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(54) Title: PERISTALTIC PUMP ASSEMBLY AND REGULATOR THEREFOR

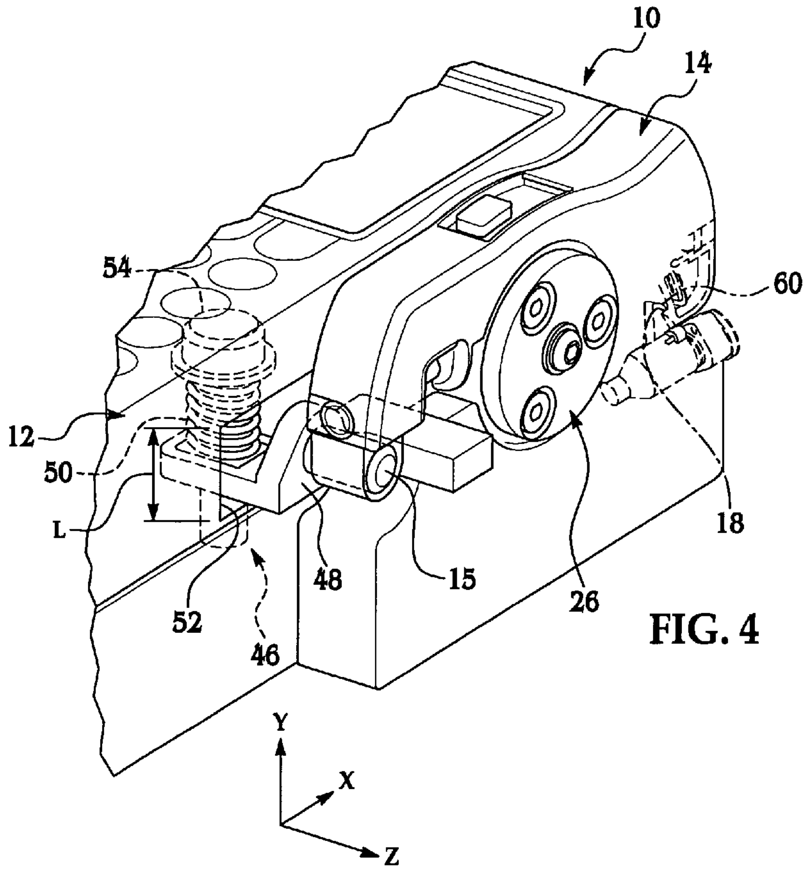

FIG. 4

(57) Abstract: A peristaltic pump assembly includes a pump body and a cassette removably attached thereto, wherein the cassette includes a race configured to provide a compression surface for a tube supported by the cassette. A roller assembly is operatively connected to the pump body, wherein the roller assembly includes a plurality of rollers configured to apply a predetermined force to the tube, thereby compressing the tube against the race. The peristaltic pump assembly further includes a regulator disposed in the pump body and operatively connected to the cassette, where the regulator is configured to regulate the predetermined force applied to the tube.

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PERISTALTIC PUMP ASSEMBLY AND REGULATOR THEREFOR

BACKGROUND

[0001] The present disclosure relates generally to peristaltic pump assemblies and, more particularly, to a peristaltic pump assembly and a regulator therefor.

[0002] Peristaltic pumps are often used to deliver fluid in a very controlled manner such as, for example, the intravenous delivery of medicine to a patient. The peristaltic pump may generally include a pump body having a cassette removably attached thereto, and a tube supported by the cassette. A fluid (e.g., medicine) flows through the tube, generally by increments, as the tube is occluded against a race formed in the cassette. Occlusion of the tube may occur by a compression force applied to the tube by the rollers in response to rotational movement of a planetary system of rollers driven by a motorized drive shaft.

[0003] In some instances, small variations in the size and/or location of at least some components in the pump assembly may cause at least some variation in the compression force. This may also lead to at least some variation in the load applied to the pump motor. One way of controlling at least some of these variations is to maintain a substantially constant force applied to the tube by the rollers. This may be accomplished by coupling each roller with a spring, where the spring forces the roller against the tube via a relatively constant force.

SUMMARY

[0004] As disclosed herein, a peristaltic pump assembly includes a pump body and a cassette removably attached thereto, wherein the cassette includes a race configured to provide a compression surface for a tube supported by the cassette. A roller assembly is operatively connected to the pump body, wherein the roller assembly includes a plurality of rollers configured to apply a predetermined force to the tube, thereby compressing the tube against the race. The peristaltic pump assembly further includes a regulator disposed in the pump body and operatively connected to the cassette.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Features and advantages of embodiment(s) of the present disclosure will become apparent by reference to the following detailed description and drawings, in which like reference numerals correspond to similar, though perhaps not identical components. Reference numerals having a previously described function may or may not be described in connection with other drawings in which they appear.

[0006] Fig. 1 is a perspective view of an embodiment of a peristaltic pump assembly including a removable cassette;

[0007] Fig. 2 is a perspective, plan view of the pump body shown in Fig. 1;

[0008] Fig. 3 is an enlarged, exploded, perspective view of the removable cassette shown in Fig. 1; and

[0009] Fig. 4 is a cutaway, perspective view of the pump assembly depicting an embodiment of a regulator disposed therein.

DETAILED DESCRIPTION

[0010] Embodiment(s) of the peristaltic pump assembly including the regulator as disclosed herein advantageously allow a substantially constant force to be applied on a tube, which is supported by a cassette, and by a plurality of rollers of the pump assembly. The substantially constant force applied to the tube allows the tube to be occluded by the rollers in a relatively consistent manner, thereby improving the operating performance of the pump assembly at least with regard to, e.g., the accuracy of the amount of fluid to be delivered by the pump assembly to a patient, the amount of power consumed by the pump assembly, the operating life of the cassette, the operating life of a roller mechanism employed by the pump assembly, and the operating life of a pump motor also employed by the pump assembly. The substantially constant force may also reduce the noise level of the pump assembly when the pump assembly is operating.

[0011] Other advantages of the pump assembly including the regulator include simplification of the pump assembly process, whereby adjustment(s) and/or calibration(s) of the regulator may not be necessary once the pump assembly has been assembled. Also, variations in the cassette, as well as the size and/or location of the cassette and/or other components within the pump assembly, may generally have little effect on the substantially constant force applied to the tube by the plurality of rollers.

[0012] As defined herein, the term "substantially constant force" refers to a force having a measured value remaining within about 10% of a median value. Non-limiting examples of "substantially constant forces," as referred to herein, include a substantially constant compression force and a substantially constant spring force.

[0013] With reference to Figs. 1 and 2, the peristaltic pump assembly 10 generally includes a pump body 12 and a cassette 14 removably attached thereto by an attachment member 15. In an illustrative example, the peristaltic pump assembly 10 will be described herein as including a mounting pin as the attachment member 15 (though it is to be understood that various alternate examples of the attachment member 15 may be used). Details of an example of a method of removably attaching the cassette 14 to the pump body 12 via the mounting pin 15 may be found in U.S. Application Serial No. 11/862,302 filed concurrently herewith (Docket No. DP-315954), which is commonly owned by the Assignee of the present disclosure, and is incorporated herein by reference in its entirety. It is to be understood, however, that other suitable means and/or methods for removably attaching the cassette 14 to the pump body 12 may also be considered as being within the spirit and scope of the present disclosure.

[0014] The pump body 12 further includes a cassette receiving portion 16 having a partial cavity 20 defined by a floor (not shown) and two opposing walls 22, 24. A roller assembly 26 (e.g., a roller mechanism) is housed within the cavity 20 and operatively connected to the pump body 12. Roller assembly 26 includes a plurality of satellite rollers 28 arranged in a planetary configuration. The rollers 28 rotate as an assembly, as well as individually, in response to rotational forces imparted thereto by a motorized drive shaft (not shown). The motorized drive shaft may be operated by a pump motor (not shown), which are both operatively connected to the pump body 12.

[0015] An exploded view of the cassette 14 is generally depicted in Fig. 3, where the cassette 14 includes a cassette body 30 and a cover 32 disposed thereon. The cassette 14 may be disposable, as desired. The cassette body 30 includes an inlet 34 formed in an end 36 thereof and an outlet 38 formed in another end 40 thereof. The inlet 34 and outlet 38 are configured to receive first and second ends of a tube 42 (shown in Fig. 1), thereby supporting the tube 42 in the cassette 14.

[0016] In a non-limiting example, the tube 42, which is also disposable, may be classified as substantially flexible so that the tube may be compressed and/or occluded by the rollers 28, as will be described further below. In an embodiment, the tube 42 is made of a polymeric material. Non-limiting examples of suitable polymeric materials include silicones, AUTOPRENE (an opaque thermoplastic rubber with high wear resistance derived from SANTOPRENE, commercially available from Advanced Elastomer Systems, a subsidiary of ExxonMobil Chemical located in Houston, TX), VITON (a black fluoroelastomer with resistance to concentrated acids, solvents, ozone, radiation and temperatures up to 200°C with good chemical compatibility, commercially available from DuPont Performance Elastomers located in Wilmington, Delaware), TYGON (good chemical resistance with a clear finish, commercially available from Saint-Gobain Performance Plastics Corporation located in Akron, Ohio), PROTHANE II (a transparent, blue, polyester, polyurethane tubing with good chemical resistance, commercially available from Randolph Austin Company located in Manchaca, Texas), and/or the like, and/or combinations thereof. The inner diameter of the tube 42 may be selected based on the desirable flow rates and the desirable viscosities of the fluid that will flow therethrough.

[0017] The cassette 14 further includes a race 44 formed therein and configured to provide a compression surface for the tube 42. It is to be understood that during operation of the pump, the rollers 28 apply a compression force against the tube 42 in response to rotational movement of the rollers 28. The compression force compresses the tube 42 against the race 44 to thereby substantially occlude the tube 42. This compression force is a predetermined force controlled by a regulator 46 of the pump assembly 10. As such, in response to the rotational movement of the rollers, portions of the flexible tube 42 that are in contact with the rollers 28 compress or are otherwise occluded against a wall of the cassette 14. As a result, fluid is temporarily retained in the tube 42 between the occluded points. In this manner, fluid is urged through the tube 42 via peristaltic wave action. Details of an example of a suitable cassette 14 may be found in U.S. Application Serial No. ________, filed concurrently herewith (Docket No. DP-315956), which is commonly owned by the Assignee of the present disclosure, and is incorporated herein by reference in its entirety.

[0018] As depicted in Fig. 4, the regulator 46 is disposed in the pump body 12 and is operatively connected to the cassette 14. It is to be understood, however, that the regulator 46 may otherwise be disposed in the peristaltic pump assembly 10, e.g. adjacent to the pump body 12 and/or as part of the pumping mechanism assembly. In an embodiment, the regulator 46 includes a slide member 48 having the mounting pin 15 connected thereto. The slide member 48 may be any suitable support member capable of moving along a substantially linear path of length L. In an embodiment, and as shown in Fig. 4, a window 52 is formed in the pump body 12. At least a portion of the slide member 48 extends through the window 52. The window 52 is configured to allow the slide member 48 (including the mounting pin 15 connected thereto) to linearly slide or otherwise move a distance along a length L in response to changes/variations in the pump assembly 10 or components thereof (e.g., variations in the wall thickness of the tube 42 at the compression area of the race 44, wear of the rollers 28, thermal length variations of components, manufacturing variations, etc.).

[0019] Movement of the slide member 48 (e.g., in the window 52) may be restricted by the regulator 46 via a spring 50 also provided therewith and operatively connected to the slide member 48. The spring 50 may be operatively situated such that the spring 50 compresses along substantially the same linear direction as the slide member 48. In an embodiment, the spring 50 may be selected from those having a spring constant ranging from about 3 lb_f/in (0.525 N/mm) to about 5 lb_f/in (0.875 N/mm). Non-limiting examples of suitable springs include helical springs, clock springs, torsion springs, compression springs, extension springs, leaf springs, elastomeric bodies, and/or the like, and/or combinations thereof.

[0020] In an embodiment, a predetermined pre-load may be applied to the spring 50 using a pre-loading member 54 operatively connected thereto. As shown in Fig. 4, the pre-loading member 54 may be a shoulder bolt extending through the spring 50 and through a bore (not shown) formed in the slide member 48. It is to be understood that other devices may suitably be used as the pre-loading member 54, non-limiting examples of which include screws, pegs, pins, shafts, and/or the like, and/or combinations thereof. In a non-limiting example, the predetermined pre-load applied to the spring 50 ranges from about 1.5 lb_f (7 N) to about 3 lb_f (14 N).

[0021] The regulator 46 is generally configured to regulate and/or control the compression force applied to the tube 42 by the rollers 28 so that the compression force is a substantially constant force. To accomplish this, the regulator 46 restricts the amount of the compression force applied to the tube 42 within a predetermined boundary or range. The predetermined boundary or range may be determined, e.g., based on the spring constant of the spring 50 and the distance that the slide member 48 travels in order to compress the spring 50. Restricting the amount of the compression force may be accomplished by allowing the mounting pin 15 (which is connected to the slide member 48) to move in response to changes and/or variations in the peristaltic pump assembly 10. In a non-limiting example, such changes and/or variations include variations in the individual components of, or the assembly 10 as a whole (as mentioned above), e.g., when the assembly 10 is infusing a fluid to a patient.

[0022] In an embodiment, before the cassette 14 is mounted to the pump body 12, the slide member 48 is slightly pre-loaded (e.g., a pre-load of about 2 lb_f to about 2.5 lb_f) via compression of the spring 50. Upon mounting the cassette 14, the slide member 48 moves in the y-direction from its pre-load position, and the spring 50 compresses slightly further beyond the pre-load force. The tube 42 is substantially occluded under the force applied by the spring 50. During operation of the roller mechanism, as the rollers 28 rotate, slight variations and/or changes in the size of the tube 42, various components of the cassette 14, the rollers 28, and/or the like are controlled by the slide member 48 by moving the slide member 48, against the spring 50, in the y-direction along the substantially linear path of length L. It is to be understood that movement of the slide member 48 is relatively small in order to sufficiently control the changes in the pump assembly 10 components, etc., and to maintain a substantially constant compression force applied to the tube 42 by the rollers 28. In a non-limiting example, the slide member 48 moves a length L ranging from about 0.25 mm to about 0.5 mm.

[0023] Although the pump assembly 10 has been described including the regulator 46 operatively connected to the mounting pin 15, it is to be understood that the regulator 46 may otherwise be operatively connected to a pump body retaining feature 56 (shown in Fig. 2) disposed or otherwise formed in the pump body 12. In an embodiment, the pump body retaining feature 56 is configured to matingly engage a cassette retaining feature 58 (shown in Fig. 3) formed on the cassette body 30, thereby securing the cassette 14 to the pump body 12 when assembled therewith.

[0024] Also disclosed herein is a method of regulating the predetermined force applied to the tube 42 by a plurality of rollers 28 in the peristaltic pump assembly 10, thereby compressing the tube 42. The method is accomplished by providing pump assembly 10 including the regulator 46, and regulating the predetermined force applied to the tube 42.

[0025] It is to be understood that the term “connect/connected” or the like is broadly defined herein to encompass a variety of divergent connecting arrangements and assembly techniques. These arrangements and techniques include, but are not limited to (1) the direct connection between one component and another component with no intervening components therebetween; and (2) the connection of one component and another component with one or more components therebetween, provided that the one component being “connected to” the other component is somehow operatively coupled to the other component (notwithstanding the presence of one or more additional components therebetween).

[0026] While several embodiments have been described in detail, it will be apparent to those skilled in the art that the disclosed embodiments may be modified. Therefore, the foregoing description is to be considered exemplary rather than limiting.

<u>What is claimed is</u>:

1. A peristaltic pump assembly, comprising:

a pump body;

a cassette removably attached to the pump body, wherein the cassette includes a race configured to provide a compression surface for a tube supported by the cassette;

a roller assembly operatively connected to the pump body, wherein the roller assembly includes a plurality of rollers configured to apply a predetermined force to the tube, thereby compressing the tube against the race; and

a regulator disposed in the pump body and operatively connected to the cassette, wherein the regulator is configured to regulate the predetermined force applied to the tube.

2. The peristaltic pump assembly as defined in claim 1 wherein the regulator includes:

a slide member; and

a spring operatively connected to the slide member.

3. The peristaltic pump assembly as defined in claim 2 wherein the regulator further includes a pre-loading member operatively connected to the spring, wherein the pre-loading member is configured to apply a predetermined preload to the spring.

4. The peristaltic pump assembly as defined in claim 3 wherein the predetermined preload ranges from about 1.5 lb_f to about 3 lb_f.

5. The peristaltic pump assembly as defined in claim 3 wherein the pre-loading member is selected from shoulder bolts, screws, pegs, pins, shafts, or combinations thereof.

6. The peristaltic pump assembly as defined in claim 2 wherein the slide member is configured to move a predetermined distance in response to changes in the peristaltic pump assembly.

7. The peristaltic pump assembly as defined in claim 2 wherein the regulator further includes a mounting pin operatively connected to the slide member, a pump body retaining feature operatively connected to the slide member, or combinations thereof, wherein the mounting pin, the pump body retaining feature, or combinations thereof are configured to move in combination with the slide member.

8. The peristaltic pump assembly as defined in claim 7 wherein, when the mounting pin, the pump body retaining feature, or combinations thereof moves, the regulator substantially regulates the predetermined force.

9. The peristaltic pump assembly as defined in claim 2 wherein the predetermined force, the other predetermined force, or combinations thereof are substantially constant forces.

10. The peristaltic pump assembly as defined in claim 2 wherein the spring is selected from helical springs, clock springs, torsion springs, compression springs, extension springs, leaf springs, elastomeric bodies, or combinations thereof.

11. The peristaltic pump assembly as defined in claim 2 wherein the spring is selected from a spring having a spring constant ranging from about 3 lb_f/in to about 5 lb_f/in.

12. A regulator for a peristaltic pump, the regulator comprising:

a slide member; and

a spring operatively connected to the slide member;

wherein the regulator regulates a predetermined force applied to a tube by a plurality of rollers of a roller assembly of the peristaltic pump.

13. The regulator as defined in claim 12, further comprising a pre-loading member operatively connected to the spring, wherein the pre-loading member is configured to apply a predetermined preload to the spring.

14. The regulator as defined in claim 12 wherein the slide member is configured to move a predetermined distance in response to changes in the peristaltic pump assembly.

15. The regulator as defined in claim 12, further comprising a mounting pin, a pump body retaining feature, or combinations thereof operatively connected to the slide member, wherein the mounting pin, the pump body retaining feature, or combinations thereof are configured to move in combination with the slide member.

16. The regulator as defined in claim 15 wherein when the mounting pin, the pump body retaining feature, or combinations thereof moves, the regulator substantially regulates the predetermined force.

17. A method of regulating a force applied to a tube by a plurality of rollers of a roller assembly in a peristaltic pump, thereby compressing the tube, the method comprising:

regulating the force applied to the tube using a regulator disposed in a pump body of the peristaltic pump and operatively connected to a cassette, the cassette being removably attached to the pump body, the cassette including a race configured to provide a compression surface for the tube.

18. The method as defined in claim 17 wherein the regulator includes:

a slide member; and

a spring operatively connected to the slide member, whereby the slide member moves a predetermined distance in response to changes in the peristaltic pump assembly.

19. The method as defined in claim 18 wherein the regulator further includes an attachment member configured to move in combination with the slide member, and wherein regulating the force applied to the tube is accomplished by moving the attachment member.

20. The method as defined in claim 19 wherein moving the attachment member is accomplished by:

compressing the spring upon mounting the cassette to the pump body; and

allowing the slide member including the attachment member to move along a substantially linear path.

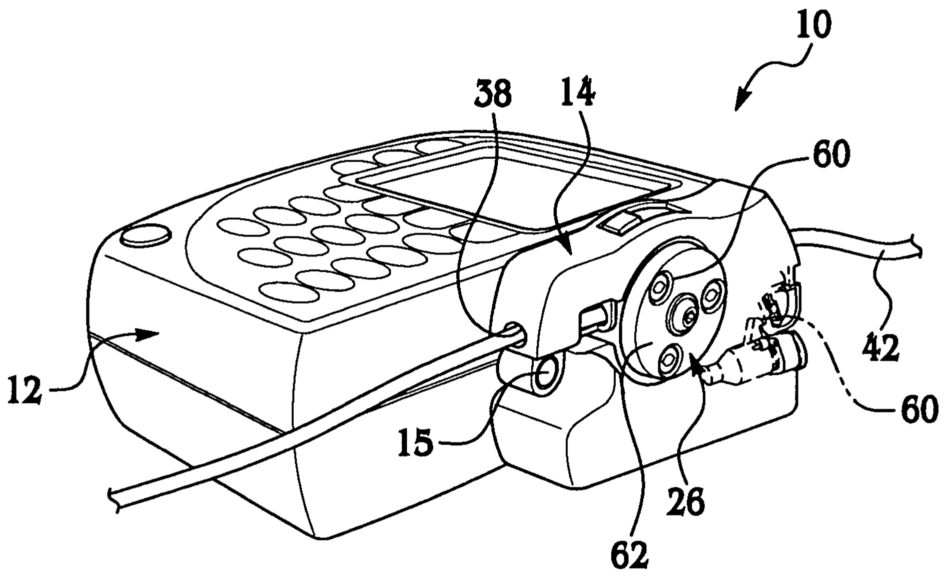

FIG. 1

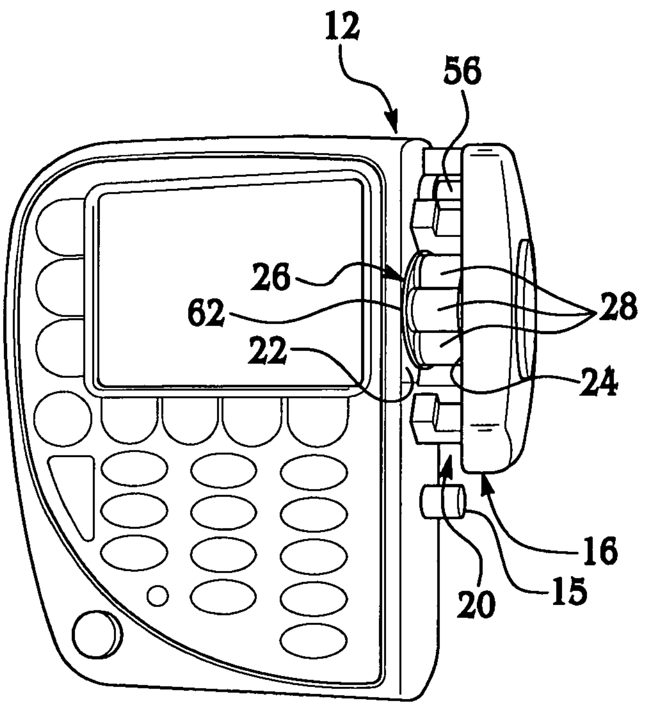

FIG. 2

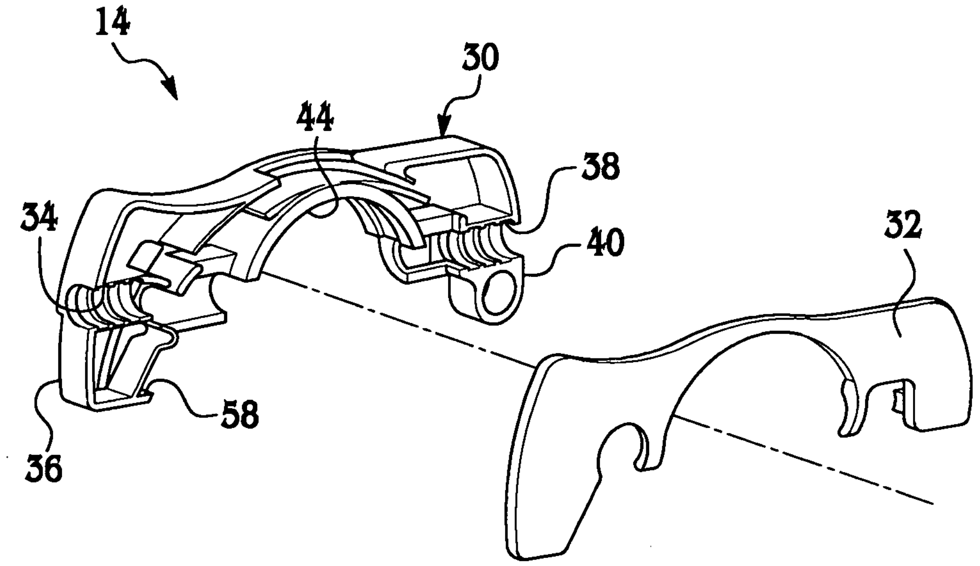

FIG. 3

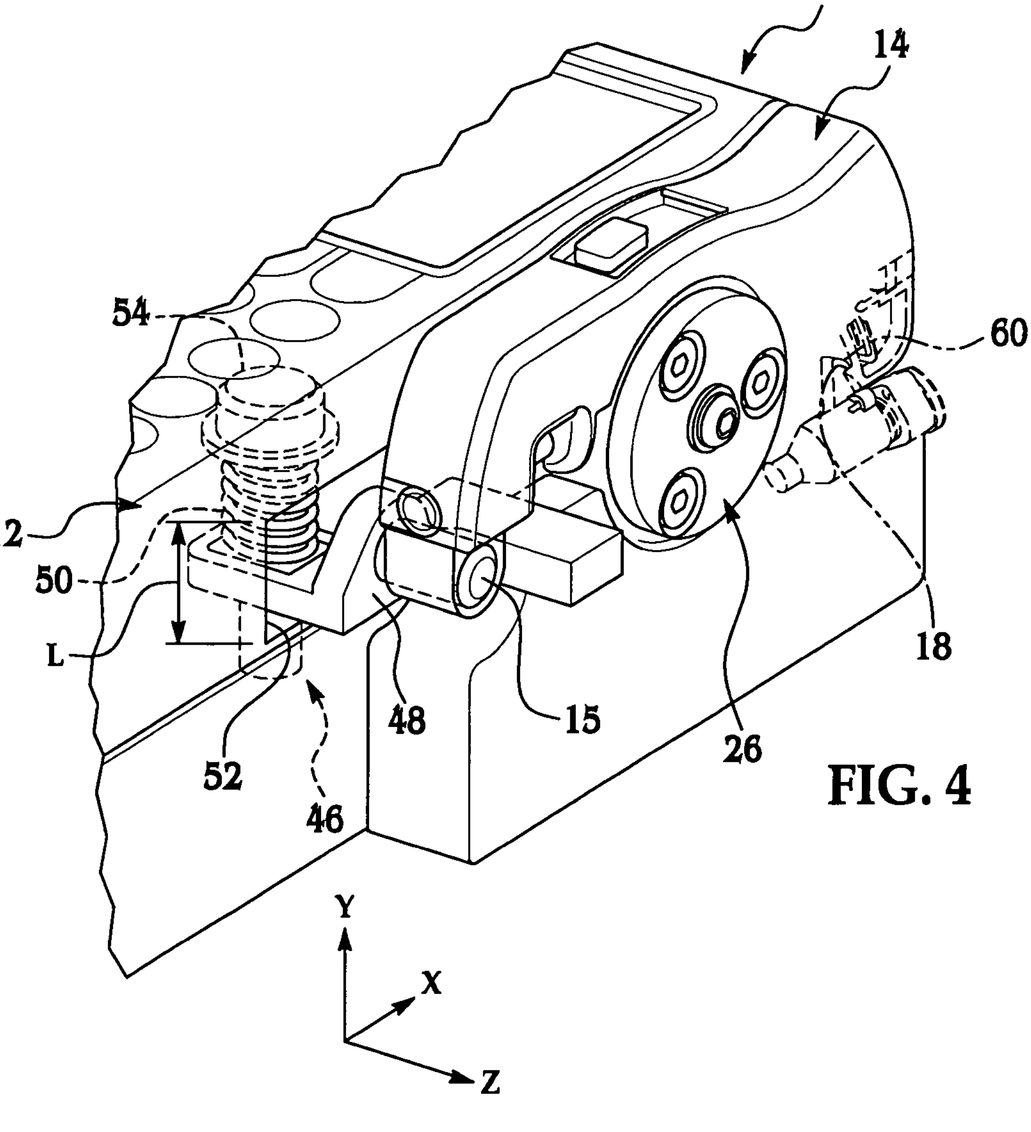

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/11131

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F04B 43/08 (2008.04)
USPC - 417/477.1
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)
417/477.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
417/476-477.7 604/153; term limited search

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (PGPB, USPT, EPAB, JPAB)
Search terms: peristaltic pump cassette regulator compression tube force fluid medical occlude occlusion race roller slide spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0048161 A1 (Moubayed), 1 March 2007 (01.03.2007), Fig 4, occlusion element 92, and guide pin 102, Fig 2, housing 12, cassette 60, para [0010]-[0012], [0014]-[0017], [0040]-[0042], [0048], [0052], [0054], [0057], [0063]-[0064], claims 16, 46 and 47	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 November 2008 (15.11.2008)	01 DEC 2008

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774