(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 718 039 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.06.1996 Bulletin 1996/26

(51) Int. Cl.[6]: **B04B 5/04**

(21) Application number: **96102779.4**

(22) Date of filing: **07.11.1990**

(84) Designated Contracting States:
DE GB

(30) Priority: **07.11.1989 US 432646**
13.07.1990 US 552631

(62) Application number of the earlier application in accordance with Art. 76 EPC: **91900113.1**

(71) Applicant: **E.I. DU PONT DE NEMOURS AND COMPANY**
Wilmington Delaware 19898 (US)

(72) Inventors:
- **Romanauskas, William Andrew**
Southbury, Connecticut 06488 (US)
- **Sheeran, Edward Thomas, Jr.**
Southbury, Connecticut 06488 (US)

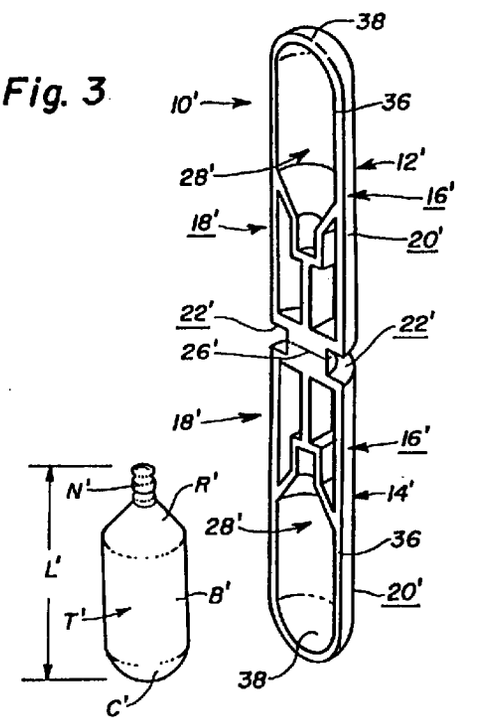
(74) Representative: **Selting, Günther, Dipl.-Ing. et al**
Patentanwälte
von Kreisler, Selting, Werner
Postfach 10 22 41
50462 Köln (DE)

Remarks:
This application was filed on 24 - 02 - 1996 as a divisional application to the application mentioned under INID code 62.

(54) Centrifuge tube adapter

(57) The adapter (10[3]) supports a closed centrifuge tube within a cavity of a vertical angle centrifuge rotor and comprises two adapter segments (12[3],14[3]) forming a recess corresponding to the size and shape of the entire length of the centrifuge tube able to be disposed therein.

Fig. 3



EP 0 718 039 A2

Description

The present invention relates to an adapter for holding a centrifuge tube in a centrifuge rotor cavity, and in particular, to an adapter having two segments.

In the operation of a centrifuge it is important that the size and shape of the tube in which a liquid sample is carried closely conforms to the size and shape of the cavity in the centrifuge rotor in which the tube is received. During centrifugation the centrifugal force exerted on the tube itself and the liquid therein act to deform the centrifuge tube. A centrifuge tube which does not closely conform to the rotor cavity may thus be deformed to the point of rupture. Even if the tube does not rupture the deformation may make the tube difficult to remove from the rotor cavity. Moreover, even if the deformed tube is removable from the rotor, the return of the tube to its undeformed shape may agitate the contents of the tube to an extent that destroys the sample separation.

When the shape and size of a centrifuge tube does not closely conform to the shape and size of the rotor cavity in which it is to be disposed a device known as a tube adapter is usually employed. The tube adapter has an interior cavity having a shape and size which closely conforms to the shape and size of the centrifuge tube being adapted. The exterior shape and size of the adapter closely conforms to the shape and size of the rotor cavity in which it is to be used. The adapter serves to support a tube within the cavity in which it is received and thus serves to prevent deformation of the tube during centrifugation.

United States Patent 3,998,383 and United States Patent 4,015,775 disclose centrifuge rotors of the vertical angle type. In such a rotor the axis of the rotor cavities is substantially parallel to the axis of rotation. When using a vertical angle rotor it is necessary that a cap is provided at the mouth of each cavity to impose a vertical restraining force on the tube disposed in the cavity. Even though the tube may be disposed in an adapter received within the cavity, without such a capping arrangement the possibility exists that the pressure of the liquid during centrifugation may rupture the tube. United States Patent 3,998,383 exemplifies a typical capping arrangement for a vertical angle rotor.

Such capping arrangements must be individually threaded into the rotor body. Moreover, in order to provide proper support it is necessary that the capping arrangement is in intimate contact with the tube. Improper assembly can thus lead to the possibility of tube rupture and/or cap failure. For these reasons such capping arrangements are believed disadvantageous.

Exemplary of an adapter formed of two piece construction is the device shown in United States Patent 3,674,197. This adapter comprises two discrete segments, each of which has an indentation therein. When joined the indentations form a recess for receiving a collapsible bag during centrifugation. The adapter disclosed in this patent includes aperture(s) through which tubes from the bag exit the adapter. Thus, the possibility exists that the bag may extrude through these apertures if the adapter were to undergo centrifugation in a vertical angle rotor.

An adapter arrangement formed of two discrete adapter segments and useful to support the capped end of a centrifuge tube is available as part of the Nalgene Ultra-Lok Tube System sold by Fisher Scientific Incorporated.

United States Patent 4,692,137 discloses a tube adapter for open mouth tubes, the adapter having two segments which are hinged along the lateral edges of the segments. The hinge axes align in parallel relationship to the axis of the cavity in which the adapter is received. The disposition of hinges along the lateral edges of the segments is believed disadvantageous in that such a disposition may interfere with the insertion or removal of the adapter into or from the rotor cavity.

It is an object of the present invention to provide a tube adapter for a vertical angle type centrifuge rotor.

This object is achieved by the features of claim 1.

The present invention relates to an adapter for supporting a closed centrifuge tube having a predetermined size and configuration within a cavity in a vertical angle centrifuge rotor. The rotor is rotatable to a predetermined maximum speed. The adapter has a central axis extending therethrough that, in use, aligns in parallel relationship both with the axis of the rotor cavity in which the adapter is disposed and with the axis of rotation of the vertical angle rotor. The adapter comprises a first and a second adapter segment, each of which has an exterior surface and a mating surface thereon. Each segment has an indentation in the mating surface thereof. The indentations are shaped such that when the segments are joined along their mating surfaces the indentations cooperate to define a recess able to totally surround a centrifuge tube disposed therein. Each adapter segment is fabricated of a material that has sufficient strength to withstand the vertical forces created by the pressure of a liquid under centrifugation. Thus, use of an adapter in accordance with this aspect of the present invention permits a tube to be centrifuged in a vertical angle centrifuge rotor without the necessity of a capping mechanism being placed in the rotor cavity.

The indentation in each segment is shaped such that when the segments are in the mated position the recess so defined is sized to closely correspond to the size and configuration of the centrifuge tube over its entire length.

In another embodiment the mating surface on each adapter segment defines a predetermined angle with respect to a plane that is normal to a plane containing the line of action along which the adapter segments are joined. Inclination of the mating surfaces of the adapter segments allows the same to displace relative to each other to totally fill the rotor cavity in which they are disposed without any separation being defined between the segments. Inclined mating surfaces may be provided on any of the adapter segments disclosed in the present application.

The invention will be more fully understood from the following detailed description thereof, taken in connection with the accompanying drawings, which form a part of this application and in which:

Figure 1 does not belong to the present invention and is an exploded perspective view of an adapter for supporting the neck region of a centrifuge tube of the type in which a portion of the tube neck has a constricted region thereon when capped, the adapter being shown in the open position;

Figure 2 is a fragmentary elevation view, in section, of the tube adapter of Figure 1 in use and supporting the neck portion of a centrifuge tube in a fixed angle rotor cavity;

Figure 3 does not belong to the present invention and is an exploded perspective view of an adapter for supporting the full length of a centrifuge tube within a rotor cavity, the adapter being shown in the open position;

Figure 4 is a fragmentary elevation view, in section, of the tube adapter of Figure 3 in use and supporting a centrifuge tube over its entire axial length in a fixed angle rotor cavity;

Figure 5 is a perspective view similar to Figure 3 of a modification of the embodiment of the tube adapter there shown for use with an open top tube;

Figure 6 is a fragmentary elevation view, in section, of the centrifuge tube adapter of Figure 5 in use and supporting a centrifuge tube over its entire axial length in a fixed angle rotor cavity;

Figure 7A is a perspective view of an adapter in accordance with the present invention used to support a closed tube within the cavity of a vertical angle rotor, the adapter segments being independent of each other, while Figure 7B is a modification of the embodiment of adapter shown in Figure 7A in which the adapter segments are hinged;

Figure 8 is a fragmentary elevational view of an adapter shown in either Figure 7A or 7B in use and supporting a centrifuge tube over its entire axial length in a vertical angle centrifuge rotor cavity, with a portion of the tube being broken away; and

Figures 9A and 9B are sectional views teen along section lines 9A-9A, 9B-9B in Figure 8 showing the inclination of the mating surfaces of the adapter segments, the view of Figure 9A illustrating the relationship of the adapter segments with respect to each other, with respect to the tube received in the adapter, and with respect to the rotor cavity in which the adapter is placed while rotor is at rest while the view of Figure 9B shows the relationship of the adapter segments with respect to each other, with respect to the tube received in the adapter, and with respect to the rotor cavity in which the adapter is placed when the rotor is rotating.

Throughout the following detailed description, similar reference numerals refer to similar elements in all Figures of the drawings.

Figure 1 not belonging to the present invention is an exploded perspective view of an adapter, generally indicated by the reference character 10. The adapter 10 is useful for supporting a centrifuge tube T of the type having a body portion B with a closed end C, the body B tapering through a transition region R to a narrowed neck region N. The neck N serves as the liquid port through which a liquid under test may be loaded into the tube T. When the tube T is capped at least one portion D of the neck N becomes radially inwardly constricted, thereby forming a constricted region in the neck of the tube. Preferably the capping assembly disclosed in United States Patent 4,552,278 (Romanauskas) is used to cap the tube, so that the neck N of the tube has a corrugated configuration imparted thereto. The corrugated configuration has at least one but preferably a plurality of circumferentially extending corrugations formed in the neck N.

The adapter 10 is comprised of a first adapter segment 12 and an identical second adapter segment 14. Each segment 12, 14 has an exterior surface 16 and a planar mating surface 18 thereon. The exterior surface 16 of each segment is defined by a generally cylindrical lateral surface portion 20 and a planar upper surface portion 22. In the preferred instance an enlarged collar 24 is disposed intermediate the lateral surface portion 20 and the upper surface portion 22. When the segments 12, 14 are mated together the mating surfaces 18 thereof are joined in abutting contact. As will become clearer herein the member so produced has an axis 10A (best seen in Figure 2) extending therethrough. As is best seen in Figure 2 the configuration and size of the adjacent lateral surface portions 20 closely corresponds to the configuration and diameter of a rotor cavity 40 in which the adapter 10 is used. The upper surface portions 22 of the conjoined segments are accessible when the adapter 10 is received in the rotor cavity 40.

The segments 12 and 14 are connected and supported for relative pivotal movement with respect to each other by at least one hinge 26. The hinge 26 may take the form of a live hinge bridging the upper surface portions 22 of the segments 12, 14, or may, if desired, take the form of a coined hinge. The term "live hinge" refers to a hinge type, typically made of a polypropylene material, which must be flexed or bent before the plastic is cooled or permanently set. Such hinges are complete without secondary operations. The term "coined hinge" refers to a hinge that is cold-formed, usually by a stamping operation. The stamping operation creates a narrower and a thinner flexing region which defines a hinge.

These forms of hinges are defined in the Handbook of Plastics and Elastomers, McGraw-Hill Book Company 1975, (Charles A. Harper, Editor) at page 12-9.

However formed, the axis 26A of the hinge 26, that is, the axis about which occurs the relative pivotal motion of the segments, extends perpendicular to the axis 10A of the adapter 10. This relationship of the hinge axis 26A to the axis 10A of the adapter 10 is best illustrated in Figure 2.

The mating surface 18 of each of the adapter segments 12, 14 has an indentation 28 therein. The indentation 28 in each segment 12, 14 corresponds to the size and contour of at least a portion of the tube T. Thus, when the segments 12, 14 are mated, the indentations 28 therein cooperate to define a recess 30 (Figure 2) that corresponds to the size and shape of at least a predetermined portion of the tube T that is received therein.

In the embodiment of Figure 1, in which the adapter 10 is configured and sized to support only the neck N and the transition region R of the tube T, at least one but preferably both indentations 28 contains a feature 34, in the form of a circumferentially extending ridge, that corresponds in size and is located complementarily to the position of the constriction D in the neck N of the tube.

The adapter 10 shown in Figures 1 and 2 is especially useful when the diameter of body B of the tube T is equal to the diameter of a cavity 40 in a centrifuge rotor 42, but the overall length L of the tube T is less than the axial length of the cavity. The rotor cavity 40 has an axis 40A therethrough that aligns in parallel relationship with the axis 10A of the adapter 10 when the same is disposed therein. In use, as is best seen in connection with Figure 2, the adapter 10 defined by the mated segments 12, 14 serves to support the neck N and the transition region R of the tube T within the cavity 40.

To mount the tube T in the cavity, the tube T is inserted into one of the segments 12, 14, so that the feature 34 on the segment(s) is received within the constricted region D in the neck N of the tube T when the segments are in the mated position. The segments 12, 14 are then pivoted about the hinge axis 26A to place the mating surfaces 18 thereon in abutting contact. This closes the adapter 10 around the tube T and thus permits the tube T to be manipulated by manipulation of the adapter 10. The tube T and the adapter 10 are then axially inserted into the cavity 40. The preferred instance the tube T bottoms against the closed end of the cavity 40.

The axial length of the adapter 10 is selected such that when the tube T is received in the cavity 40, the upper surface portions 18 on the segments 12, 14 are accessible to a user. The hinge 26 may be formed so as to define a useful lifting appliance, as shown in Figure 2. Thus, to withdraw the tube T at the end of a centrifugation run, a user grasps the hinge 26 and lifts the tube from the cavity 40. It should be appreciated from the foregoing that the feature 34 in such an instance defines a lifting surface which acts against the material of the tube in the constricted region D in the neck N thereof, and thus serves to transmit the lifting force to the tube T to withdraw the same from the cavity. The tube T may is withdrawn without unduly agitating the separation within the tube T.

In some cases the rotor 42 may have a shoulder 44 defined about the mouth of the cavity 40. The shoulder 44 is preferably located on the rotor 42 at a position that is axially beneath the collars 24 on the segments 12, 14 when the adapter is received within the cavity, thereby to guard against the possibility that tube rupture will permit the adapter 10 to enter into the cavity 40.

The segments 12, 14 with the hinge 26 therebetween are preferably integrally formed from a suitable material, such as polypropylene. Of course, the segments 12, 14 may be otherwise fabricated from one or more pieces, using other manufacturing techniques and other materials, and assembled to define the adapter 10. Similar techniques may be used to form any other embodiment of the adapter illustrated and discussed herein.

For those instances wherein the diameter of the tube T is less than the corresponding diameter of the cavity 40 the adapter 10' shown in Figures 3 and 4 finds utility.

The recess 30' (Figure 4) formed by the cooperative association of the indentations 28' in the mated adapter segments 12', 14' is configured to correspond to the size and shape of the tube T' over the entire axial length L' thereof. For this purpose the segments 12', 14' are each provided with an axial extension 36 having a bottom wall 38. The bottom wall 38 need not completely close the bottom of the adapter 12', 14, , as is illustrated, but may only partly close the same. The presence of the extension 36 and the bottom wall 38 permit the recess 30' defined when the segments 12', 14' are joined to receive the entire axial length L' of the tube T'.

Figure 4 illustrates this adapter 10' in use. When the tube T' is received in the recess 30' the closed end C' of the tube T' is contacted by the interior surface of the bottom wall 38. Preferably the indentations 28' in the segments 12', 14' are placed such that the tube T' lies as close to the bottom of the rotor cavity 40, thereby to maximize the centrifugal force imposed on the liquid sample. It should also be noted that the feature 34 present in the embodiment of Figure 1 is not required, since the requisite lifting force transmission surface is defined by the bottom wall 38 operating against the bottom end C' of the tube T'. It is also noted that the collar 24 may be eliminated.

Figure 5 illustrates a modification of the embodiment shown in Figure 3. In this embodiment, the tube T" has the form of a test tube, with no constriction present to define a neck N. In this instance, the segments 12", 14" are modified to exhibit indentations 28" similar to those shown in Figure 3, but which correspond in size and shape to the test tube T" over the entire axial length L" thereof.

The hinge between the segments is disposed on the upper surface portion of the exterior surface of the adapter segments. Such a disposition is believed advan-

tageous in that it locates the hinge at a position where the hinge does not interfere with the receipt of the adapter within the rotor cavity. At the same time the hinge defines a useful lifting appliance.

Although the adapter previously illustrated and discussed may find utility in the environment of a vertical angle rotor, such a utilization may typically require the provision of a suitable capping arrangement to prevent tube failure. The capping arrangement is required in the case that the adapter does not completely surround the tube, such as shown in Figures 1 and 2. However, a capping arrangement is also required if the adapter does completely surround the tube, as shown in Figures 3 through 6, but does not have sufficient strength to withstand the vertical force due to liquid pressure under centrifugation.

As outlined earlier, capping arrangement may be viewed as disadvantageous for various reasons. Accordingly, it is believed desirable to provide an adapter able to support a closed tube T in a vertical angle rotor without the necessity of a capping mechanism. Figures 7A and 7B illustrate such an adapter in accordance with the present invention. Figure 7A illustrates an unhinged embodiment of the vertical angle rotor adapter, while Figure 7B shows a hinged embodiment thereof.

The vertical angle rotor adapter shown in Figures 7A and 7B is generally indicated by the reference character 10^3 and is generally similar to the adapters 10' and 10" discussed in connection with Figures 3 and 5 in the sense that the adapter 10^3 is arranged to totally surround the tube T disposed therewithin. The adapter 10^3 comprises a first adapter segment 12^3 and a second adapter segment 14^3. Each segment 12^3, 14^3 has an exterior surface 16^3 thereon. The exterior surface 16^3 of each segment 12^3, 14^3 is defined by a generally cylindrical lateral surface portion 20^3 and a planar upper surface portion 22^3.

In accordance with the embodiment of the invention shown in Figures 7A and 7B the adapter segment 12^3 has a planar mating surface 18^3 thereon while the adapter segment 14^3 has a planar mating surface 19^3 thereon. For a reason which is explained more fully herein the mating surfaces 18^3 and 19^3 on the segments 12^3 and 14^3, respectively, are angled with respect to a predetermined reference plane, to be defined. The inclination of the mating surfaces 18^3 and 19^3 on the segments 12^3 and 14^3, respectively, is believed best seen in Figures 9A and 9B.

The mating surfaces 18^3 and 19^3 of each of the adapter segments 12^3 and 14^3, respectively, each have an indentation 28^3 therein. The indentation 28^3 in each segment 12^3 and 14^3 corresponds to the size and contour of the entire axial length L of the tube T. Thus, when the segments 12^3 and 14^3 are mated the indentations 28^3 therein cooperate to define a recess 30^3 (Figure 8) that corresponds to the size and shape of the entire axial length of the tube T (Figures 1 and 8) that is received therein. That is to say, the indentations 28^3 in each segment are shaped such that when the segments 12^3 and 14^3 are joined along their respective mating surfaces 18^3 and 19^3 the indentations 28^3 in each segment cooperate to define a recess 30^3 able to totally surround a centrifuge tube T disposed therein.

Figure 8 illustrates the adapter 10^3 in accordance with the present invention in use in the environment of a vertical angle centrifuge rotor 42^V. In such a rotor the axis of each cavity 40^V is parallel or approaching parallel (with an inclination angle of not more than fifteen (15) degrees) to the axis of rotation A of the rotor. As seen from Figure 8 the adapter 10^3 has a central axis 10^3A that in use, aligns with the axis of the cavity 40^V in which it is disposed and with the axis of rotation A of the vertical angle rotor 42^V.

In the embodiment of the invention shown in Figure 7A, the segments 12^3, 14^3 are independent of each other. These segments 12^3, 14^3 may be joined by moving each segment toward the other along a line of action 48 thereby to bring the mating surfaces 12^3, 14^3 thereof in abutting contact. As used herein the term "line of action" is meant to denote that direction of motion which joins the segments 12^3, 14^3 such that, in a given predetermined plane perpendicular to the central axis 10^3A simultaneous contact of both sides of the segments 12^3, 14^3 occurs.

In Figure 7B the segments 12^3, 14^3 are connected and supported for relative pivotal movement with respect to each other by at least one hinge 26^3. The pivotal axis 26^3A (Figure 8) of the hinge 26^3, that is, the axis about which occurs the relative pivotal motion of the segments 12^3, 14^3, extends perpendicular to the axis 10^3A of the adapter 10^3. As discussed earlier the hinge 26^3 may take the form of a live hinge bridging the upper surface portions 22^3 of the segments 12^3, 14^3, or may, if desired, take the form of a coined hinge. Accordingly the segments 12^3, 14^3, as shown in the embodiment of Figure 7B may also be joined by moving each segment toward the other along the line of action 48. In the embodiment of Figure 7B it is noted that the line of action 48 also lies in the plane perpendicular to the pivotal axis 26^3A of the hinge 26^3.

With reference to the sectional views of Figures 9A and 9B, the inclination of the surfaces 18^3, 19^3 may be most clearly seen. (Sectioning of the adapter has been ommitted from Figures 9A and 9B for clarity of illustration). When the segments 12^3, 14^3 are joined, the tube T is totally surrounded by the adapter 10^3. By inclining the mating surfaces 18^3, 19^3 the segments 12^3, 14^3 may expand during centrifugation to fill the entirety of the rotor cavity 40^V. Thus, any variations in the size of the various cavities 40^V in a given rotor, variations in cavity size from rotor to rotor, and variations in the thickness of the segments from adapter to adapter may be accommodated without breaking the total containment of the tube T by the adapter.

It is also clear from Figure 9A that when the segments 12^3, 14^3 are mated the interior surface of the interior recess 30^3 of the adapter 10^3 is interrupted by the inwardly projecting comers 50 on the mating surface 19^3

of the segment 14^3, The comers 50 lie inwardly of the corresponding corners 52 defined on the mating surface 12^3. The radial distance R_1 measured between the central axis 10^3A and the interior surface of the adapter segment 14^3 in the region of the indentation 28^3 therein is less than the radial distance R_2 measured between the central axis 10^3A and the interior surface of the adapter segment 12^3 in the region of the indentation 28^3 therein. For reference purposes it is convenient at this point to define the radial distance R_3 as the distance between the central axis 10^3 and the exterior surface of the adapter segment 14^3 in the region of the indentation 28^3 therein and the radial distance R_2 as the distance between the central axis 10^3 and the exterior surface of the adapter segment 12^3 in the region of the indentation 28^3 therein. The thickness of the segment 12^3 is equal to the difference between the distances R_4 and R_2, while thickness of the segment 14^3 is equal to the difference between the distances R_3 and R_1.

To accommodate the instance where the rotor cavity 40^V is at its largest possible tolerance and the thickness of the segments of the adapter are at their smallest possible tolerance, the arc length of the inner surface of the segment 14^3 (i.e., the distance between the points 50-50) in a plane perpendicular to the adapter axis 10^3A (the plane of Figure 9A) plus the arc length of the inner surface of the segment 12^3 (i.e., the distance between the points 52-52) in the same plane must equal the circumference of the inside of the adapter in a plane perpendicular to the adapter axis 10^3A in the case when the adapter of the smallest segment thickness is conformed to the largest rotor cavity, as illustrated in Figure 9B.

The magnitude of angles of inclination of the surfaces may be measured by reference to a reference plane 54. The reference plane 54 is that plane that contains both the vertical central axis 10^3 of the adapter 10^3 and at least one of the inwardly projecting corners 50 of the adapter segment 14^3. Alternatively, the reference plane 54 may be defined as the plane that is normal to the line of action 48 (superimposed on Figure 9A) along which the segments 12^3, 14^3 are joined together. Measured with respect to the reference plane 54 the inclination of the surfaces 18^3 and 19^3 lies in the range of angles from about 10 to about 80 degrees. Preferably, each angle is forty five (45) degrees.

It should be noted that although the surfaces 18^3 and 19^3 are shown as being inclined to the same degree (i.e., the angles of the surfaces 18^3 and 19^3 with respect to the reference plane 54 are equal), such is not necessarily required. It is only necessary that the inclination of the surfaces 18^3 and 19^3 be such that the segments are maintained in mutual contact if they expand during centrifugation to fill the cavity 40^V. It should also be noted that the segments 12^3 and 14^3 may be other than circular, and can be ellipsoidal, if desired.

An adapter in accordance with this embodiment of the present invention may be fabricated from any suitable material so long as the resulting adapter has sufficient strength (as that term is defined herein). The material of choice must exhibit other desirable properties, such as appropriate ultimate strength, appropriate modulus of elasticity, suitable chemical compatibility with any liquid sample being centrifuged and ability to withstand autoclaving. Suitable plastic materials include polypropylene, polyamide, acetal, polyphenylene oxide, polyvinyl choloride, polycarbonate or polyethylene. Other plastic or metallic materials (either homogeneous (neat) or fiber reinforced) with similar or better mechanical and chemical properties for the application under consideration may also be used. The adapter may be formed in any convenient manner consistent with the material selected, such as molding, machining, casting or forging.

In order to support a tube T in a vertical angle rotor without the assistance of the restraining force provided by a capping mechanism, the adapter 10^3 must exhibit sufficient strength to absorb the forces imposed on the tube T by the pressure of the liquid therein. Thus, as the term is used herein,"sufficient strength" means that the adapter must be able to withstand the forces imposed on it during centrifugation without failing or deforming to the extent that the tube carried therein ruptures.

Whether a given adapter sufficient strength, and thus falls within the scope of the claims of the present invention, can be determined from various readily ascertainable operating parameters of the vertical angle rotor in which the adapter is to be used and the application to which the adapter is to be put. These parameters are the specific weight of the liquid sample within the tube received by adapter, the radius R_i which represents the minimum distance to the sample from the axis A of rotation (Figure 8), the diameter D_o (Figure 8) of the rotor cavity, the thickness of the adapter segment, the inside diameter of the tube, and the speed of rotation of the vertical angle rotor.

The pressure at any location across the diameter of the tube in which the liquid sample is disposed is

$$P = \frac{\omega^2}{2g}\,\alpha(R_o^{\,2}-R_i^{\,2}) \qquad (1)$$

where

P is the pressure in Newton per m^2 (psi),

ω is the rotational velocity of the rotor (radians per second),

g is acceleration due to gravity in meter per second^2 (inches per second^2),

α is the specific weight of the sample in Newton per meter^3 (Lbf per inch^3),

R_o is the distance to the point of interest x where the pressure value is desired from the center of rotation in meters (inches), and

R_i is the minimum distance to the sample from the axis A of rotation in meters (inches).

The total vertical force F that the adapter must withstand is then found by integrating this pressure function over the circular cross sectional area of the inside of the tube.

Knowing the adapter dimensions and the force F, the average stress in the wall of the adapter can be determined in accordance with the relationship:

$$s = \frac{F}{(\pi/4)(D_o^2 - D_i^2)} \quad (2)$$

where

s is the stress in Newton per meter^2 (psi),

F is the force in Newton (Lbf)

D_o is the diameter of the rotor cavity, and

D_i is the inside diameter of the adapter when operating at speed, which equals the diameter of the rotor cavity minus the thickness of each of the segments of the adapter (Figure 9B).

Based on the identity of the material used in the given adapter, the modulus of elasticity of that material may be readily obtained. An estimation of the vertical deformation of the adapter may be found by multiplying the initial length of the adapter by the average stress divided by the modulus of modulus of elasticity of the adapter material. If the average stress calculated in Equation (2) is less than the ultimate strength of the adapter material, and the predicted deformation is less that the deformation that will cause first leakage in the tube carried within the adapter, then the given adapter is to be construed to have sufficient strength for at least one operating cycle, and therefore fall within the contemplation of the present invention. The determination of sufficient strength as set forth above under operating conditions will verify both the analysis and the conclusion of the sufficiency of strength of the adapter.

It should be understood that it is within the contemplation of this invention to use an adapter in accordance herewith to support a tube or a predetermined portion thereof within a cavity provided in another adapter, thereby making the use of the adapter in accordance with this invention amenable for use in the environment of a swinging bucket rotor.

Claims

1. An adapter (10^3) for supporting a closed centrifuge tube (T) within a cavity (40^V) of a vertical angle centrifuge rotor (42^V), the tube (T) having a body portion (B) that tapers through a transition region (R) to a narrowed neck region (N), the adapter (10^3) having an axis (10^3A) extending therethrough,
characterized by
the adapter (10^3) comprising a first and a second adapter segment (12^3, 14^3), each segment having an exterior surface (16^3) and a mating surface (18^3, 19^3) thereon,
the mating surfaces (18^3,19^3) of the adapter (10^3) extending generally axially along each adapter segment (12^3,14^3),
each segment (12^3,14^3) having an indentation in the mating surface (18^3,19^3) thereof,
the indentation in each segment (12^3,14^3) being shaped such that, when the segments (12^3,14^3) are joined along their mating surfaces (18^3,19^3), the indentations cooperate to define a recess,
the recess corresponding to the size and shape of the entire length of the centrifuge tube (T) able to be disposed therein,
the body portion (B), the transition region (R) and the neck region (N) being totally surrounded by the adapter segments (12^3,14^3),
the mating surfaces (18^3,19^3) being in contacting relationship with each other over at least the neck and transition regions (N,R) of the tube (T), and
the adapter (10^3) being fabricated of a material that has sufficient strength to withstand the vertical forces created by the pressure of a liquid carried in the tube (T) under centrifugation that act against the neck and transition regions (N,R) of the tube (T).

2. The adapter (10^3) of claim 1, wherein the mating surface (18^3) on the first adapter segment (12^3) defines a first predetermined angle with respect to a predetermined reference plane (54) while the mating surface (19^3) on the second adapter segment (14^3) defines a predetermined angle with respect to the predetermined reference plane (54), the reference plane (54) being defined as the plane that contains the axis (10^3A) of the adapter (10^3) and that lies normal to the line of action (48) along which the segments (12^3,14^3) of the adapter (10^3) are mated.

3. The adapter (10^3) of claim 2, wherein the first predetermined angle and/or the second predetermined angle are within the range from about ten to about eighty degrees.

4. The adapter (10^3) of one of claims 1-3, further comprising at least one hinge (26^3) connecting the segments (12^3,14^3) and supporting the relative pivotal movement, about a hinge axis (26^3A), of at least one segment (12^3,14^3) with respect to the other from an open to a mated position, the hinge axis (26^3A) extending perpendicular to the axis (10^3A) of the adapter (10^3).

Fig. 2

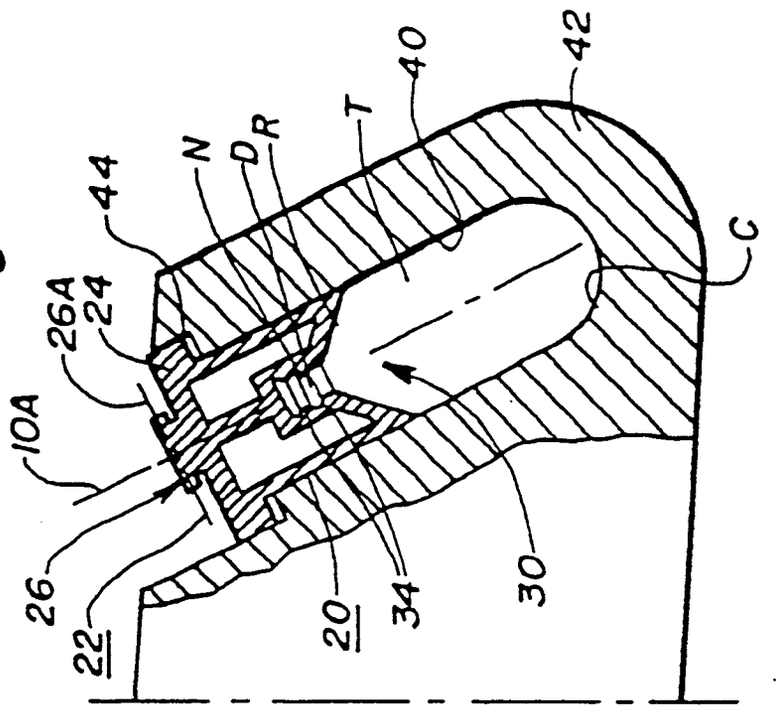

42
40
T
R
D
N
44
24
26A
10A
26
22
20
34
30
C

Fig. 1

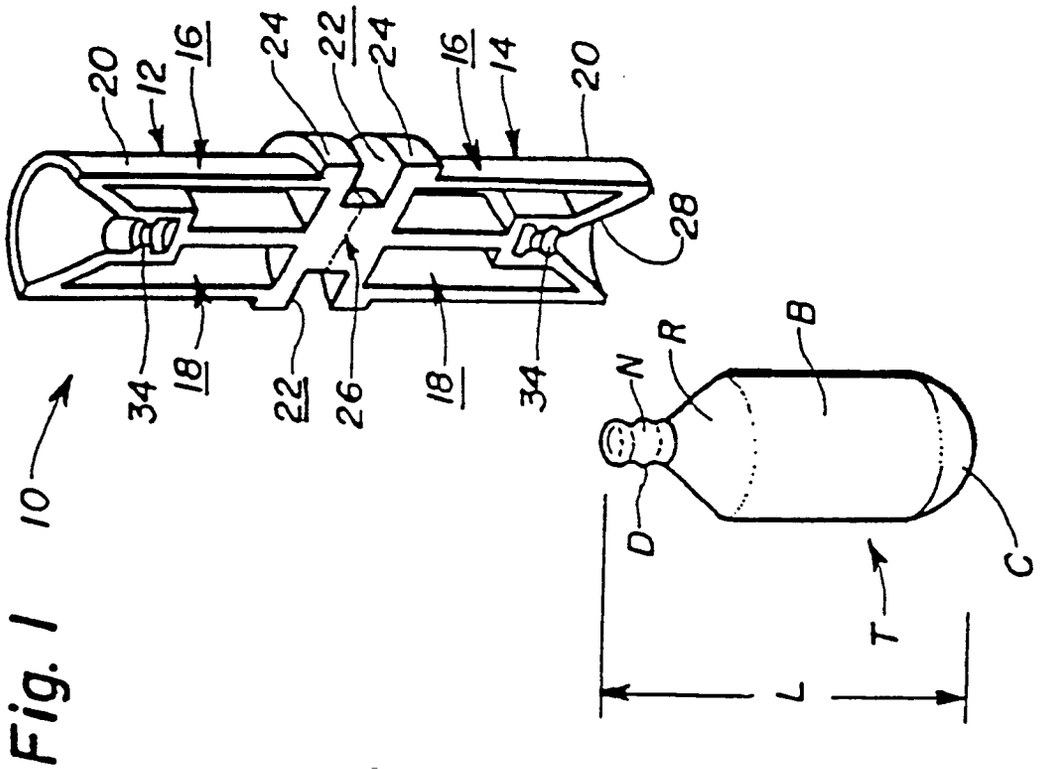

10
20
12
16
24
22
24
16
14
20
28
34
18
22
26
18
34
N
R
B
D
C
T
L

Fig. 4

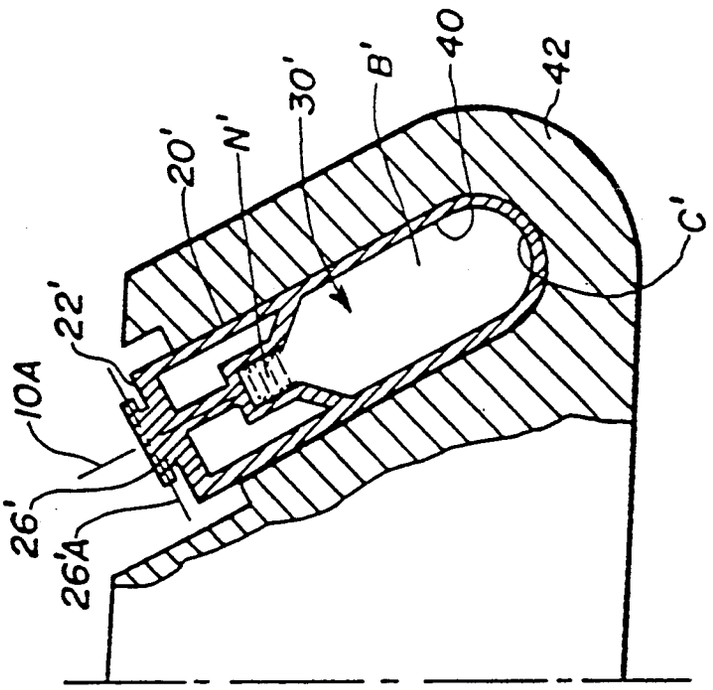

20'
N'
30'
B'
40
42
C'
22'
10A
26'
26'A

Fig. 3

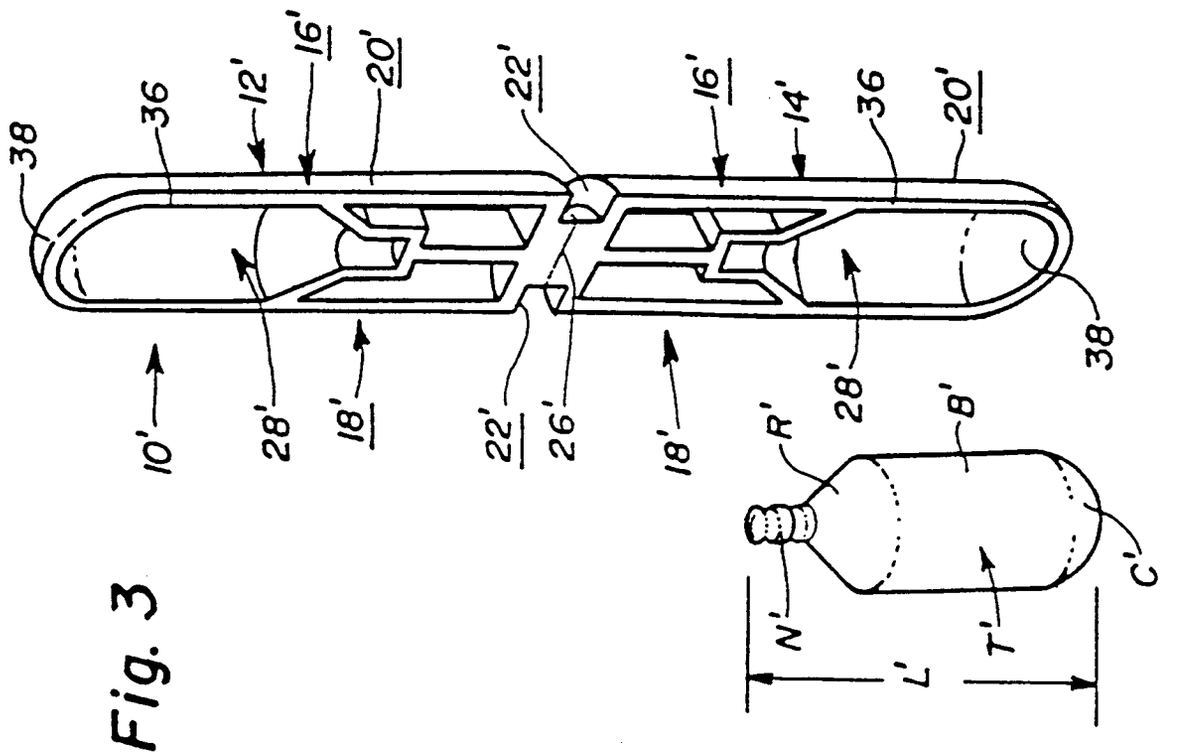

38
36
12'
16'
20'
22'
16'
14'
36
20'
10'
28'
18'
22'
26'
18'
28'
38
R'
8'
N'
T'
C'
L'

Fig. 6

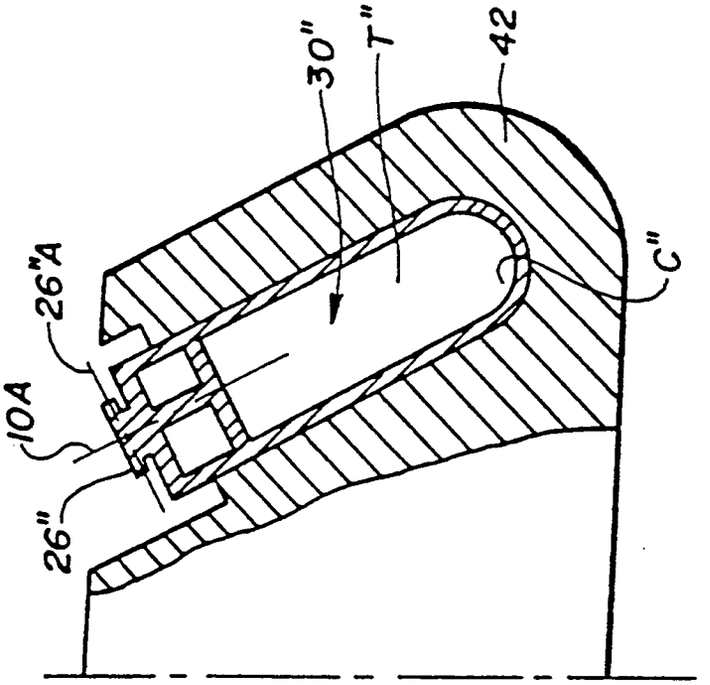
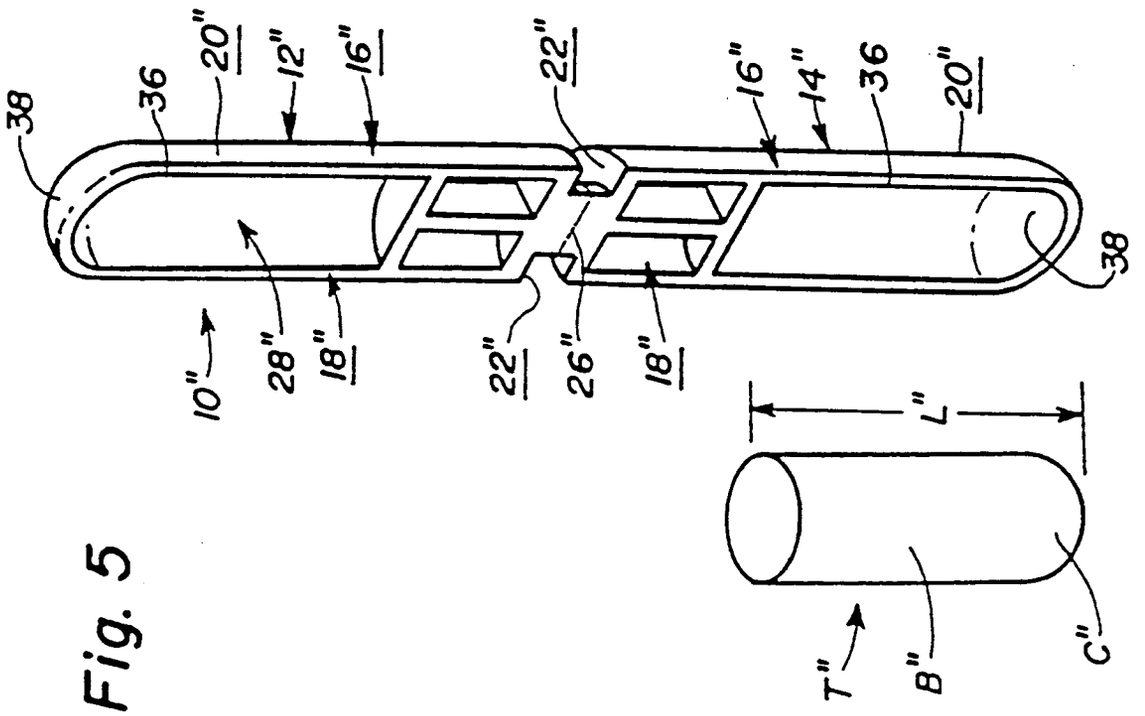

30"
T"
42
C"
26"A
10A
26"

Fig. 5


38
36
20"
12"
16"
22"
16"
14"
36
20"
38
10"
28"
18"
22"
26"
18"
L"
T"
B"
C"

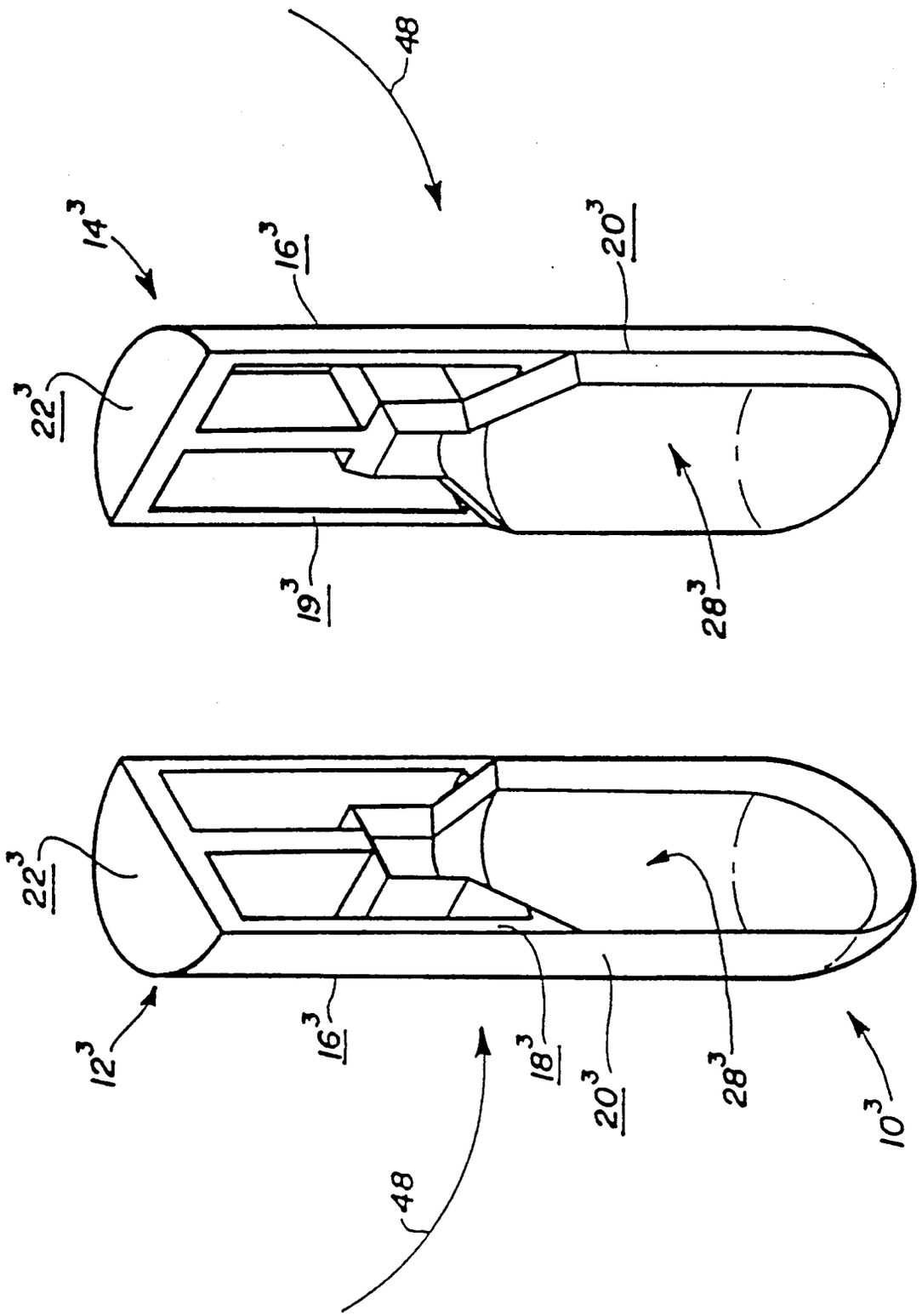


Fig. 7A

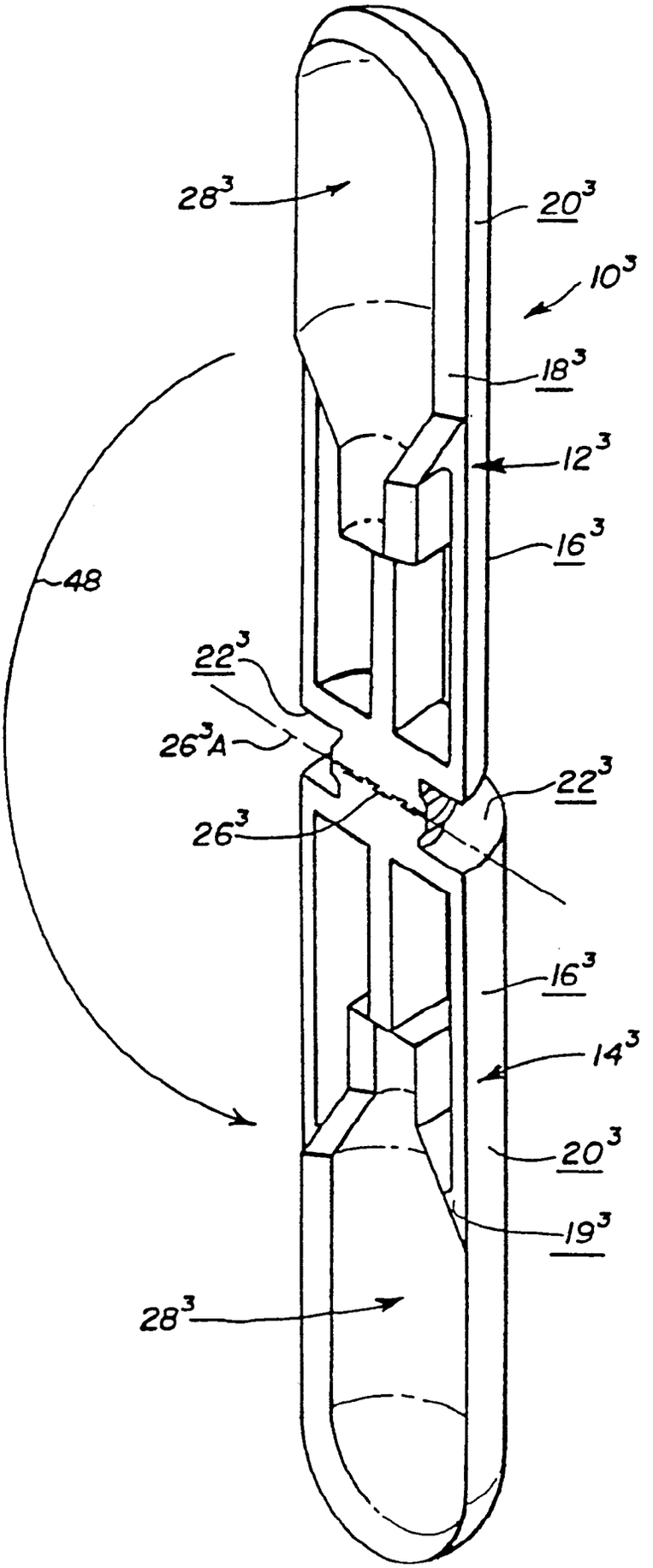
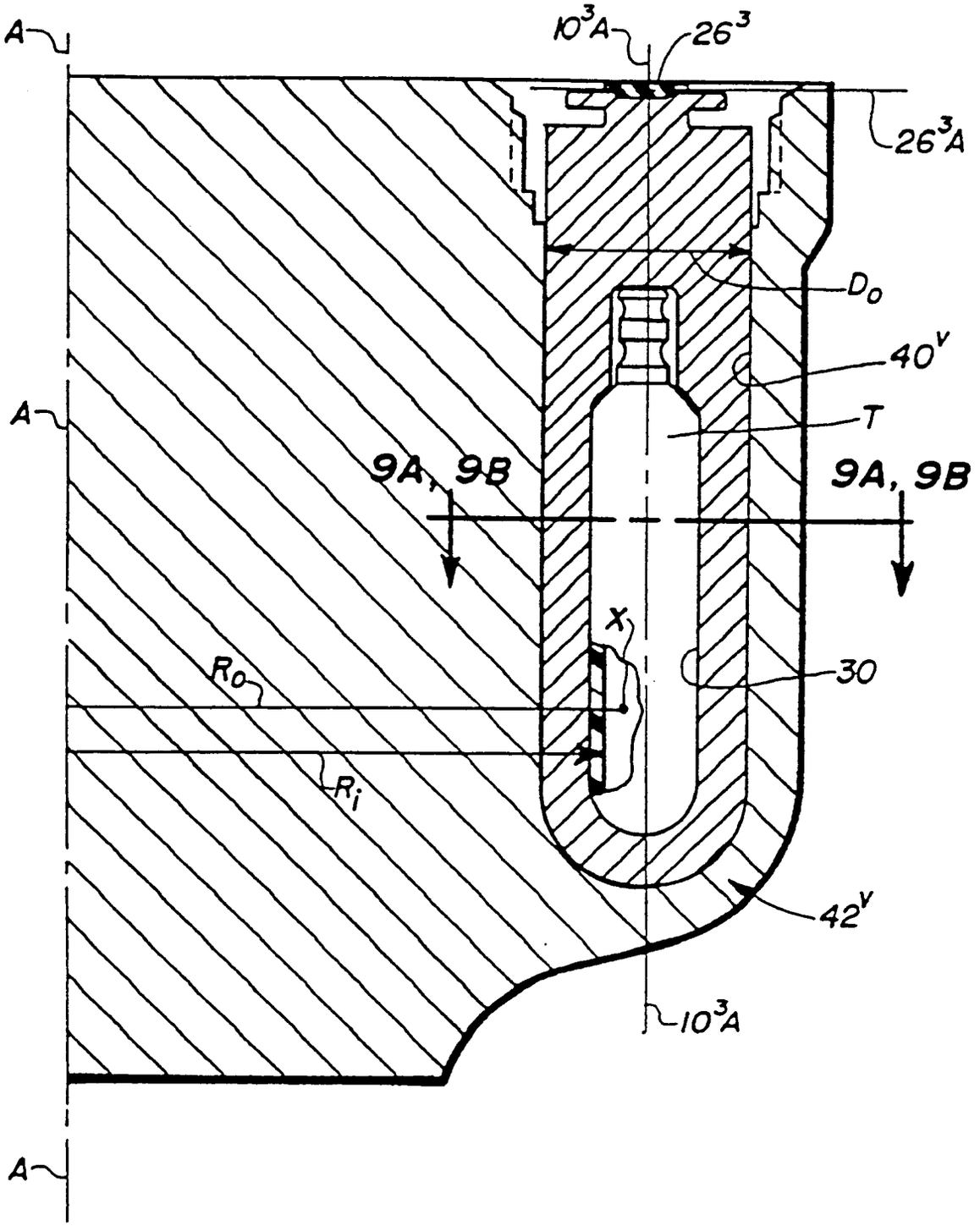


Fig. 7B

Fig. 8



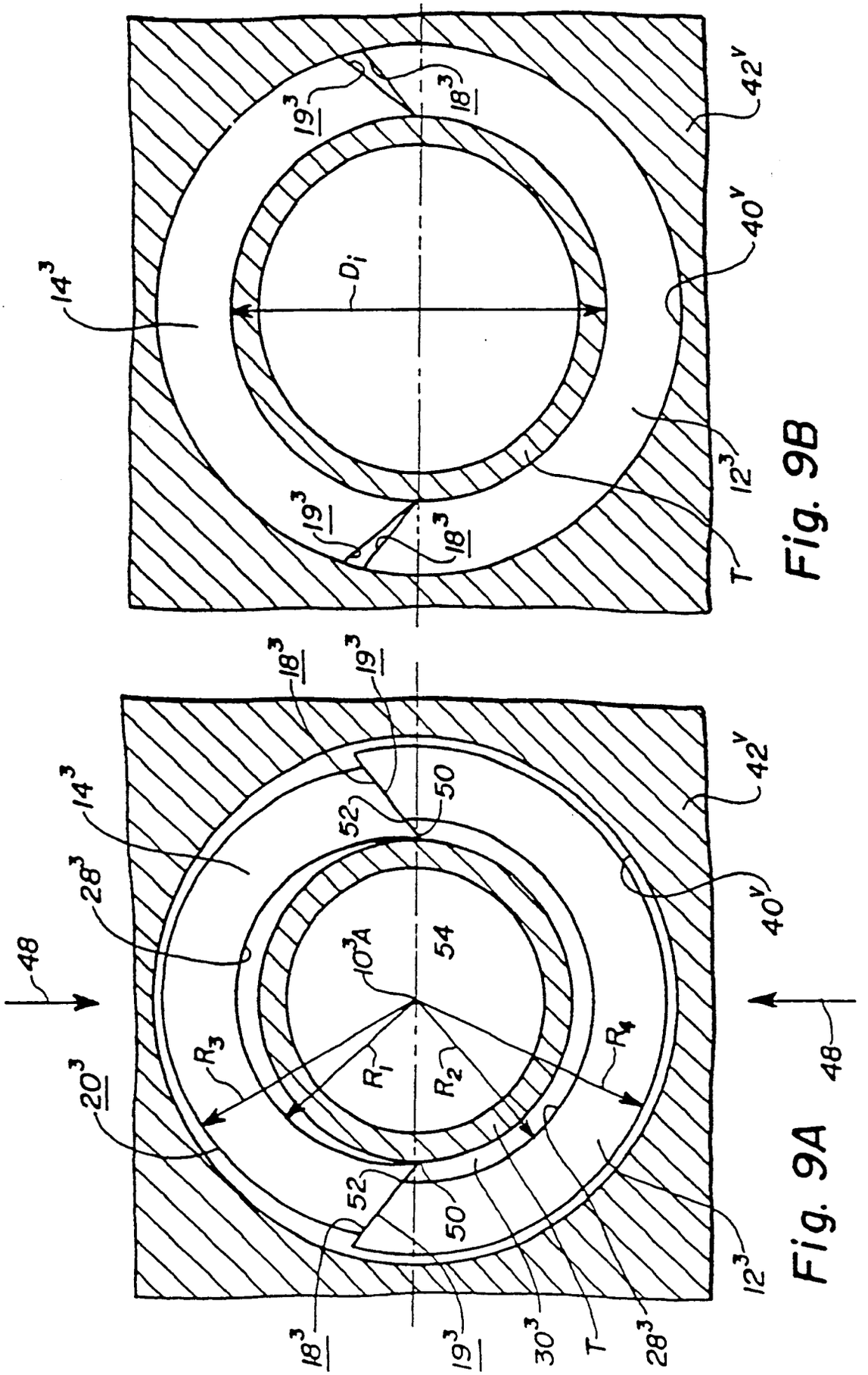

14³
Di
19³
18³
42ᵛ
40ᵛ
12³
T
48
28³
20³
R3
R1
R2
R4
10³A
54
52
50
30³

Fig. 9B

Fig. 9A