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(54) **CLOSURE FOR CONTAINER FOR HOLDING BIOLOGICAL SAMPLES**

(57) **ABSTRACT**

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A closure for a container, e.g., a tube, for a sample, e.g., a biological sample. The closure comprises a seal and an adapter to mount the seal onto the container. In one embodiment, the adapter is a cap that is inserted over the mouth of the container. The adapter is typically cylindrical in shape and is characterized by having a circular top with a cylindrical side wall projecting from the top. The top of the adapter has an opening formed therein. The opening generally surrounds the axis of the cylindrically-shaped adapter. The opening has dimensions sufficient to accommodate a sampling device for obtaining access to the contents of the container. The seal depends from the surface of the top of the cap that faces the interior of the container. The seal has a peripheral portion enclosing an interior portion. The peripheral portion has a side wall and a bottom wall. The seal is preferably frusto-conical in shape, with the larger end of the seal adjacent to the top of the adapter and the smaller end of the seal facing the interior of the container. In this preferred embodiment, the seal is attached to the adapter by means of a flange that surrounds the larger end of the seal. An opening for allowing a sampling device to gain access to the contents of the container is formed either in the bottom wall of the seal or in the side wall of the seal at a position close to the bottom wall of the seal.

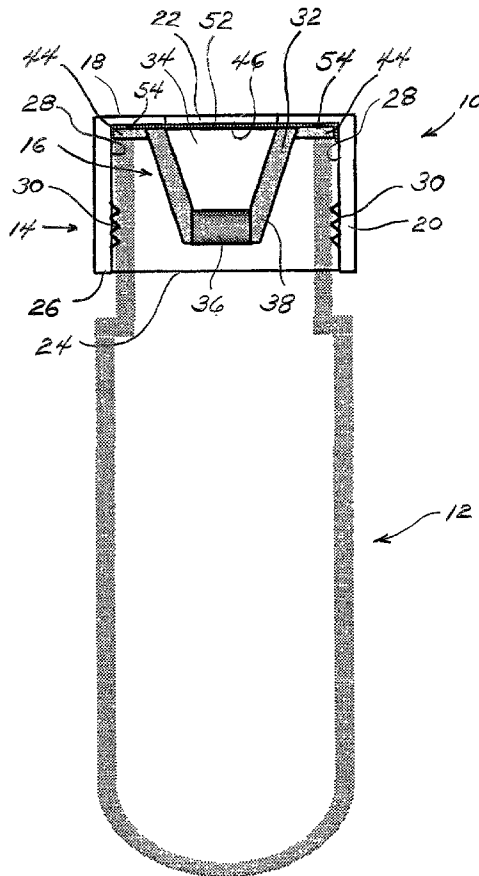
(21) Appl. No.: **09/953,799**

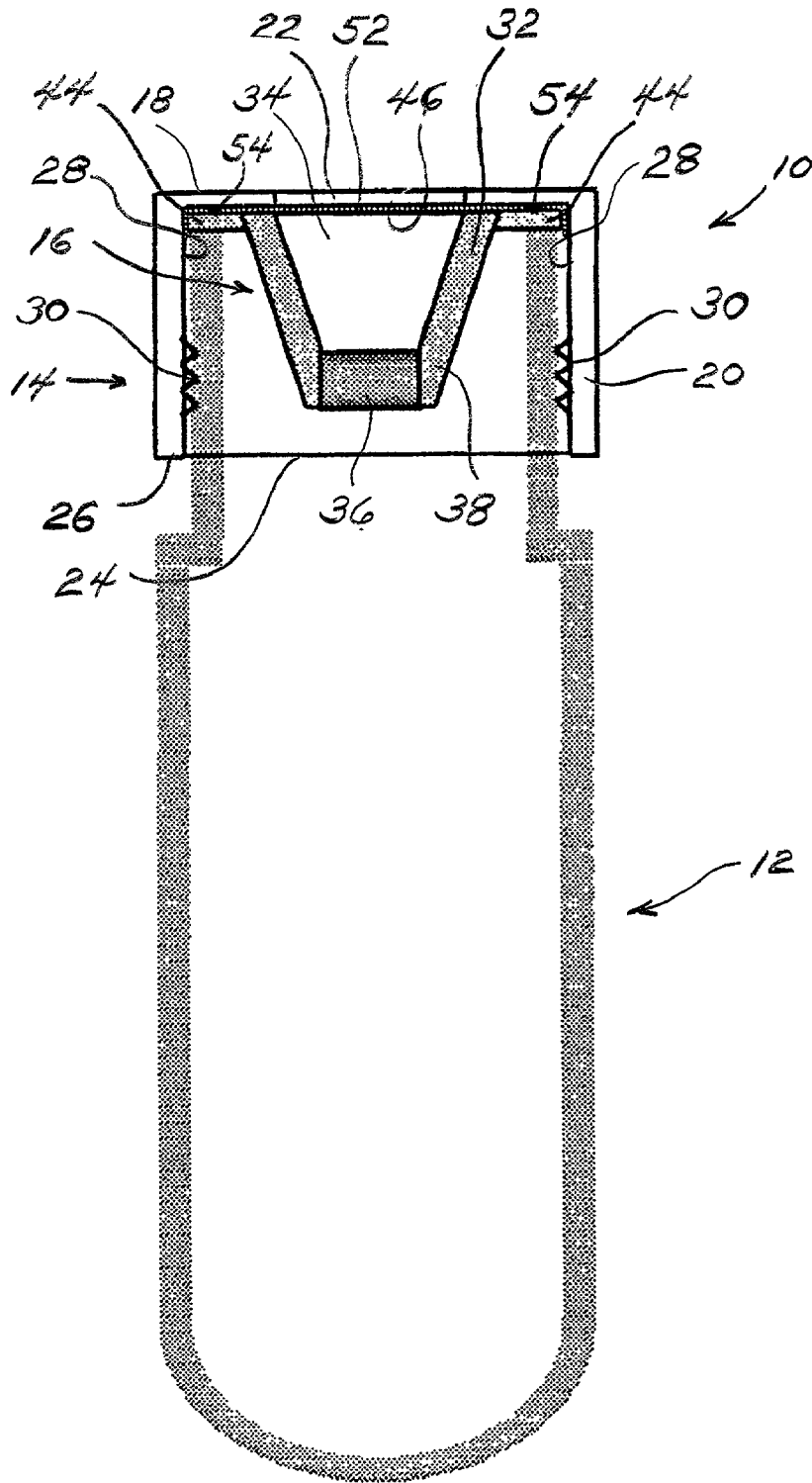
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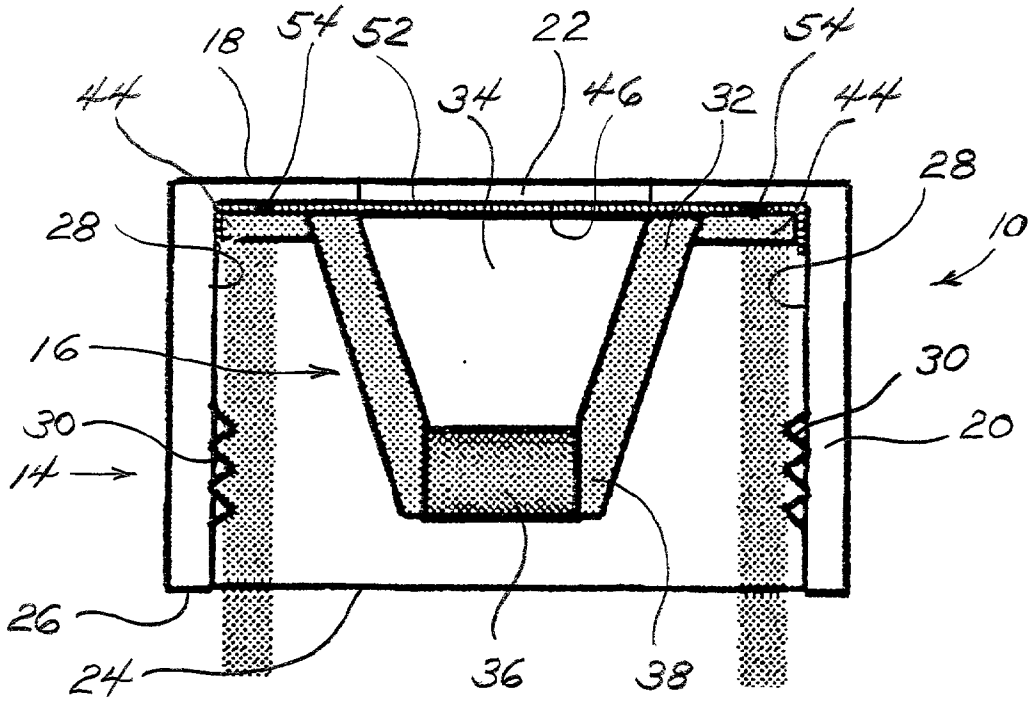


FIG. 2

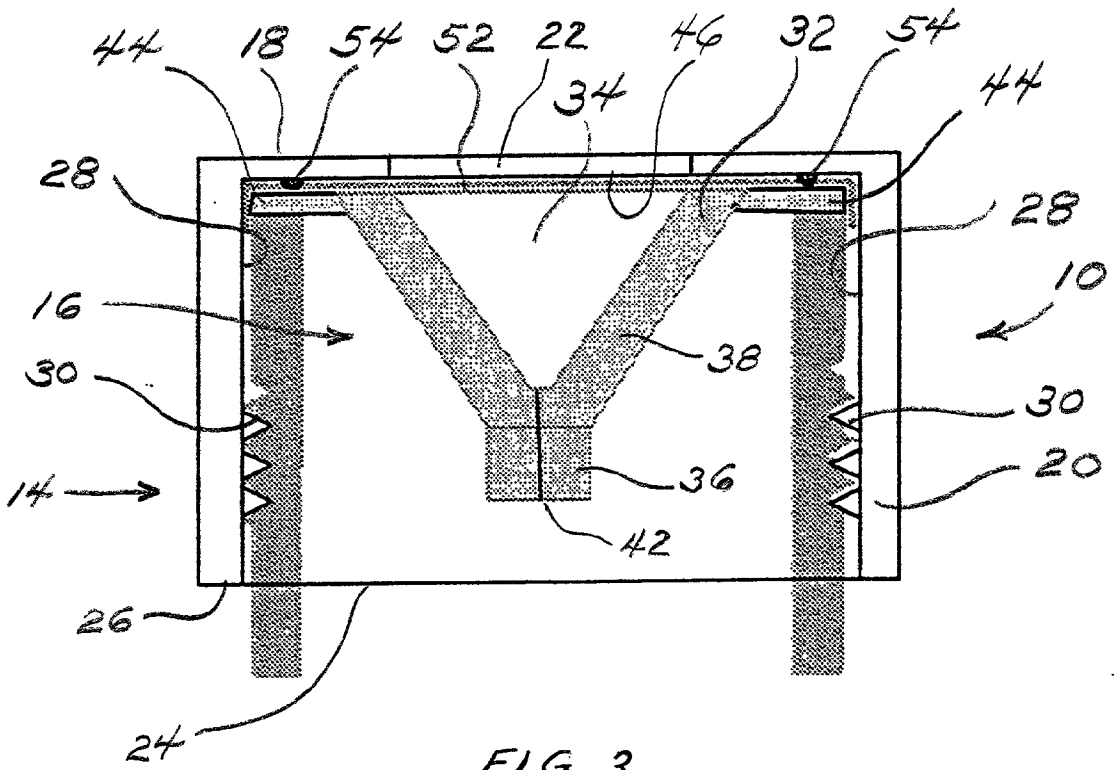


FIG. 3

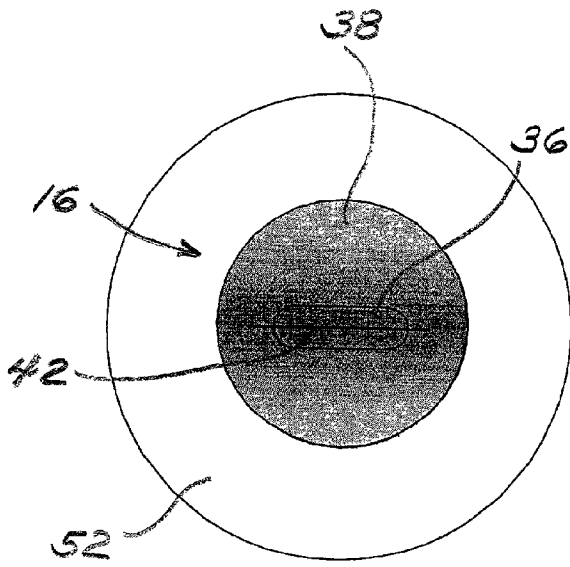


FIG. 4

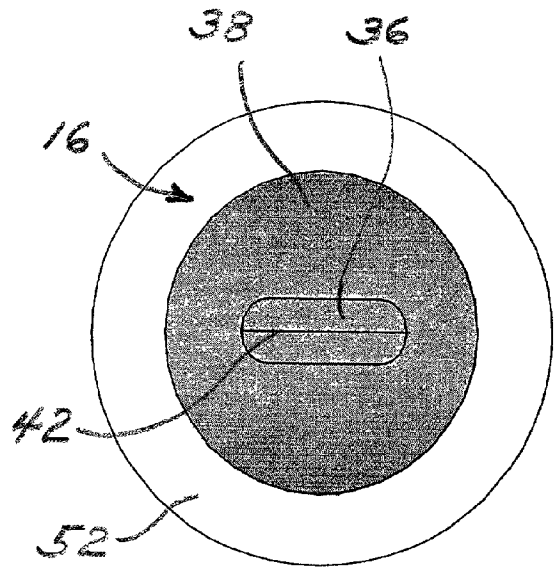


FIG. 5

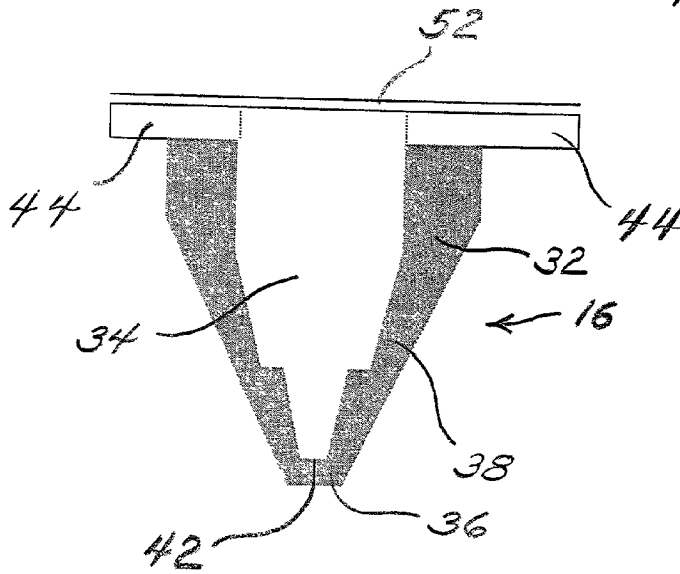


FIG. 6

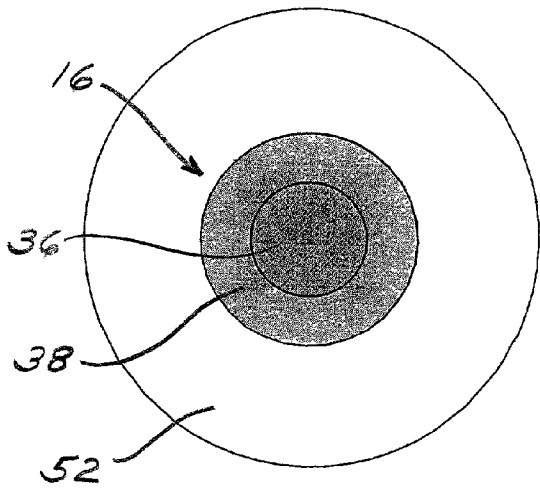


FIG. 7

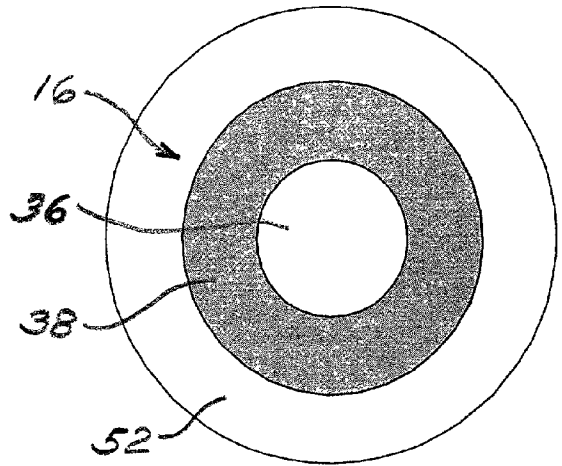


FIG. 8

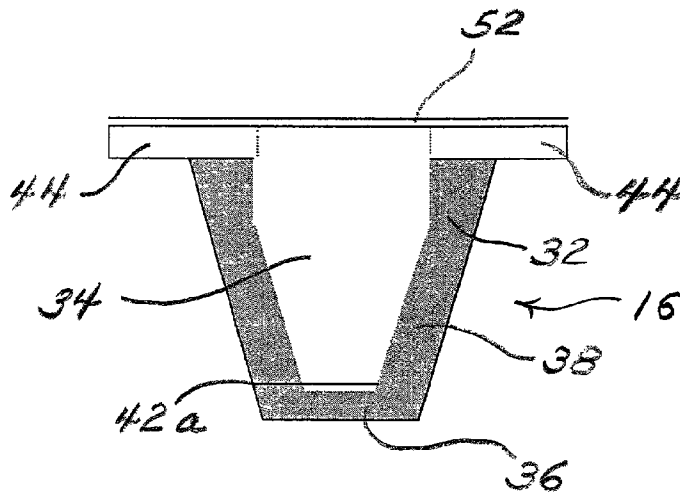


FIG. 9

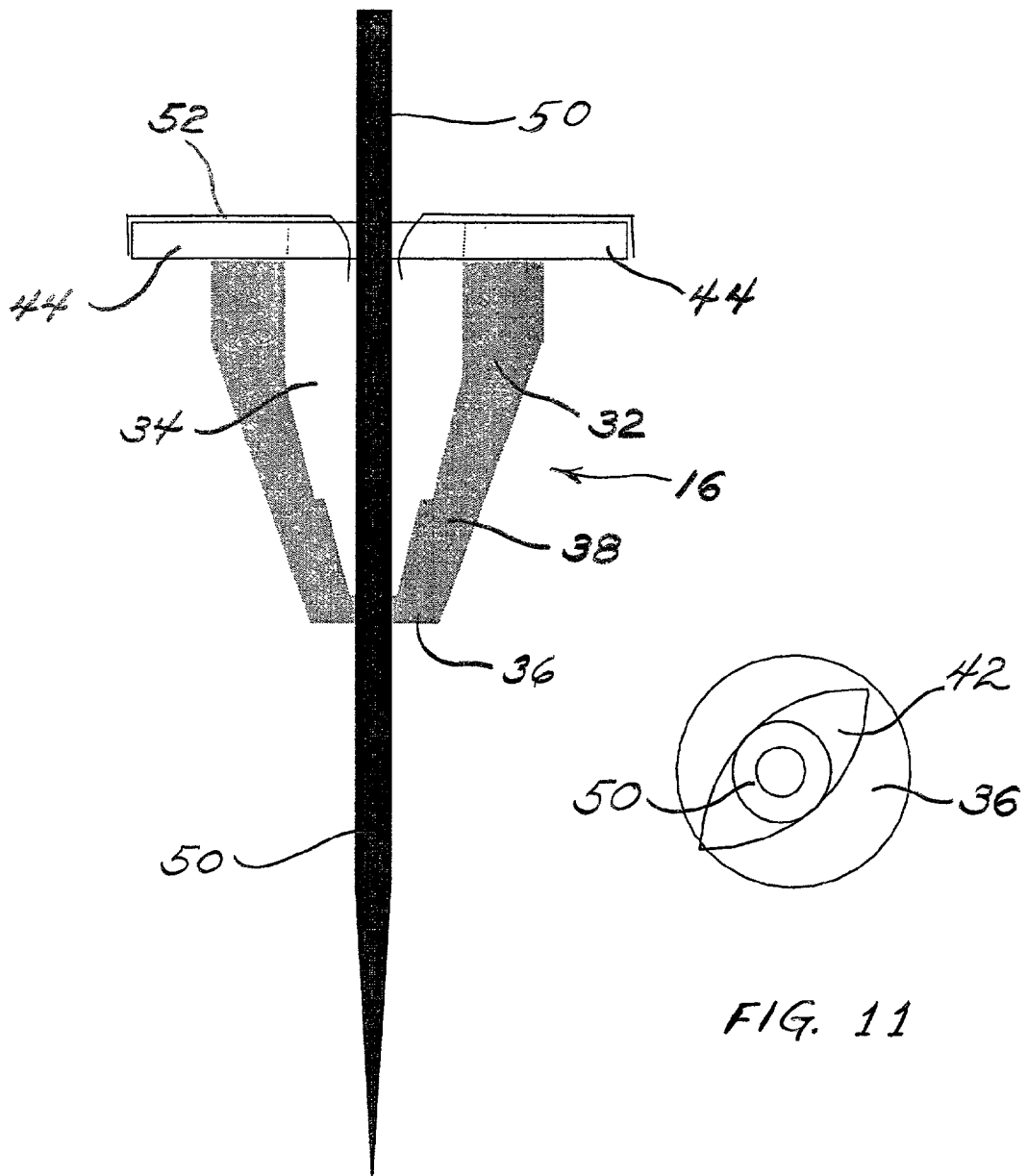
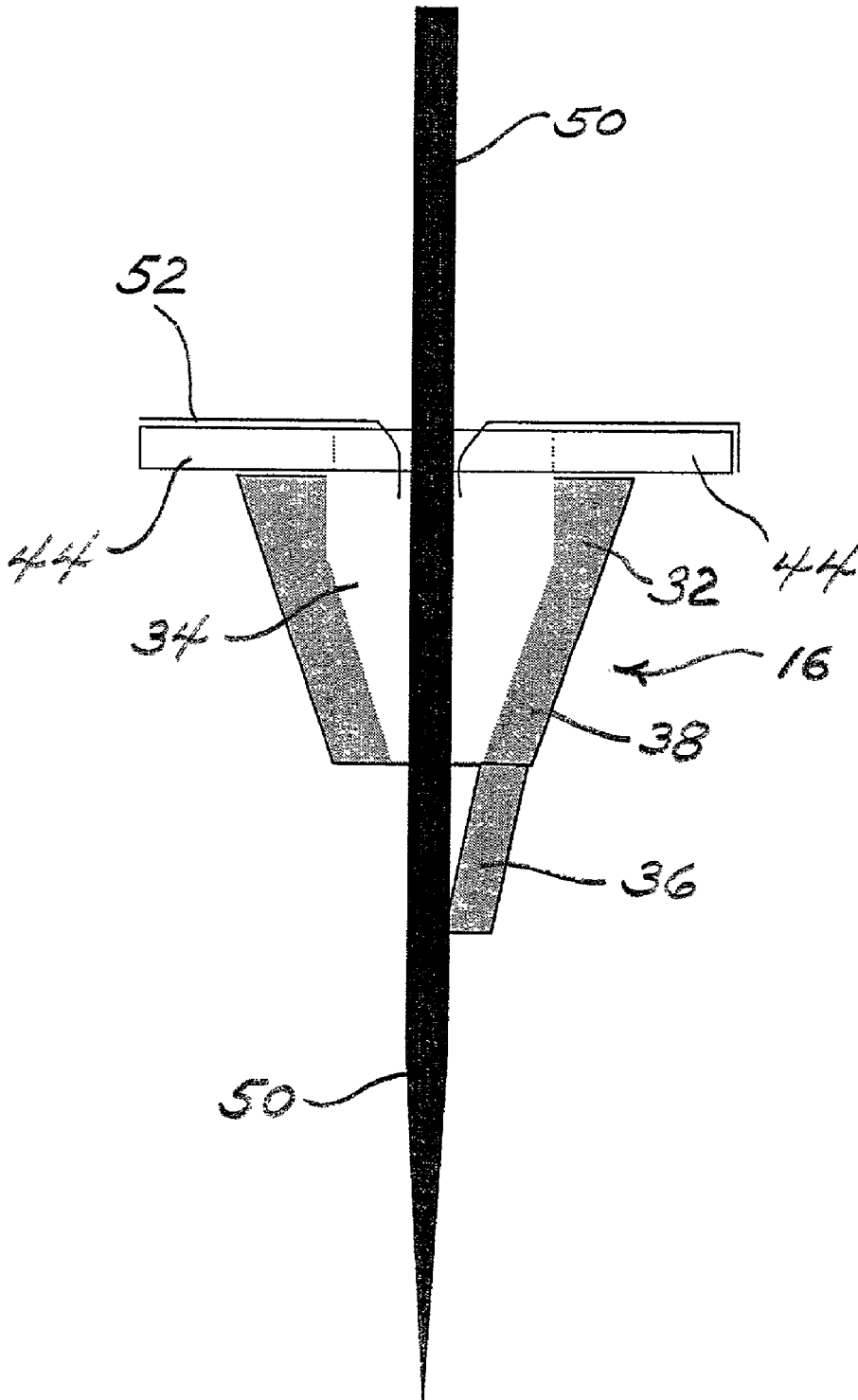


FIG. 10

FIG. 11

FIG. 12



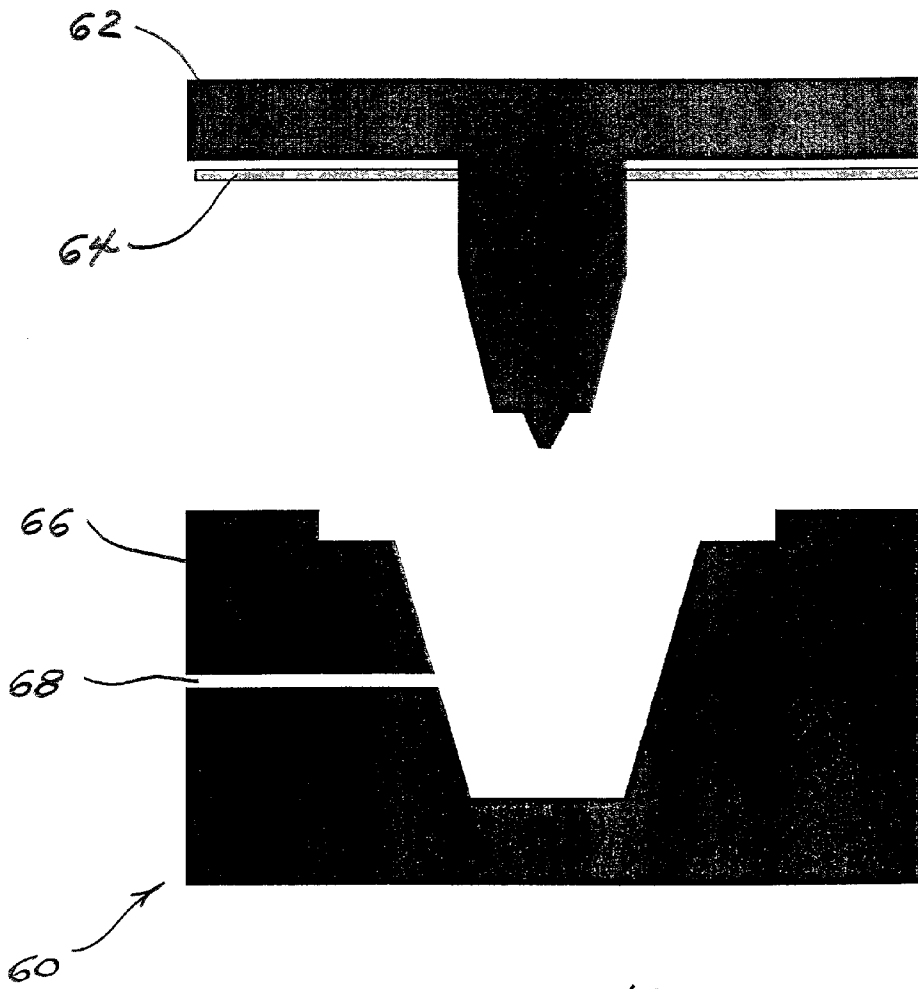


FIG. 13

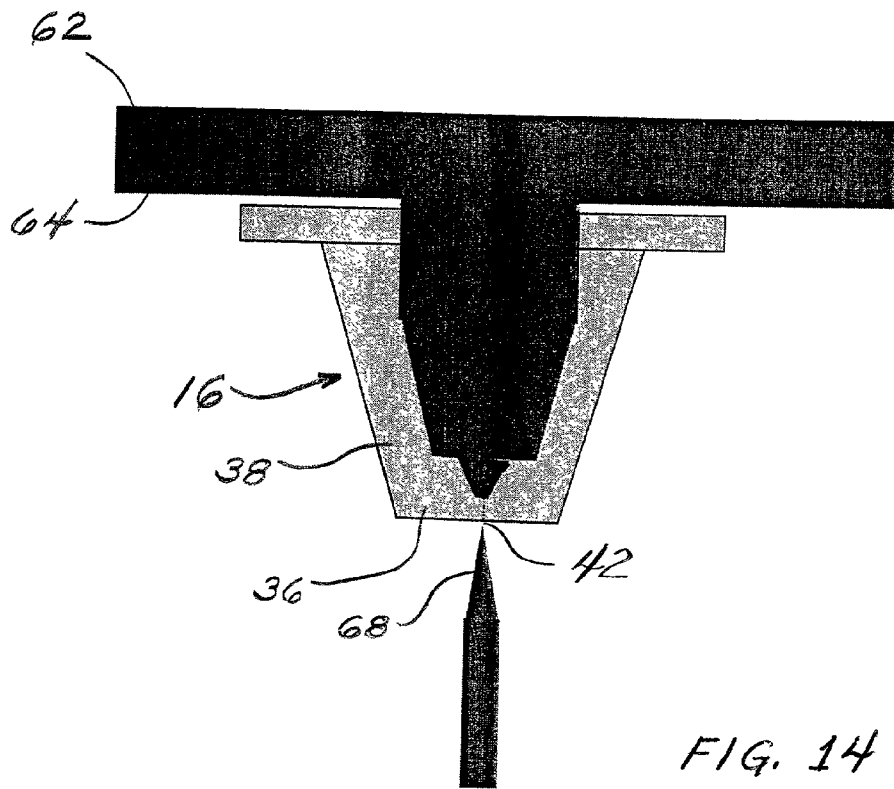


FIG. 14

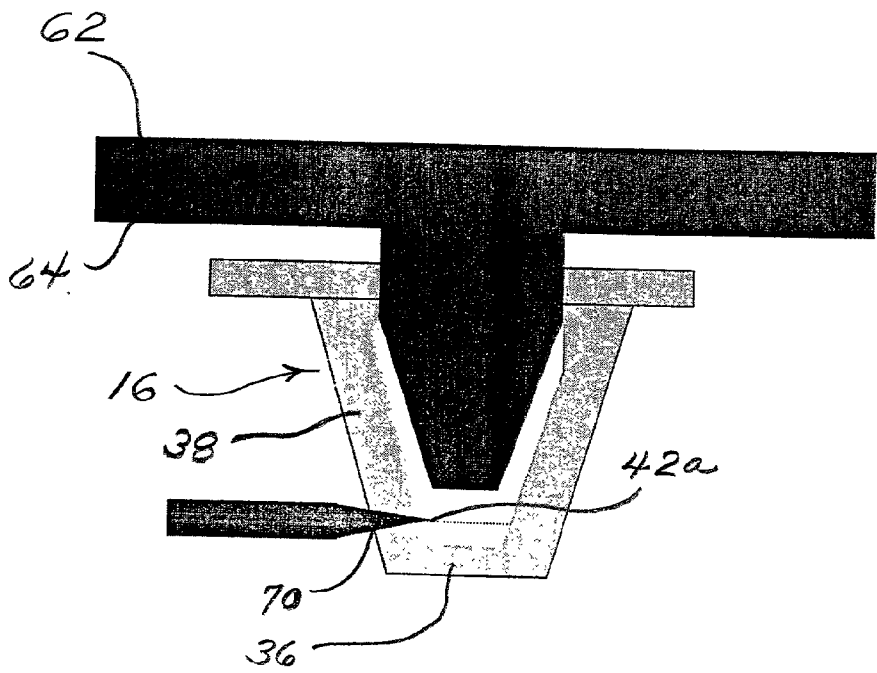


FIG. 15

CLOSURE FOR CONTAINER FOR HOLDING BIOLOGICAL SAMPLES

1. FIELD OF THE INVENTION

[0001] This invention relates to containers, and, more particularly, to closures for containers.

2. DISCUSSION OF THE ART

[0002] Capping and uncapping of containers, e.g., tubes containing biological samples, is a repetitive task that is performed daily in analytical laboratories. The task is difficult to automate. In addition, the task subjects analytical chemists to a considerable risk of exposure to biohazards. Furthermore, the task can also cause numerous injuries. Capping and uncapping of containers containing biological samples is also time-consuming. It has been estimated that the task requires about 0.6 minute per container or approximately 60 minutes per analytical batch at a cost of approximately \$150 per batch. Indirect savings from preventing work-related injuries and improving the morale of analytical chemists cannot be estimated, but such savings may be substantial. For these reasons, analytical laboratories prefer that sample tubes be equipped with resealable septa.

[0003] Sample tubes equipped with resealable septa are available from several vendors. All known resealable septa are made of an elastic material, such as rubber. This elastic material may be punctured by means of a sharp needle. However, it has been found that the resealable septa form a seal that interferes with the sampling process. Commercially available septa are made of elastic material designed to form a tight seal around a sampling device, e.g., a pipette or a needle. The junction between the sampling device and the septum is usually gas-tight. If the sample tube is nearly full, withdrawal of liquid will create a substantial vacuum that will interfere with the action of sampling. In addition, the sample tube must be held down by force, because the septum tends to bind with the sampling device as the sampling device is withdrawn from the sample tube.

[0004] In addition, when the sampling device is withdrawn from the sample tube, the opening formed by the puncture, which opening is generally irregular in shape, may or may not reseal properly, thereby leaving the quality of the portion of the sample remaining questionable. Furthermore, puncturing the septum with a blunt or thick object, such as the tip of a pipette, is impossible without damaging the tip of the pipette.

[0005] Accordingly, it would be desirable to provide a resealable closure for a container that eliminates the need for capping and uncapping the container. It would also be desirable to provide a resealable closure for a container that does not interfere with the sampling activity of the sampling device. It would also be desirable to provide a resealable closure for a container that can be opened by a sampling device, without leading to damage of the sampling device. It would also be desirable to provide a resealable closure that can be opened without adversely affecting the resealability of the closure.

SUMMARY OF THE INVENTION

[0006] In one aspect, this invention provides a closure for a container, e.g., a tube, for a sample, e.g., a biological

sample. The closure comprises a seal and an adapter to mount the seal onto the container. In a second aspect, this invention provides the seal alone, independent of the adapter. In a third aspect, this invention provides an assembly comprising the closure of this invention and a container.

[0007] In one embodiment, the adapter is a cap that is inserted over the mouth of the container. The adapter is typically cylindrical in shape and is characterized by having a circular top with a cylindrical side wall projecting from the top. The top of the adapter has an opening formed therein. The opening generally surrounds the axis of the cylindrically-shaped adapter. The opening has dimensions sufficient to accommodate a sampling device for obtaining access to the contents of the container.

[0008] The seal depends from the surface of the top of the adapter that faces the interior of the container. The seal has a peripheral portion enclosing an interior portion. The peripheral portion has a side wall and a bottom wall. The seal is preferably frusto-conical in shape, with the larger end of the seal adjacent to the top of the adapter and the smaller end of the seal being closer to the interior of the container. In this preferred embodiment, the seal is joined to or brought in close association with the adapter by means of a flange that surrounds the larger end of the seal. It is preferred that a cover, e.g., a rupturable membrane, be interposed between the top of the adapter and the flange of the seal. The seal need not be frusto-conical in shape. For example, the seal can be cylindrical in shape, in which case the seal would be attached to the adapter by means of a flange that surrounds the end of the seal that is proximal to the top of the adapter.

[0009] An opening for allowing a sampling device to gain access to the contents of the container is formed either in the bottom wall of the seal or in the side wall of the seal at a position close to the bottom wall of the seal. The opening should be of a shape and a size such that the pressure in the container will be substantially equal to the ambient pressure at all times, particularly when the sampling device is inserted into the interior of the container. Moreover, the opening should be of a shape and a size such that the transfer of liquid may be performed with high precision. Preferably, the opening is in the shape of an elongated slit. It is preferred that the elongated slit be precut and have smooth edges to facilitate both access of the sampling device to the contents within the container and removal of the sampling device from the container. Because the slit is precut rather than formed by puncturing the bottom wall of the seal, the sampling device is not held tightly by the seal and may be withdrawn from the opening in the seal easily. It is preferred that the elongated slit be of sufficient length that the distance around the periphery of the slit (i.e., twice the length of the slit) is greater than the circumference of a typical sampling device, e.g., a pipette.

[0010] To reduce evaporation of the sample, a lubricant can be applied to the opening to form a physical barrier between the sample in the container and the environment outside of the container.

[0011] A pipette can be used as the sampling device to provide access to the sample through the opening in the seal. A vacuum will not be created as long as the length of the opening in the seal is sufficiently large relative to the diameter of the sampling device. For example, the diameter of the tip of the pipette is preferably less than approximately

0.6 times the length of the opening in the seal. When the opening is precut, and thus has a smooth surface for contacting the tip of the pipette, a satisfactory seal is assured after the pipette is withdrawn from the opening, even after the pipette has penetrated the opening and been removed from the opening repeatedly.

[0012] The closure of this invention provides numerous benefits. One major benefit involves facilitation of automation of sampling operations. A second major benefit involves reduction of exposure of analytical chemists to biohazardous materials. A third major benefit involves the saving of time in obtaining access to the contents of a container, which also results in a reduction of costs associated with obtaining access to the contents of the container. A fourth major benefit involves allowing a sampling device to open the closure without the sampling device being damaged by the opening process. A fifth major benefit involves the ability to open the closure without adversely affecting the resealability of the seal. A sixth major benefit involves a closure that does not interfere with the sampling activity of the sampling device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a side view in elevation of a cross section of the closure of this invention attached to a container, e.g., a sampling tube.

[0014] FIG. 2 is an enlarged view of the closure of FIG. 1.

[0015] FIG. 3 is an enlarged view of the closure of FIG. 1, the closure being rotated 90° relative to the position thereof shown in the views of FIGS. 1 and 2.

[0016] FIG. 4 is a top plan view of one embodiment of the closure of this invention.

[0017] FIG. 5 is a bottom plan view of the embodiment of the closure of FIG. 4.

[0018] FIG. 6 is a side view in elevation of a cross section of the embodiment of the closure of FIG. 4.

[0019] FIG. 7 is a top plan view of another embodiment of the closure of this invention.

[0020] FIG. 8 is a bottom plan view of the embodiment of the closure of FIG. 7.

[0021] FIG. 9 is a side view in elevation of a cross section of the embodiment of the closure of FIG. 7.

[0022] FIG. 10 is a side view in elevation illustrating a sampling device, e.g., a pipette, inserted into the opening of the seal of the closure of FIG. 4.

[0023] FIG. 11 is a top plan view illustrating the deformation of the opening in the seal when a sampling device is inserted through the opening of the closure of FIG. 4.

[0024] FIG. 12 is a side view in elevation illustrating a sampling device, e.g., a pipette, inserted into the opening in the seal of the closure of FIG. 7.

[0025] FIG. 13 is a schematic diagram of a mold suitable for making the seal of the closure of this invention.

[0026] FIG. 14 is a schematic diagram illustrating how a sharp edge is oriented to form a precut opening in one embodiment of the seal of this invention.

[0027] FIG. 15 is a schematic diagram illustrating how a sharp edge is oriented to form a precut opening in another embodiment of the seal of this invention.

DETAILED DESCRIPTION

[0028] As used herein, the term “septum” means a thin membrane between two cavities. The expression “sampling device” means a device for removing a sample from a container. The term “adapter” means a device for fitting a seal to a container. The term “seal” means a substantially airtight or substantially watertight closure for preventing or reducing seepage of moisture or air. The term “precut” means cut in advance of first access by a sampling device.

[0029] This invention provides a closure for a container for biological samples. The closure employs a seal having an opening that allows a sampling device to obtain access to the contents of the container, but also prevents the contents from flowing through the opening when access to the contents of the container is not desired. The shape of the opening is such that the contents of the container are not exposed to the environment when the container is not in use, i.e., when a sample is not being removed from the container.

[0030] Referring now to FIGS. 1, 2, 3, 4, 5, and 6, a closure 10 for a container 12 comprises an adapter 14 and a seal 16. The function of the adapter 14 is to position the seal 16 on the portion of the container 12 that surrounds the mouth of the container 12. In a preferred embodiment, the adapter 14 is a structure having a cylindrical shape comprising a circular top 18 having a cylindrically shaped wall 20 projecting from the periphery of the top 18. The adapter 14 has an opening 22 formed through the top 16 thereof and another opening 24 at the end 26 of the adapter 14 distal from the top 16 of the adapter 14. In one embodiment, the interior surface 28 of the cylindrically shaped wall 18 of the adapter 14, i.e., the surface facing the mouth of the container 12, may comprise threads 30. By means of these threads 30, the adapter 14 can be screwed into the proximal end of a threaded container that contains a biological sample. The interior surface 28 of the cylindrically shaped wall 20 of the adapter 14 is not required to contain threads. For example, in another embodiment, the cylindrically shaped wall 20 of the adapter 14 can be constructed to fit over the proximal end of a container by means of friction only. Alternatively, in still another embodiment, the cylindrically shaped wall 20 of the adapter 14 can be constructed to fit over the proximal end of a container by means of a snap-fit ring. In addition, another type of adapter can be heat sealed to a well on a multi-well plate. It should also be noted that the adapter 14 need not be cylindrical in shape. In other words, the particular shape of the adapter 14 is not critical. However, the adapter 14 must be of such a shape and construction that it can fit over the mouth of the container 12 and maintain the seal 16 in the proper position.

[0031] The seal 16 comprises a peripheral portion 32 that surrounds an interior portion 34. The peripheral portion 32 comprises a bottom wall 36 and a side wall 38. The function of the peripheral portion 32 is to seal the contents of the container 12 from the environment when the container 12 is not being used, e.g., when being stored or transported. The interior portion 34 is designed so as to allow a sampling device to be readily guided to an opening 42 in the bottom wall 36, through which the sampling device passes to obtain

access to the contents of the container 12. It is preferred that the seal 16 be frusto-conical in shape. However, other shapes for the seal 16 are also suitable, e.g., cylindrical. The shape of the seal 16 should be selected so that when the seal 16 is cooled, the contraction of the material of the seal 16 will allow the opening 42 in the seal 16 to close rather than to open. When the opening 42 is closed, evaporation of the contents of the container is prevented and freezer-burn of the contents of the container is reduced. The seal 16 typically undergoes cooling when the container 12 is being stored. The peripheral portion 32 is properly positioned with respect to the top 18 of the adapter 14 and the mouth of the container 12 by means of a flange 44. The flange 44 is in close proximity to the interior surface 46 of the top 18 of the adapter 14 and is in contact with the rim 48 of the container 12.

[0032] The preferred shape of the opening 42 in the seal 16 can be characterized as an elongated slit, which, as stated previously, can be formed in the bottom wall 36 of the seal 16. See FIGS. 4, 5, and 6. In an alternative embodiment, an opening 42a can be formed in the side wall 38 of the seal 16 at a position near the bottom wall 36. See FIGS. 7, 8, and 9. In any embodiment, it is preferred that the opening 42 or 42a be formed so that a sampling device can be guided vertically, i.e., parallel to the side walls of a container having the shape of the container 12 of FIG. 1.

[0033] The opening 42 is preferably formed in such a manner that the edges of the opening 42 are relatively smooth. Smooth edges will allow the seal 16 to be effective upon resealing even if the edges are slightly misaligned. If the edges are not smooth but jagged (as when the opening is created by a puncturing device), the alignment must be perfect in order for the seal 16 to be adequate upon resealing. The jagged edges of an opening formed by a puncturing device will not come together perfectly upon removal of the puncturing device, and, consequently, some openings in the seal will remain, thereby allowing seepage of the contents from the container. The same features described for the opening 42 are also preferred for the opening 42a.

[0034] Referring now to FIGS. 6 and 10, the closure 10 in FIG. 6 is shown as being closed, with no sampling device entering through the opening 42. The closure 10 in FIG. 10 is shown with a sampling device 50 positioned through the opening 42. The opening 42 allows the sampling device 50 to easily pass through the closure 10 to obtain access to the contents of the container 12; the opening 42 also allows the sampling device 50 to be easily withdrawn from the closure 10. It is preferred that the length of the opening 42 be greater than approximately 1.6 times the diameter of the sampling device 50. FIG. 11 shows how the seal 16 appears when the sampling device 50 is inserted into the opening 42.

[0035] Referring now to FIGS. 9 and 12, the closure 10 in FIG. 9 is shown as being closed, with no sampling device entering through the opening 42a. The closure 10 in FIG. 12 is shown with a sampling device 50 positioned through the opening 42a. The opening 42a allows the sampling device 50 to easily pass through the closure 10 to obtain access to the contents of the container 12; the opening 42a also allows the sampling device 50 to be easily withdrawn from the closure 10. It is preferred that the length of the opening 42a be sufficient to allow the sampling device 50 to displace the

bottom wall 36 of the seal 16 a sufficient distance to make it possible for the sampling device 50 to obtain access to the contents of the container 12.

[0036] It is preferred that a cover 52 be inserted between the major interior surface 46 of the top 18 of the adapter 14 and the flange 44 of the seal 16. The purpose of the cover 52 is to prevent biological samples from being lost or otherwise adversely affected during transport. Because the sample is normally transported from a clinical site, the container, typically a tube, may assume any possible orientation during shipping (vertical, horizontal, inverted, etc.). Moreover, the container may experience changes in temperature, including changes of a magnitude sufficient to induce thawing. Samples are normally transported in a frozen condition, e.g., the container is typically packed in dry ice. The cover 52 is a rupturable, preferably non-stretching, membrane, rendered impervious to vapor by being coated with a hydrophobic material, such as, for example, a release agent. Release agents are described in *Encyclopedia of Polymer Science and Engineering*, 2nd Edition, Vol. 14, John Wiley & Sons, Inc. (1988), pages 411-420, incorporated herein by reference. The cover 52 can compensate for the potential failure of the seal 16 (e.g., the potential failure of the seal 16 to prevent a liquid from a partially thawed sample from leaking or seeping from an inverted tube or partially inverted tube, etc.). The cover 52 is preferably made of such a material that it can be ruptured easily by means of a sampling device. Suitable materials for forming the cover 52 include, but are not limited to, thin metallic foils (e.g., aluminum foil) and thin polymeric sheets (e.g., regenerated cellulose). The particular thickness of the cover 52 can be selected by one having ordinary skill in the art. In addition to substantially eliminating evaporation and leakage of a thawed or partially thawed sample, the cover 52 also provides evidence of physical integrity of the sample prior to analysis. The cover 52 is positioned at a sufficient distance from the opening 42 or 42a, so that residual fragments of material from the cover 52 are prevented from being drawn into the opening 42 or the opening 42a and interfering with the seal.

[0037] The cover 52 is preferably adhered to the major interior surface 46 of the top 18 of the adapter 14 by means of an adhesive or by means of friction between the cover 52 and the major interior surface 46 of the top 18 of the adapter 14. The major surfaces of the cover 52 are preferably circular in shape in order to conform to the shape of the container 12 and the adapter 14, both of which are typically cylindrical in shape. The areas of the major surfaces of the cover 52 can be slightly less than, equal to, or slightly greater than the area of the major interior surface 46 of the top 18 of the adapter 14. If the area of the major surface of the cover 52 is slightly less than or equal to the area of the major interior surface 46 of the top 18 of the adapter 14, the cover 52 is preferably adhered to the major interior surface 46 of the top 18 of the adapter 14 by means of an adhesive. If the area of the major surface of the cover 52 is greater than the area of the major interior surface 46 of the top 18 of the adapter 14, the cover 52 can be adhered to the major interior surface 46 of the top 18 of the adapter 14 by means of a friction fitting, or by an adhesive. The cover 52 may be inserted into the adapter 14 alone or the cover 52 may be inserted into the adapter 14 along with the seal 16. When the area of the cover 52 exceeds the area of the major interior surface 46 of the top 18 of the adapter 14, the cover 52 is preferably adhered to the adapter 14 by means of a friction

fitting, the peripheral edge of the cover 52 deforming around the flange 44 of the seal 16, whereby the cover 52 is prevented from being pulled out of the container 12 upon removal of the sampling device 50. The cover 52 may be designed to have varying thickness over its major surface, such that only that portion of the cover 52 in register with the opening 42 is easily rupturable. Because the cover 52 is made of a material that does not stretch easily, the advancing tip of the sampling device is capable of rupturing the cover 52. After being ruptured, the cover 52 will continue to be held in position by the seal 16 and the adapter 14. The adapter 14 may contain a circular ridge 54 to aid in holding the cover 52 in place.

[0038] The cover 52 can be made of an easily rupturable material having little elasticity, such as, for example, oriented or porous polypropylene. If the cover 52 is made of a porous material, in order to provide enhanced rupturability, it is preferably coated with an inert oil, e.g., mineral oil or perfluorinated hydrocarbon oil, to provide a barrier to prevent gas diffusion. The cover is preferably not wettable by water (or serum or urine). Perfluorinated hydrocarbon oil is preferred, because it is a poor solvent for drug substances.

[0039] While the dimensions of the components of the closure of this invention are not critical, typical dimensions are being provided to illustrate the size of a typical closure. For use with a test tube having a diameter of about 11 mm, a cylindrical adapter 14 has an outside diameter of 12.7 mm ($\frac{1}{2}$ inch), an inside diameter of 8 mm ($\frac{5}{16}$ inch), and a wall thickness of 2.4 mm ($\frac{3}{32}$ inch). The height of the side wall 16 of the adapter 14 is 19 mm ($\frac{3}{4}$ inch). A sampling device that can be used with the foregoing adapter 14 has a diameter of 3.9 mm (0.155 inch).

[0040] A frusto-conical seal 16 has a height of 6.4 mm ($\frac{1}{4}$ inch). The larger base, i.e., the base that is adjacent to the top 18 of the adapter 14 has an inside diameter of 7.9 mm (0.31 inch). The smaller base, i.e., the base in which or near which the opening 42 is formed, has an inside diameter of less than 7.9 mm, but the precise diameter is influenced by the size of the sampling device expected to be used. The diameter of the smaller base must be of sufficient size to accommodate the sampling device. The thickness of the bottom wall 36 and the thickness of the side wall 38 vary from about 0.4 mm (0.015 inch) to about 1 mm (0.04 inch). The diameter of the tip of the sampling device is preferably less than approximately 0.6 times the length of the opening 42 in the seal 16.

[0041] A small quantity of sealing aid or lubricant, such as, for example, hydrocarbons, mineral oil, silicones, fluorinated hydrocarbons, can be used to coat the opening 42 to reduce evaporation of the sample through the opening 42 during storage or transport of the sample. See, for example, *Encyclopedia of Polymer Science and Engineering*, 2nd Edition, Vol.14, John Wiley & Sons, Inc. (1988), pages 411-420. It is preferred that the sealing aid or lubricant be capable of avoiding crystallization at temperatures ranging from about -20° to about -70° C. In addition, it is preferred that the sealing aid or lubricant be compatible with the material of the seal 16, be insoluble in water, and not be capable of dissolving analytes in the sample. The use of a sealing aid or lubricant is optional.

[0042] The seal 16 and the adapter 14 can be formed separately. The adapter 14 can be prepared by one of ordinary skill in the art of injection molding. See, for

example, *Encyclopedia of Polymer Science and Engineering*, 2nd Edition, Vol. 8, John Wiley & Sons, Inc. (1987), pages 102-137, incorporated herein by reference. Adapters suitable for this invention are commercially available, but can be made to special order, particularly if the adapter 14 is to contain a circular ridge 54 to aid in holding the cover 52 in place. A representative example of a polymeric material suitable for preparing the adapter is polypropylene.

[0043] It is preferred to form the seal 16 by means of a molding process. FIG. 13 show a mold 60 onto which the material needed to form the seal 16 is cast. The seal 16 can be made of a flexible material that retains some flexibility at temperatures of ranging from about -20° C. to about -70° C., the typical temperature for storing samples. Suitable materials for preparing the seal include, but are not limited to, natural rubber (retains flexibility down to a temperature of about -60° C.); styrene-butadiene rubber (retains flexibility down to a temperature of about -50° C.); polyisoprene (retains flexibility down to a temperature of about -55° C.); silicone rubber (retains flexibility down to a temperature of about -80° C.); fluorosilicone rubber (retains flexibility down to a temperature of about -60° C.); ethylene propylene rubber (retains flexibility down to a temperature of about -60° C.). It is preferred that the material of the seal 16 have a heat expansion coefficient lower than that of the container, which is typically a polypropylene tube. Molding processes are well known to those of ordinary skill in the art of molding flexible, polymeric materials. See, for example, *Encyclopedia of Polymer Science and Engineering*, 2nd Edition, Vol. 8, John Wiley & Sons, Inc. (1987), pages 102-137.

[0044] Referring now to FIGS. 13, 14, and 15, the mold 60 comprises three components 62, 64, and 66. Two components 62 and 64 are used to form the portion of the seal 16 that is to face the top 18 of the adapter 14. One component 66 is used to form the portion of the seal 16 that is to face the contents of the container 12. After the material that forms the seal 16 is cured, gas will be introduced into a passageway 68 in the component 66 to separate the seal 16 from the component 66. To form the opening 42 in the bottom wall 36 of the seal 16, a slit can be cut by subjected a sharp edge 68 to sufficient pressure after the component 66 is separated from the seal 16. See FIG. 14. Then, the cut seal 16 is removed from the assembly of components 62 and 64. To form an opening 42a in the side wall 38 of the seal 16 is more difficult. In order to form an opening in the side wall 38 of the seal 16, the seal 16 is retracted slightly from the assembly of components 62 and 64 to allow a cutting blade to form the opening 42a in the side wall 38 of the seal 16. Then the opening 42a in the side wall 38 of the seal 16 is cut by a sharp edge 70. See FIG. 15. Then, the cut seal 16 is removed from the assembly of components 62 and 64. The opening in the bottom wall 36 is preferred because it will bind the sampling device 50 less when the sampling device is removed from the opening 42 in the seal 16.

OPERATION

[0045] In order to use the closure 10 of this invention, the cover 52 is inserted into the adapter 14 so as to contact the major interior surface 46 of the top 18 thereof. The seal 16 is then inserted into the adapter 14 so that the cover 52 is between the flange 44 of the seal 16 and the major interior surface 46 of the top 18 of the adapter 14. The assembly is

screwed onto or fitted onto a container 12 containing a biological sample by means of the adapter 14. During shipment, the biological sample will be sealed in the container 12, and little, if any, of the sample will seep out of, leak out of, or evaporate from the container. In order to obtain access to the biological sample in the container, a sampling device 50, such as, for example, a pipette, is inserted through the opening 22 in the top 18 of the adapter 14 with sufficient force to rupture the cover 52 and penetrate the opening 42 in the seal 16. The biological sample or a portion thereof can be withdrawn by means of the sampling device 50. The sampling device 50 can subsequently be withdrawn from the container 12. Because of the nature of the opening 42, the seal 16 securely seals the container 12. Of course, there may be some seepage, leakage, or evaporation, but much less than in the case of resealable containers that must be capped and uncapped repeatedly.

[0046] If the opening 42a is on the side wall 38 of the seal 16, the sampling device depresses the bottom wall 36 to allow the sampling device to obtain access to the contents of the container 12.

[0047] Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention, and it should be understood that this invention is not to be unduly limited to the illustrative embodiments set forth herein.

What is claimed is:

1. A closure for a container, said closure comprising an adapter and a seal, said seal comprising a peripheral portion surrounding an interior portion, said peripheral portion comprising a side wall and a bottom wall, wherein one of said side wall or said bottom wall has an opening formed therein, said opening allowing insertion of a sampling device therethrough and retraction of said sampling device therefrom.

2. The closure of claim 1, wherein said adapter comprises a top having an opening formed through said top and a wall projecting from said top, said adapter having another opening at the end of said adapter distal from said top of said adapter.

3. The closure of claim 2, wherein said adapter is a structure having a cylindrical shape comprising a circular top having a cylindrically shaped wall projecting from the periphery of said circular top, said adapter having an opening formed through said circular top thereof and another opening at the end of said adapter distal from said circular top of said adapter.

4. The closure of claim 2, wherein said adapter has a cover attached thereto, said cover being a rupturable membrane covering said opening in said top of said adapter.

5. The closure of claim 4, wherein the cover is placed between said top of said adapter and said peripheral portion of said seal.

6. The closure of claim 1, wherein said side wall of said seal is adjacent to said adapter.

7. The closure of claim 1, wherein said opening formed in said bottom wall or in said side wall of said seal is an elongated slit.

8. The closure of claim 7, wherein said elongated slit has a length at least 0.6 times the diameter of said sampling device.

9. The closure of claim 1, wherein a lubricant is applied over said opening in said bottom wall or in said side wall of said seal.

10. An assembly comprising a container and the closure of claim 1.

11. A seal comprising a peripheral portion surrounding an interior portion, said peripheral portion comprising a side wall and a bottom wall, wherein one of said side wall or said bottom wall has an opening formed therein, said opening allowing insertion of a sampling device therethrough and retraction of said sampling device therefrom.

12. The seal of claim 11, wherein said opening is an elongated slit.

13. The seal of claim 12, wherein said elongated slit has a length at least 0.6 times the diameter of said sampling device.

14. The seal of claim 11, wherein a lubricant is applied over said opening of said seal.

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