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(54) HINGED CENTRIFUGE TUBE ADAPTER

SCHWENKBARES PASSTEIL FÜR ZENTRIFUGENRÖHREN

ADAPTATEUR DE TUBE CENTRIFUGE ARTICLE

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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 acts 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.

Exemplary of an adapter formed of a single unitary member is the device disclosed in United States Patent 4,304,356 (Chulay et al.). This adapter supports only the neck region of the centrifuge tube and is fabricated of a material having a lower density than the liquid being carried therein to prevent bottoming of the adapter in the rotor cavity in the event of tube rupture.

Exemplary of an adapter formed of two piece construction is the device shown in United States Patent 3,674,197 (Mitchell et al.), assigned to the assignee of this invention. 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 is available as part of the Nalgene Ultra-Lok Tube System sold by Fisher Scientific Incorporated. The adapter segments support the neck region of the centrifuge tube. It is composed of two discrete adapter segments which support the capped neck region of the centrifuge tube.

United States Patent 4,692,137 (Anthony) discloses a tube adapter for open mouth tubes. The top of

the tube adapter is open and the body of the adapter is composed of 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.

United States Patent 3,998,383 (Romanauskas et al.) and United States Patent 4,015,775 (Rohde), both assigned to the assignee of the present invention, 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 be 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 (Romanauskas et al.) 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 be 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.

In view of the foregoing it is believed advantageous to provide an adapter for use in a vertical angle rotor that eliminates the necessity of a capping mechanism for the rotor cavity.

It is the object of the present invention to improve the handling of an adapter for centrifuge tubes. The adapter of the present invention is defined by claim 1.

The present invention relates to an adapter having an axis therethrough for supporting a centrifuge tube within a cavity in a centrifuge rotor. The cavity itself has an axis therethrough, with the axis of the adapter, in use, aligning in parallel relationship with the axis of the cavity. The adapter comprises a first and a second adapter segment, each segment having an exterior surface and a mating surface thereon. Each segment has an indentation in the mating surface thereof. The segments may be connected by at least one hinge that supports the segments for relative pivotal movement about a hinge axis from an open to a mated position. The hinge axis extends perpendicular to the axis of the adapter.

When in the mated position the mating surfaces of the segments are in contacting relationship and the indentations therein cooperate to define a recess having a predetermined shape. In one embodiment of the adapter of the present invention, used with a centrifuge tube having a body with a neck thereon in which a por-

tion of the neck has a constricted region when the tube is capped, the indentation in each segment is shaped such that when the segments are in the mated position the recess is sized to closely correspond to the configuration of at least the neck of the tube. In this embodiment at least one of the segments has a feature on the mating surface thereof that projects into the indentation therein. When the segments are in the mated position and the neck of the tube is received within the adapter the feature is received within the constricted region of the neck of the tube. A collar may be provided to prevent the bottoming of the tube in the cavity.

In another embodiment of the adapter of the present invention 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 is an exploded perspective view of an adapter according to a first embodiment of the present invention 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 an exploded perspective view of an adapter according to a second embodiment of the present invention 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 7 is a modification of the embodiment of adapter shown in Figure 3.

Figure 8 is a fragmentary elevational view of the adapter shown in Figure 7 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 taken 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 is an exploded perspective view of an adapter, generally indicated by the reference character 10, according to a first embodiment of the present invention. The adapter 10 in accordance with this embodiment 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. It should be understood that any other capping arrangement may be used, so long as any form of constricted region is imparted to the configuration of 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, in accordance with the present invention 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 be 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. In this embodiment of the invention 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 embodiment of the invention 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 in this embodiment of the invention 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 in this embodiment of the invention the collar 24 may be eliminated.

Figure 5 illustrates a modification of the embodiment of the invention 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.

In whatever one of the embodiments used, 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 advantageous 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. Figure 7 illustrates such an adapter in accordance with another embodiment of the present invention.

The vertical angle rotor adapter shown in Figure 7 is generally indicated by the reference character 10³ and is generally similar to the adapters 10' and 10'' discussed in connection with Figures 3 and 5 in the sense that the adapter 10³ is arranged to totally surround the tube T disposed therewithin. The adapter 10³ comprises a first adapter segment 12³ and a second adapter segment 14³. Each segment 12³, 14³ has an exterior surface 16³ thereon. The exterior surface 16³ of each segment 12³, 14³ is defined by a generally cylindrical lateral surface portion 20³ and a planar upper surface portion 22³.

In accordance with the embodiment of the invention shown in Figure 7 the adapter segment 12³ has a planar mating surface 18³ thereon while the adapter segment 14³ has a planar mating surface 19³ thereon. For a reason which is explained more fully herein the mating surfaces 18³ and 19³ on the segments 12³ and 14³, respectively, are angled with respect to a predetermined reference plane, to be defined. The inclination of the mating surfaces 18³ and 19³ on the segments 12³ and 14³, respectively, is believed best seen in Figures 9A and 9B. It should be understood that the mating surfaces of the adapter segments in any of the embodiments shown in Figures 1 through 6 may also be inclined in the manner shown in Figures 9A and 9B.

The mating surfaces 18³ and 19³ of each of the adapter segments 12³ and 14³, respectively, each have an indentation 28³ therein. The indentation 28³ in each segment 12³ and 14³ corresponds to the size and contour of the entire axial length L of the tube T. Thus, when the segments 12³ and 14³ are mated the indentations 28³ therein cooperate to define a recess 30³ (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 28³ in each segment are shaped such that when the segments 12³ and 14³ are joined along their respective mating surfaces 18³ and 19³ the indentations 28³ in each segment cooperate to define a recess 30³ able to totally surround a centrifuge tube T disposed therein.

Figure 8 illustrates the adapter 10³ in accordance with this aspect of 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 10³ has a central axis 10³A 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 Figure 7 the segments 12³, 14³ are connected and supported for relative pivotal movement with respect to each other by at least one hinge 26³. The pivotal axis 26³A (Figure 8) of the hinge 26³, that is, the axis about which occurs the relative pivotal motion of the segments 12³, 14³, extends perpendicular to the axis 10³A of the adapter 10³. As discussed earlier the hinge 26³ may take the form of a live hinge bridging the

upper surface portions 22³ of the segments 12³, 14³, or may, if desired, take the form of a coined hinge. Accordingly the segments 12³, 14³, 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 26³A of the hinge 26³.

With reference to the sectional views of Figures 9A and 9B, the inclination of the surfaces 18³, 19³ may be most clearly seen. (Sectioning of the adapter has been omitted from Figures 9A and 9B for clarity of illustration). When the segments 12³, 14³ are joined, the tube T is totally surrounded by the adapter 10³. By inclining the mating surfaces 18³, 19³ the segments 12³, 14³ 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 12³, 14³ are mated the interior surface of the interior recess 30³ of the adapter 10³ is interrupted by the inwardly projecting corners 50 on the mating surface 19³ of the segment 14³. The corners 50 lie inwardly of the corresponding corners 52 defined on the mating surface 12³. The radial distance R₁ measured between the central axis 10³A and the interior surface of the adapter segment 14³ in the region of the indentation 28³ therein is less than the radial distance R₂ measured between the central axis 10³A and the interior surface of the adapter segment 12³ in the region of the indentation 28³ therein. For reference purposes it is convenient at this point to define the radial distance R₃ as the distance between the central axis 10³ and the exterior surface of the adapter segment 14³ in the region of the indentation 28³ therein and the radial distance R₂ as the distance between the central axis 10³ and the exterior surface of the adapter segment 12³ in the region of the indentation 28³ therein. The thickness of the segment 12³ is equal to the difference between the distances R₄ and R₂, while thickness of the segment 14³ is equal to the difference between the distances R₃ and R₁.

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 14³ (i.e., the distance between the points 50-50) in a plane perpendicular to the adapter axis 10³A (the plane of Figure 9A) plus the arc length of the inner surface of the segment 12³ (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 10³A 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 10³ of the adapter 10³ and at least one of the inwardly projecting corners 50 of the adapter segment 14³. 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 12³, 14³ are joined together. Measured with respect to the reference plane 54 the inclination of the surfaces 18³ and 19³ 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 18³ and 19³ are shown as being inclined to the same degree (i.e., the angles of the surfaces 18³ and 19³ with respect to the reference plane 54 are equal), such is not necessarily required. It is only necessary that the inclination of the surfaces 18³ and 19³ 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 12³ and 14³ 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 chloride, 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 10³ 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

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

where

P is the pressure in Newton per meter² (psi),

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

g is acceleration due to gravity in meter per second² (inches per second²),

α is the specific weight of the sample in Newton per meter³ (Lbf per inch³),

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 meter² (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 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 than 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) for supporting a centrifuge tube (T) within a cavity (40) in a centrifuge rotor (42), the adapter (10) having an axis (10A) extending there-through that, in use, aligns in parallel relationship with an axis of the rotor cavity (40) in which the adapter (10) is disposed, the adapter comprising a first and a second adapter segment (12,14), each segment (12,14) having an exterior surface (16) and a mating surface (18) thereon, each segment having an indentation (28) in the mating surface (18), wherein in the mated position, the mating surfaces (18) of the segments (12,14) being disposed in contacting relationship and the indentations (28) therein cooperating to define a recess (30) having a size and shape that corresponds to the size and shape of at least a portion of the tube (T),

characterized by

at least one hinge (26) connecting the segments (12,14) and supporting the relative pivotal movement about a hinge axis (26A) of one segment (12;14) with respect to the other from the open to the mated position, the hinge axis (26A) extending perpendicular to the axis (10A) of the adapter.

2. The adapter (10) of claim 1, wherein the centrifuge tube (T) has a body (B) with a neck (N) thereon, a portion of the neck (N) having a constricted region thereon when the tube (T) is capped,

the indentation (28) in each segment (12,14) being shaped such that when the segments (12,14) are in the mated position the indentations (28) cooperate to define a recess (30) that corresponds to the size and shape of the neck (N) of the tube (T),

at least one of the segments (12,14) having a feature (34) on the mating surface (18) thereof that projects into the indentation (28) therein such that, when the segments (12,14) are in the mated position and the tube (T) is received within the adapter (10), the feature is received

within the constricted region in the neck (N) of the tube (T).

3. The adapter (10') of claim 1 or 2, wherein the centrifuge tube (T') has a body (B') with a predetermined configuration over its entire length, the indentation (28') in each segment (12',14') being shaped such that when the segments (12',14') are in the mated position the indentations (28') cooperate to define a recess (30') that corresponds to the size and shape of the centrifuge tube (T') over its entire length.
4. The adapter (10) of one of claims 1 - 3 further comprising an enlarged collar (24) disposed on the exterior surface (16) of at least one of the segments (12,14).
5. The adapter of claim 1 with the recess defined by the indentations (28³) in each segment (12³,14³) being shaped to receive the entire axial length of the centrifuge tube (T), the mating surfaces (18³,19³) being in contacting relationship with each other over at least the neck (N) and transition regions (R) of the tube (T), the mating surface (18³) on the first adapter segment (12³) having a pair of edges thereon that projects into the second adapter segment (14³).
6. The adapter (10³) of one of claims 3-5, wherein the mating surface (18³) on the first adapter segment (12³) defines a first predetermined angle with respect to a predetermined reference plane (54) while the mating surface (19³) on the second adapter segment (14³) defines a second predetermined angle with respect to the predetermined reference plane (54), the reference plane (54) being defined as the plane that contains the axis (10³A) of the adapter (10³) and that lies normal to the line of action (48) along which the segments (12³,14³) of the adapter (10³) are mated.
7. The adapter (10³) of claim 6, wherein the first predetermined angle and/or the second predetermined angle are within the range from about ten to about eighty degrees.
8. The adapter (10) of one of claims 1-7, wherein the centrifuge rotor (42) is a vertical angle rotor, and wherein the adapter segments (12,14) are fabricated of a material that has sufficient strength to withstand the vertical forces created by the pressure of a liquid under centrifugation.

Patentansprüche

1. Adapter (10) zum Stützen eines Zentrifugenröhrchens (T) in einem Hohlraum (40) eines Zentrifugenrotors (42), wobei der Adapter (10) eine sich

durch diesen erstreckende Achse (10A) aufweist, die sich im Gebrauch in parallelem Verhältnis zu einer Achse des Rotorhohlraums (40), in dem der Adapter (10) angeordnet ist, ausrichtet, wobei der Adapter ein erstes und ein zweites Adaptersegment (12, 14) aufweist, wobei jedes Segment (12, 14) eine Außenfläche (16) und eine Paßfläche (18) aufweist, wobei jedes Segment eine Vertiefung (28) in der Paßfläche (18) aufweist, bei dem die Paßflächen (18) der Segmente (12, 14) in der zusammengefügten Position in Kontakt miteinander angeordnet sind und die darin ausgebildeten Vertiefungen (28) zur Bildung einer Ausnehmung (30) zusammenwirken, deren Größe und Form der Größe und Form wenigstens eines Teils des Röhrchens (T) entspricht, gekennzeichnet durch wenigstens ein Gelenk (26), das die Segmente (12, 14) miteinander verbindet und die relative Schwenkbewegung eines Segments (12, 14) in bezug auf das andere aus der offenen in die zusammengefügte Position um eine Gelenkachse (26A) unterstützt, wobei sich die Gelenkachse (26A) senkrecht zur Achse (10A) des Adapters erstreckt.

2. Adapter (10) nach Anspruch 1, bei dem das Zentrifugenröhrchen (T) einen Körper (B) mit einem daran ausgebildeten Hals (N) aufweist, wobei ein Teil des Halses (N) einen verengten Bereich aufweist, wenn das Röhrchen (T) mit einer Kappe versehen ist,

wobei die Vertiefung (28) in jedem Segment (12, 14) derart ausgebildet ist, daß, wenn sich die Segmente (12, 14) in der zusammengefügten Position befinden, die Vertiefungen (28) zur Bildung einer Ausnehmung (30) zusammenwirken, die der Größe und Form des Halses (N) des Röhrchens (T) entspricht,

wobei wenigstens eines der Segmente (12, 14) einen Vorsprung (34) an der Paßfläche (18) aufweist, der derart in die Vertiefung (28) vorsteht, daß, wenn die Segmente (12, 14) in der zusammengefügten Position sind und das Röhrchen (T) in dem Adapter (10) aufgenommen ist, der Vorsprung in dem verengten Bereich des Halses (N) des Röhrchens (T) aufgenommen ist.

3. Adapter (10') nach Anspruch 1 oder 2, bei dem das Zentrifugenröhrchen (T') einen Körper (B') mit einer vorbestimmten Konfiguration über seine gesamte Länge aufweist, wobei die Vertiefung (28') in jedem Segment (12', 14') derart ausgebildet ist, daß, wenn sich die Segmente (12', 14') in der zusammengefügten Position befinden, die Vertiefungen (28') zu Bildung einer Ausnehmung (30') zusam-

menwirken, die über die gesamte Länge der Größe und Form des Zentrifugenröhrchens (T) entspricht.

4. Adapter (10) nach einem der Ansprüche 1 - 3, ferner mit einem verbreiterten Kragen (24), der auf der Außenfläche (16) wenigstens eines der Segmente (12, 14) vorgesehen ist. 5
5. Adapter nach Anspruch 1, bei dem die von den Vertiefungen (28³) in jedem Segment (12³, 14³) gebildete Ausnehmung zur Aufnahme der gesamten axialen Länge des Zentrifugenröhrchens (T) ausgebildet ist, wobei sich die Paßflächen (18³, 19³) über zumindest den Hals (N) und Übergangsbereiche (R) des Röhrchens (T) in Anlage aneinander befinden, wobei die Paßfläche (18³) des ersten Adaptersegments (12³) zwei Ränder aufweist, die in das zweite Adaptersegment (14³) hineinragen. 10 15
6. Adapter (10³) nach einem der Ansprüche 3-5, bei dem die Paßfläche (18³) des ersten Adaptersegments (12³) einen ersten vorbestimmten Winkel in bezug auf eine vorbestimmte Bezugsebene (54) bildet, während die Paßfläche (19³) des zweiten Adaptersegments (14³) einen zweiten vorbestimmten Winkel in bezug zu der vorbestimmten Bezugsebene (54) bildet, wobei die Bezugsebene (54) als die Ebene definiert ist, die die Achse (10³A) des Adapters (10³) einschließt und senkrecht zur Bewegungslinie (48) liegt, entlang der die Segmente (12³, 14³) des Adapters (10³) zusammengefügt werden. 20 25 30
7. Adapter (10³) nach Anspruch 6, bei dem der erste vorbestimmte Winkel und/oder der zweite vorbestimmte Winkel im Bereich zwischen ungefähr 10 und ungefähr 80 Grad liegen. 35
8. Adapter (10) nach einem der Ansprüche 1-7, bei dem der Zentrifugenrotor (42) ein Vertikalwinkelrotor ist, und bei dem die Adaptersegmente (12, 14) aus einem Material bestehen, das ausreichend fest ist, um den vertikalen Kräften, die von einer zentrifugierten Flüssigkeit ausgeübten Druck erzeugt werden, zu widerstehen. 40 45

Revendications

1. Un adaptateur (10) pour supporter un tube de centrifugeuse (T) dans une cavité (40) ménagée dans un rotor de centrifugeuse (42), l'adaptateur (10) ayant un axe (10A) le traversant qui, en service, s'aligne parallèlement à un axe de la cavité de rotor (40) dans laquelle l'adaptateur (10) est disposé, l'adaptateur comprenant des premier et deuxième segments ou parties d'adaptateur (12, 14), chaque segment (12, 14) comportant une surface extérieure (16) et une surface d'adaptation ou d'ajustement à l'autre segment (18), chaque segment ayant 50 55

une échancrure (28) ménagée dans la surface d'adaptation (18), de telle manière que dans la position d'ajustement, les surfaces d'adaptation (18) des segments (12, 14) soient mises en contact et que les échancrures (28) qui y sont ménagées coopèrent pour définir une cavité (30) ayant une taille et une forme correspondant à la taille et à la forme d'au moins une partie du tube (T), caractérisé par:

- au moins une charnière (26) reliant les segments (12, 14) et supportant le déplacement relatif de pivotement autour d'un axe d'articulation (26A) d'un segment (12; 14) par rapport à l'autre, depuis la position ouverte jusqu'à la position ajustée, l'axe d'articulation (26A) s'étendant perpendiculairement à l'axe (10A) de l'adaptateur.

2. L'adaptateur (10) selon la revendication 1, dans lequel le tube de centrifugeuse (T) comporte un corps (B) muni d'un col (N), une partie du col (N) présentant une zone rétreinte sur le col lorsque le tube (T) est coiffé par l'adaptateur, 25

l'échancrure (28) ménagée dans chaque segment (12, 14) étant formée de telle manière que, lorsque les segments (12, 14) se trouvent dans la position ajustée, les échancrures (28) coopèrent pour définir une cavité (30) qui correspond à la taille et à la forme du col (N) du tube (T), au moins l'un des segments (12, 14) présente sur sa surface d'adaptation (18) une partie en saillie (34), qui fait saillie dans l'échancrure (28) de telle manière que, lorsque les segments (12, 14) se trouvent dans la position ajustée et lorsque le tube (T) est logé dans l'adaptateur (10), la partie en saillie soit logée dans la zone rétreinte dans le col (N) du tube (T).

3. L'adaptateur (10) selon la revendication 1 ou 2, dans lequel le tube de centrifugeuse (T) présente un corps (B') ayant une configuration prédéterminée sur toute sa longueur, l'échancrure (28) ménagée dans chaque segment (12', 14') étant formée de telle manière que, lorsque les segments (12', 14') se trouvent dans la position ajustée, les échancrures (28') coopèrent pour définir une cavité (30') qui correspond à la taille et à la forme du tube de centrifugeuse (T'), sur toute sa longueur.
4. L'adaptateur (10) selon l'une des revendications 1 à 3, comprenant en outre un collet élargi (24) disposé sur la surface extérieure (37) d'au moins l'un des segments (12, 14).
5. L'adaptateur selon la revendication 1, dans lequel la cavité définie par les échancrures (28³) ména-

gées dans chaque segment (12^3 , 14^3) est conformée pour recevoir toute la longueur axiale du tube de centrifugeuse (T), les surfaces d'adaptation (18^3 , 19^3) étant en relation de contact entre elles au moins sur le col (N) et sur des zones de transition (R) du tube (T), la surface d'adaptation (18^3) se trouvant sur le premier segment d'adaptateur (12^3) comportant deux bords qui viennent faire saillie dans le deuxième segment d'adaptateur (14^3).

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6. L'adaptateur (10^3) selon l'une des revendications 3 à 5, dans lequel la surface d'adaptation (18^3) se trouvant sur le premier segment d'adaptateur (12^3) définit un premier angle prédéterminé par rapport à un plan de référence (54) prédéterminé, tandis que la surface d'adaptation (19^3) se trouvant sur le deuxième segment d'adaptateur (14^3) définit un deuxième angle prédéterminé par rapport au plan de référence (54) prédéterminé, le plan de référence (54) étant défini comme étant le plan qui contient l'axe (18^3A) de l'adaptateur (10^3) et qui est perpendiculaire à la ligne d'action (48) le long de laquelle sont adaptés ou ajustés les segments (12^3 , 14^3) de l'adaptateur (10^3).

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7. L'adaptateur (10^3) selon la revendication 6, dans lequel le premier angle prédéterminé et/ou le deuxième angle prédéterminé sont compris dans la plage allant d'environ dix à environ quatre vingt degrés.

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8. L'adaptateur (10) selon l'une des revendications 1 à 7, dans lequel le rotor de centrifugeuse (42) est un rotor à angle vertical et dans lequel les segments d'adaptateur (12, 14) sont fabriqués en un matériau qui présente une résistance suffisante pour résister aux forces verticales exercées par la pression d'un liquide soumis à la centrifugation.

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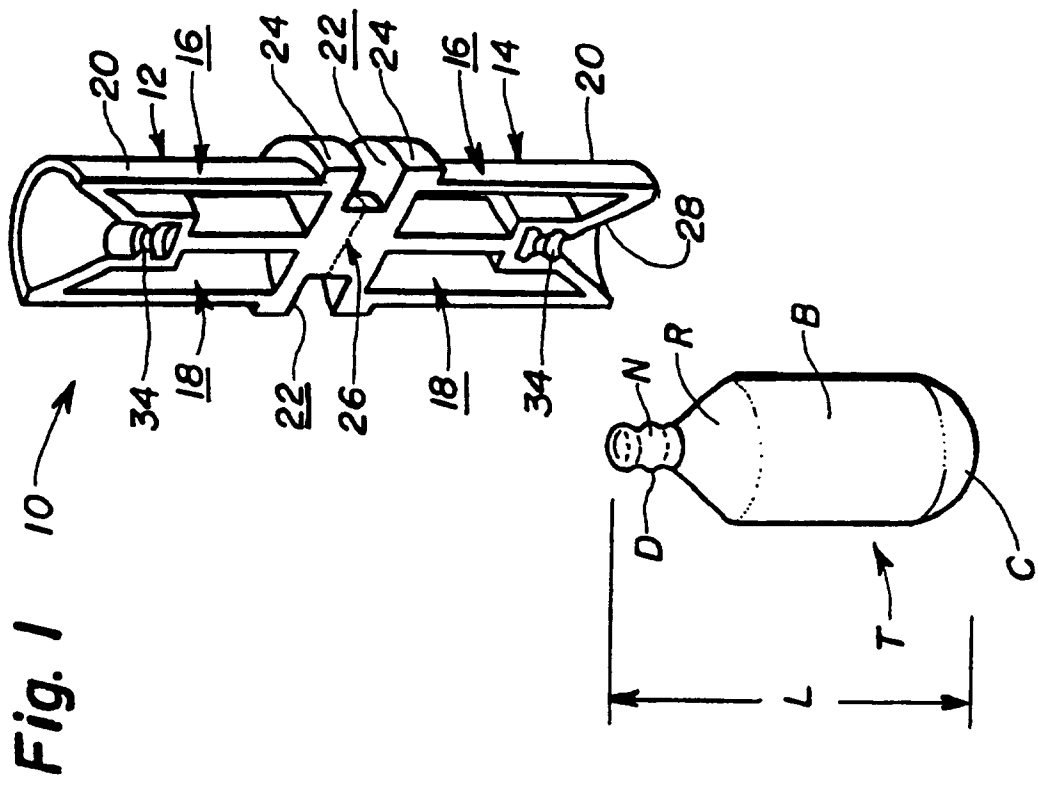
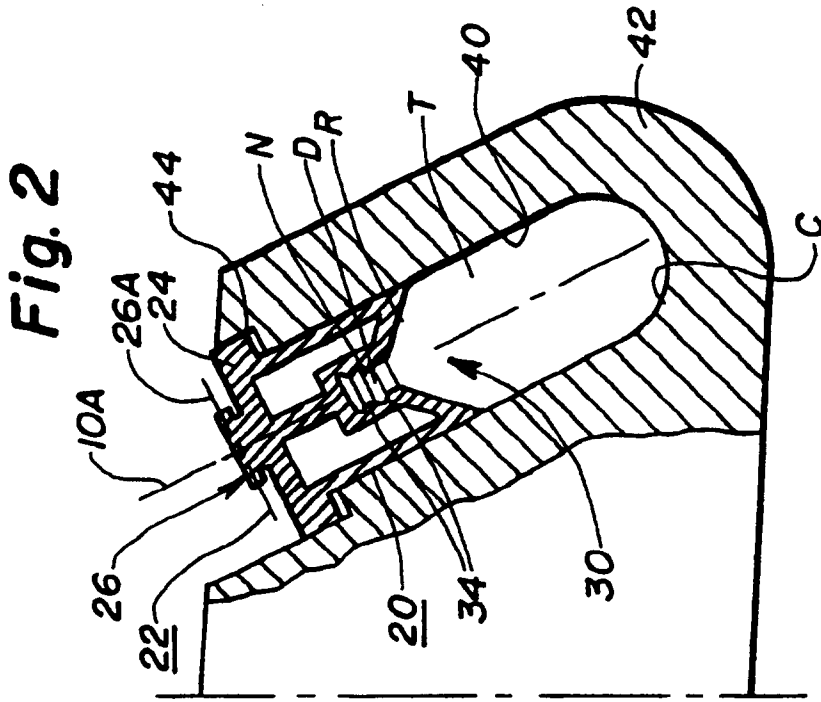


Fig. 4

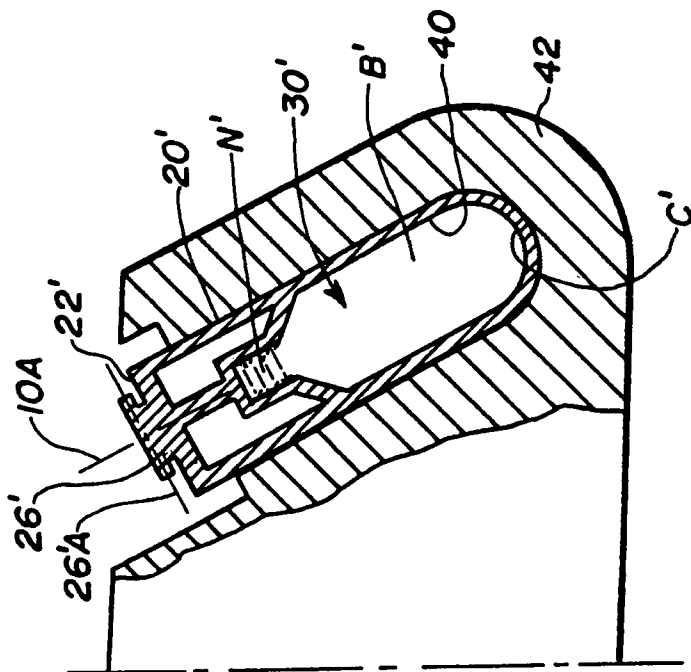


Fig. 3

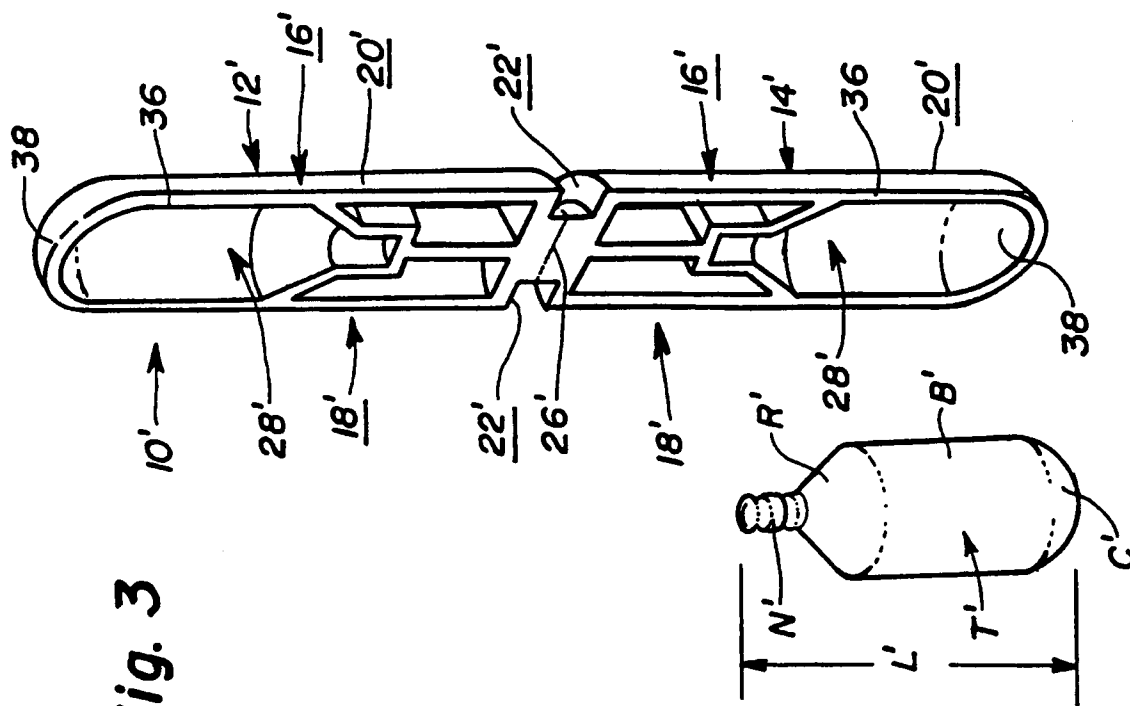


Fig. 6

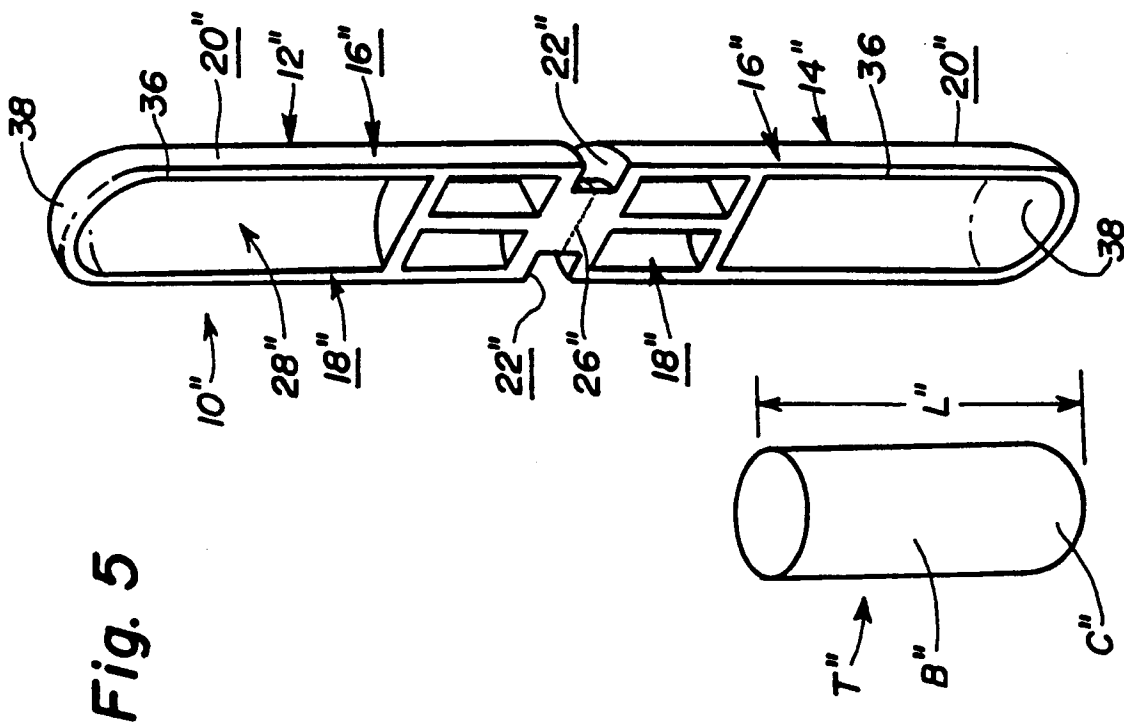
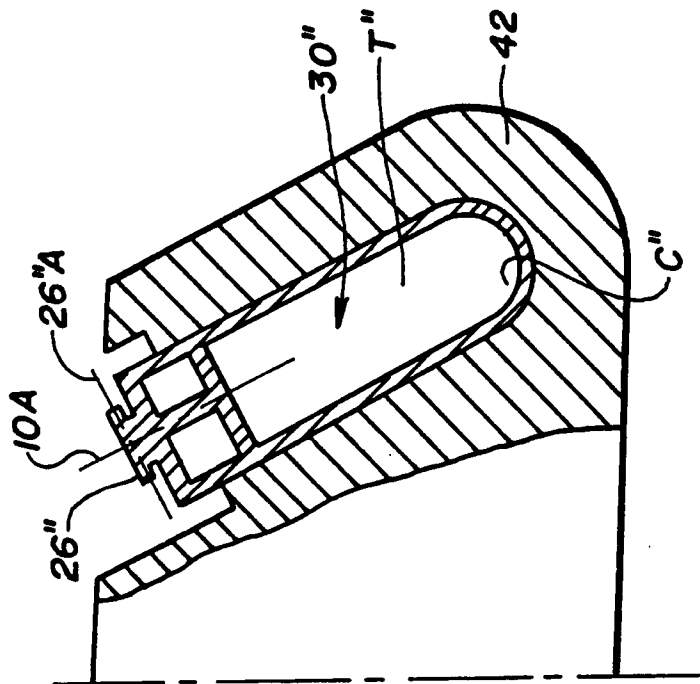


Fig. 5

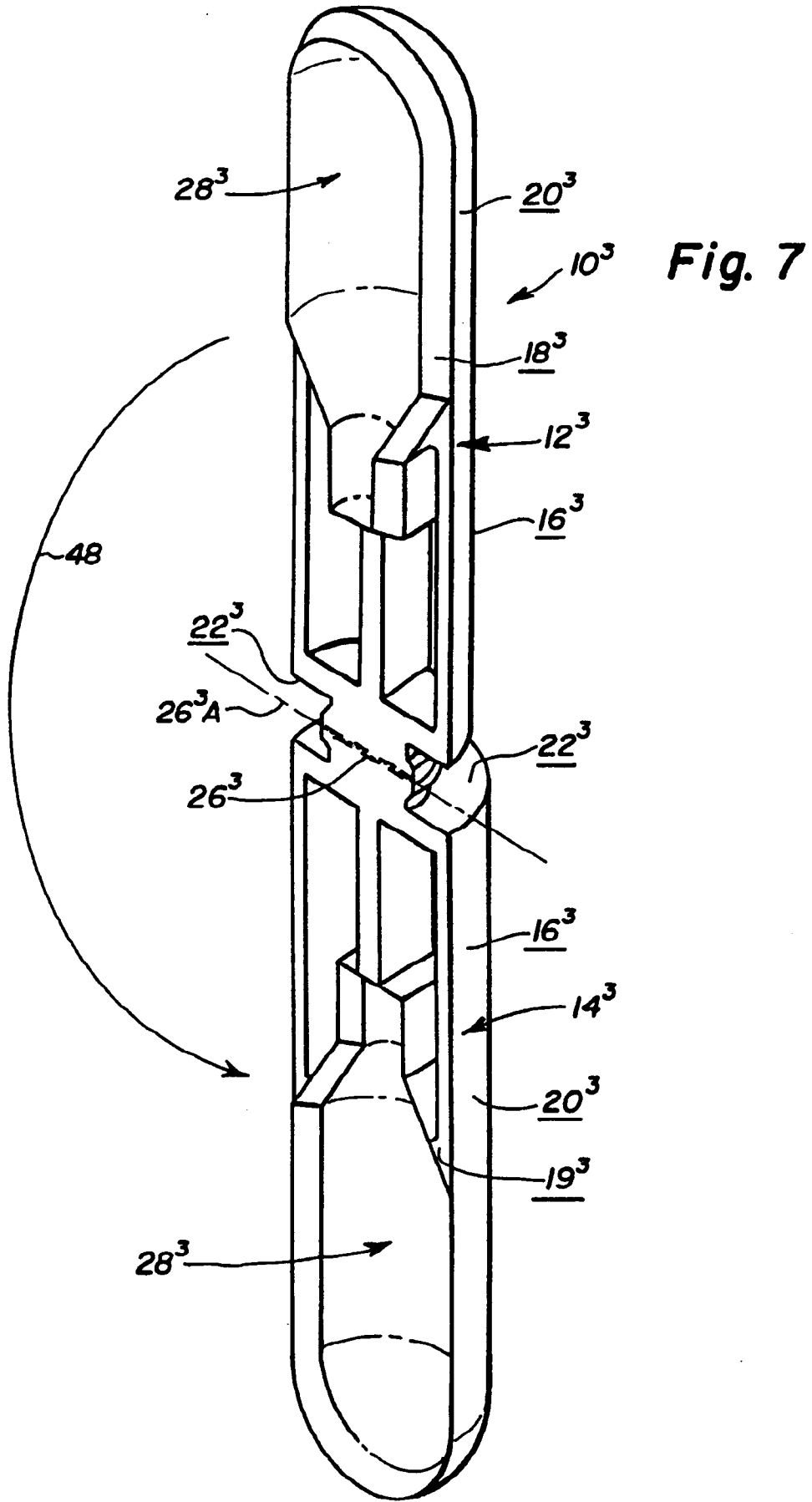
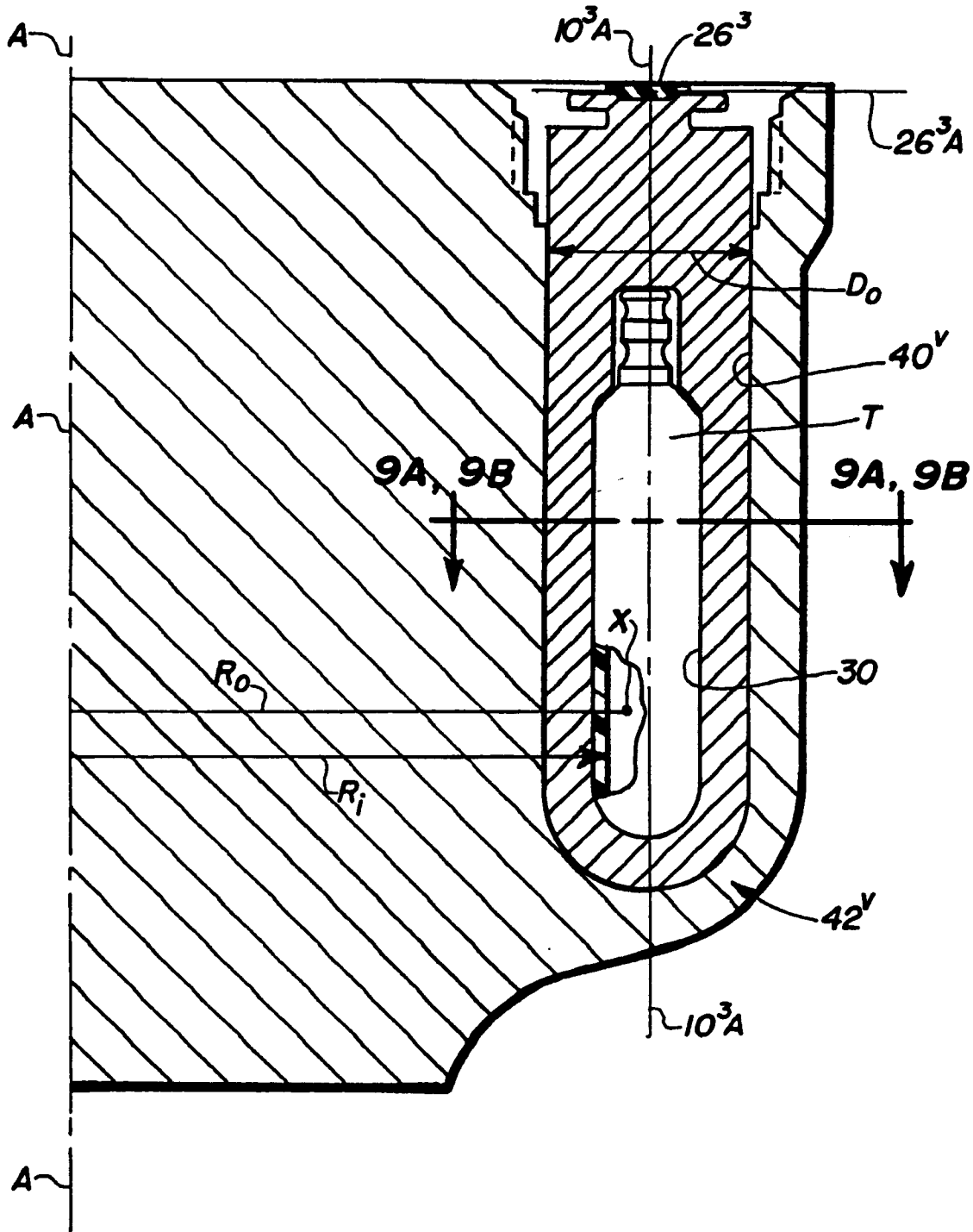


Fig. 8



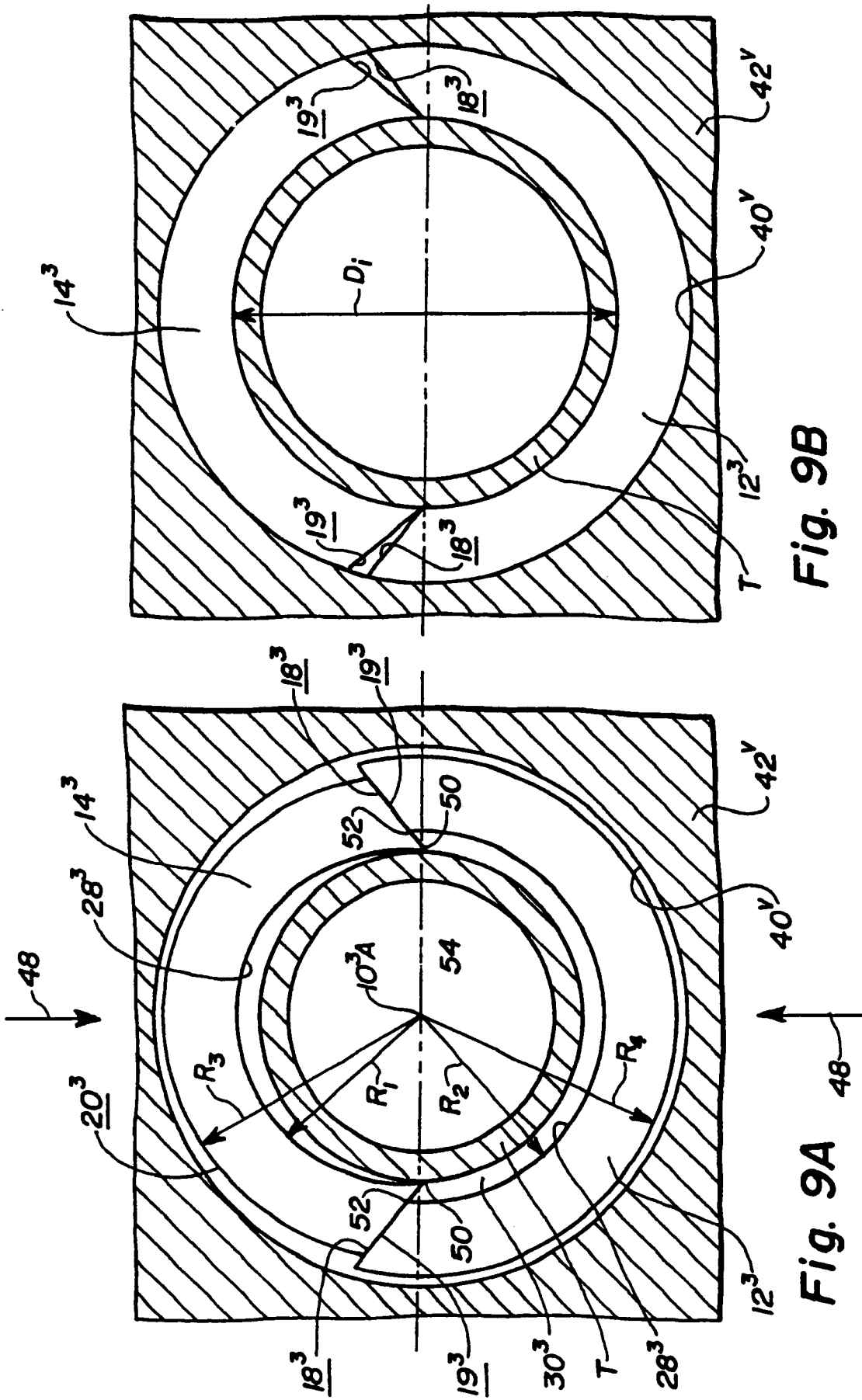


Fig. 9B

Fig. 9A