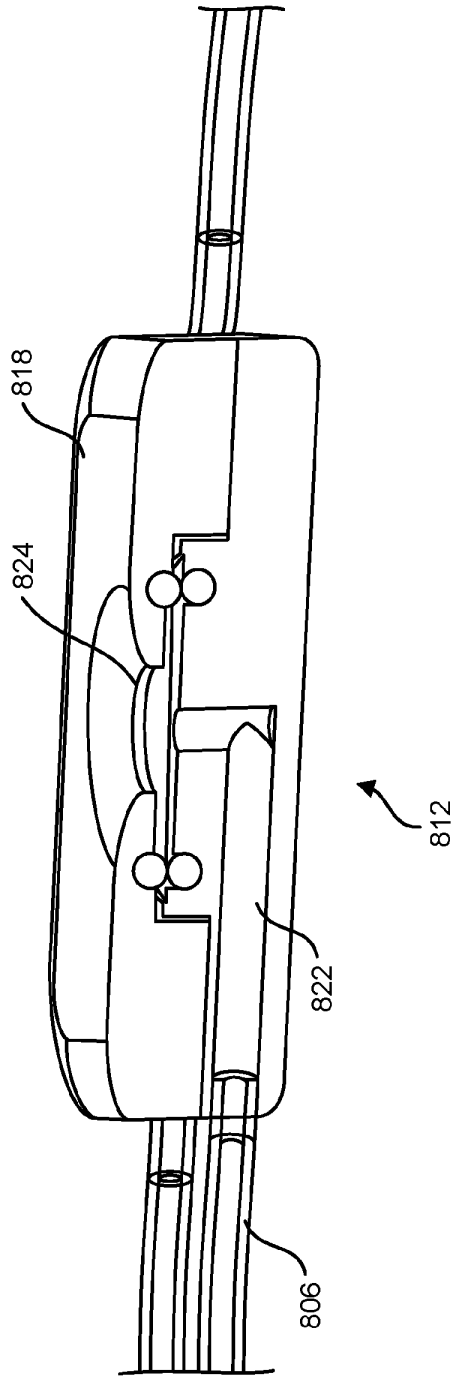


FIG. 8B

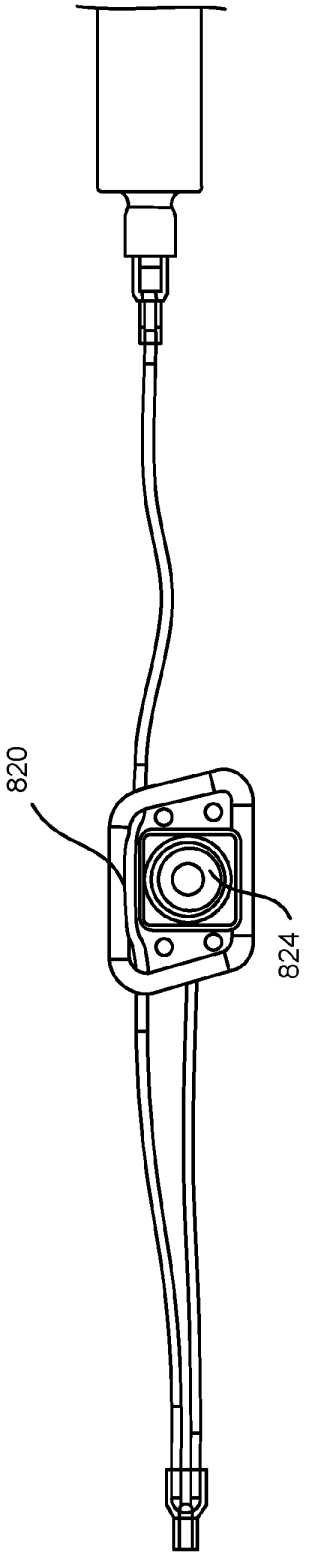


FIG. 8C

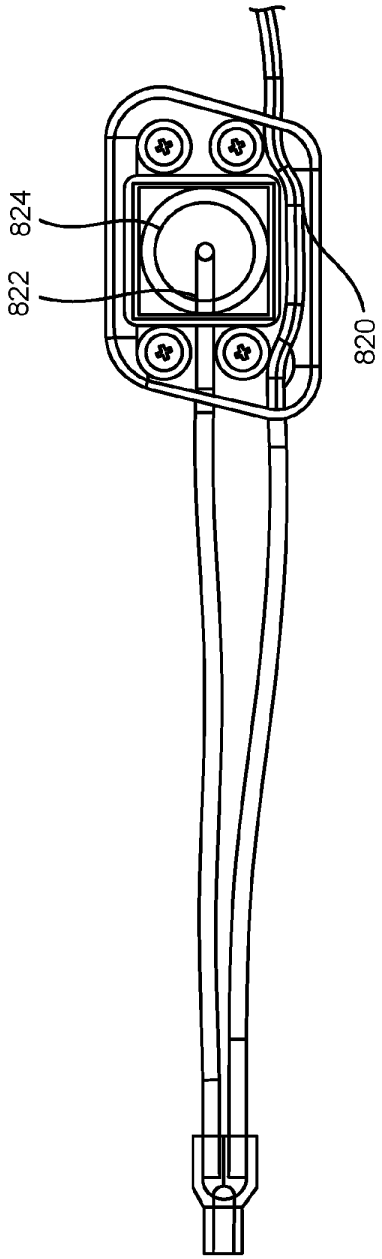


FIG. 8D

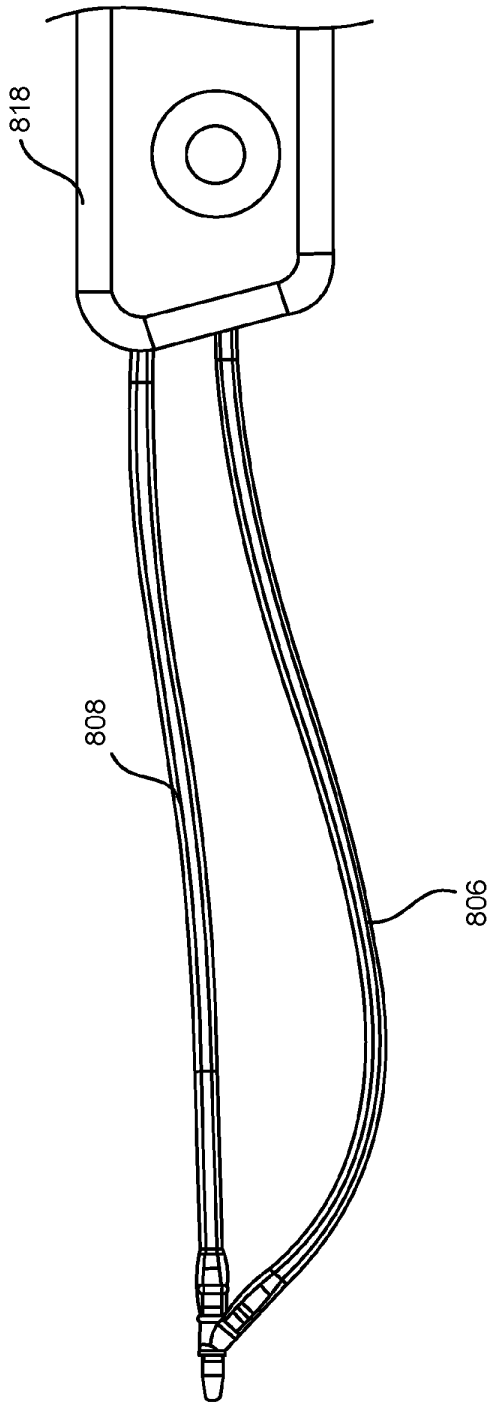


FIG. 8E

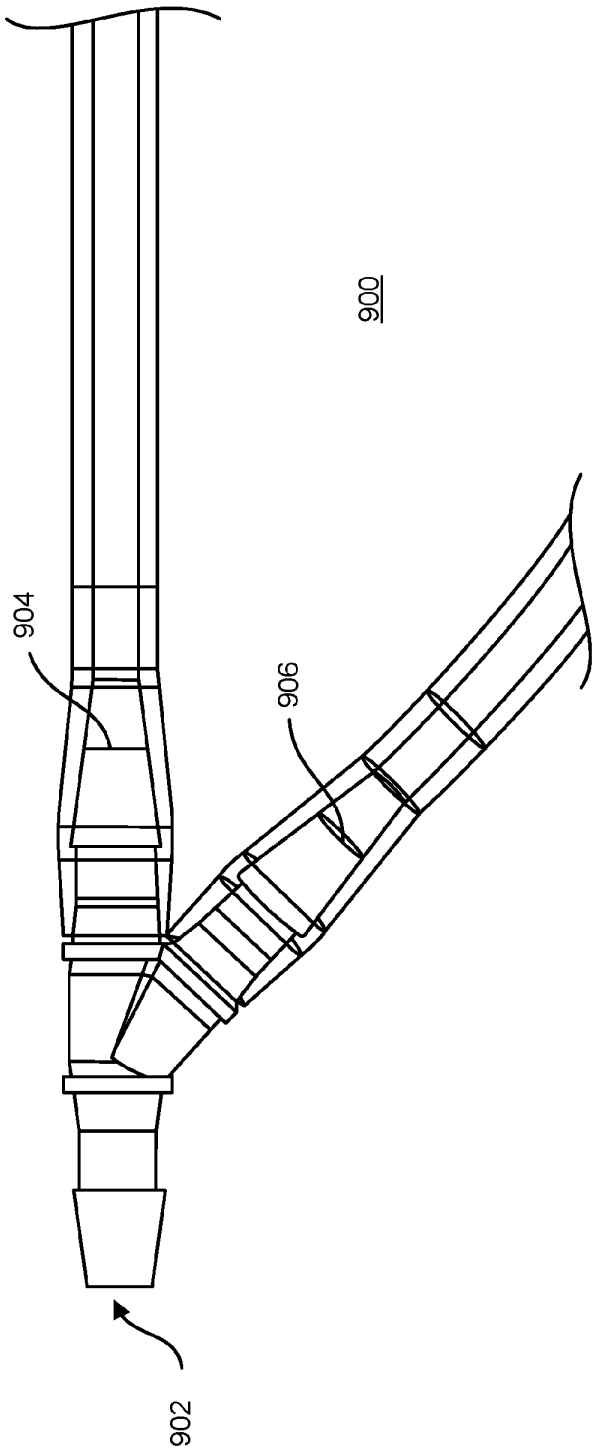


FIG. 9

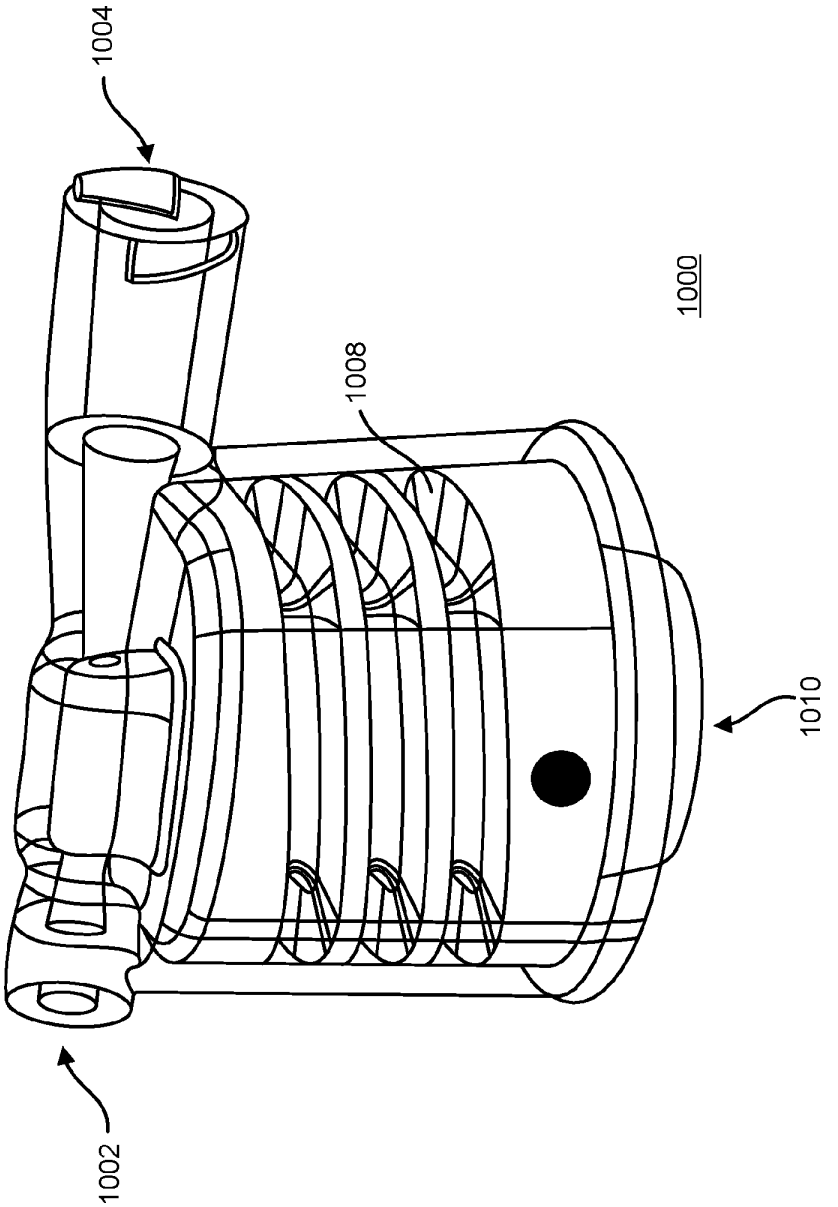


FIG. 10A

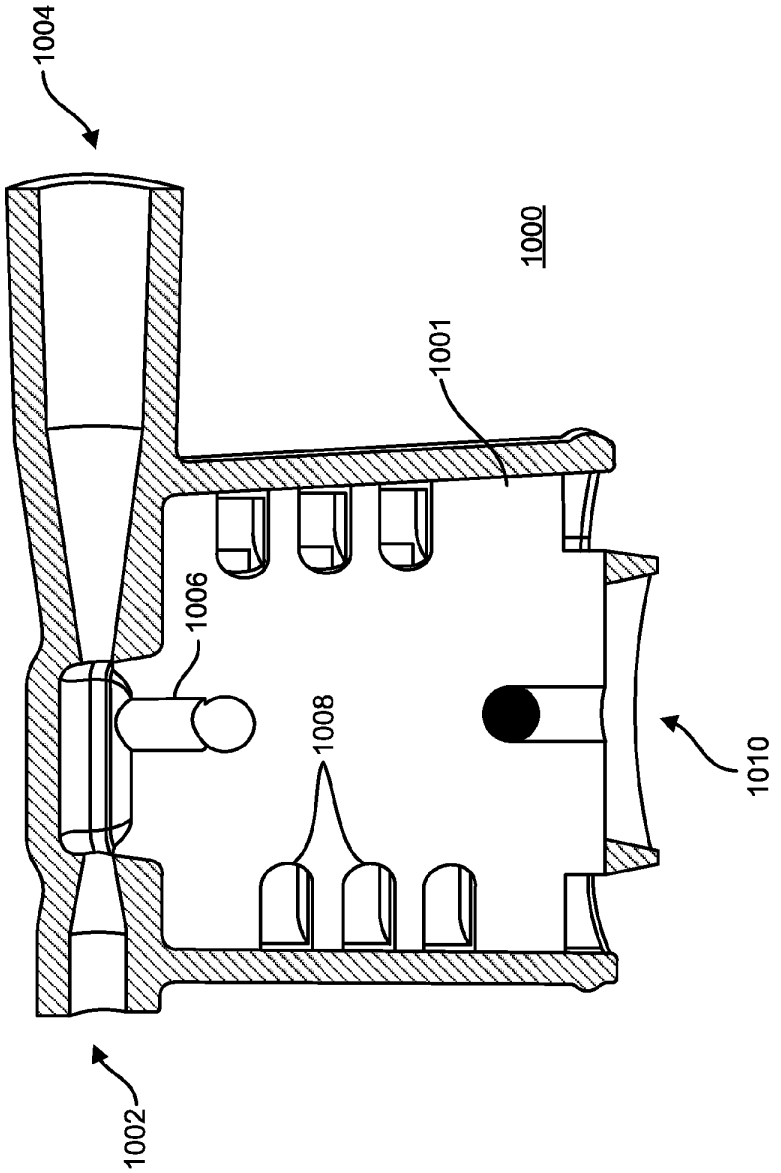


FIG. 10B

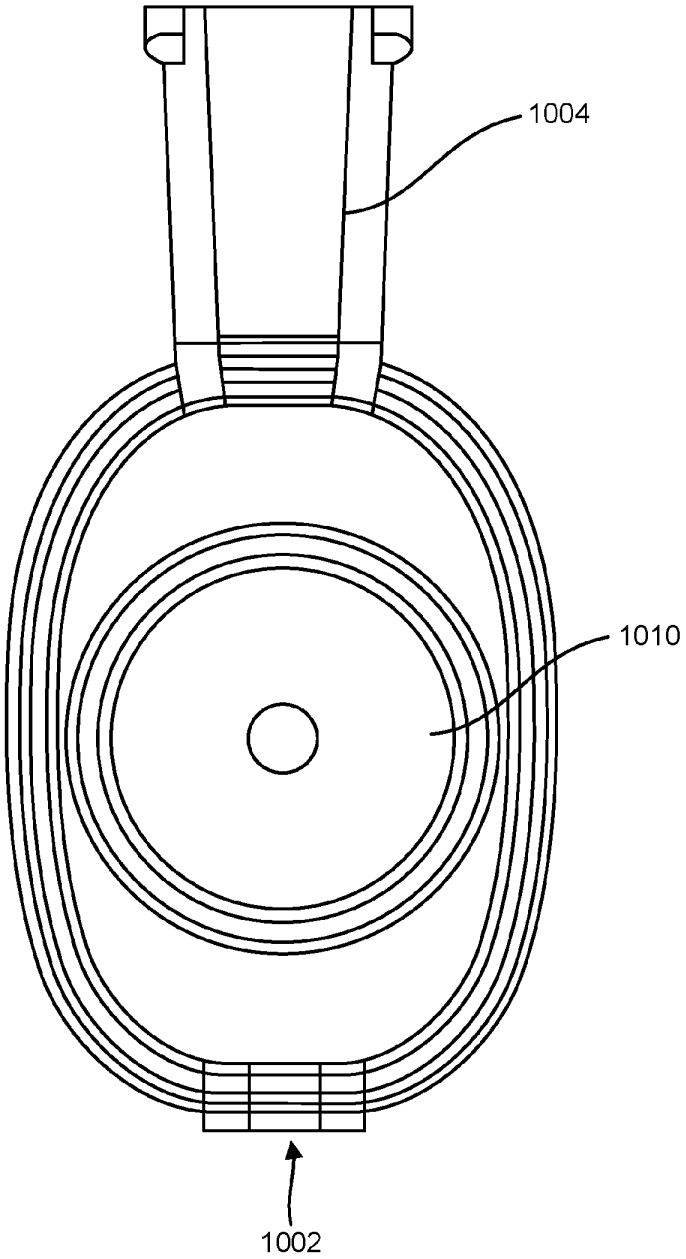


FIG. 10C

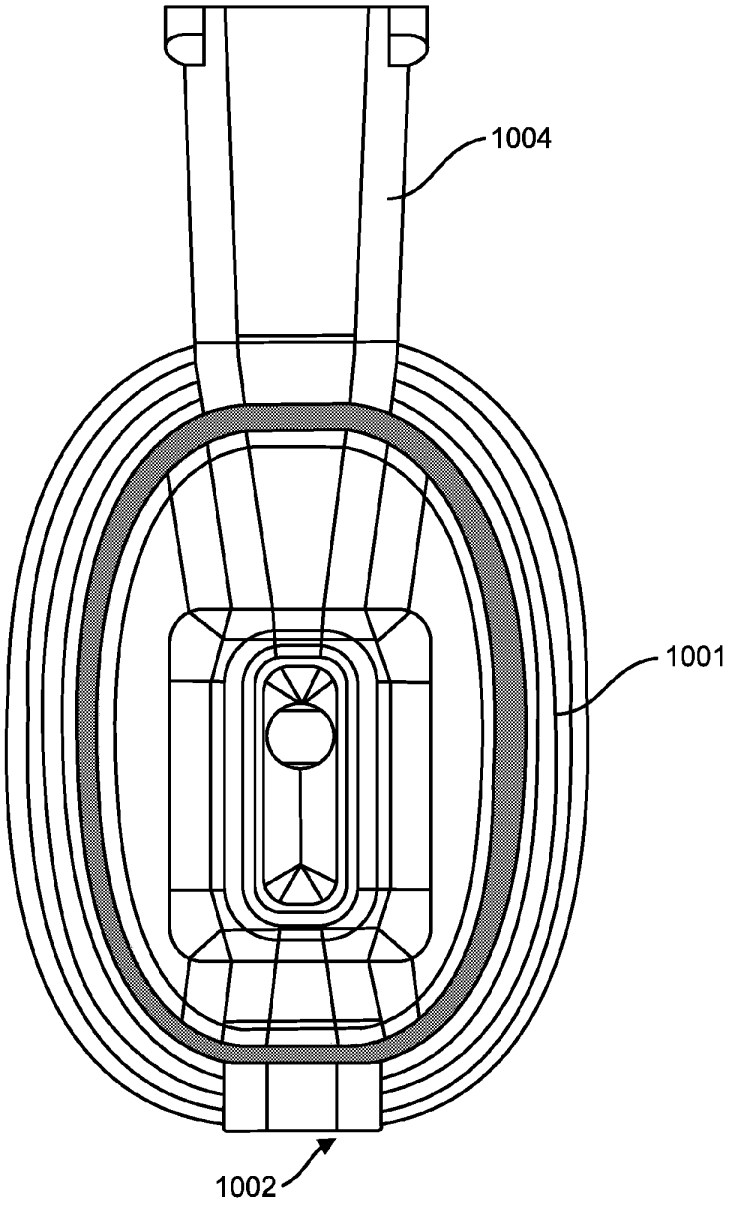


FIG. 10D

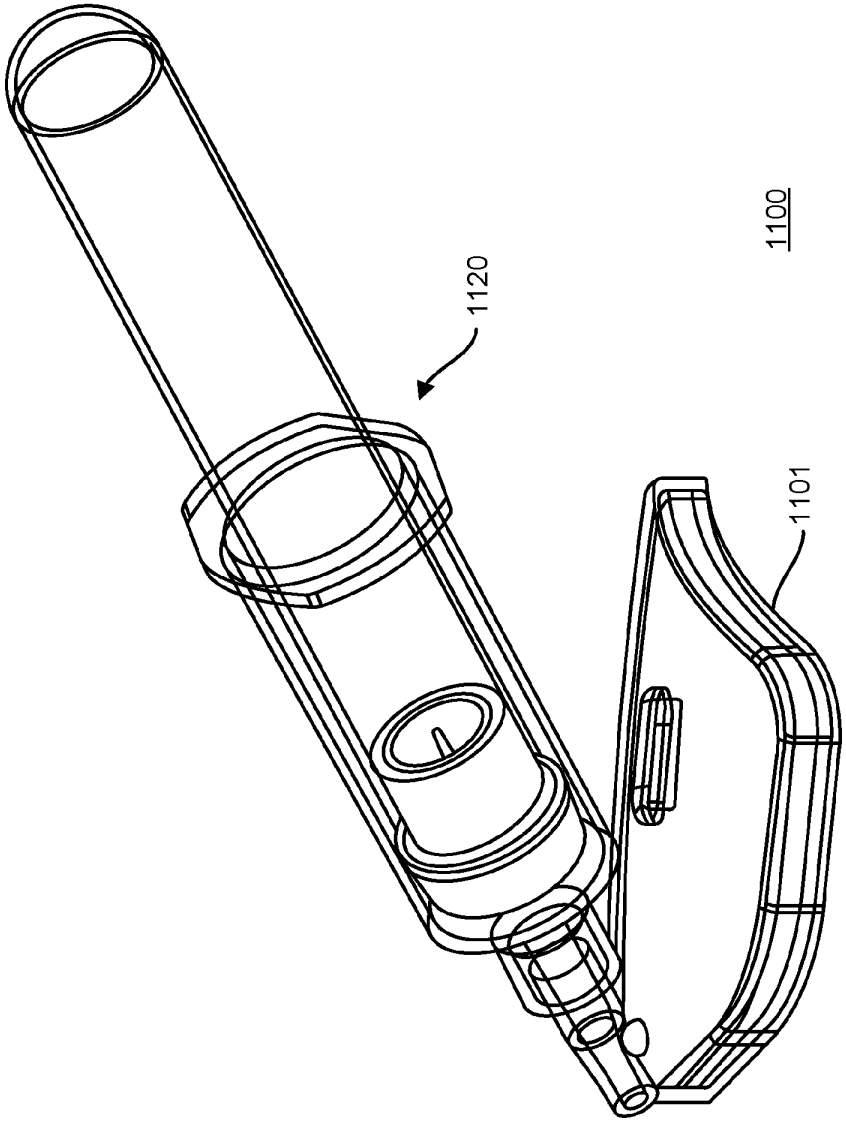


FIG. 11A

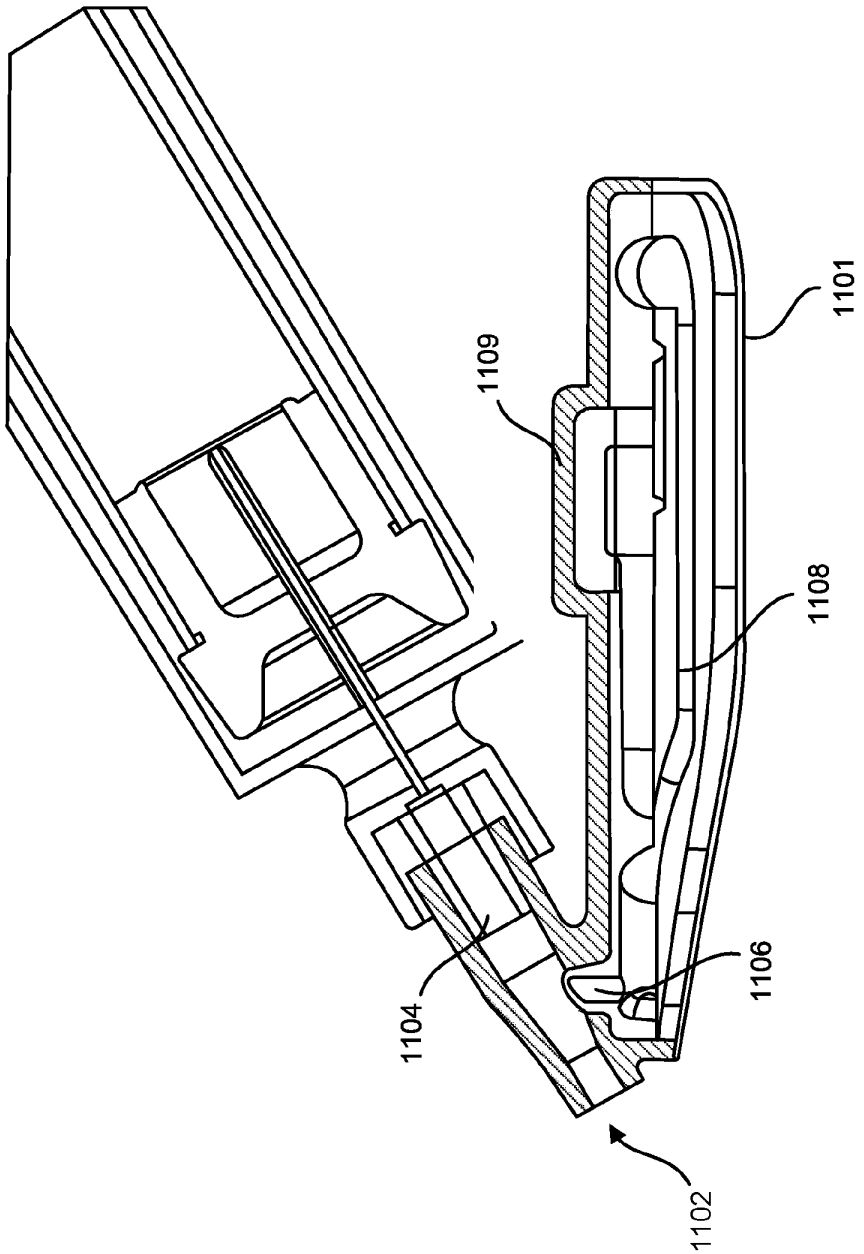


FIG. 11B

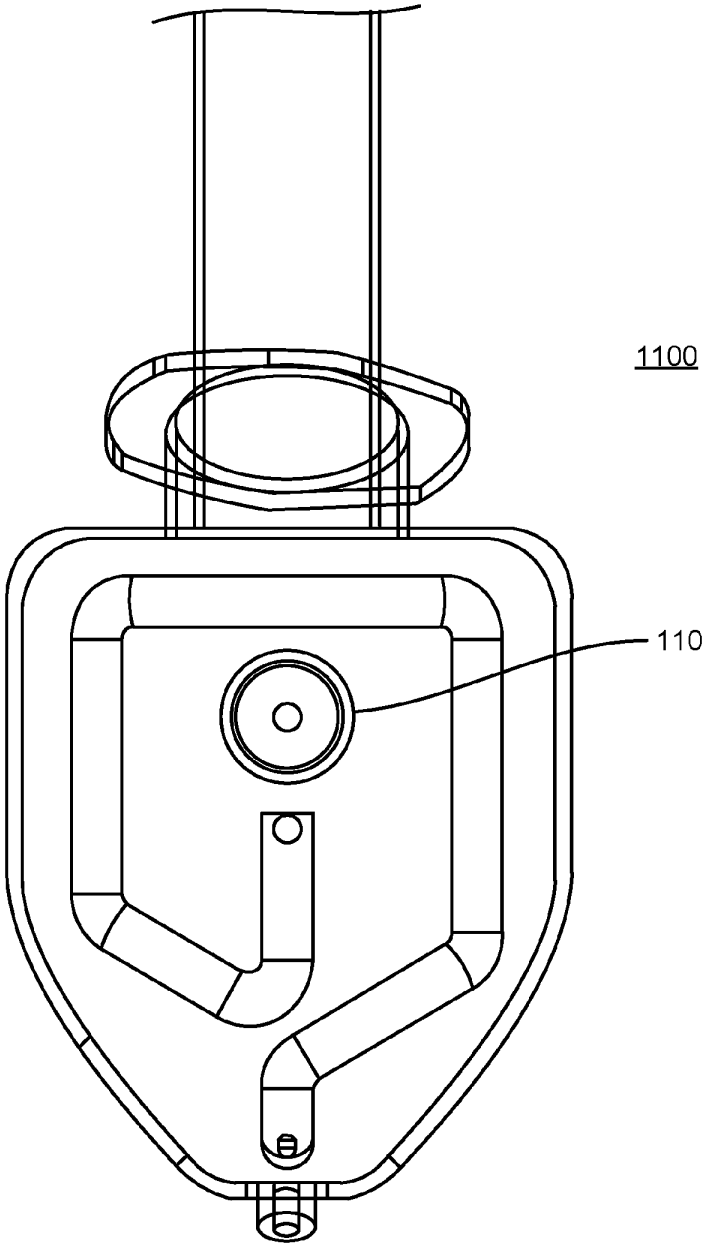


FIG. 11C

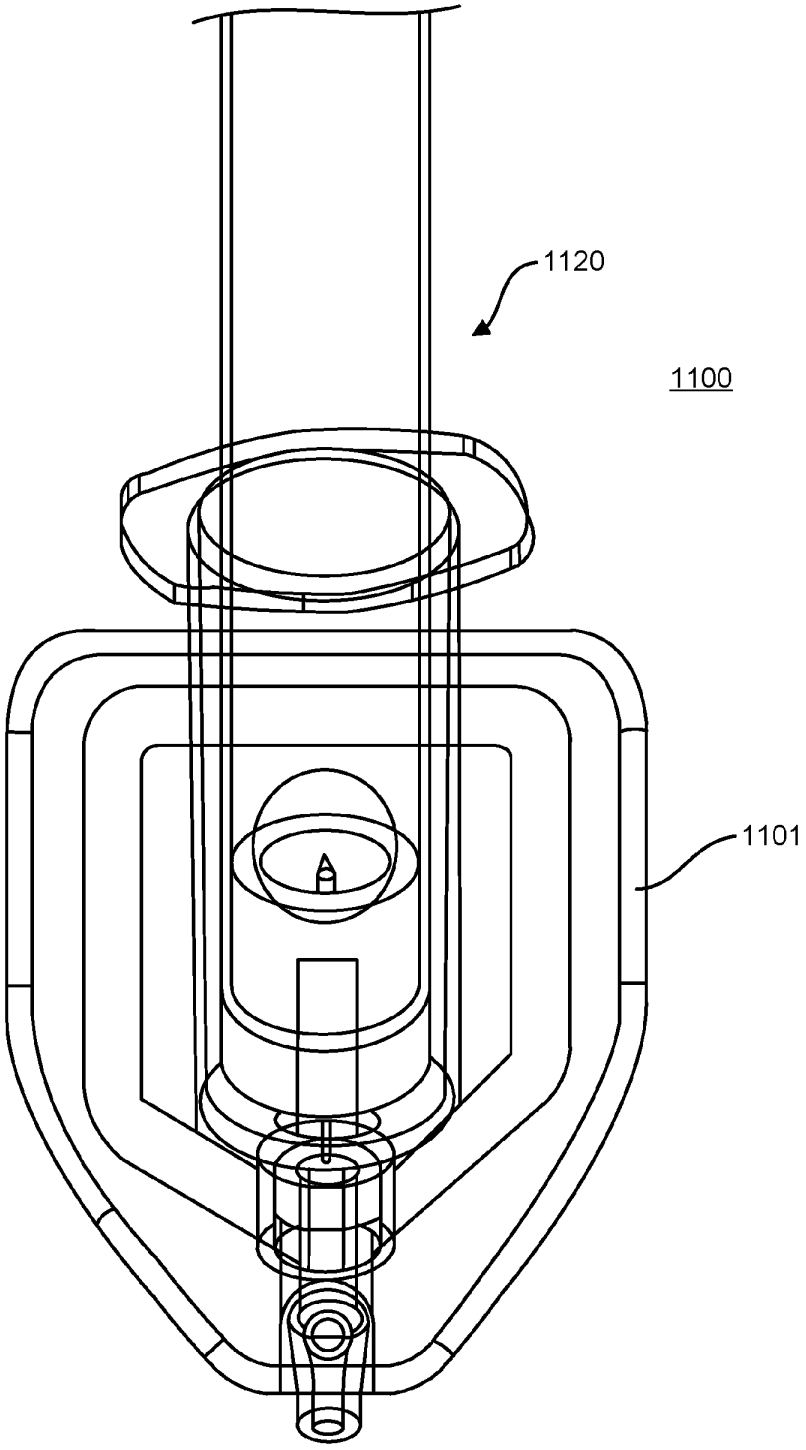


FIG. 11D

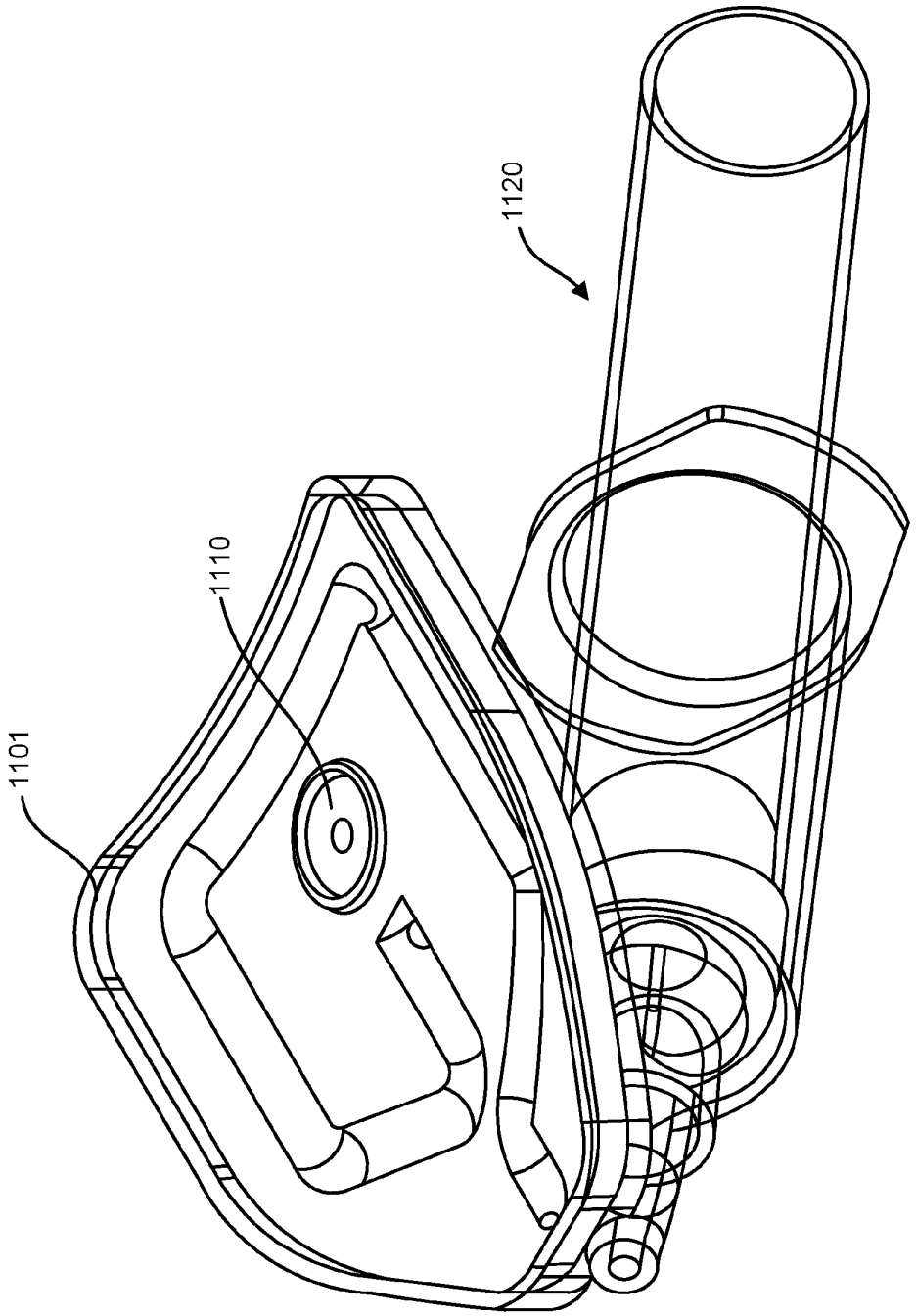


FIG. 11E

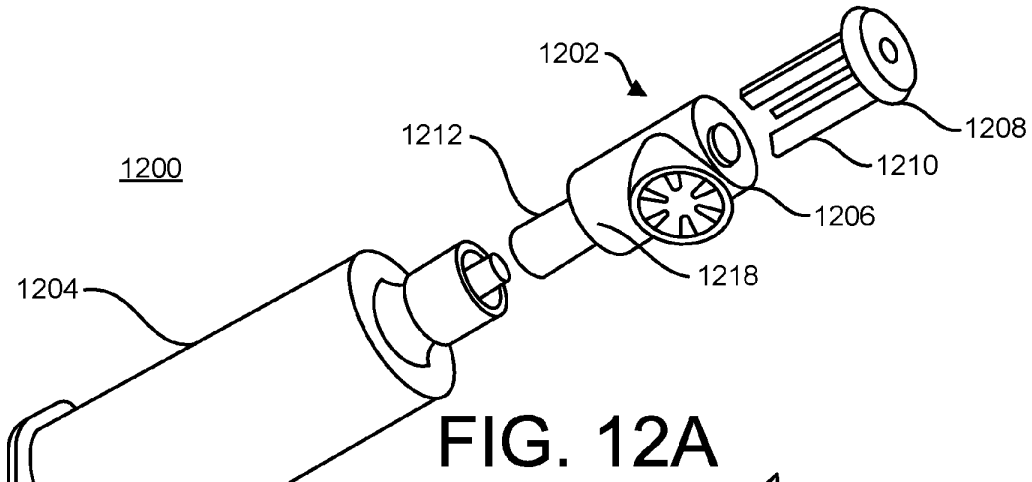


FIG. 12A

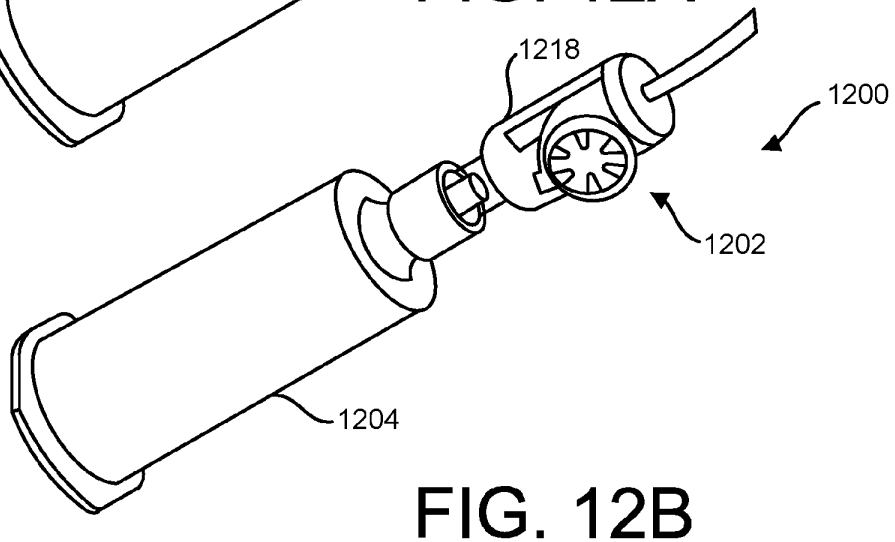


FIG. 12B

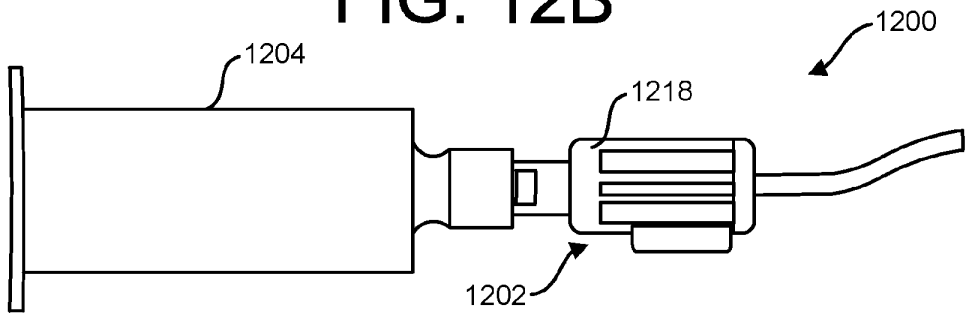


FIG. 12C

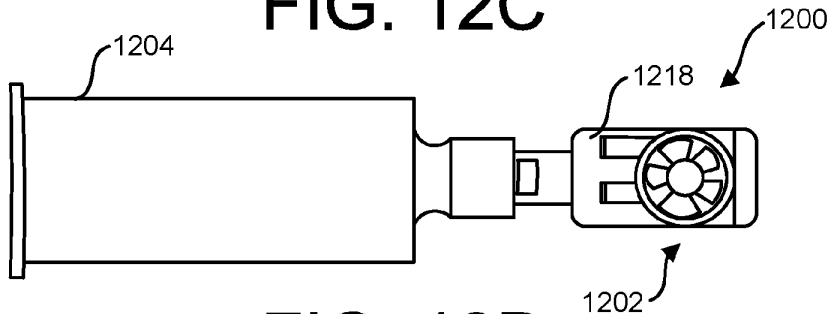


FIG. 12D

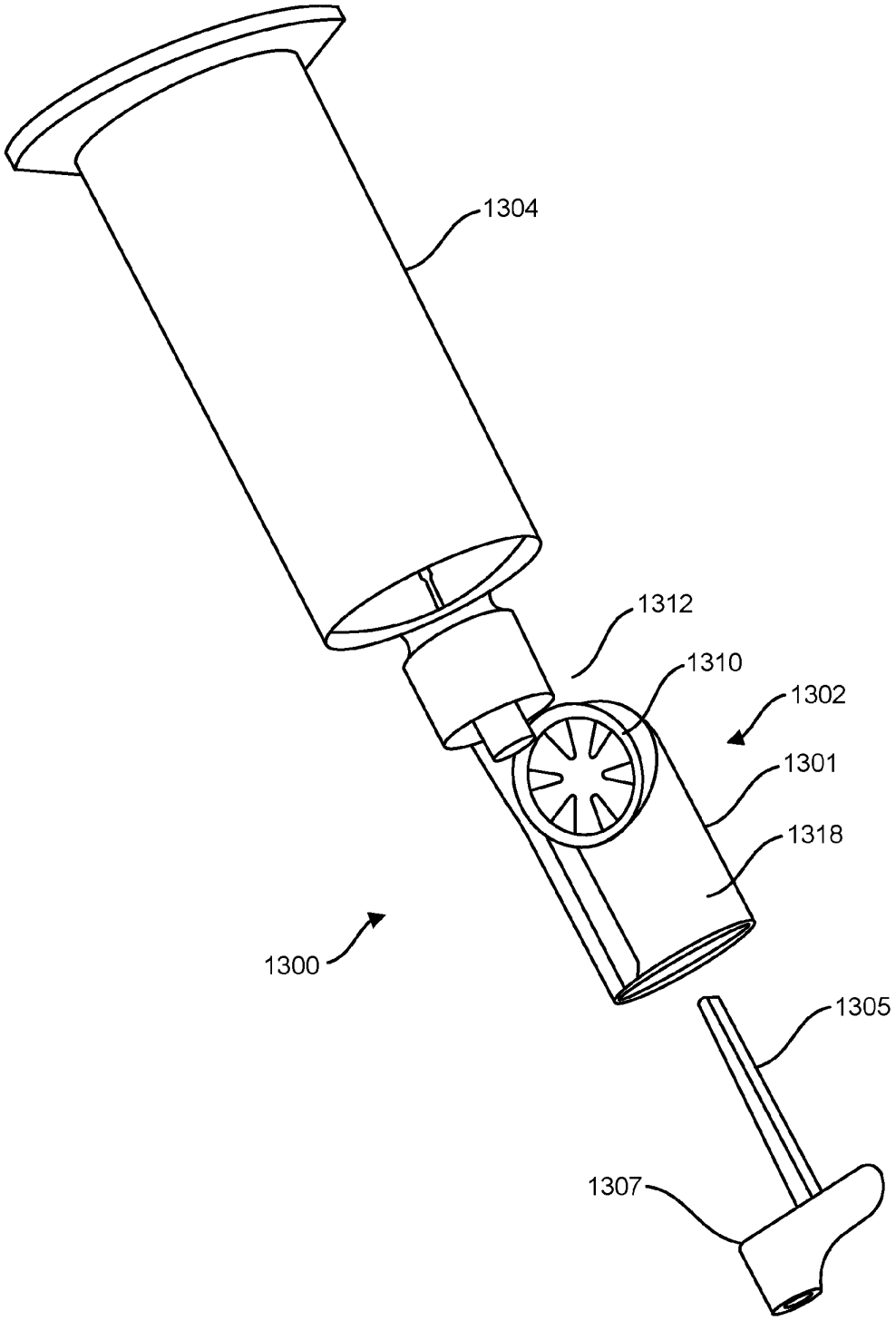


FIG. 13A

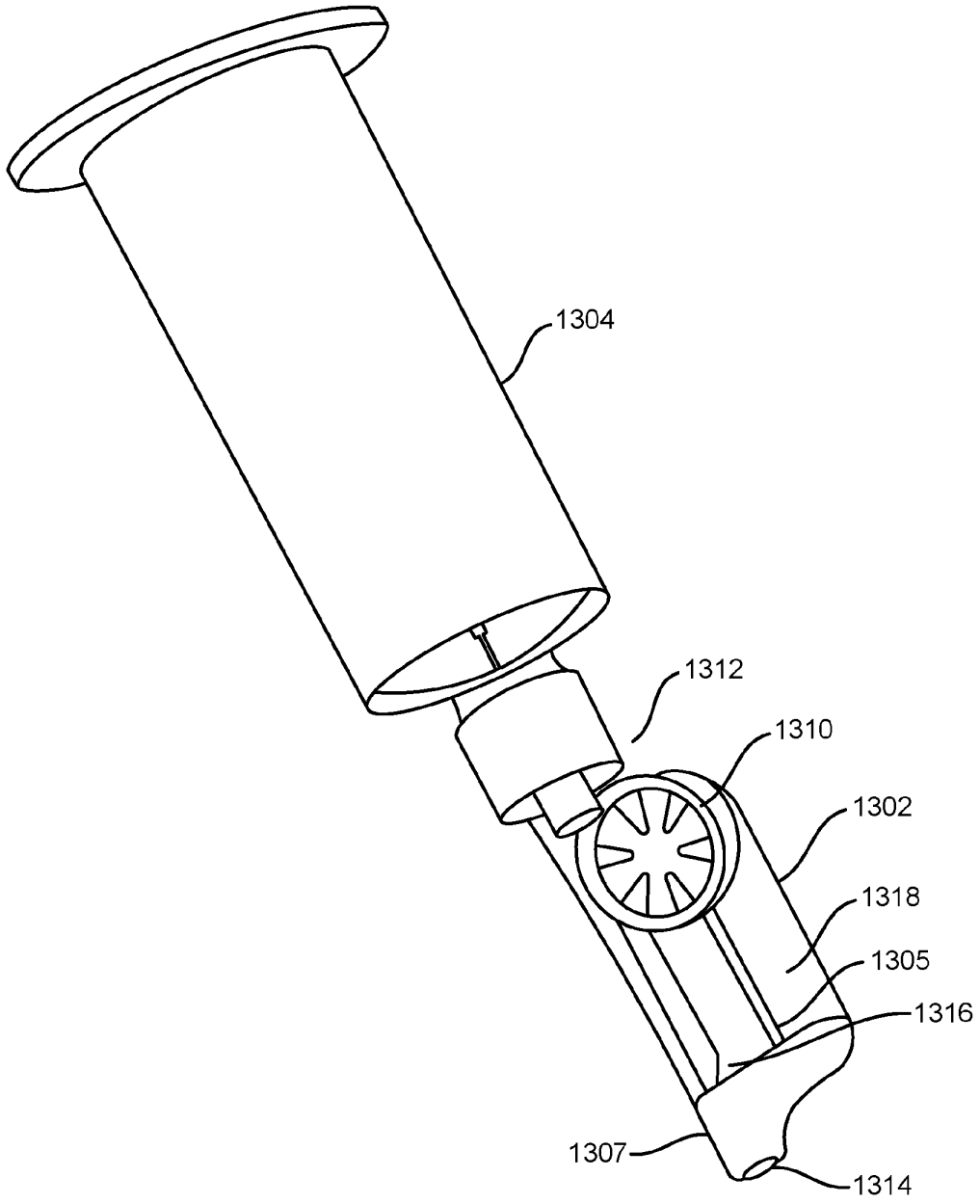


FIG. 13B

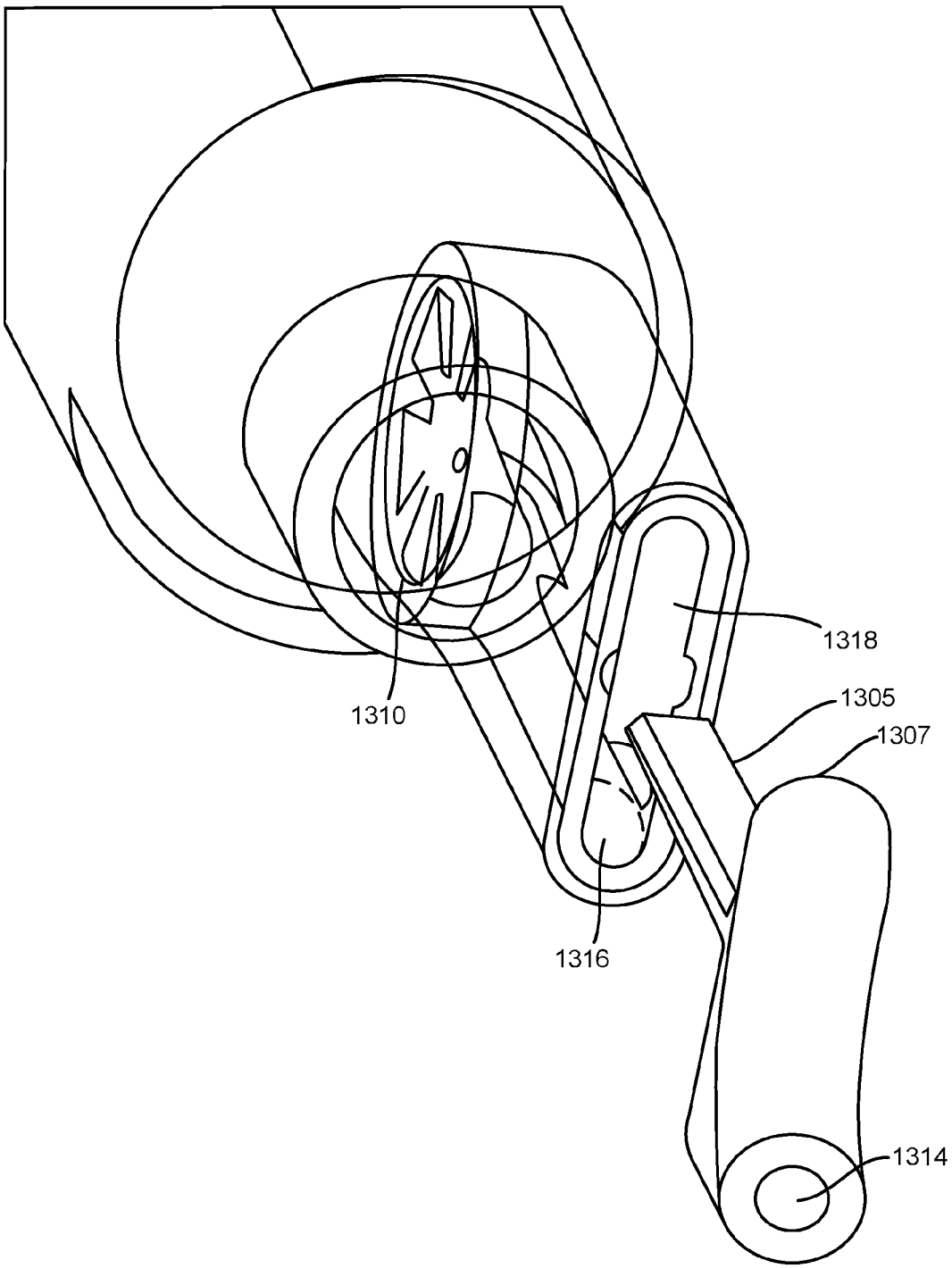


FIG. 13C

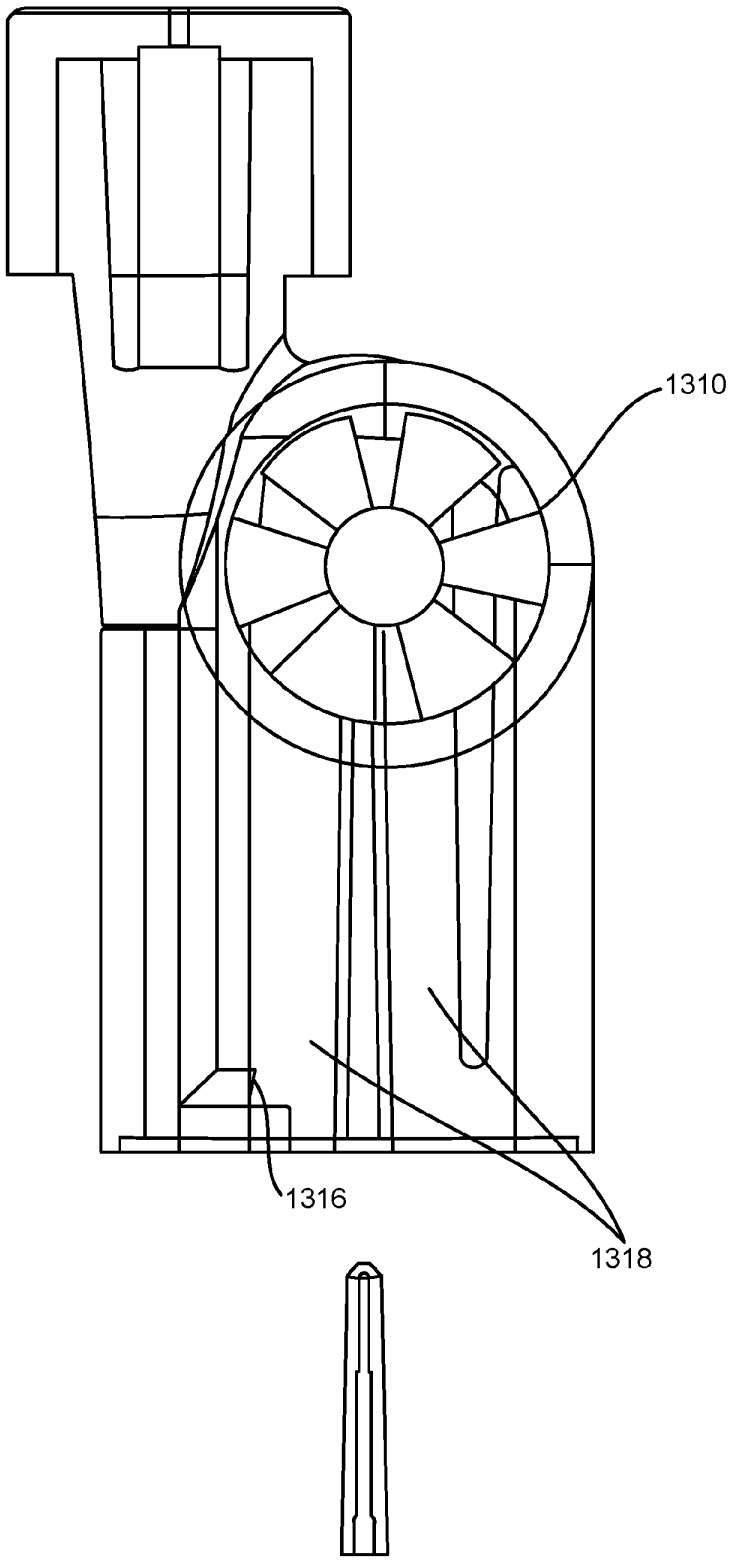


FIG. 13D

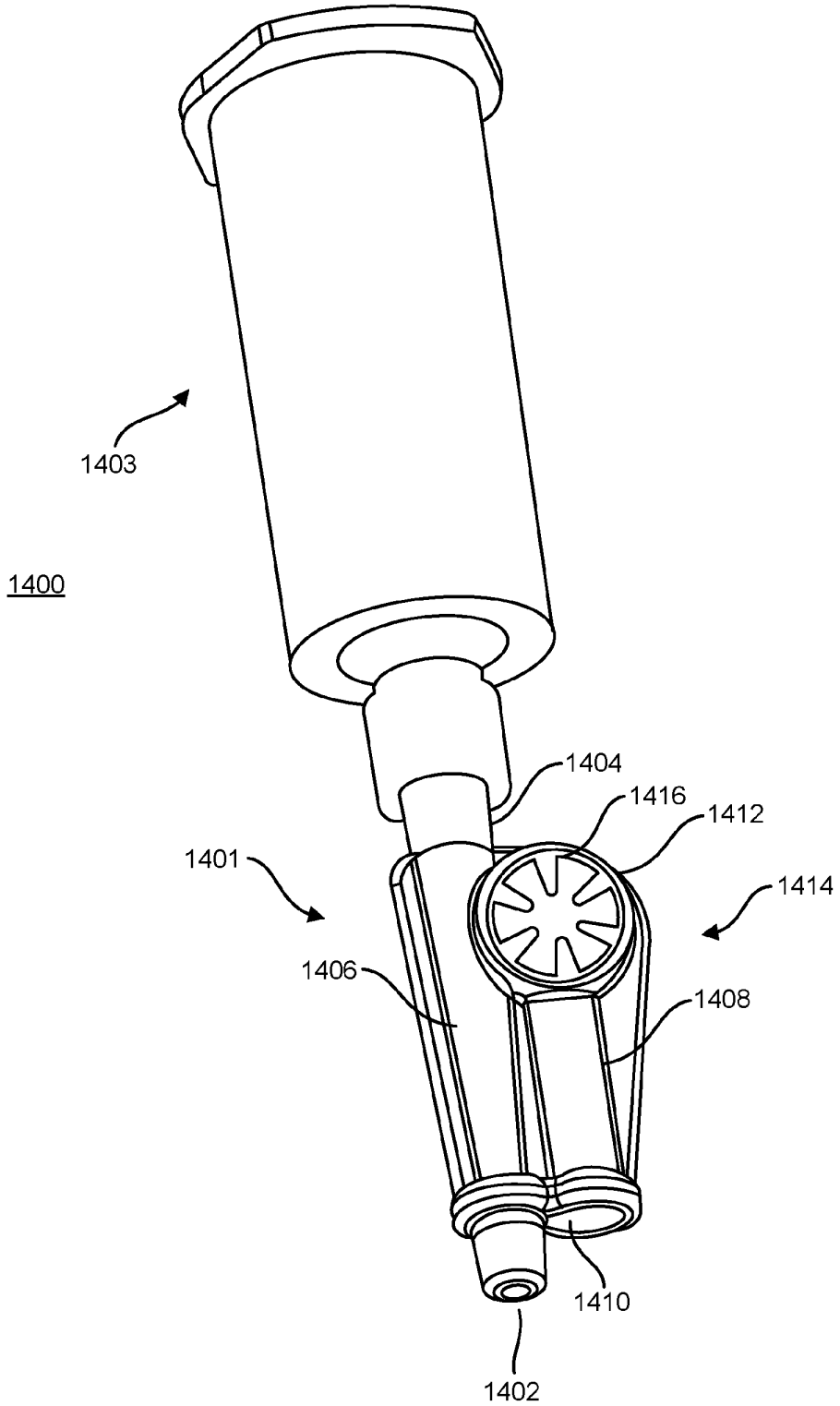


FIG. 14A

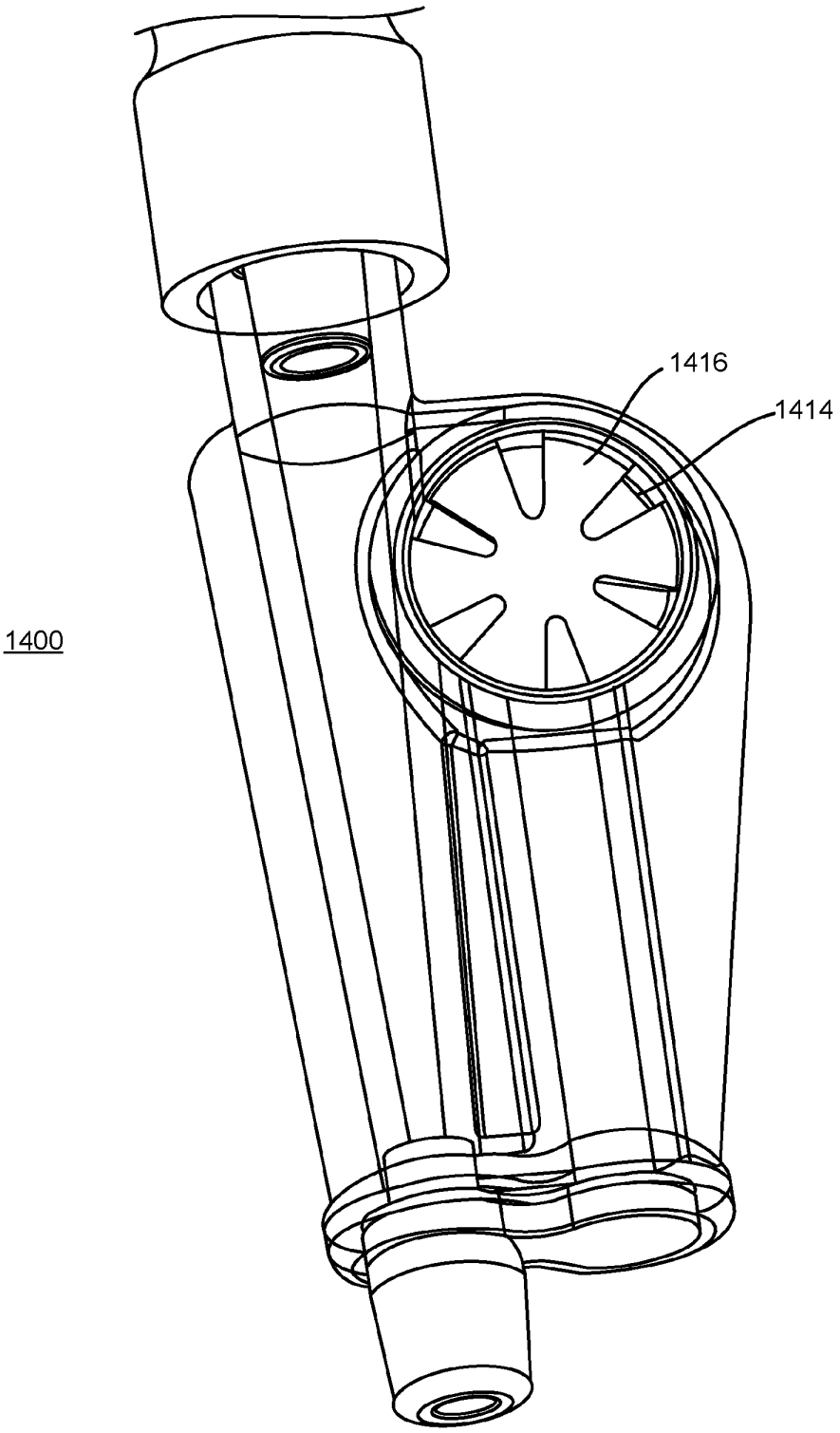


FIG. 14B

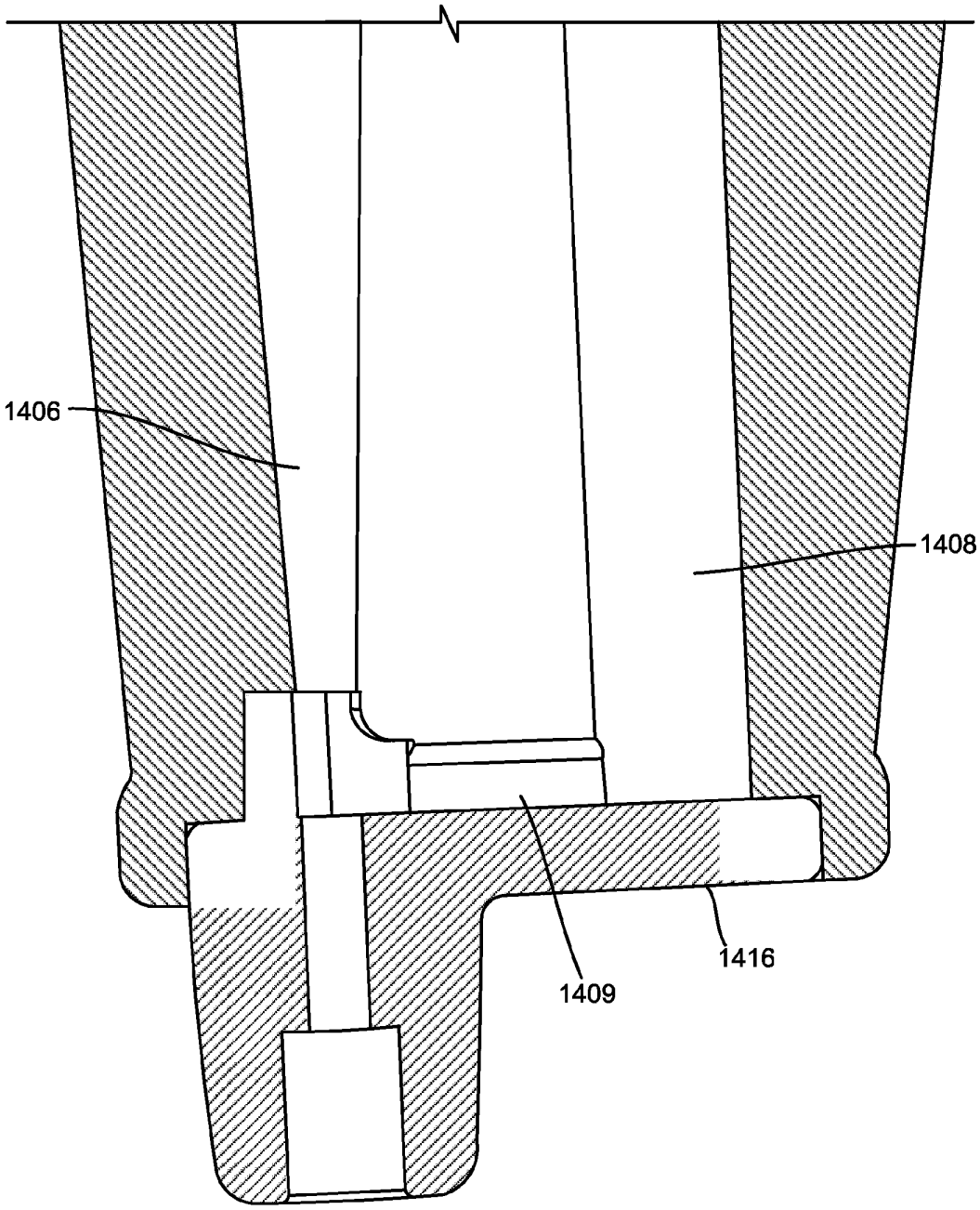


FIG. 14C

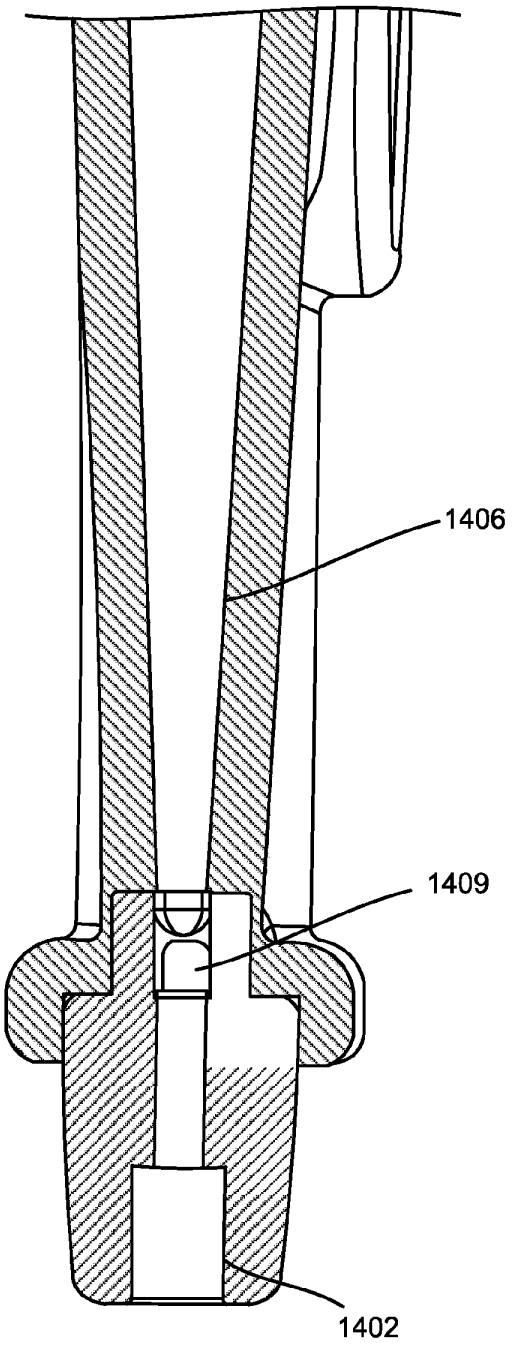


FIG. 14D

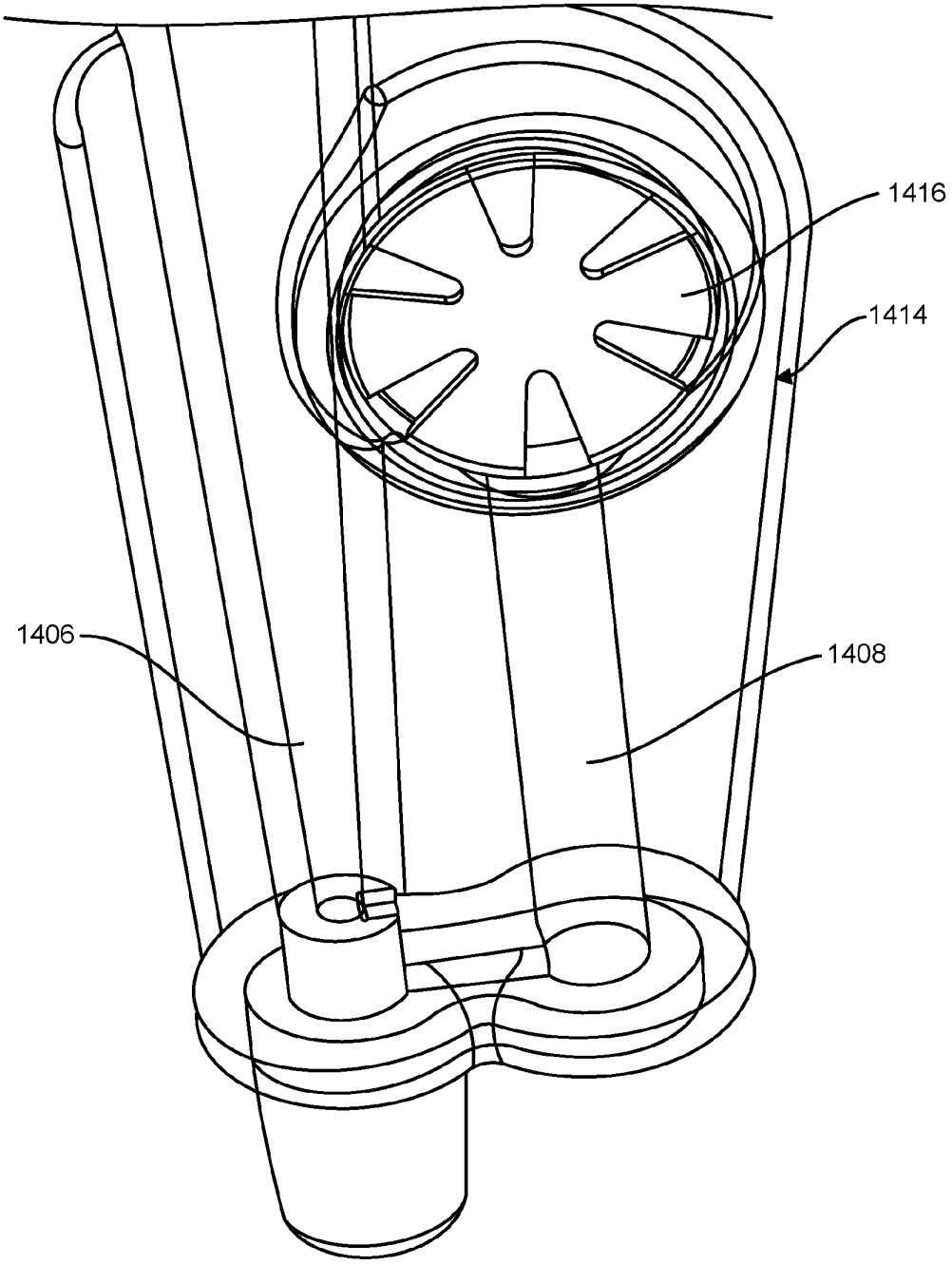


FIG. 14E

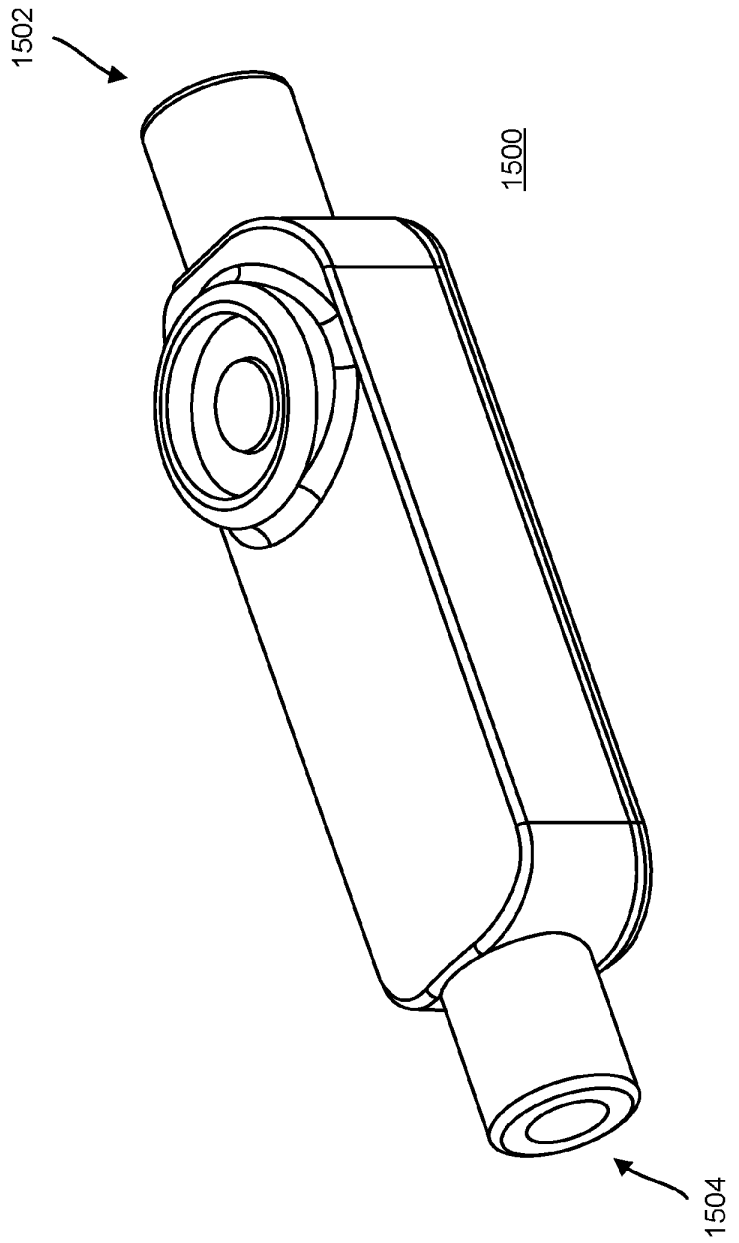


FIG. 15A

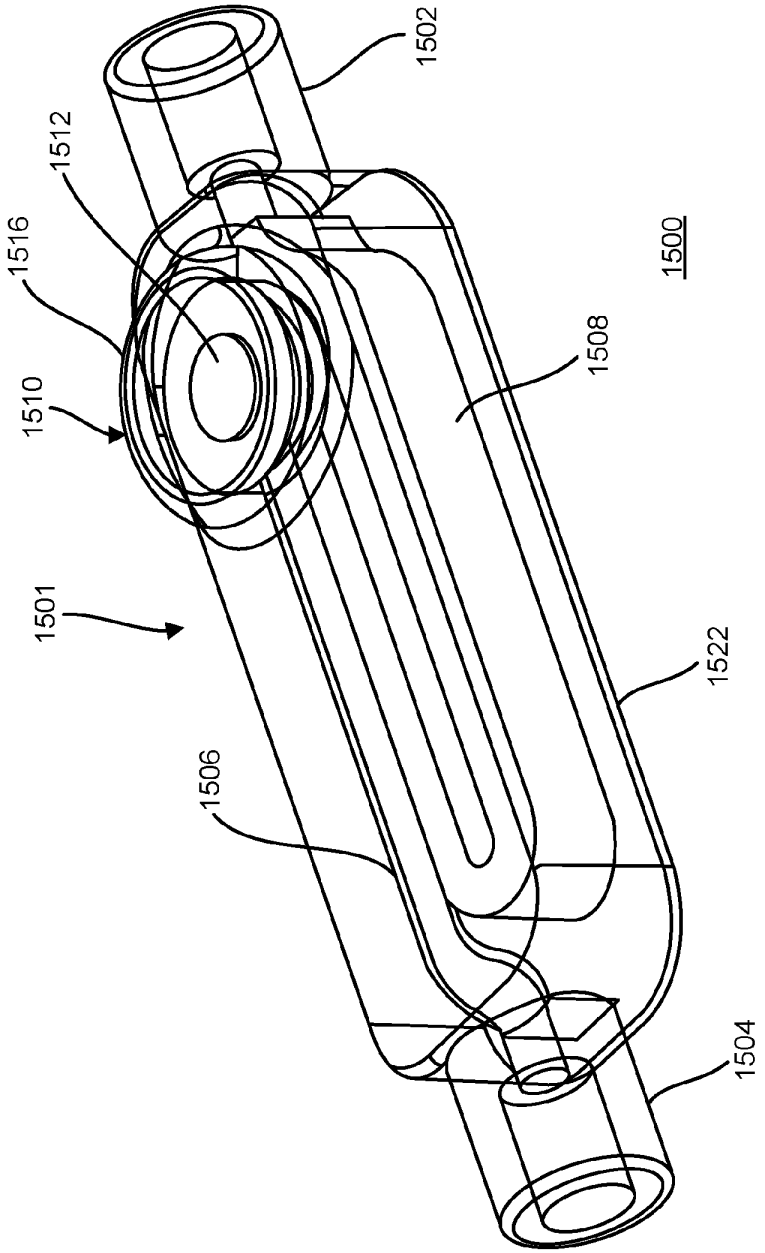


FIG. 15B

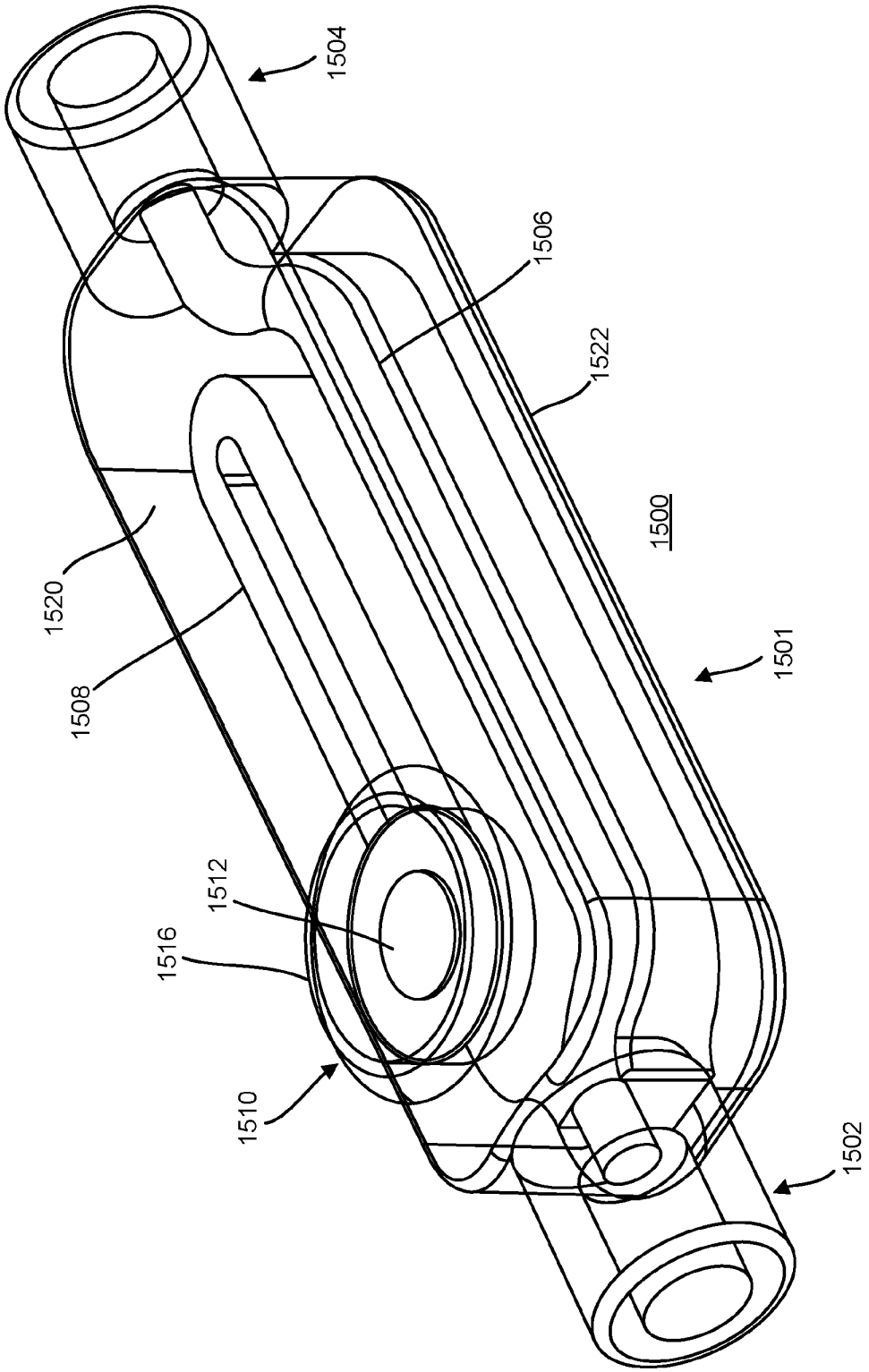


FIG. 15C

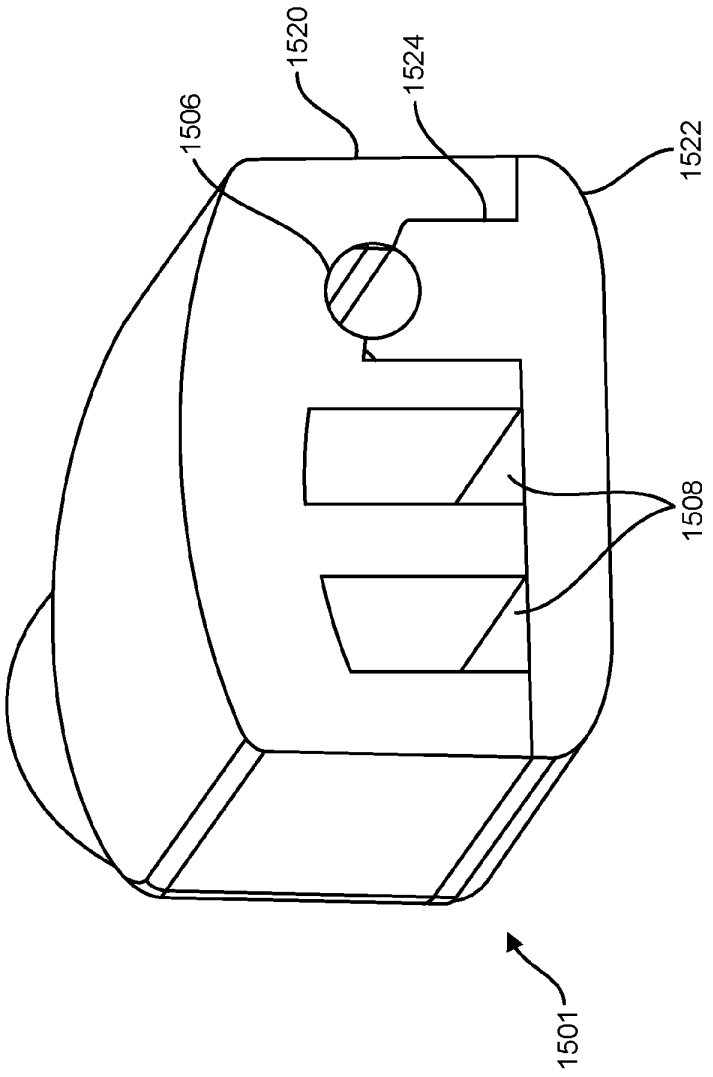


FIG. 15D

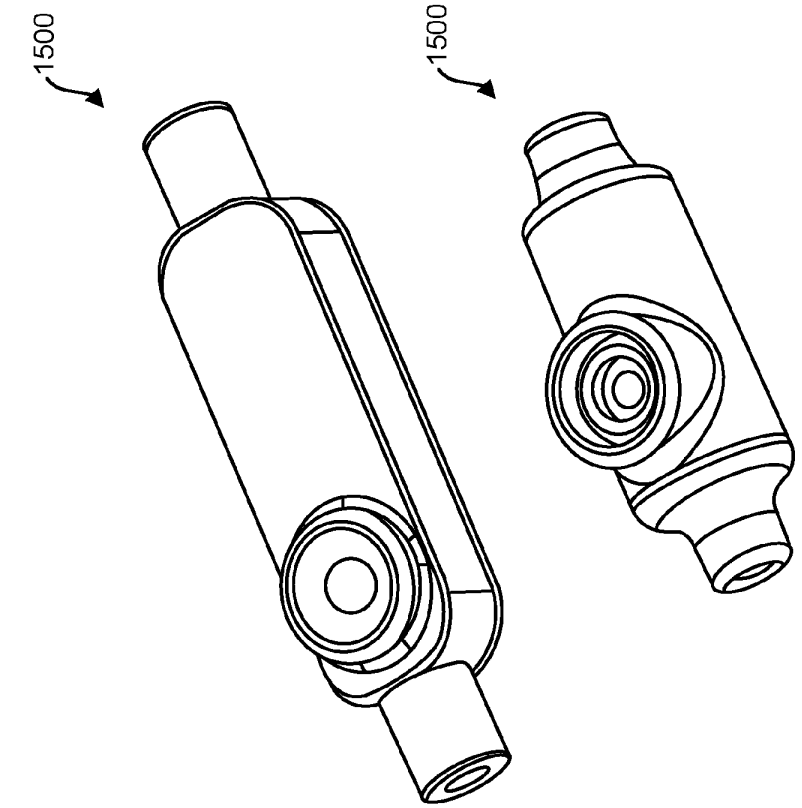


FIG. 15F

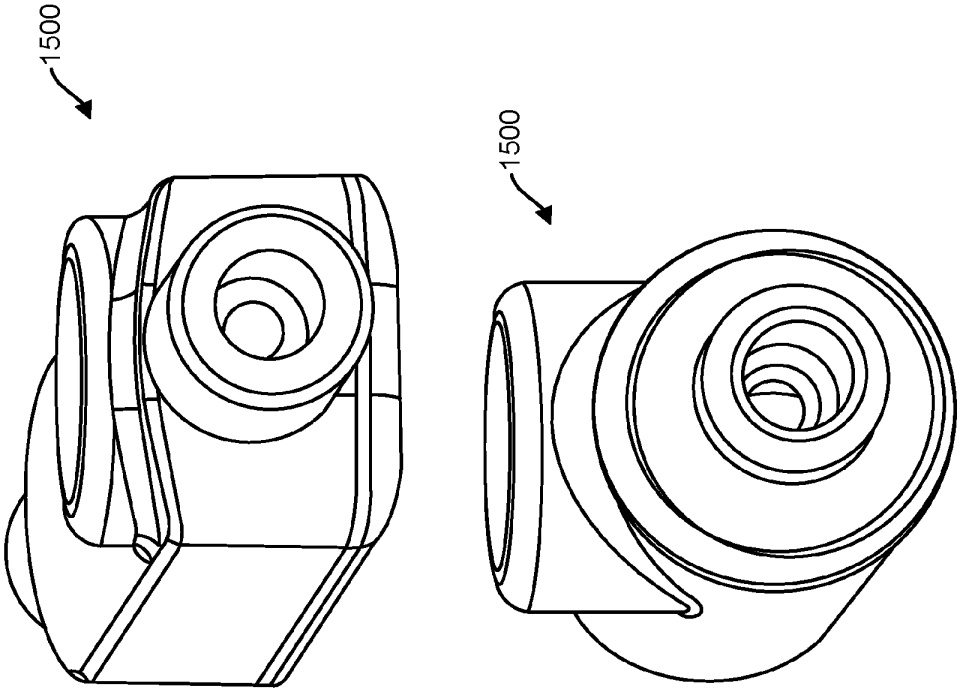


FIG. 15E

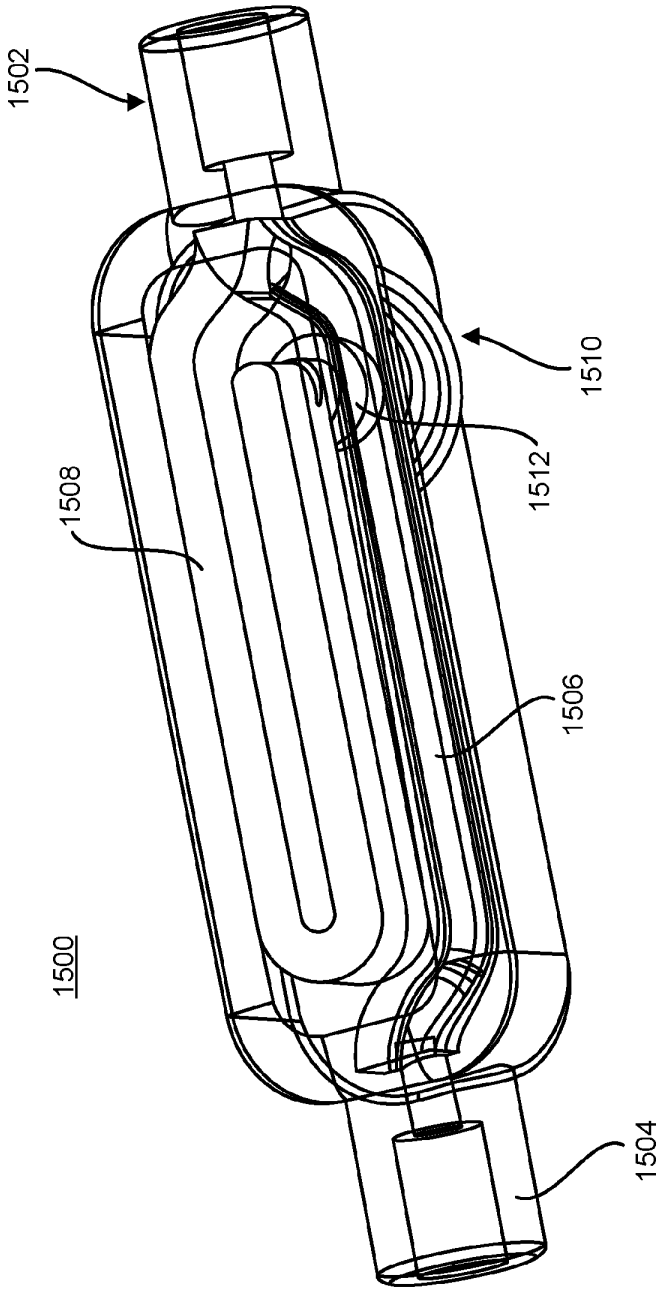


FIG. 15G

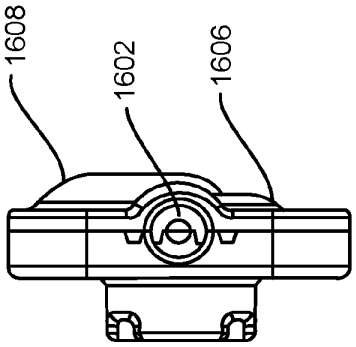


FIG. 16C

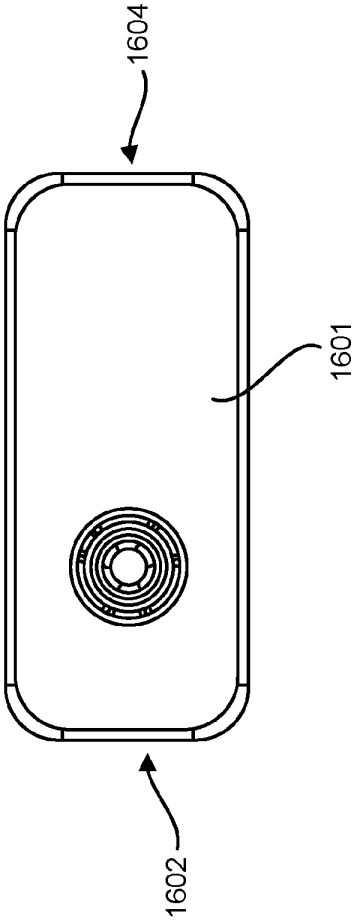


FIG. 16A

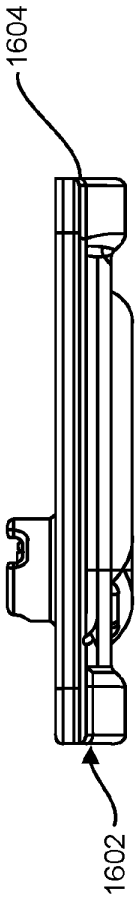


FIG. 16B

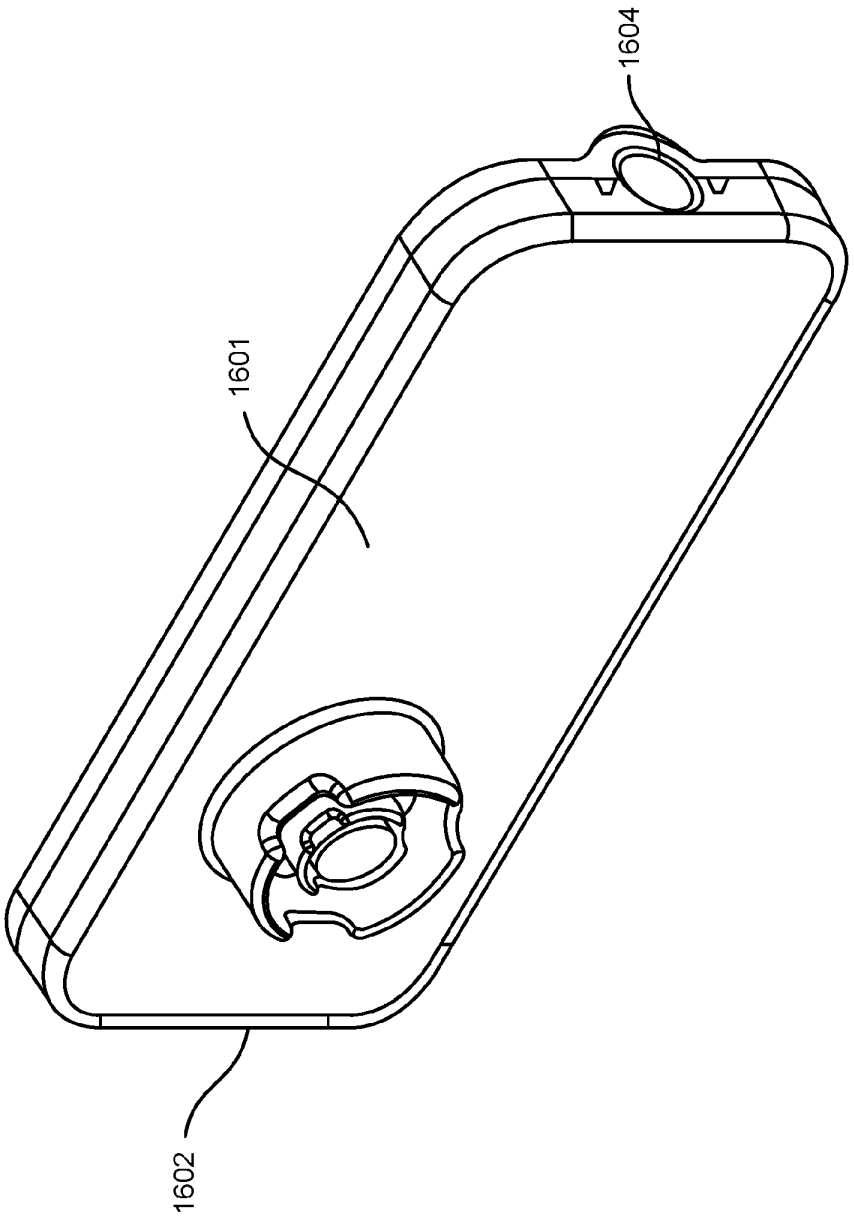


FIG. 16D

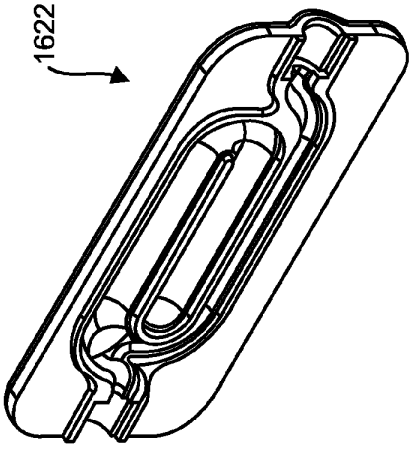


FIG. 17B



FIG. 17E

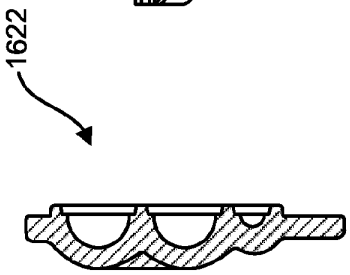


FIG. 17D

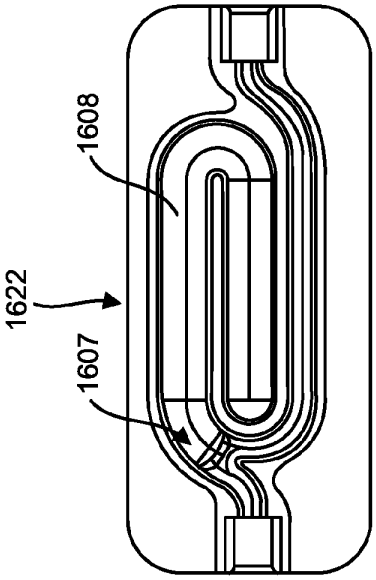


FIG. 17A

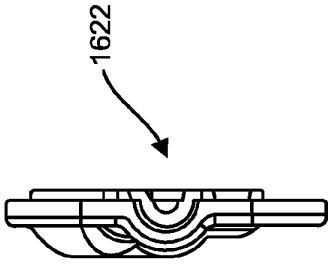


FIG. 17C

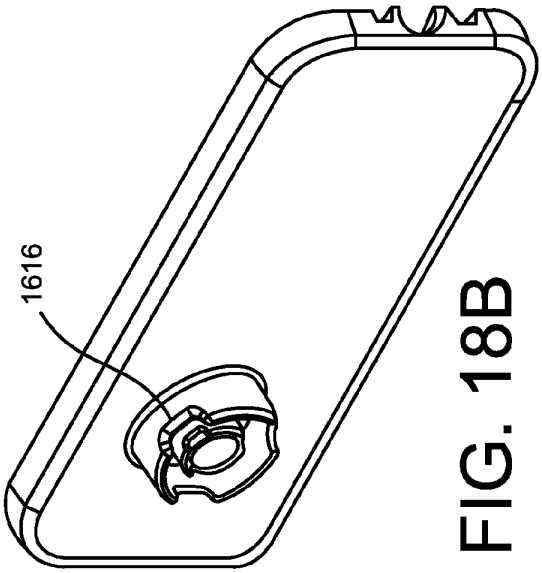


FIG. 18B

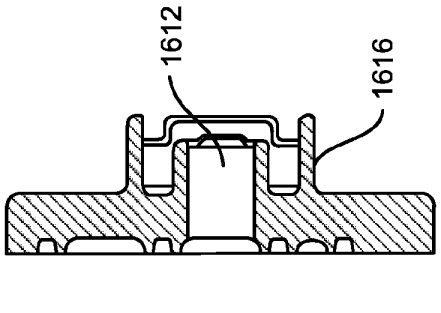


FIG. 18F

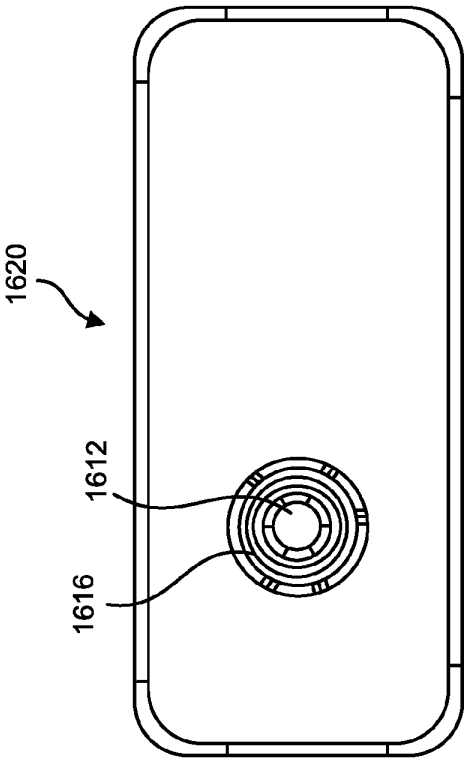


FIG. 18A

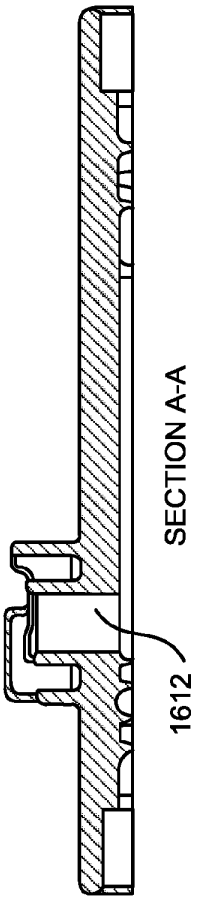


FIG. 18D

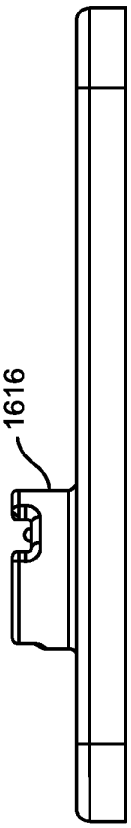


FIG. 18E

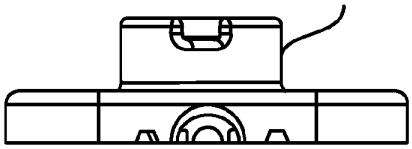


FIG. 18C

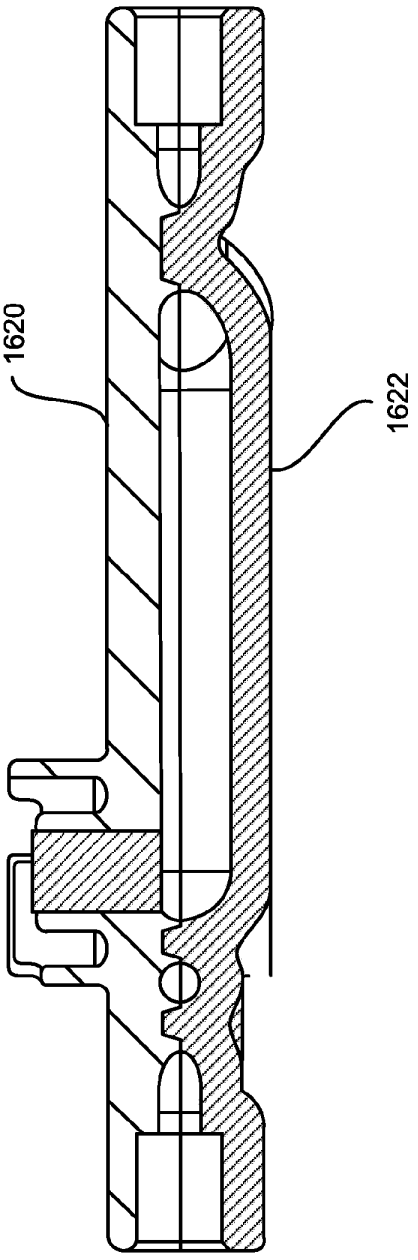


FIG. 19A

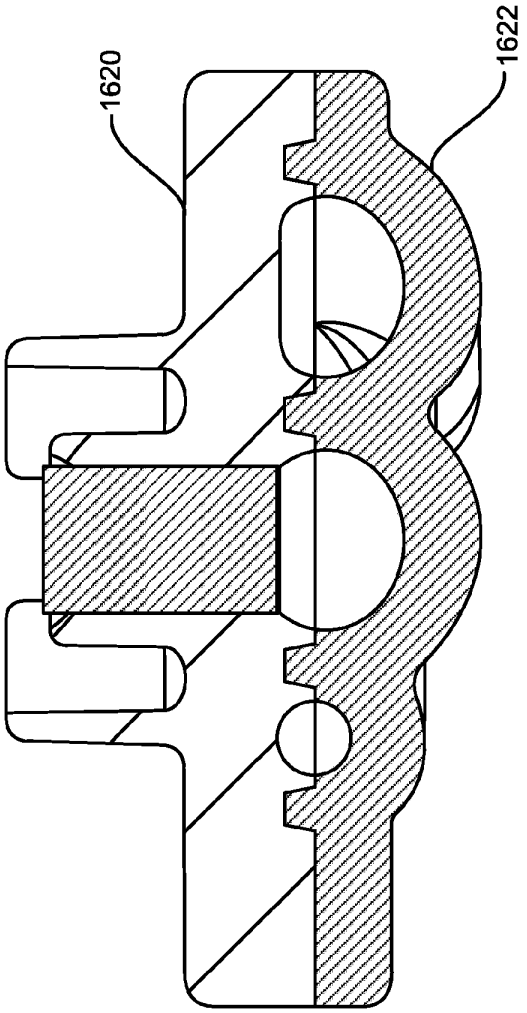


FIG. 19B

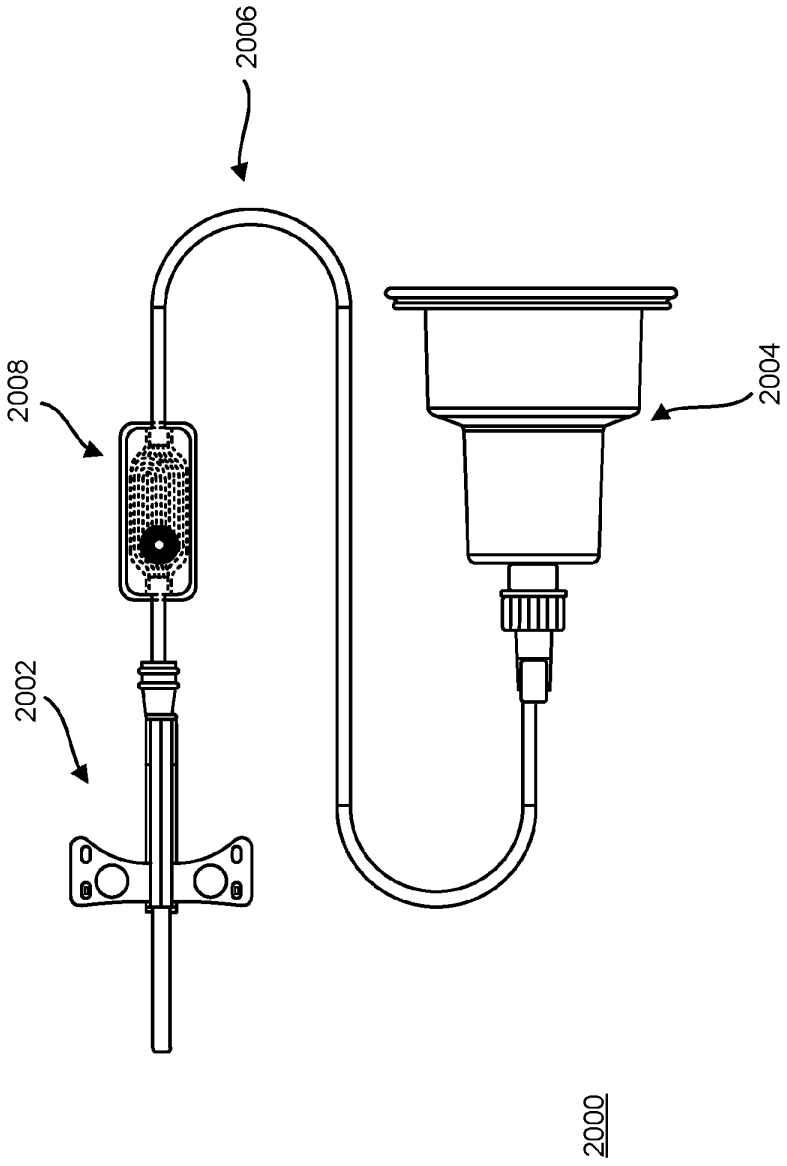


FIG. 20

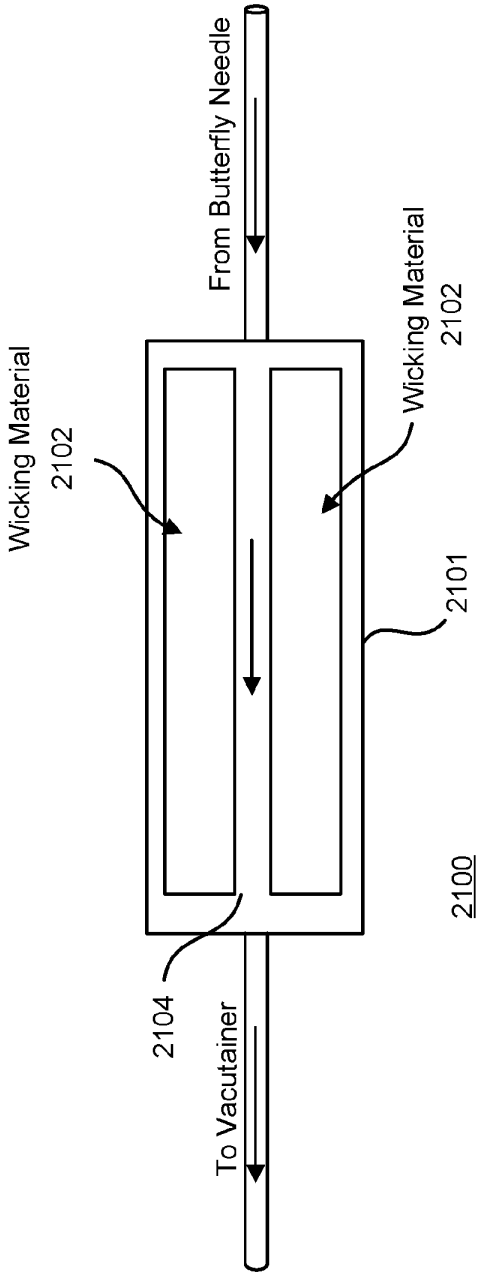

From Butterfly Needle
Wicking Material
2102
Wicking Material
2102
2101
2100
2104
To Vacutainer

FIG. 21

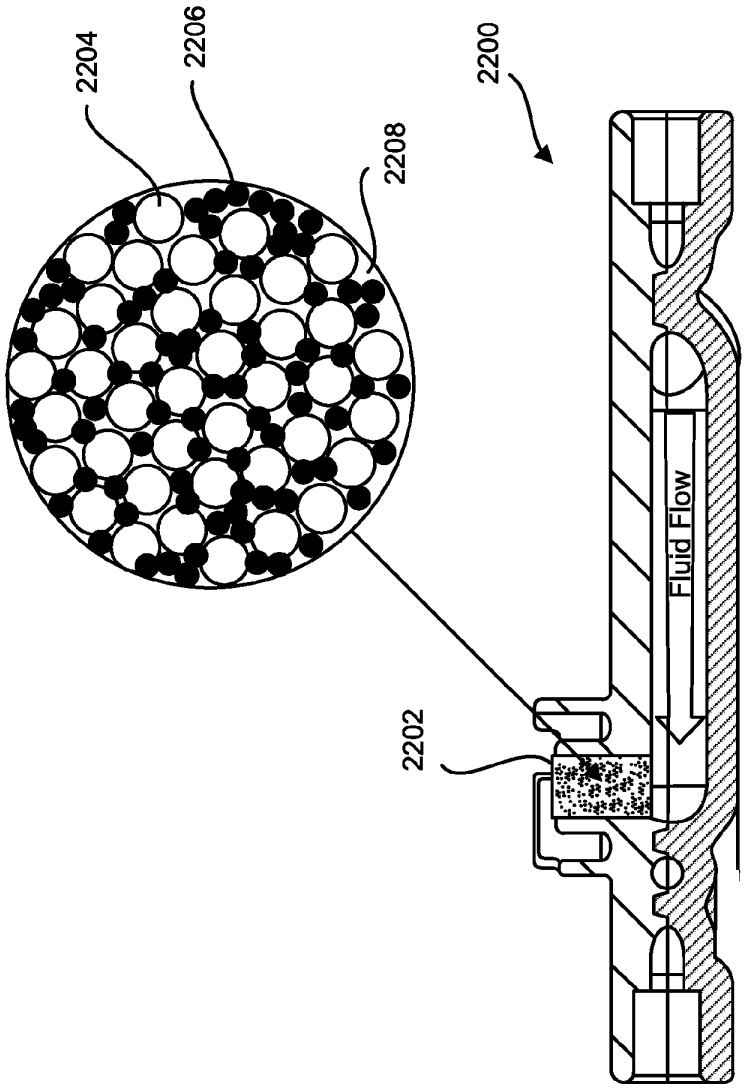


FIG. 22A

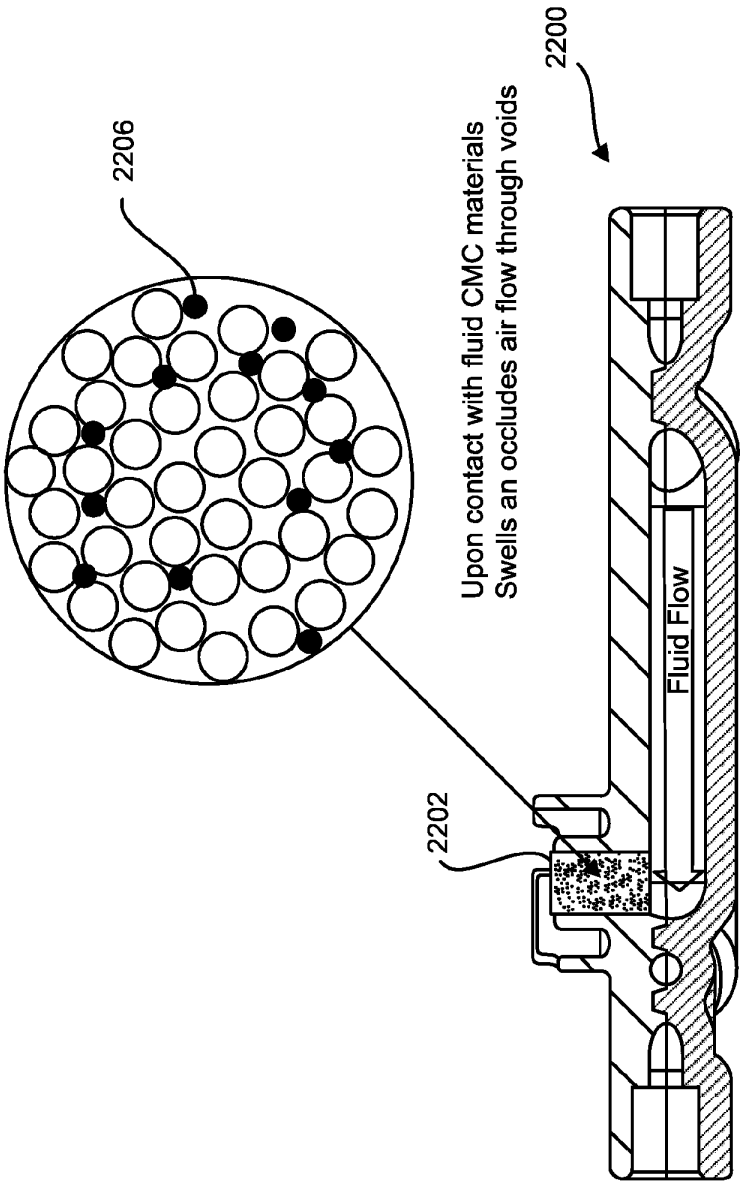

2200
2206
Upon contact with fluid CMC materials
Swells an occludes air flow through voids
Fluid Flow
2202

FIG. 22B

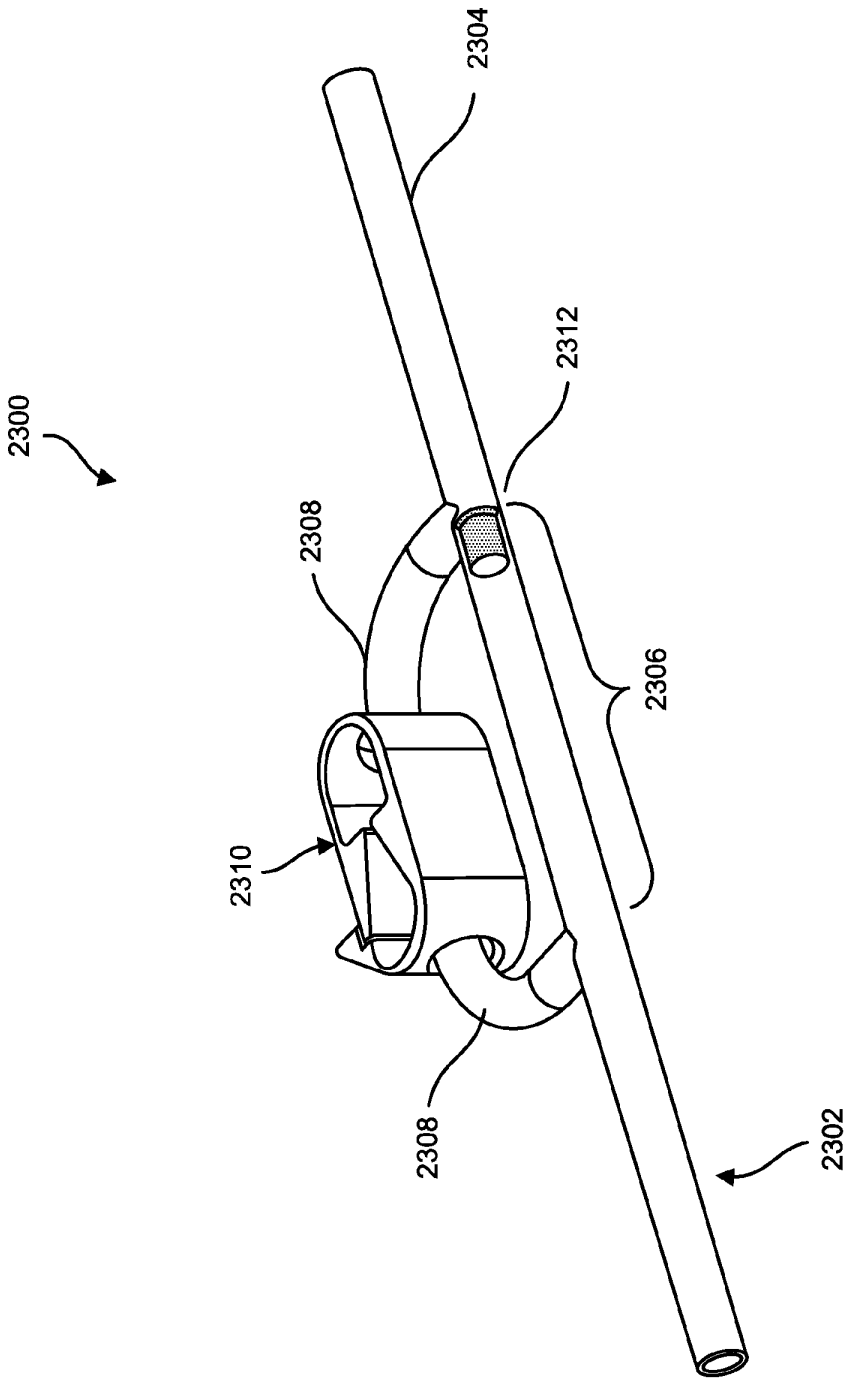


FIG. 23A

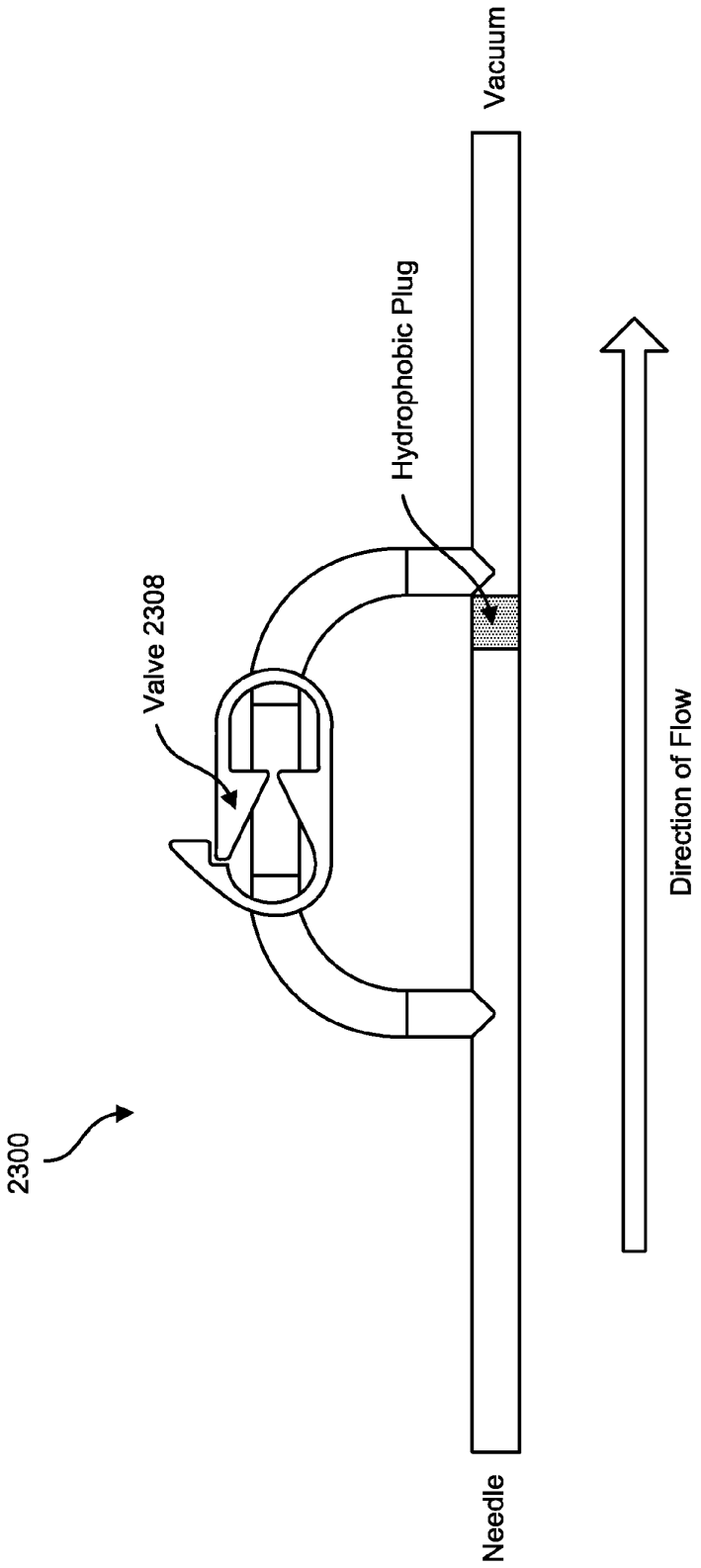

Vacuum
Hydrophobic Plug
Valve 2308
Direction of Flow
2300
Needle

FIG. 23B

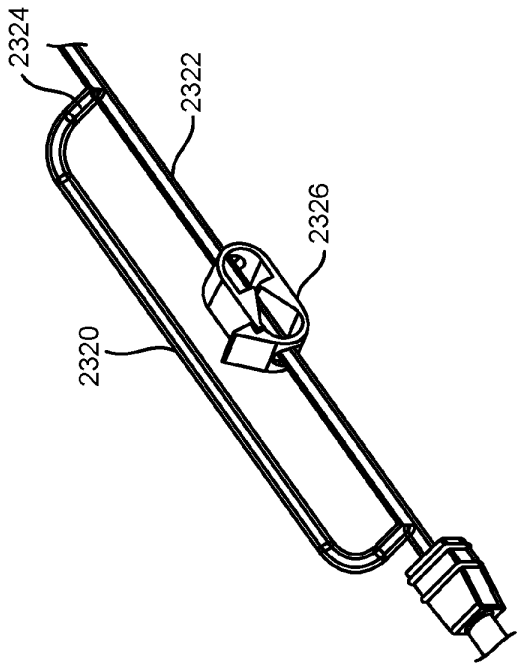


FIG. 23D

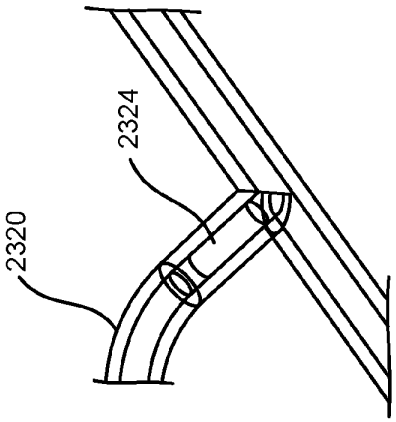


FIG. 23E

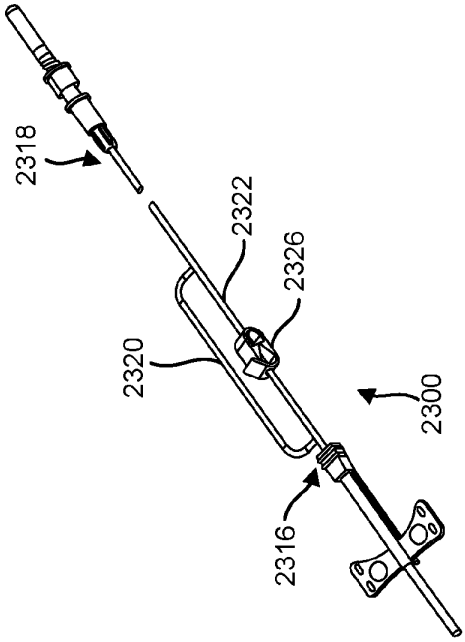


FIG. 23C

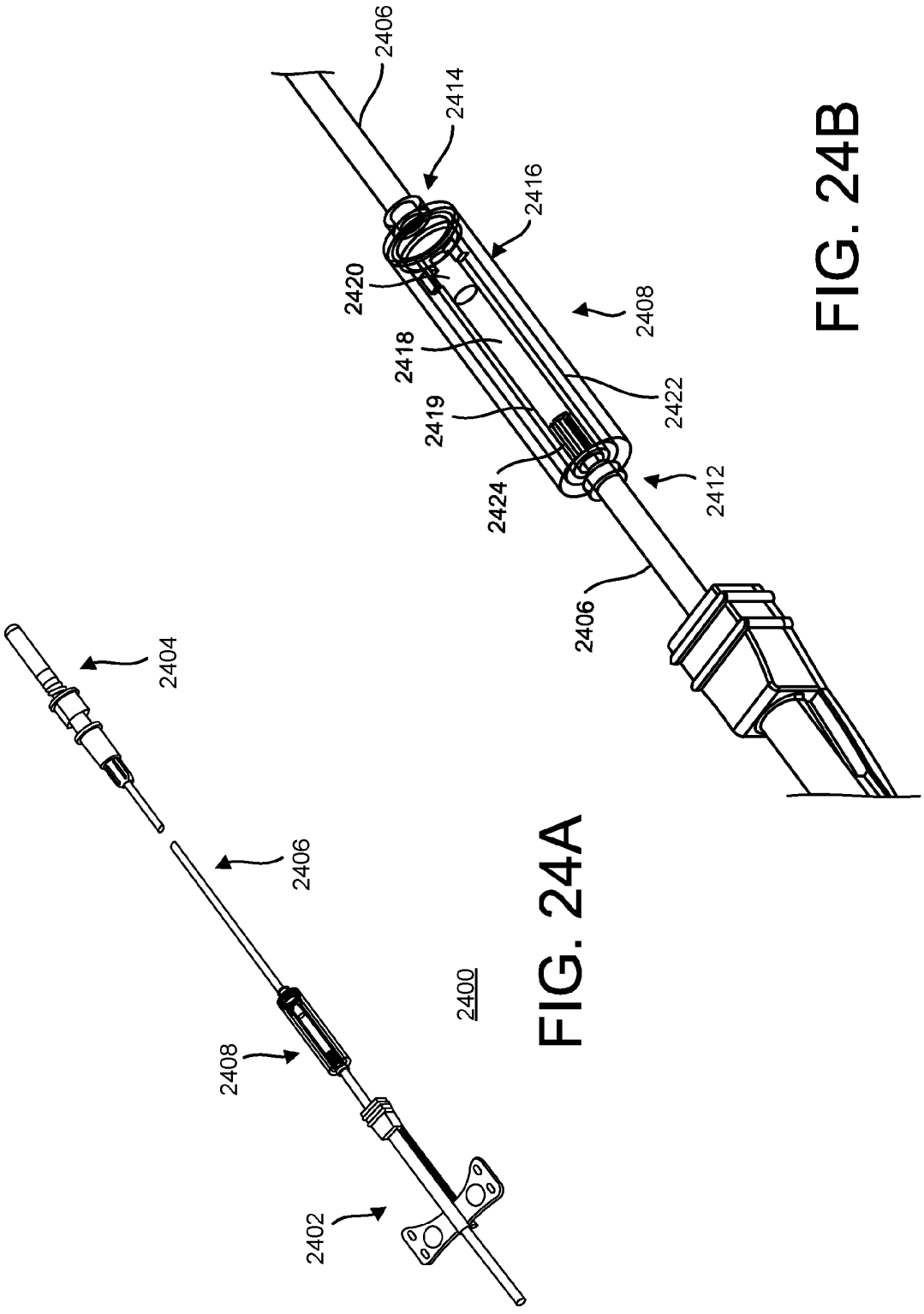


FIG. 24B

FIG. 24A

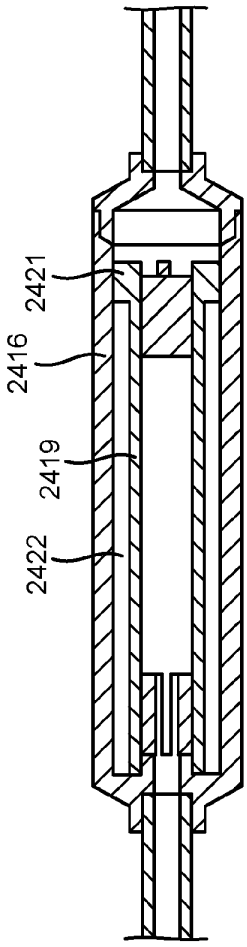


FIG. 24C

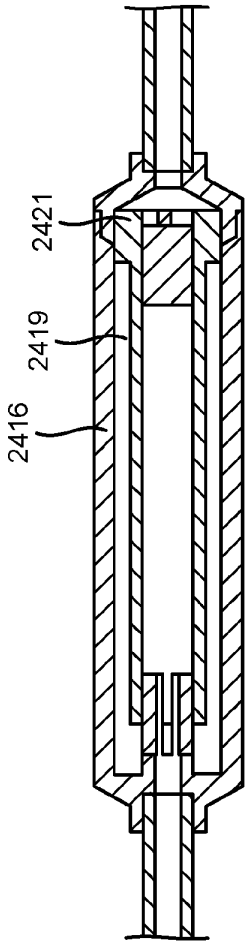


FIG. 24D

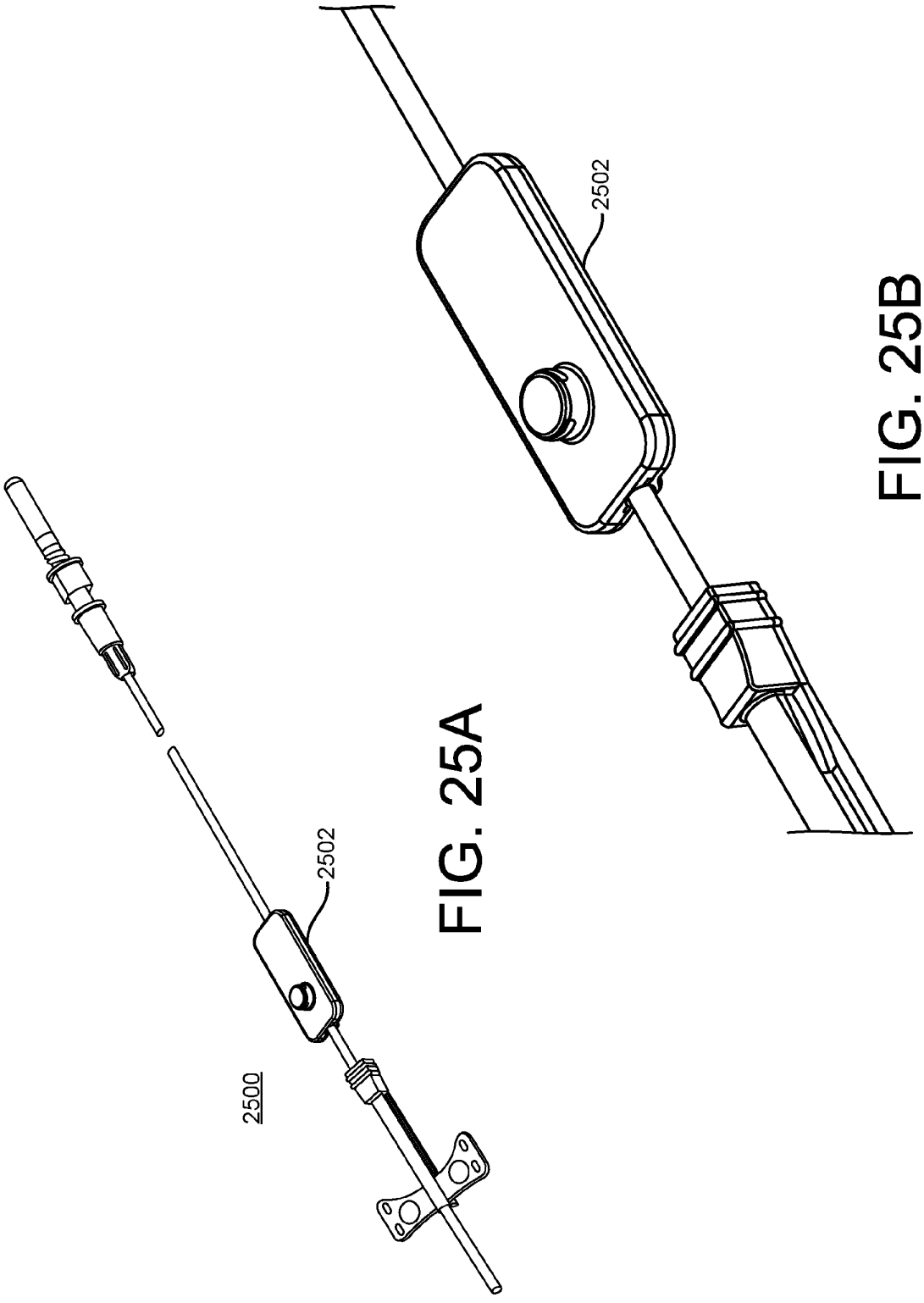


FIG. 25A

FIG. 25B

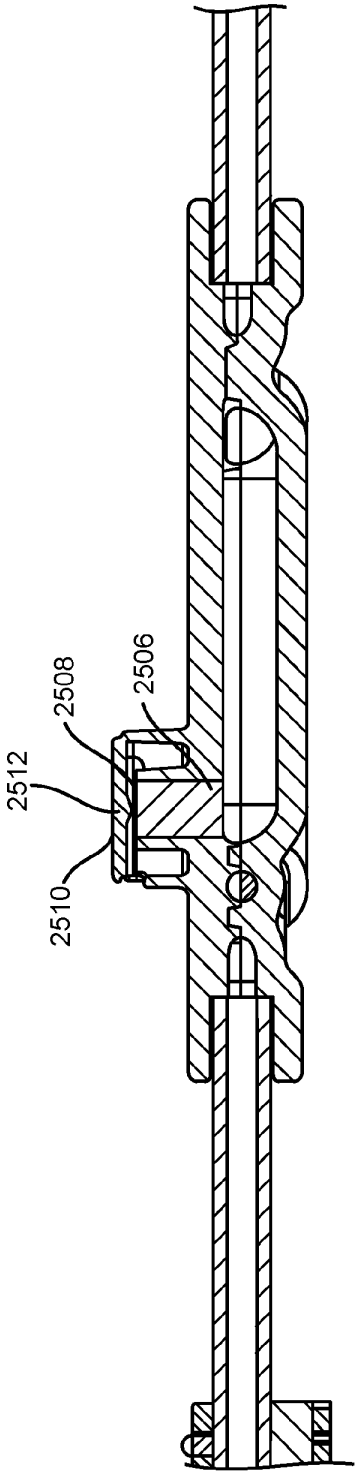


FIG. 25C

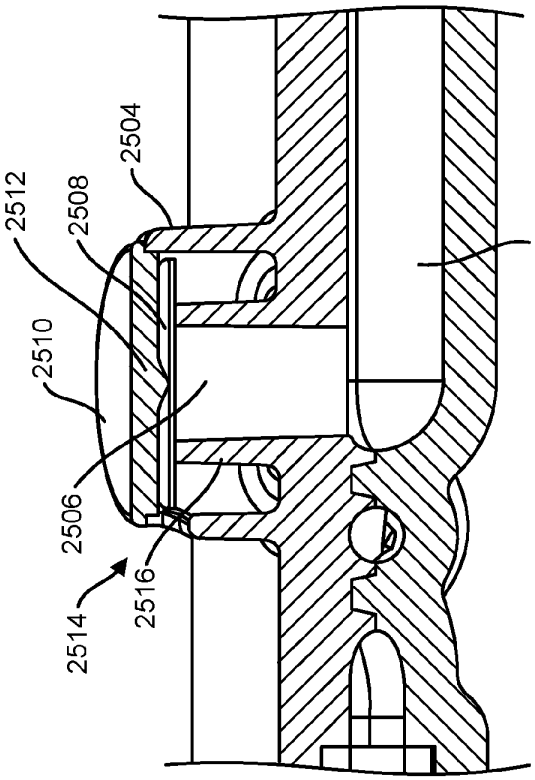


FIG. 25D

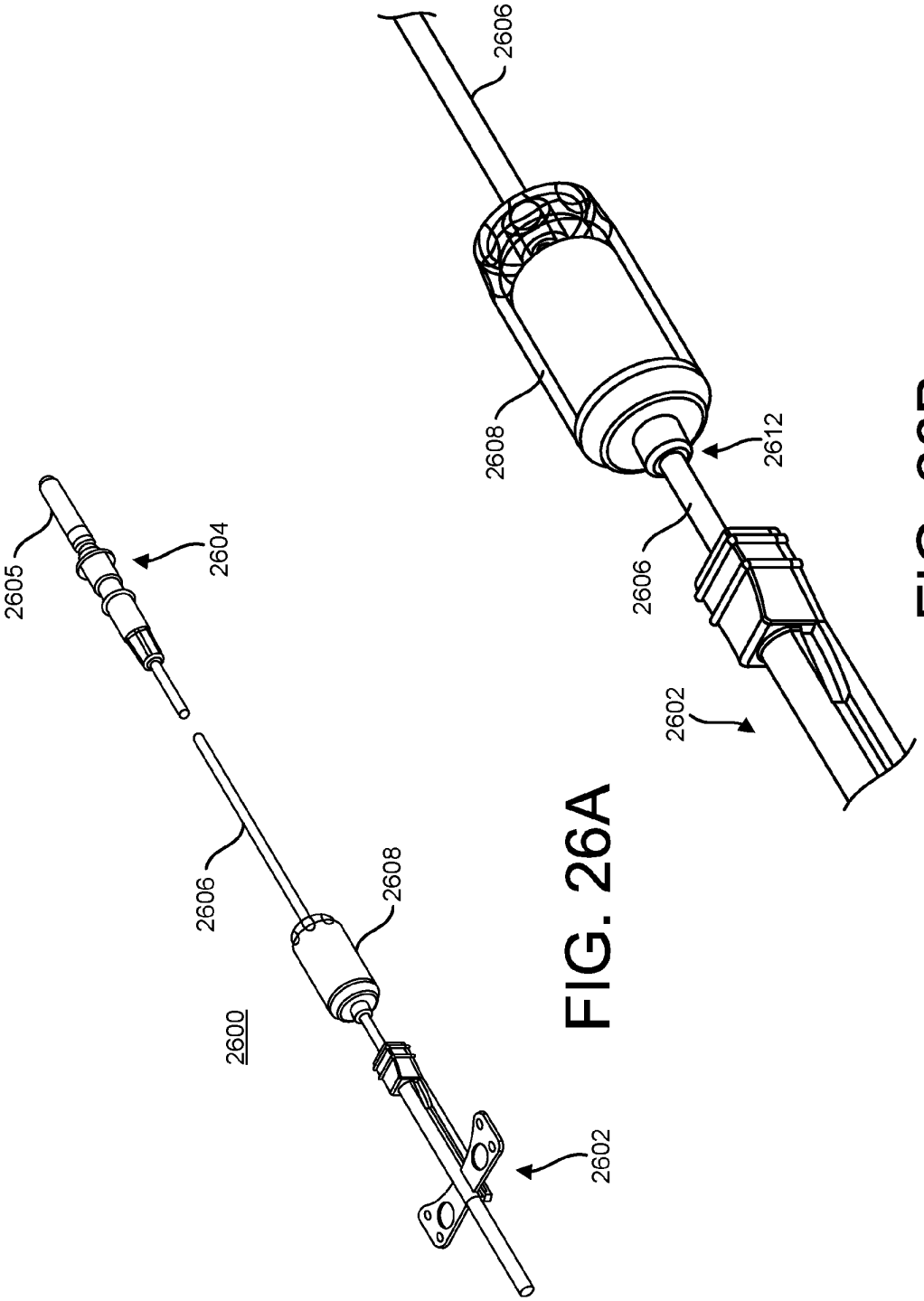


FIG. 26B

FIG. 26A

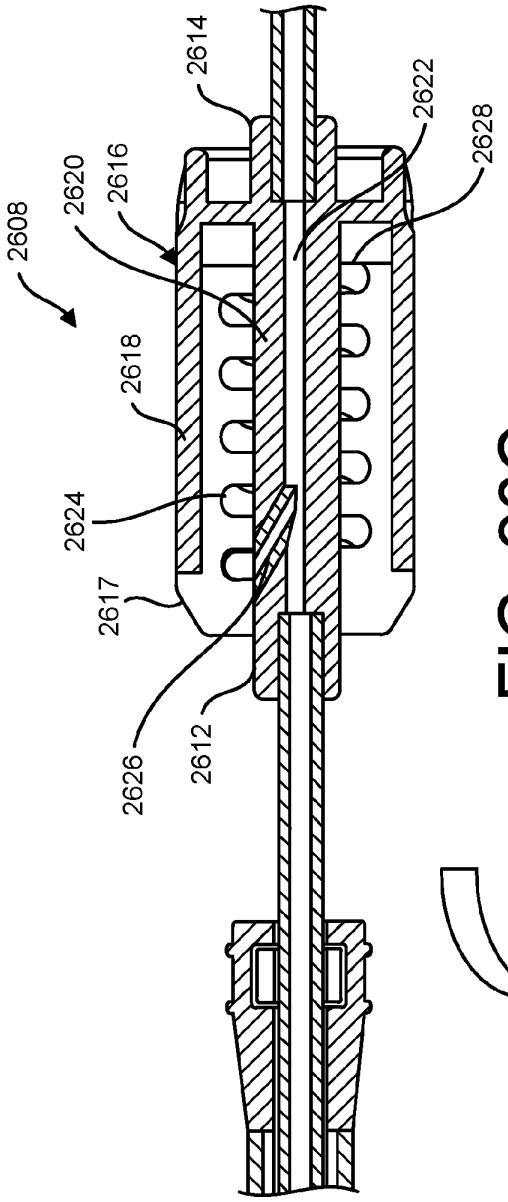


FIG. 26C

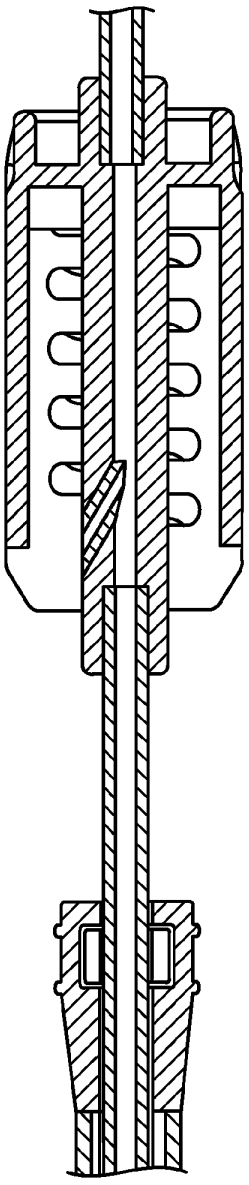


FIG. 26D

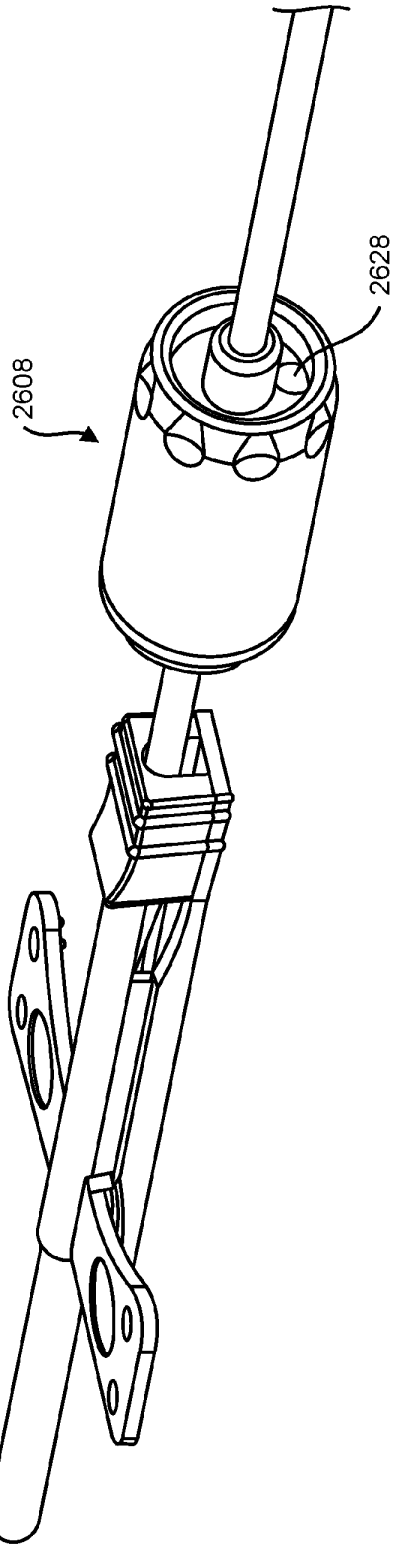


FIG. 26E

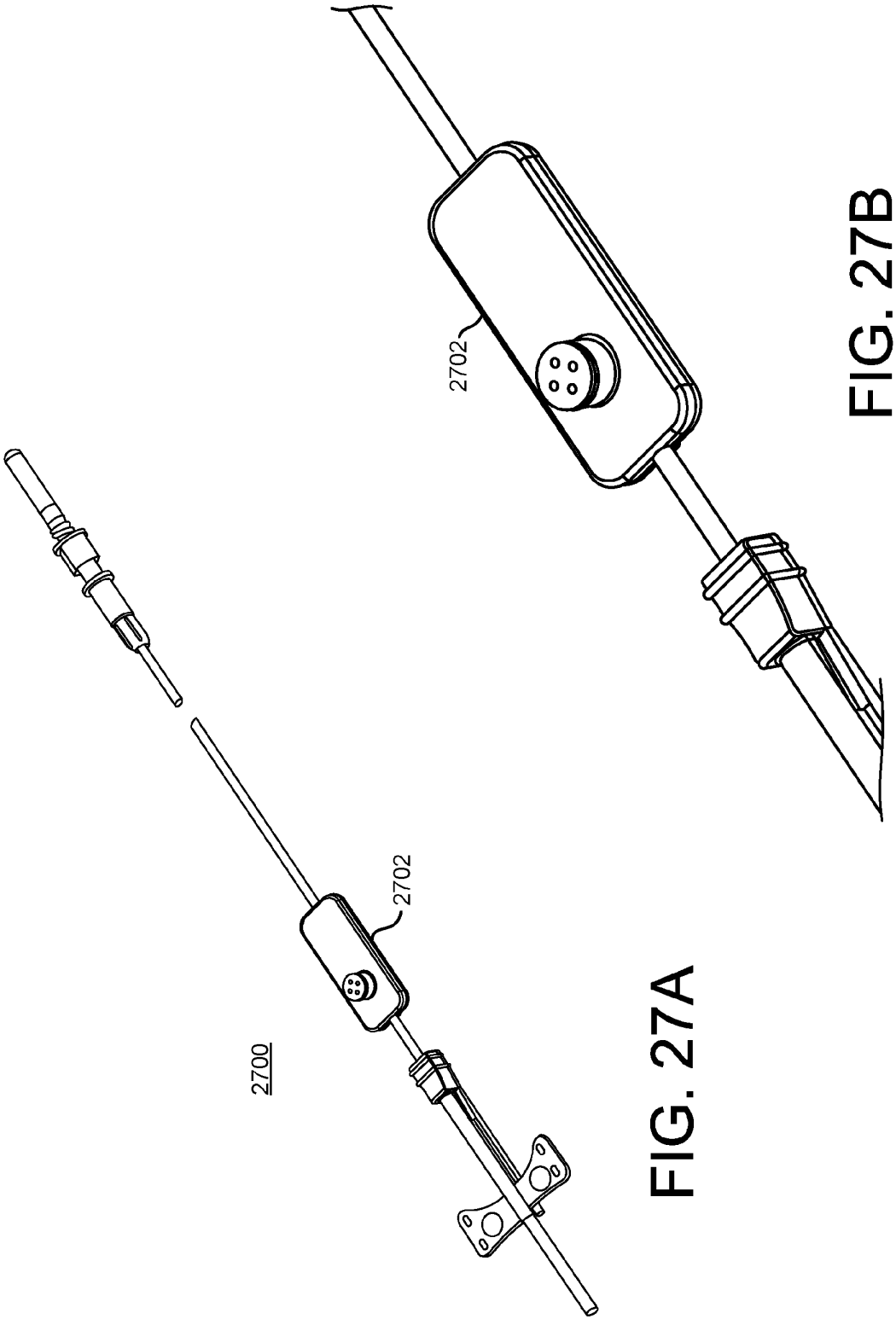


FIG. 27A

FIG. 27B

Replacement Sheet
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PCT/US2017/068569

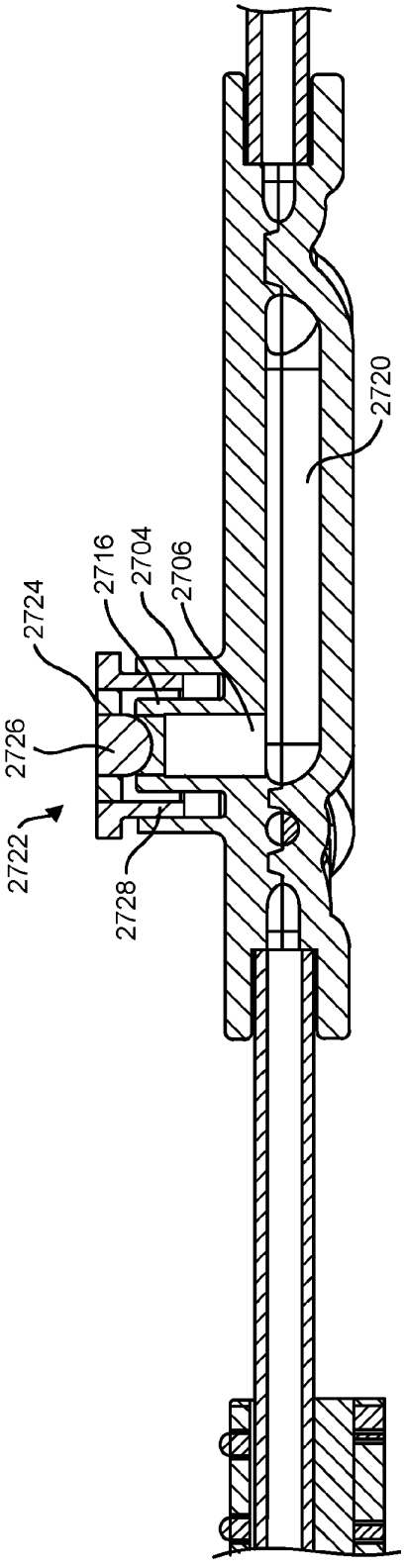


FIG. 27C

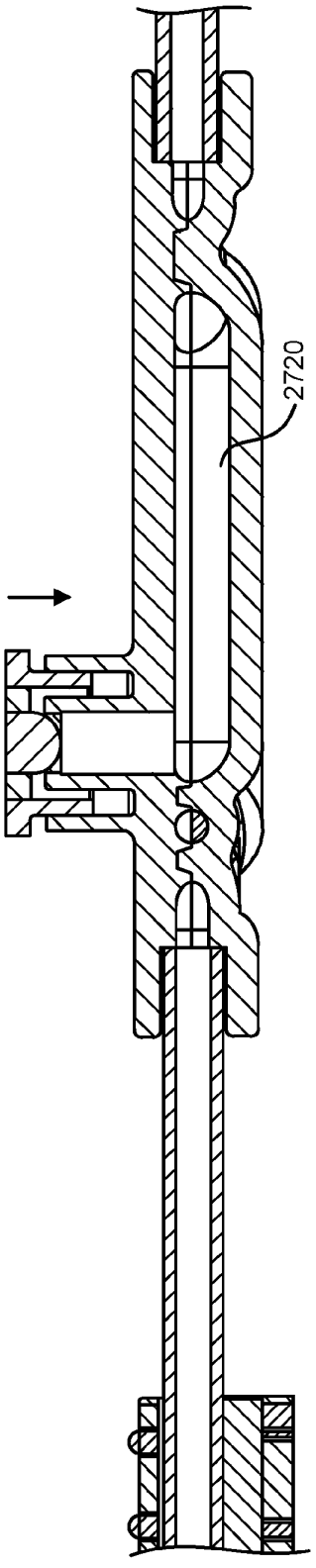


FIG. 27D

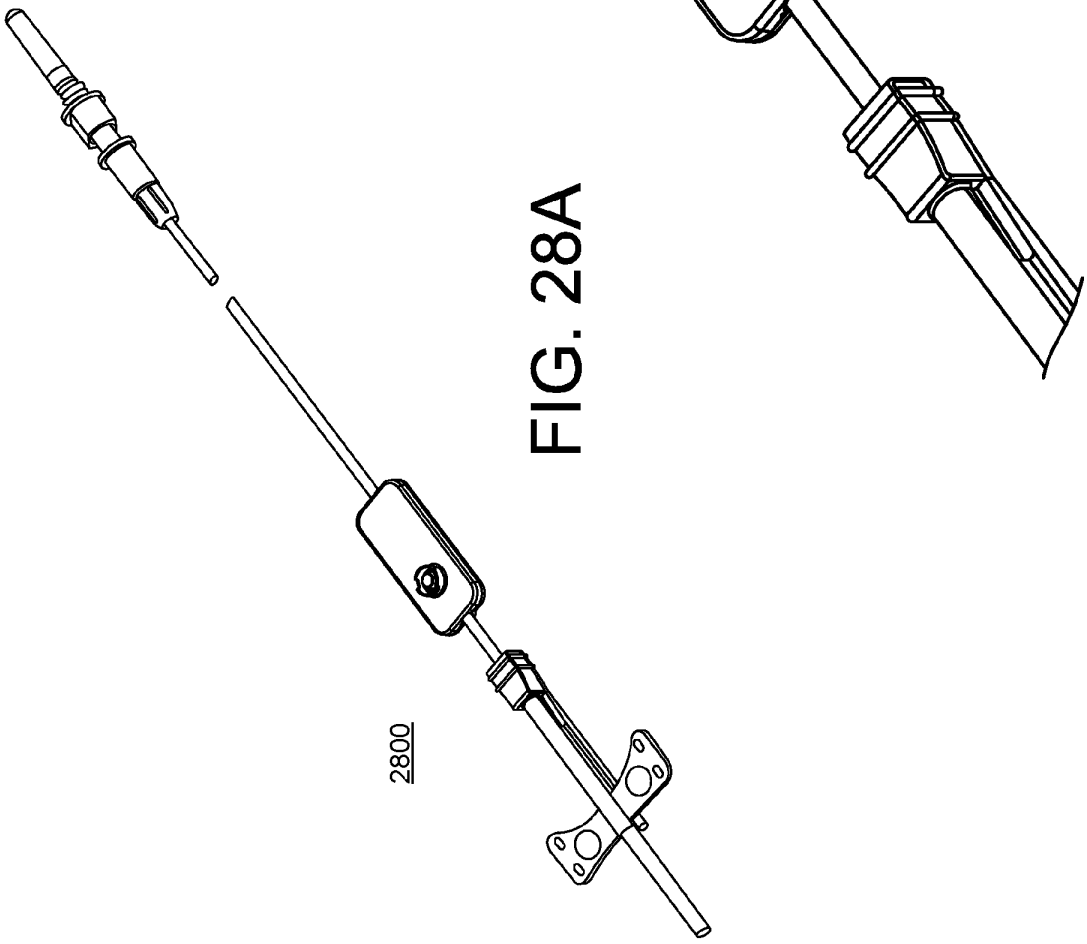


FIG. 28A

FIG. 28B

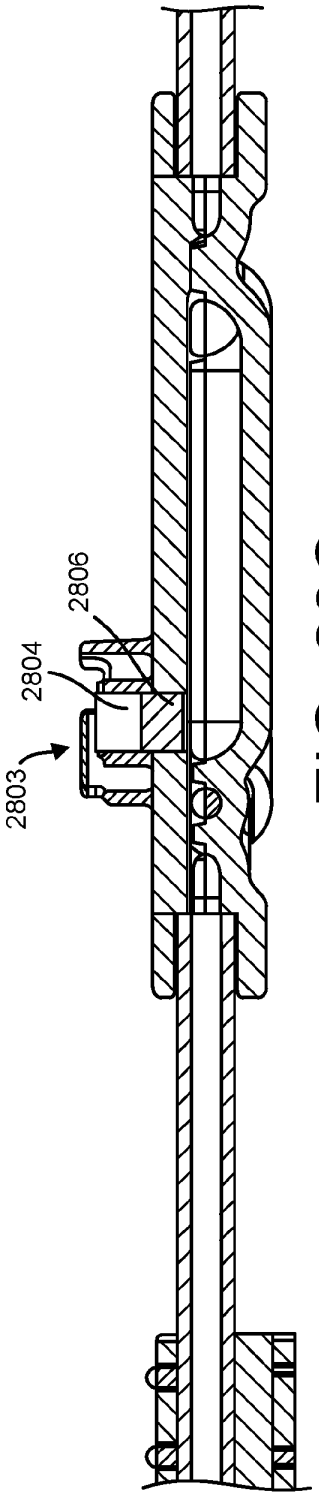


FIG. 28C

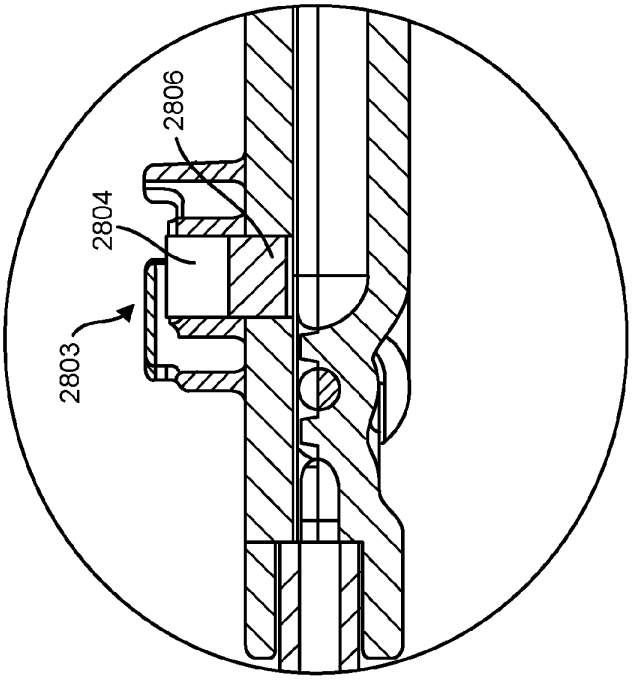


FIG. 28D

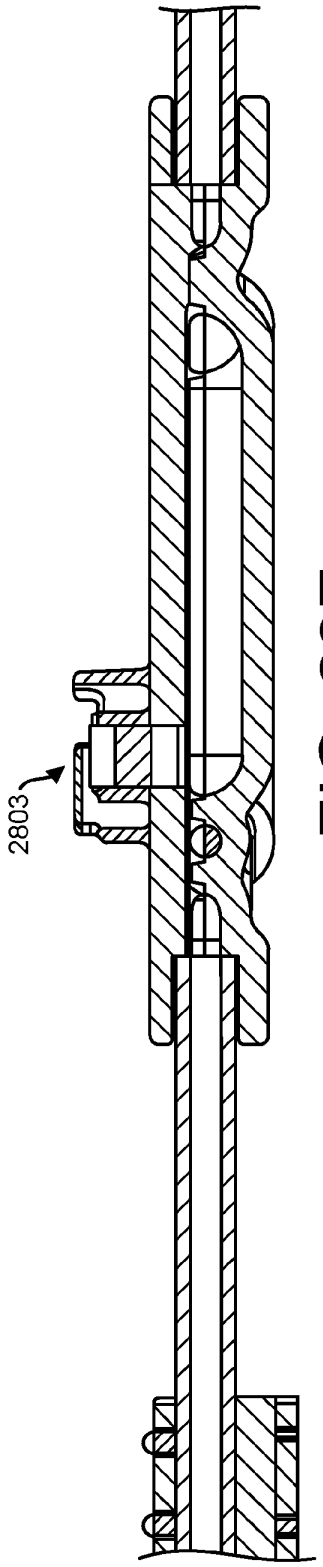


FIG. 28E

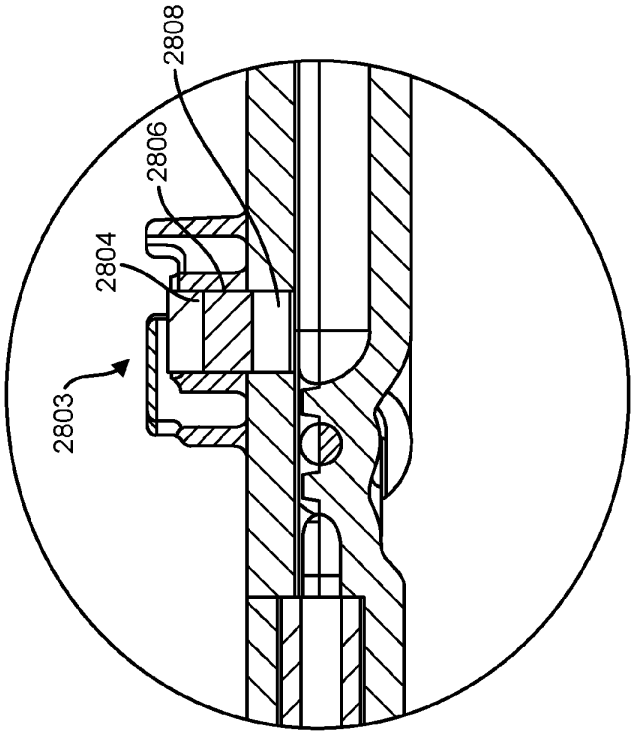


FIG. 28F

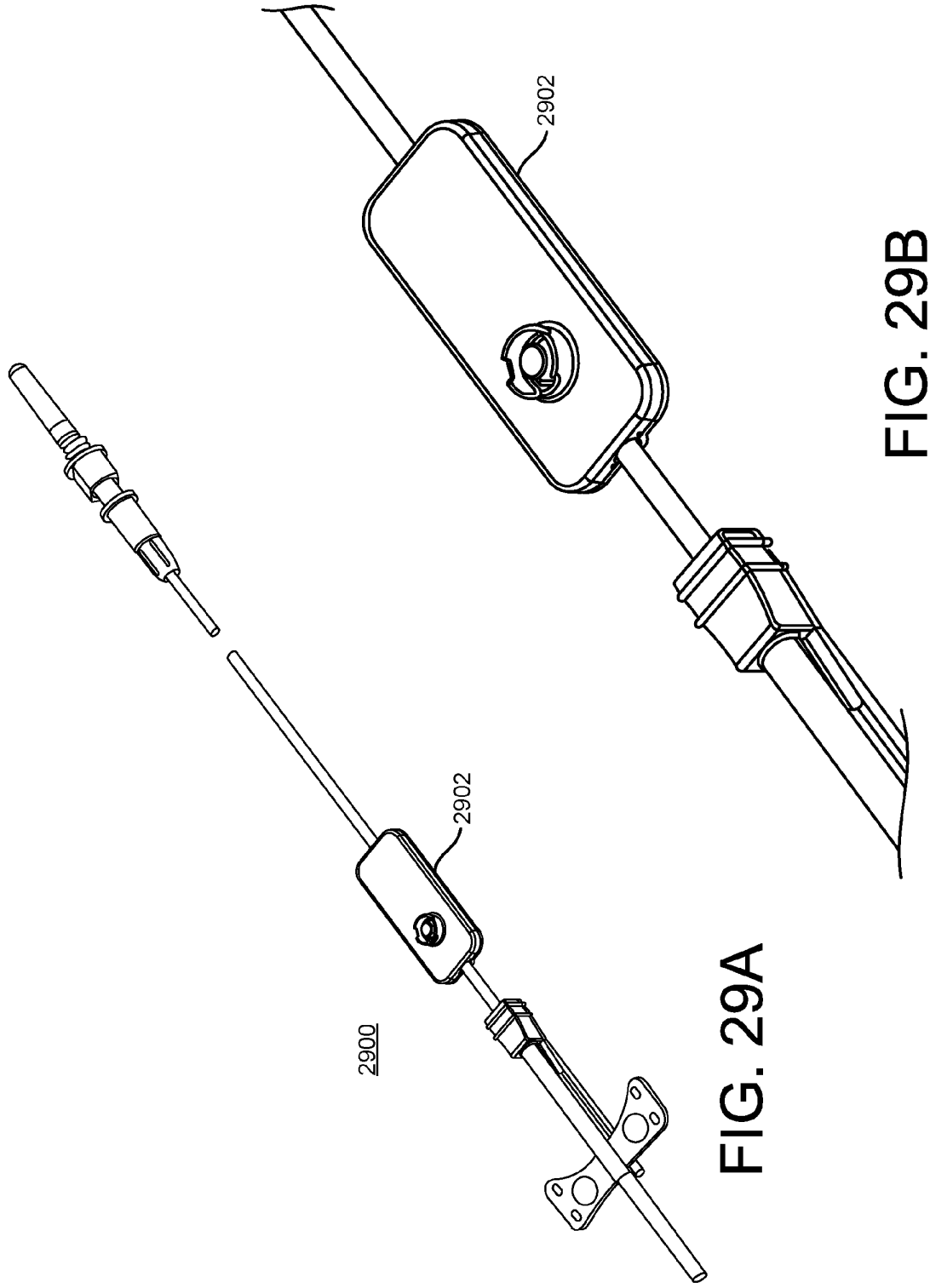


FIG. 29B

FIG. 29A

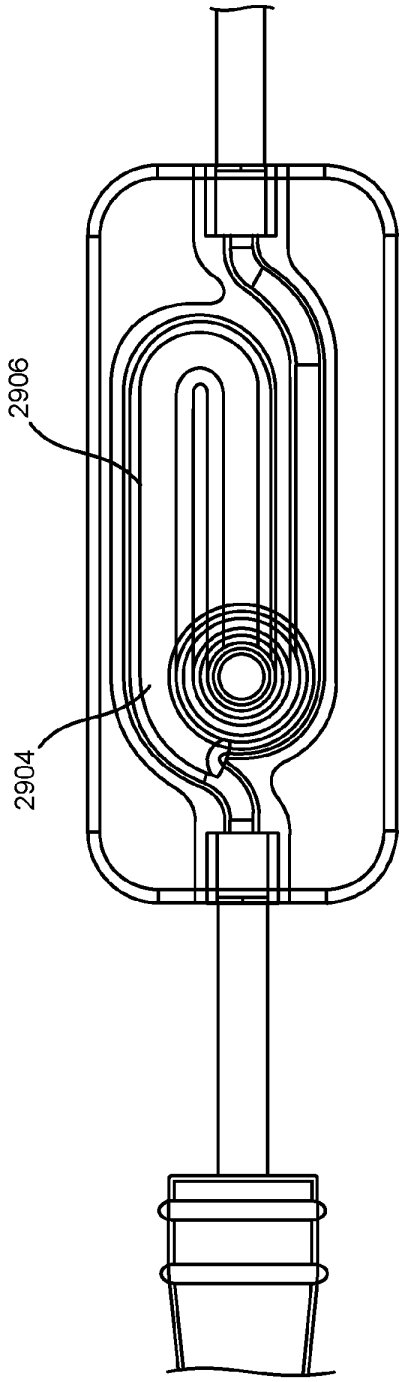


FIG. 29C

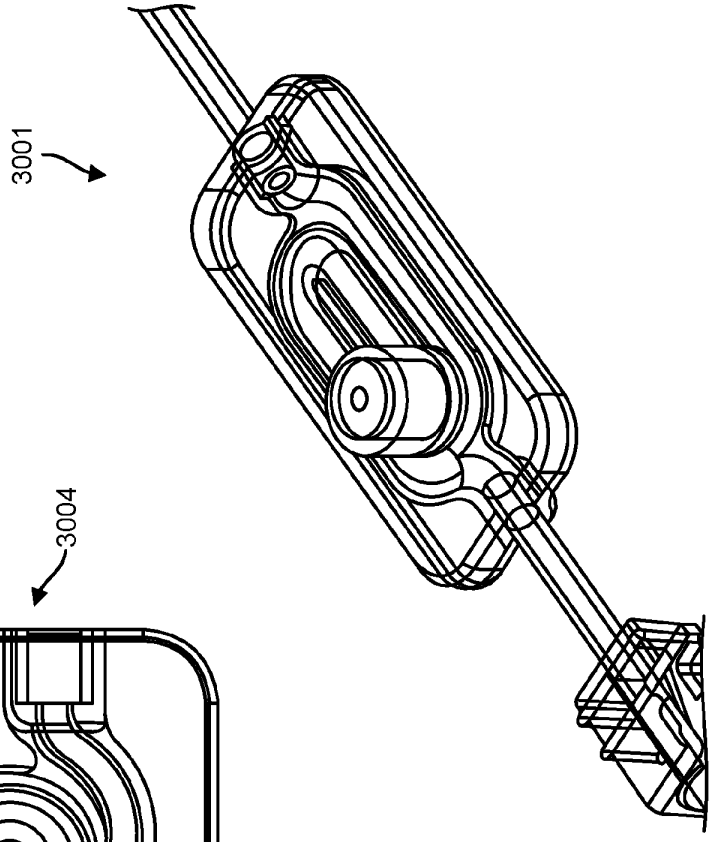


FIG. 30B

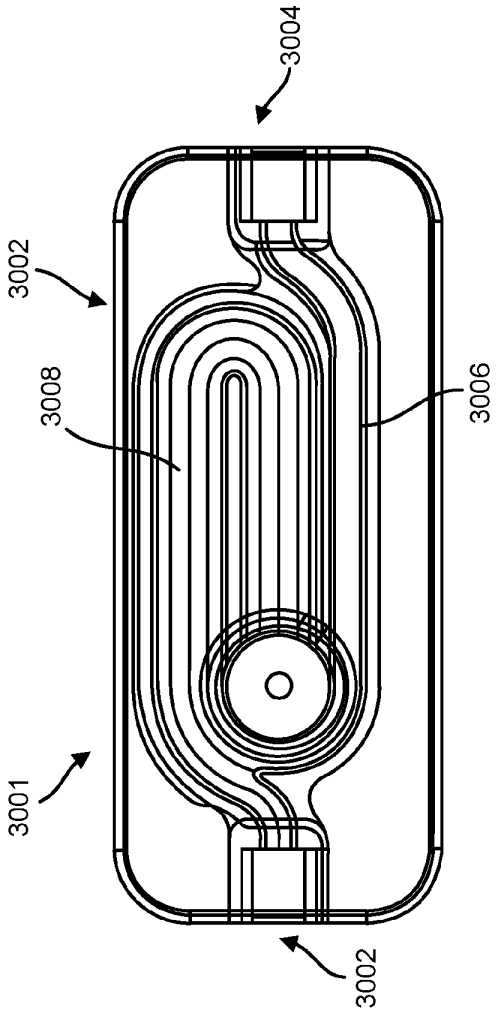


FIG. 30A

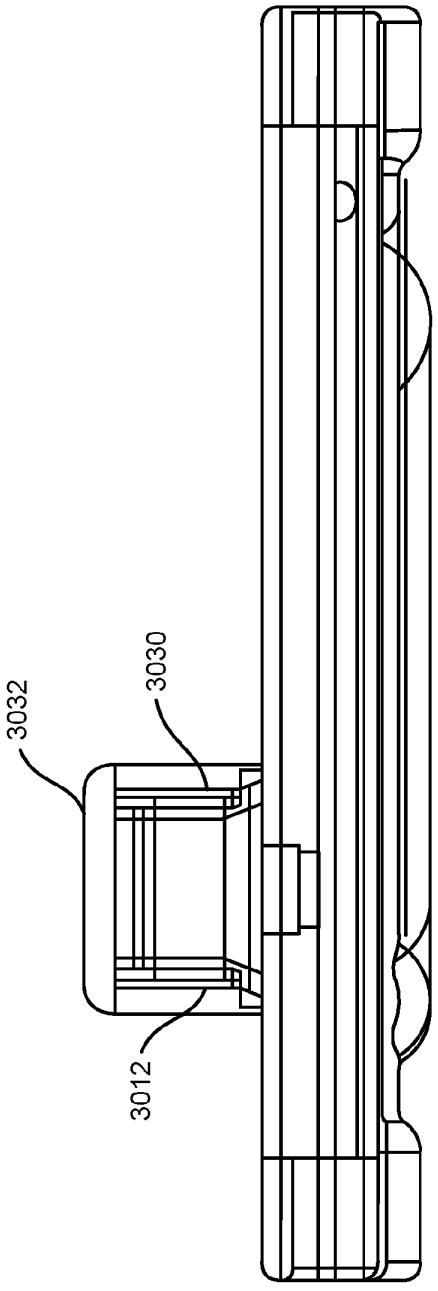


FIG. 30C

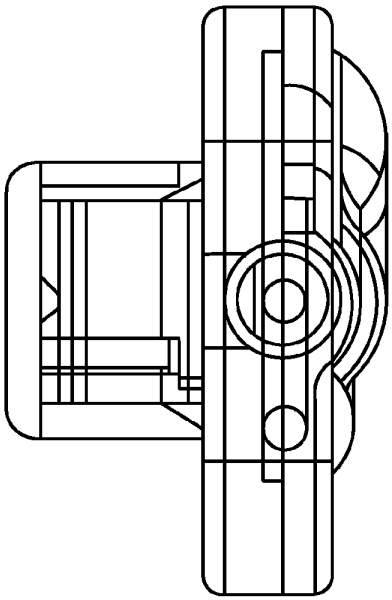


FIG. 30D

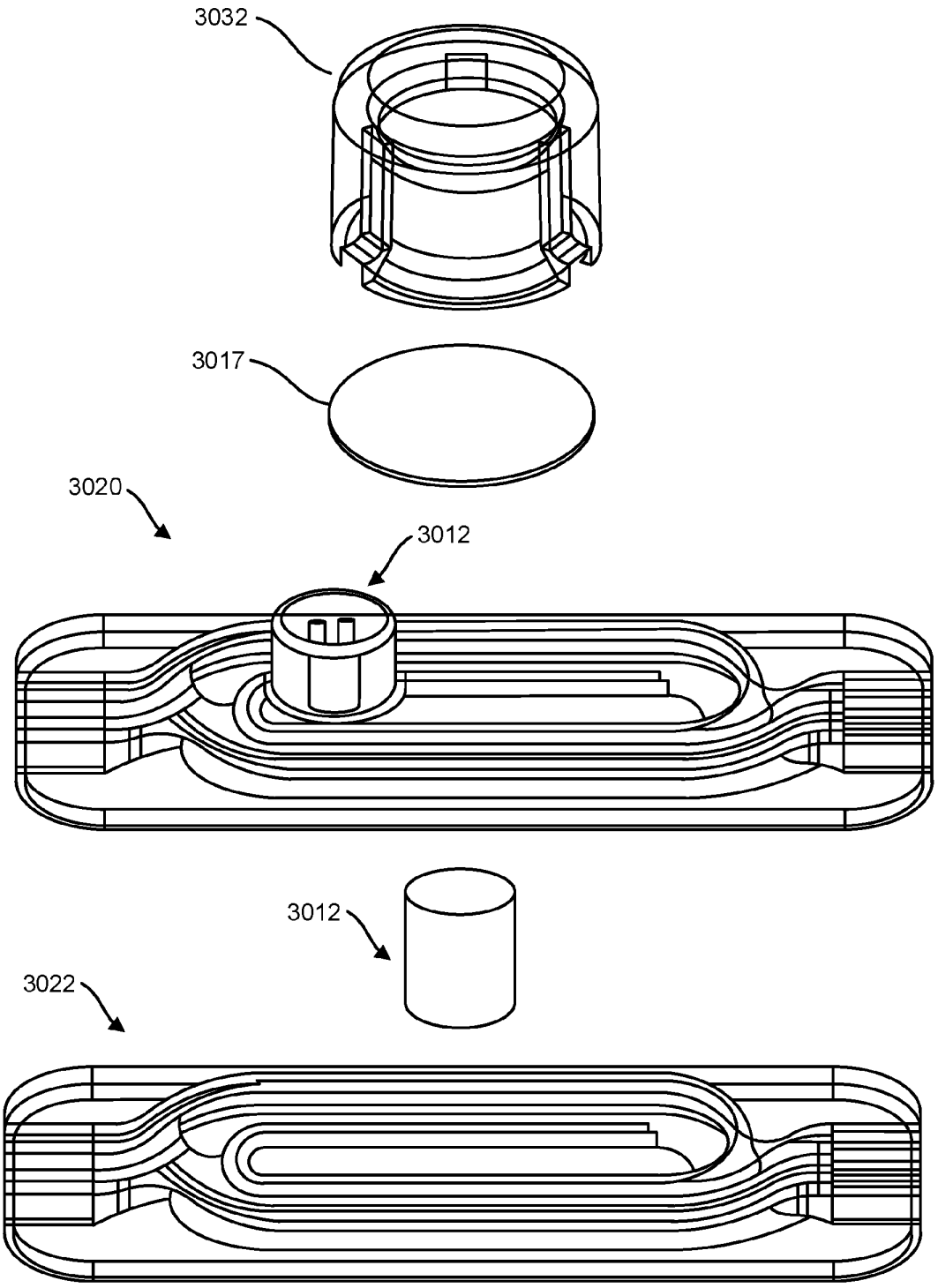


FIG. 30E

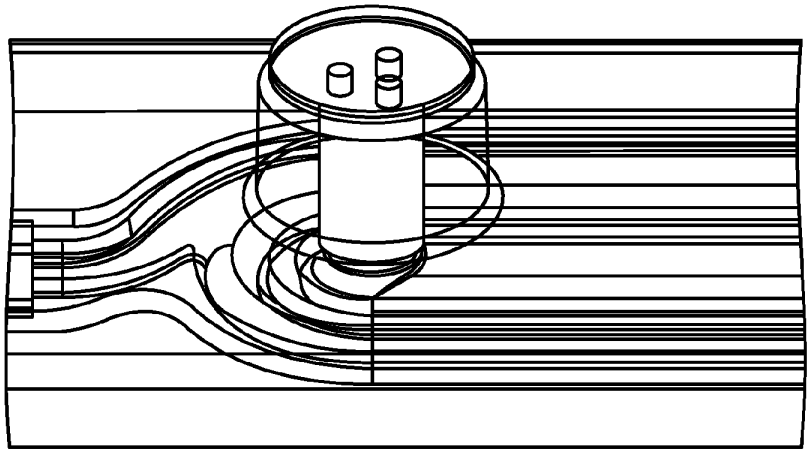


FIG. 30F

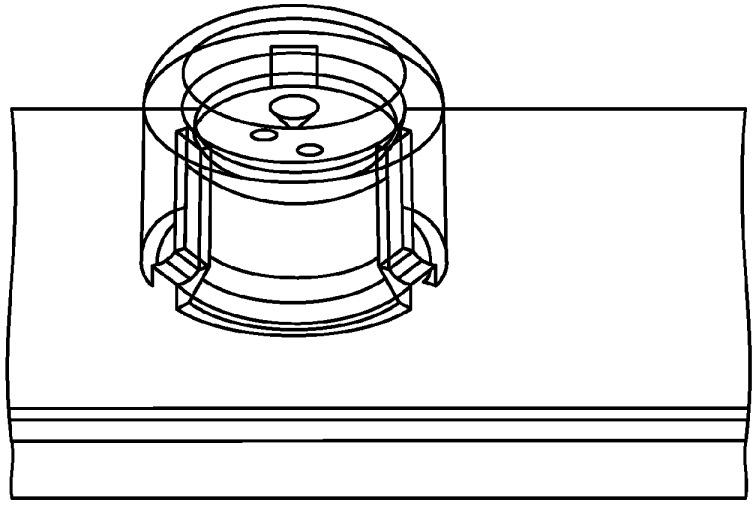


FIG. 30G

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/068569

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/15 A61B5/153 A61B5/154 A61B5/157
ADD.

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)
A61B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/039348 A1 (BULLINGTON GREGORY J [US] ET AL) 6 February 2014 (2014-02-06) the whole document	1-20
A	US 2014/107564 A1 (BULLINGTON GREGORY J [US] ET AL) 17 April 2014 (2014-04-17) the whole document	1-20
A	US 4 813 433 A (DOWNEY JOHN M [US]) 21 March 1989 (1989-03-21) the whole document	1-20
A	US 2013/317391 A1 (BULLINGTON GREGORY J [US] ET AL) 28 November 2013 (2013-11-28) abstract paragraph [0048] - paragraph [0075]; figures 2-12	1-20

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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

"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
29 March 2018	25/04/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nielsen, Michael

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/068569

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/181352 A1 (MAGNOLIA MEDICAL TECHNOLOGIES INC [US]; BULLINGTON GREGORY J [US]; PAT) 5 December 2013 (2013-12-05) abstract paragraph [1090]; figures 11,12 -----	1-20

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/068569

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014039348 A1	06-02-2014	US 2014039348 A1	06-02-2014
		US 2016113560 A1	28-04-2016
		WO 2014022275 A1	06-02-2014
US 2014107564 A1	17-04-2014	EP 2906269 A1	19-08-2015
		US 2014107564 A1	17-04-2014
		US 2015367069 A1	24-12-2015
		WO 2014058945 A1	17-04-2014
US 4813433 A	21-03-1989	NONE	
US 2013317391 A1	28-11-2013	US 2013317391 A1	28-11-2013
		US 2015099996 A1	09-04-2015
		US 2015351678 A1	10-12-2015
WO 2013181352 A1	05-12-2013	AU 2013267448 A1	18-12-2014
		AU 2017216493 A1	07-09-2017
		CA 2875118 A1	05-12-2013
		CN 104902817 A	09-09-2015
		CN 107736901 A	27-02-2018
		EP 2854643 A1	08-04-2015
		EP 3173021 A1	31-05-2017
		JP 6242386 B2	06-12-2017
		JP 2015519145 A	09-07-2015
		JP 2018034009 A	08-03-2018
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		US 2015351679 A1	10-12-2015
		WO 2013181352 A1	05-12-2013

J-PlatPat 特許情報プラットフォーム

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Literature display help

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Japanese Patent Application Laid-Open No. 02-224742

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(54) [Title of invention] Improved blood sampling device

(51) [International patent classification 5th edition]

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A61M 1/02 370

[FI]

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A61M 1/02 370

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[Total number of pages] 10

(21) [Application number] Japanese Patent Application Hei 1-338039

(22) [Filing date] December 26, 1989

(31)) [Priority claim number] 292490

(32) [Priority date] December 30, 1988

(33) [Priority claim country] United States of America (US)

(71) [Applicant]
[Identification number] 999999999
[Name] Spacelabs Inc.
(72) [Inventor]
[Name] John A. R. Cater
(74) [Agent]
[Name] Minoru Nakamura (7 others)

wrap up close —

(57) [Abstract] Since this gazette is application data before electronic filing, abstract data is n ot recorded.

The scope of the claims open —

Claims:
(1) In a coupling used by medical personnel in drawing and storing blood from a patient to ins ert the needle of the needle assembly into the patient to draw the blood sample, the coupling comprises first
and an elongated hollow shaft having a second end; and a
first portion of the shaft fixedly connecting the needle assembly to the shaft so that blood dra wn by the needle can be delivered to the shaft. and an adapter sleeve attached to a second e nd of said shaft for
connecting said shaft to a blood storage means,
for communicating blood received by said shaft; an opening connected to said shaft between an adapter sleeve and said connecting member and communicating with said connecting mem ber.
(2) The coupling of claim 1, further comprising means for blocking blood flow and exhausting air trapped within said shaft.
(3) intermediate the opening and the adapter sleeve, wherein the means for evacuating air re stricts blood flow from the shaft to the adapter sleeve while permitting air flow from the shaft to the adapter sleeve; 3. A coupling according to claim 2, comprising flow control means locat ed within said shaft of.
(4) The coupling of Claim 3, wherein said flow control means comprises a microporous hydrop hobic plug.
(5) The coupling of claim (4) further comprising needle guide means for guiding a needle coup

led to blood reservoir means through said plug and for coaxially fitting said needle with said s haft.

(6) The cup according to (2), further comprising blood storage means for temporarily storing a portion of blood drawn from a patient, said blood storage means being sealably connectable to said opening. ring.

(7) The coupling of claim (6), wherein said blood storage means comprises a syringe.

(8) Further comprising valve means fixedly positioned intermediate said opening and said shaf t for enabling selective communication between said shaft and said opening. coupling.

(9) The coupling of claim 2, further comprising means for sealing said opening.

(10) In a blood collection device used by medical personnel to withdraw and store a blood sa mple from a patient, needle means adapted to be inserted into the patient to withdraw the blo od

sample

; coupling means for connecting the means to the blood storage means,

said coupling means having first and second openings;and adapted to direct blood from said n eedle means to said first and second openings.

(11) The coupling of claim 10, further comprising means for blocking blood flow to exhaust air trapped within said coupling means.

(12) the means for evacuating air restricts blood flow from the needle means to the first openi ng while permitting air flow from the needle means to the first opening; 12. The blood collecti on device of claim 11, comprising flow control means positioned within said coupling means b etween said first and second openings.

(13) The blood collection device of Claim 12, wherein said flow control means comprises a mic roporous hydrophobic plug.

(14) The blood collection device of (13) further comprising needle guide means for guiding a n eedle coupled to blood reservoir means through said plug and coaxial with said coupling mean s.

(15) The method according to (14), further comprising blood storage means for temporarily st oring a portion of the blood drawn from the patient, said blood storage means being sealingly connectable to said second opening. A blood collection device as described.

(16) The blood collection device of (12), wherein said blood storage means comprises a syring e.

(17) The blood collection device of (12) further comprising means for sealing said second ope ning.

(18) further comprising valve means disposed intermediate said needle means and said secon d opening for enabling selective communication between said needle means and said second opening. The blood sampling device according to (12).

(19) said needle means is an elongate needle for insertion into a patient and leading from sai d needle to said coupling means;

13. The blood collection device of claim 12, comprising: a tube, said tube being generally tran sparent so that medical personnel can see blood being directed therethrough.

(20) A blood collection device for use by medical personnel in drawing and collecting blood sa mples from a patient, comprising needle means for drawing blood from a patient and coupling means for selectively connecting blood reservoir means to

said

needle means. wherein

said coupling means is secured to said needle means, said coupling means being positioned b etween said first opening and said needle means and a first opening for receiving blood storag e means; a hollow shaft, said coupling means further comprising a second opening for receivi ng blood storage means, said second opening being connected to said first opening and said n eedle; Mounted on the shaft between means,

the blood sampling device restricts the flow of blood from the shaft to the first opening, but re stricts the flow of blood from the shaft to the first opening.The blood collection device further comprising a flow control device located within the shaft intermediate the first and second ope nings to allow gas flow to the first opening.

(21) further comprising blood storage means for temporarily storing a portion of blood, said bl ood storage means being sealed to said second opening for receiving blood delivered from sai d needle means to said shaft; 21. A blood collection device according to claim 20, adapted for coupling.

(22) said blood storage means comprises a syringe having a blood storage chamber and a plu nger located within said blood storage chamber, said syringe sealing said blood storage chamb er to said second opening; 22. A blood collection device according to claim 21, further compri sing means for connecting with.

(23) The blood collection device of Claim 20, wherein said flow control means comprises a mic roporous hydrophobic plug.

(24) further comprising blood storage means for storing a blood sample, said blood storage m eans being sealingly attachable to said first opening for insertion through said plug, thereby 2 4. A blood collection device according to claim 23, comprising a needle adapted to lead blood f rom the shaft to said blood storage means.

(25) guiding means located within said shaft between said plug and said first opening for guidi ng said needle of said blood storage means through said plug and making said needle coaxial with said shaft; 25. The blood collection device of claim 24, further comprising:

(26) within said shaft between said flow control means and said first opening for guiding a ne edle coupled to said blood storage means through said flow control means and coaxial with sai d shaft; 21. A blood collection device according to claim 20, further comprising guide means l ocated at the .

(27) The blood collection device of Claim 20, further comprising valve means for selectively all owing communication between said shaft and said second opening.

(28) said needle means comprises a needle for insertion into a patient to withdraw a blood sa mple and an elongated tube for guiding blood withdrawn from a patient to said coupling mean s, said tube being flexible

; 21. A blood collection device according to claim 20, and wherein the blood being conducted by said tube is generally transparent so as to be visible to medical personnel.

(29) further comprising a syringe having a blood storage chamber and a plunger positioned wi thin the blood storage chamber, the syringe having means for sealingly connecting the blood s torage chamber to the second opening; 29. A blood collection device according to claim 28, fu rther comprising.

(30) The blood collection device of (11) further comprising cap means for sealing said second opening.

(31) in drawing and collecting a blood sample from a patientA blood collection device for use by medical personnel comprising a

first elongated needle member having an insertion end and an attachment end, said insertion end adapted for insertion into a patient, said first needle member comprising: has a coaxial p assageway for carrying blood drawn from a patient from the insertion end to the attachment e nd and includes a

needle receiving end, a mating end, and from the needle receiving end to the mating end. an d said mounting of said first needle member

such that blood drawn from a patient is conveyed by said first needle member to said first fe male connector. means for fixedly and sealingly connecting an end to a receiving end of said fi rst female connector; a

mating end; a mounting end; and a coaxial extending from said mating end to said mounting end. further comprising a first male connector having a passageway, wherein the mating end of the first male connector is adapted to receive blood conveyed to the first female connector by the first male connector;

first and second ends and a passage extending from the first end to the second end sealingly mated to the mating end of the first female connector; and wherein the first end of the tube i s connected to the attachment end of the first male connector such that blood received by the first male connector is carried by the tube. sealingly attached to the portion, the tube being fl exible and generally transparent so that blood received by the tube is visible to medical perso nnel;

Further comprising a coupling having an elongated hollow shaft and a connecting member att ached to a first end of said shaft, said coupling securing a second end of said tube to said cou pling. to sealably connect to a second end of the shaft, thereby conveying blood received by t he tube to the coupling, the coupling being attached to a second end of the shaft connecting t he shaft to blood storage means. and the coupling is fixedly attached to the shaft between the adapter sleeve and the connecting member such that blood received by the coupling flows int o and out of the second female connector. a plug communicatively further comprising a secon

d female connector in communication with said connecting member and positioned within said shaft of said coupling between said second female connector and said adapter sleeve; wherein said plug is adapted to allow gas to escape from said shaft to effectively block blood flow from said shaft to said adapter sleeve.

(32) a second needle member having an insertion end, a connecting end, a coaxial passageway extending from said insertion end to said connecting end, and a vacutainer means for storing blood drawn from a patient

; The vacutainer means is fixedly attached to the second needle member, the adapter sleeve is positioned such that the vacutainer means is press fit into the adapter sleeve, and the second 32. A blood collection device according to claim 31, wherein a needle member is configured to be inserted through said plug, thereby conveying blood received by said shaft of said coupling to said vacutainer means.

(33) located within said coupling between said plug and said adapter sleeve for guiding said second needle member to insert said second needle member into said plug coaxial with said coupling; 33. A blood collection device according to claim 32, further comprising a needle guide means for receiving the blood.

(34) needle guide means located within said coupling between said plug and said adapter sleeve for guiding a needle coupled to blood storage means for coaxial insertion of said needle into said coupling; 32. The blood collection device of claim 31, further comprising:

(35) further comprising cap means adapted to engage said second female connector and thereby seal said second female connector to prevent blood from flowing out of said second female connector; A blood sampling device according to claim (31).

(36) Further comprising a syringe for temporarily storing blood, said syringe having a blood storage chamber and a plunger located within said blood storage chamber, said syringe being in communication with said blood storage means. (31) adapted to mate with said second female connector such that blood received by said coupling is stored within said syringe.

(37) located within said coupling between said plug and said adapter sleeve for guiding said second needle member to insert said second needle member into said plug coaxial with said coupling; 37. A blood collection device according to claim 36, further comprising a needle guide means for receiving the blood.

(38) a second needle member having an insertion end, a connecting end, a coaxial passageway extending from said insertion end to said connecting end, and a vacutainer means for storing blood drawn from a patient

; The vacutainer means is fixedly attached to the second needle member, the adapter sleeve is positioned such that the vacutainer means is press fit into the adapter sleeve, and the second A needle member is configured to be inserted through said plug, thereby carrying blood received by said shaft of said coupling to said vacutainer means.38. The blood collection device of claim 37.

(39) The blood collection of claim (37) further comprising first, second and third cap means re

spectively sealing said first needle means, said second female connector and said adapter slee ve. Device.

(40) The blood collection device of claim (31) further comprising valve means coupled to said second female connector for selectively communicating between said second female connector and said shaft.

(41) needle means for withdrawing blood from a patient

and

temporarily storing a first blood portion withdrawn from the patient in a blood collection devic e used by medical personnel to withdraw and store a blood sample from a patient; syringe me ans and

coupling means sealingly connecting said needle means to said syringe means, said coupling means including flow control means for venting air trapped within said needle means and said coupling means. said coupling means further comprising adapter means adapted to receive bl ood storage means and direct blood to said coupling means for storage; A blood collection dev ice wherein the means are further configured to return said first blood portion to the patient.

(42) said coupling means comprises a coupling having an elongated hollow shaft, said couplin g means attached to a first end of said shaft fixedly connecting said needle means to said cou pling; further comprising a connecting member, said adapter means being attached to a secon d end of said shaft, said coupling receiving said syringe means, said shaft between said adapt er means and said connecting member; 42. A blood collection device according to claim 41, fu rther comprising a connecting member fixedly attached to.

(43) The blood collection device of Claim 42, wherein said flow control means comprises a plu g positioned within said shaft of said coupling between said connecting member and said adap ter means.

(44) The blood collection device of Claim 43, wherein said plug comprises a microporous hydr ophobic plug.

(45) said needle means comprises a needle for insertion into a patient to withdraw a blood sa mple and an elongated tube for conducting blood withdrawn from the patient to said coupling, said tube being flexible; 44. A blood collection device according to claim 43, and wherein bloo d being conducted by said tube is generally transparent so as to be visible to medical personn el.

(46) drawing a first blood portion from the patient to fill the blood collection device while evac uating the air trapped in the blood collection device so that the anaerobic sample is not conta minated with air trapped in the blood collection means; An anaerobic sample is taken from th e patient after generally evacuating the trapped air from the blood collection device.A method of drawing

an anaerobic blood sample from a patient comprising the step of drawing a sample of blood fr om a patient.

(47) temporarily storing the first blood portion after drawing the first blood portion and

returning the first blood portion to the patient after drawing the anaerobic blood sample
; The method of claim (46), further comprising:
(48) withdrawing the first blood portion
further comprises coupling a coupling to a syringe, the coupling sealably coupled to a needle assembly; inserting
the
needle assembly into a patient and coupling the inserted needle assembly and the coupling so that blood is directed through the needle assembly and into the coupling with the syringe atta ched
; evacuating trapped air,
connecting a vacutainer needle of a vacutainer to said vented coupling, said vacutainer needle being in communication with said inserted needle assembly, and a cup with said vacutainer at tached
.
48. The method of claim (47), comprising withdrawing said first blood portion from a ring into said syringe .
(49) wherein withdrawing the anaerobic blood sample comprises establishing blood flow betw een the needle assembly and the vacutainer after the first blood portion has been withdrawn; The method described in .
(50) The method of claim (48), wherein withdrawing the first blood portion into the syringe co mprises allowing blood to flow freely under the pressure of the patient's heart.

detailed description open —

Description:
INDUSTRIAL APPLICABILITY
The present invention is directed to apparatus for taking a blood sample from a patient, and i n particular to apparatus for obtaining a blood sample from a patient in which the partial pres sure of gas within the sample is such that the blood pressure in the patient's body is An impro ved blood collection device is directed to receiving a blood sample so as to approximately equ al the gas partial pressure therein.
(PRIOR ART)
In the medical field, it is necessary to determine the in vivo gaseous equilibrium in the blood of a patient.
A medical worker will typically be concerned with the partial pressures of oxygen and carbon d ioxide. They may also be concerned with ionic species whose activity is related to the gas bala

nce in the blood, such as hydrogen ions and calcium ions.

In order for a blood sample to be valid for gas-in-blood analysis, the sample must be under a naerobic conditions, i.e., to prevent fluctuations in the partial pressure of the gas to be tested (when the blood is outside the patient's body). Must be collected to avoid exposure to gas.The major commercially available blood collection devices that must be present are largely unsatis factory in ensuring the integrity of anaerobic blood collection. An example of a conventional d evice uses a syringe and a vented plunger, where the syringe is removed from the patient unti l the correct blood volume is obtained from the patient by pulling on the vented plunger from no void in the barrel. Slowly withdraw the blood into the barrel of the However, these devices allow some exposure of the blood sample to the atmosphere. Some amount of ambient air will be contained within the barrel before the plunger moves. Thus, the initial portion of blood is e xposed to these gases, thereby changing the partial pressure of the gases contained in this ini tial sample. No means are provided for discarding the first portion of the drawn blood, so the entire sample would be contaminated.

Further, no means are provided to protect the medical personnel of the device against acciden tal bursting or exposure to contaminated blood during the course of the procedure when using the aforementioned device.

Other devices, such as the Becton and Dickenson Vacutainer and vacutainer attachments, hav e shown improved properties to protect medical personnel from exposure to drawn blood. Ho wever, these devices also. It allows some exposure of the first part of the blood sample to the atmosphere.

In addition to the shortcomings of the prior art described above, blood collection devices that provide means for flushing, i.e., injecting, for example, nutrients, medications, etc., into the b lood stream while permitting the collection of an anaerobic blood sample are currently lackin g. not known where.

Accordingly, it is desirable to provide a device for drawing an anaerobic blood sample from a p atient, and it is further desirable to provide a device for drawing a blood sample that can also inject a liquid into the patient's blood stream, i.e., a puncture. It is further desirable to provid e such a device that allows repeated blood sampling without the need for additional needle pl acement, and during scheduled interval sampling, i.e., between other subsequent blood sampl ings. It would be desirable to provide a device for drawing blood samples that can be left in th e patient.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide a blood collection device for drawi ng an anaerobic blood sample from a patient.

It is also an object of the present invention to provide a blood collection device that can withd raw an initial contaminated blood sample portion and maintain complete anaerobicity in the re maining sample.

It is a further object of the present invention to provide a blood collection device that can inje

ct an external liquid into the patient's blood stream.

It is a further object of the present invention to provide a blood sampling device that allows re peated blood sampling without the need for additional puncture or needle placement.

Yet another object of the present invention is to provide a blood collection device that can be l eft on the patient between scheduled intervals of collection, ie, other subsequent blood collect ions.

These and other objects of the present invention are met by providing a coupling for use by m edical personnel when drawing blood from a patient and storing it, which coupling draws the b lood sample. The coupling is particularly adapted for use with a needle assembly for injecting a needle into a patient. A coupling fixedly

connects the elongated hollow shaft and the needle assembly to the shaft for withdrawal by th e needle. a connecting member attached to the first end of the shaft that delivers blood to the shaft, and a coupling attached to the second end of the shaft that connects the shaft to variou s blood storage means. The adapter sleeve further comprises an opening coupled to the shaft intermediate the adapter sleeve and the connecting member, the opening being in communica tion with the opening such that blood received in the shaft communicates with the opening. In another embodiment

of the present invention, a device is provided for blocking blood flow and venting air trapped i n the shaft, particularly flow control means, such as microporous A hydrophobic plug is locate d in the shaft intermediate the opening and the adapter sleeve to restrict blood flow from the shaft to the adapter sleeve while allowing air flow from the shaft to the adapter sleeve. 6 In a nother embodiment of the invention, a valve is provided intermediate the shaft and the openi ng to allow selective communication between the shaft and the opening.

Other embodiments of the invention are particularly pointed out and distinctly claimed in the c laims. The invention, however, as to organization and method of implementation, will best be understood from the following detailed description when read with the accompanying drawing s in which: FIG.

DETAILED DESCRIPTION OF THE INVENTION

A cross-sectional view showing the improved blood collection device of the present invention i s provided in FIG. The blood sampling device comprises an elongated needle 100 having an in sertion end 102 adapted for insertion into a patient's blood stream (artery or vein). Needle 10 0 further has an attachment end 104 attached to first connecting member 106 via cylindrical seal 108 . As is well known in the art, meter 100- has a coaxial passageway extending from in sertion end 102 to attachment end 104 that conducts blood withdrawn from the patient to firs t connecting member 106. As shown in FIG.

Cylindrical seal 10B has a central opening 110 in which mounting end 104 of needle 100 is fix edly mounted. Additionally, the cylindrical seal 108 isIt is fixedly attached to needle receiving end 112 of member 106 . The second connecting member 114 has a mating end 116 adapted to mate with the mating end 118 of the first connecting member 106 so that it is received by

the first connecting member. rice field. Blood from leaflet 100 is directed to second connecting member 114 via mating joints 116,118.

First end 120 of tube 122 is sealingly attached to attachment end 124 of second connecting m ember 114 . A tube 122 is provided for carrying blood withdrawn from the patient through tub e 100 to coupling 126 . Tubing 122 allows the needle to be easily inserted into the patient's bl oodstream and, after insertion, the coupling 126 can be disengaged by medical personnel wit hout undue movement of the total 100 and causing discomfort to the patient. Preferably, the t ube 122 is flexible so as to be operable, and preferably transparent so that the medical perso nnel can visually observe the blood drawn from the patient.

The combination of needle 100, first connecting member 106, second connecting member 11 4, and tube 122 constitutes a needle assembly, readily available from needles, connecting me mbers, and tubes well known in the art. Can be assembled. - By way of example, the first and second connecting members 106 and 114 consist of male and female Luer connectors, as is w ell known in the art.

A coupling 126 is provided for connecting the second end 128 of the tube with each of the firs t and second blood storage means 130 and 132 . To this end, coupling 126 has a connecting member 134 with a central opening that receives second end 128 of tube 122 . Connecting m ember 134 is integrally connected to elongated hollow shaft 136 such that blood delivered to coupling 126 by tube 122 is received within shaft 136 . Adapter sleeve 138 is integrally conne cted to shaft 136 at the end opposite to the end to which connecting member 134 is connecte d. Adapter sleeve 138 is in communication with shaft 136 and is provided for receiving second blood storage means 132, as will be described more fully below.

Coupling 126 further includes an opening 140 integrally connected to shaft 136 intermediate a dapter sleeve 138 and connecting member 134 .

An opening 140 is provided for connecting first blood storage means 130 to shaft 136 of coupl ing 126 . A passageway 162 is provided in shaft 136 proximate opening 140 such that openin g 140 communicates with connecting member 134 . Accordingly, blood delivered to coupling 1 26 by tube 122 is conveyed via adapter sleeve 138 and opening 140 to first and second blood storage means 130 and 132 for storage.

Coupling 126 also has a plug 142 disposed within the shaft between adapter sleeve 138 and o pening 140 . Plug 142 is a fluid flow, e.g., porous plug, venting air trapped within connecting members 106, 114, tube 122, shaft 136, and opening 140 during the early stages of a blood c ollection procedure. It consists of control means. The plug 142 is thus adapted to restrict bloo d flow from the shaft 136 to the adapter sleeve 138 and allow air flow from the shaft to the a dapter sleeve. 142 consists of a microporous, hydrophobic plug, well known in the art. Howev er, those skilled in the art will appreciate that other liquid flow control means may be used in place of the preferred microporous hydrophobic plug 142 .

As previously mentioned, opening 140 is adapted to receive first blood storage means 130 .

A cap 144 is engageable with opening 140 to seal the opening from inadvertent blood loss, w

hich often occurs when first blood storage means 130 is not connected to coupling 126 . Howe ver, in normal operation, cap 144 is removed from opening 140 and connects first blood stora ge means 130 thereto.

In a preferred embodiment of the present invention, the first blood storage means 130 compri ses a syringe of the type having a blood storage chamber 146 and a plunger 148 positioned w ithin the blood storage chamber 146 .

As is well known, in operation, plunger 148 is slowly withdrawn from blood storage chamber 1 46 so that blood enters the chamber. Blood storage means 130 further comprises connection means 150 for connecting blood storage means 130 to opening 140 . In a preferred embodim ent of the invention, opening 140 and connecting member 150 each comprise male and femal e luer connectors. However, it will be apparent to those skilled in the art that other connector members may be provided to sealingly connect first blood storage means 130 to coupling 126 .

In operation, the cap 144 is removed from the opening 140 and the blood reservoir means 13 0 is connected thereto.The blood is then withdrawn, or preferably allowed to flow freely under the pressure of the patient's heart. Meter 100 is inserted into the patient's blood stream so as to be able and delivered to shaft 136 via connecting members 106 , 114 and tubing 122 . Air trapped within connecting members 106, 114, tube 122, shaft 136 and opening 140 is displac ed by the patient's blood entering the flow passageway and vented through porous plug 142, as previously described. .

A first portion of the blood that is withdrawn or flows under cardiac pressure from the patient is exposed to trapped air before being ventilated.As it is exposed, it is generally contaminated and therefore not suitable for anaerobic blood sampling.

This first blood portion is thus withdrawn from the coupling 126 into the blood storage means 130 for temporary storage, while the anaerobic blood sample passes through the second bloo d storage means 132. to be received. After the anaerobic blood sample is received, the blood temporarily stored in blood storage means 130 is discarded or returned to the patient via tube 122 and meter 100 .

A second blood storage means 132 is connected to the coupling 126 via an adapter sleeve 13 8 for withdrawing an anaerobic blood sample. The second blood storage means 132 may com prise a Becton Dickenson vacutainer well known in the art. Blood storage means 132 has a blo od storage chamber 152 for receiving an anaerobic blood sample drawn from the patient. are doing. Needle 154 is sealingly connected to needle hub 156 and their assembly is connected t o blood storage chamber 152 via a compatible coupling 158 (commonly referred to as a vacut ainer adapter). Hermetically connected. Needle 154 has a seal to prevent communication with blood storage chamber 152, as is well known in the art. Additionally, as is well known in the a rt, blood storage chamber 152 is evacuated so as not to contain air that contaminates blood d rawn from the patient.

A compatible coupling 158 provides means for removing the seal from needle 154 in order to

place needle 154 in communication with blood storage chamber 152 .

Adapter sleeve 138 has an internal adapter chamber 160 sized to snugly receive needle hub 1 56 . The length of adapter sleeve 138 and the position of plug 142 within shaft 136 is such th at blood reservoir 132 is fully inserted into adapter sleeve 138 and needle 154 passes through passageway 162 and second end 128 of tube 122 through plug 142 . is selected to lie betwee n A needle guide 164 is positioned within coupling 126 between adapter sleeve 138 and plug 142 to allow a needle to be inserted into coupling 126 coaxially with shaft 136 . Needle guide 164 receives needle 154 during insertion of blood reservoir 132 into coupling 126 and guides t he needle prior to needle insertion into plug 142 so that the needle is coaxial with shaft 136 . provided for positioning.

In operation, blood reservoir means 130 is connected to coupling 126 via opening 140 as prev iously described for collecting an anaerobic blood sample. The meter 100 is inserted into the p atient's bloodstream and air trapped inside the meter 100, connectors 106, 114, tubing 122 a nd coupling 126 is evacuated through plug 142 as previously described.Total 154 of blood stor age means 132 is then inserted through plug 142 and into coupling 126 so that it lies beyond passageway 162 near tube 122 . The contaminated air of the blood sample is removed so that any fraction of contaminated air that accumulates within needle 154 is exhausted through plu g 142, i.e., removed from coupling 126 prior to receiving the anaerobic blood sample. It is des irable to insert gauge 154 into coupling 126 prior to storing the portion in storage means 130 .

After the soot 154 is properly inserted into the coupling 126, the first portion of contaminated blood is drawn from the coupling 126 into the blood storage means 130 for temporary storag e. At this time, the seal on needle 154 is removed by compatible coupling 158, as is well kno wn in the art, so that the anaerobic blood sample is directed to blood reservoir 152. FIG.

To ensure that substantially all of the blood directed to blood storage chamber 152 is blood re ceived from tube 122 and not blood received from blood storage chamber 146 of blood storag e means 130, total 154 is connected to passageway 162. and tube 122 and near second end 128 of tube 122 in coupling 126 in shaft 136 .

In an alternative embodiment of the present invention, when receiving an anaerobic blood sa mple, a valve capable of substantially isolating a contaminated blood sample stored in blood s torage means 130 from shaft 136 during operation; Alternatively, it may be desirable to provi de other selective coupling means.

In addition to the cap 144, a plurality of caps or other sealing means may be provided for posi tioning the total 100 to seal the chamber 160 of the adapter sleeve 138, as is common in the medical industry.

Although only some of the preferred embodiments of the novel blood collection device have b een described in detail herein, many modifications and variations will become readily apparent to those skilled in the art without the true scope and spirit of the invention. It is the intent of t he appended claims to cover all such improvements and modifications that fall within the scop

e of the claims.

Brief description of the drawing open —

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a cross-sectional view of one of the improved blood collection devices of the pre sent invention.

100 Needle

106 First connecting member

114 Second connecting member

122 Tube

126 Coupling

130.132 Blood reservoir Means

134 ... Connection member

136 ... Shaft

138 ·

140 ·

142,

144,

146.

148

154

Adapter sleeve

opening

plug

cam

blood storage chamber plunger

needle



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IMPROVED BLOOD SAMPLER

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Applicant(s): SPACELABS INC ± (SPACELABS INC)

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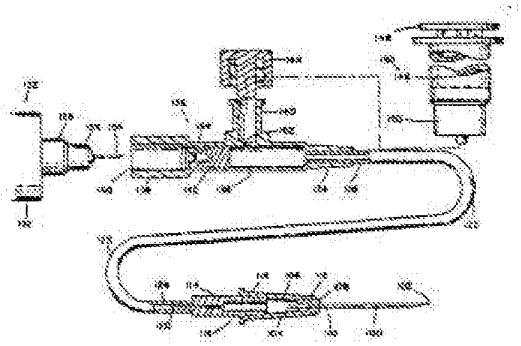
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Abstract of JPH02224742 (A)



PURPOSE: To keep completely anaerobic of the residual a blood sample, with the first sampled portion of contaminated blood removed, by fixedly coupling a slender hollow shaft and a needle assembly together, with a joint member mounted to the first end of a shaft and an adapter sleeve to the second end.

CONSTITUTION: Coupling 126 has joint member 134 which receives the second end 128 of tube 122. Adapter sleeve 138 is connected integrally to shaft 136 at an opposite end of the end to which the joint member 134 is connected. The adapter sleeve 138 communicates with the shaft 136 and receives second blood storage means 132. The coupling 126 has further opening 140 which is joined integrally to the shaft 136 between the adapter sleeve 138 and joint member 134. The blood delivered to the coupling 126 through tube 122 is transferred to the first and second blood storage means 130, 132 respectively for storage therein via the adapter sleeve 138 and opening 140.

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⑤④発明の名称　改良された血液採取装置

⑳特　願　平1-338039

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明　細　書

1.発明の名称　改良された血液採取装置

2.特許請求の範囲

(1) 患者から血液を抜き取って貯蔵する際に医療作業員によって使用され、血液サンプルを抜き取るために針組立体の針を患者に挿入する、カップリングにおいて、

第1及び第2の端部を有する細長い中空シャフトと、

前記針組立体を前記シャフトに固定して連結し、それによって、前記針によって引き抜かれた血液を前記シャフトに送ることができる、前記シャフトの第1の端部に取り付けられた接続部材と、

前記シャフトを血液貯蔵手段に接続する、前記シャフトの第2の端部に取り付けられたアダプタースリーブと、

前記シャフトによって受け入れられた血液を連通させるため、前記アダプタースリーブと前記接続部材との間の前記シャフトに連結されて前記接続部材に連通している開口部と、から成るカップリング。

(2) 血液の流れを遮断して、前記シャフト内にたまった空気を排気する手段をさらに備える請求項(1)に記載のカップリング。

(3) 前記空気を排気する手段が、前記シャフトから前記アダプタースリーブへの空気の流れを可能にしつつ、シャフトからアダプタースリーブへの血液の流れを制限する、前記開口部と前記アダプタースリーブとの中間の前記シャフト内に位置している流れ制御手段から成る請求項(2)に記載のカップリング。

(4) 前記流れ制御手段が、微孔質疎水性プラグから成る請求項(3)に記載のカップリング。

(5) 血液貯蔵手段に結合している針を前記プラグを通して案内し、前記針を前記シャフトと同軸にする針案内手段をさらに備える請求項(4)に記載のカップリング。

(6) 患者から抜き取った血液の一部を一時的に貯蔵する血液貯蔵手段をさらに備え、前記血液貯蔵手段は、前記開口部に密封して連結可能である請求項(2)に記載のカップリング。

(7) 前記血液貯蔵手段が、注射器から成る請求項(6)に記載のカップリング。

(8) 前記シャフトと前記開口部との間の選択的な連通を可能にする、前記開口部と前記シャフトの中間に固定して配置されているバルブ手段をさらに備える請求項(2)に記載のカップリング。

(9) 前記開口部を密封する手段をさらに備える請求項(2)に記載のカップリング。

(10)患者から血液サンプルを抜き取って貯蔵するために医療作業員によって使用される血液採取装置において、

血液サンプルを抜き取るために、患者に挿入されるように適合している針手段と、

前記針手段を血液貯蔵手段に連結させるカップリング手段とを備え、

前記カップリング手段は、第1及び第2の開口部を有しており、前記針手段からの血液を前記第1及び第2の開口部に導くようになっている血液採取装置。

(11)血液の流れを遮断して、前記カップリング手段内にたまった空気を排気する手段をさらに備える請求項(10)に記載のカップリング。

(12)前記空気を排気する手段が、前記針手段から前記第1の開口部への空気の流れを可能にしつつ、前記針手段から前記第1の開口部への血液の流れを制限する、前記第1及び第2の開口部の間の前記カップリング手段内に位置している流れ制御手段から成る請求項(11)に記載の血液採取装置。

(13)前記流れ制御手段が、微孔質疎水性プラグから成る請求項(12)に記載の血液採取装置。

(14)血液貯蔵手段に結合している針を前記プラグを通して案内し、前記カップリング手段と同軸になる針案内手段をさらに備える請求項(13)に記載の血液採取装置。

(15)患者から抜き取った血液の一部を一時的に貯蔵する血液貯蔵手段をさらに備え、前記血液貯蔵手段は、前記第2の開口部に密封して連結可能である請求項(14)に記載の血液採取装置。

(16)前記血液貯蔵手段が、注射器から成る請求項(12)に記載の血液採取装置。

(17)前記第2の開口部を密封する手段をさらに備える請求項(12)に記載の血液採取装置。

(18)前記針手段と前記第2の開口部との間の選択的な連通を可能にする、前記針手段と前記第2の開口部の中間に配置されているバルブ手段をさらに備える請求項(12)に記載の血液採取装置。

(19)前記針手段が、患者に挿入する針と、前記針から前記カップリング手段へ導く、細長いチューブと、から成り、前記チューブは、医療作業員が導かれている血液を前記チューブを通して見ることができるように、概ね透明である請求項(12)に記載の血液採取装置。

(20)患者から血液サンプルを抜き取って集める際に医療作業員が使用する血液採取装置において、

患者から血液を抜き取る針手段と、

前記針手段に血液貯蔵手段を選択的に連結するカップリング手段と、を備え、

前記カップリング手段は前記針手段に固定されており、前記カップリング手段は、血液貯蔵手段を受け入れる第1の開口部と、前記第1の開口部と前記針手段との間にある中空のシャフトとを有しており、前記カップリング手段は、血液貯蔵手段を受け入れる第2の開口部をさらに備えており、前記第2の開口部は、前記第1の開口部と前記針手段の間の前記シャフトに取り付けられており、

前記血液採取装置は、前記シャフトから前記第1の開口部への血液の流れを制限するが、前記シャフトから前記第1の開口部への気体の流れを可能にする、前記第1及び第2の開口部の中間の前記シャフト内部に位置している流れ制御装置をさらに備える血液採取装置。

(21)血液の一部を一時的に貯蔵する血液貯蔵手段をさらに備え、前記血液貯蔵手段は、前記針手段から前記シャフトへ送られた血液を受け入れる、前記第2の開口部へ密封して連結されるようになっている請求項(20)に記載の血液採取装置。

(22)前記血液貯蔵手段が、血液貯蔵チャンバーと前記血液貯蔵チャンバー内に位置しているプラ