May 4, 1965 E. H. WILBURN 3,181,529

VALVED BODY-FLUID SAMPLING TUBES

Filed July 30, 1962 4 Sheets-Sheet 1

FIG. 1

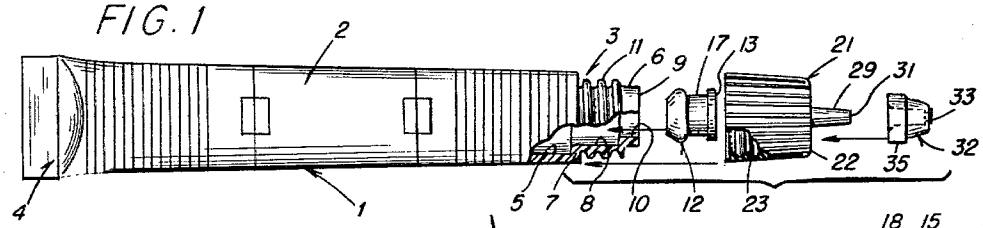


FIG. 2

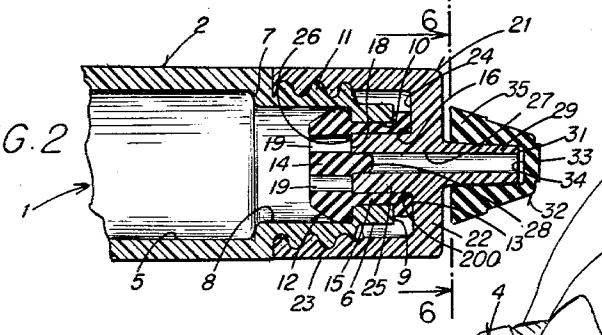
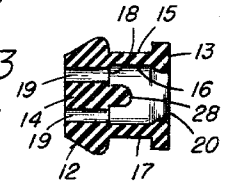


FIG. 3



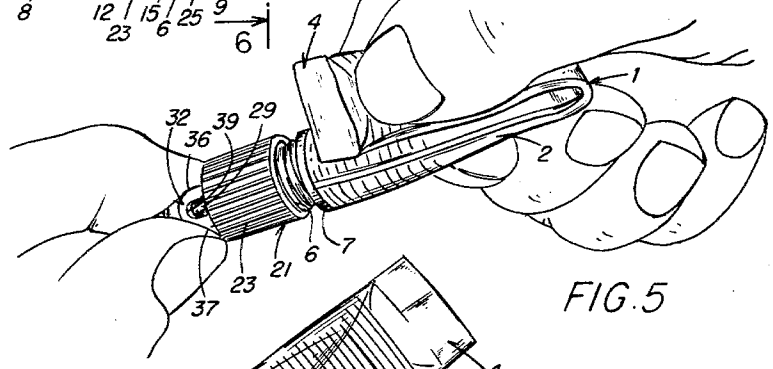


FIG. 5

FIG. 4

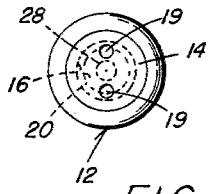
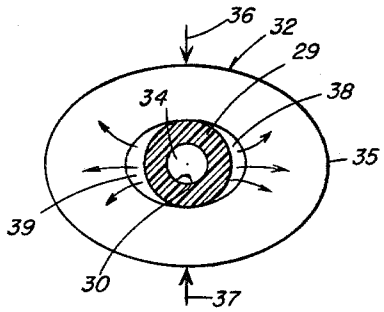


FIG. 7

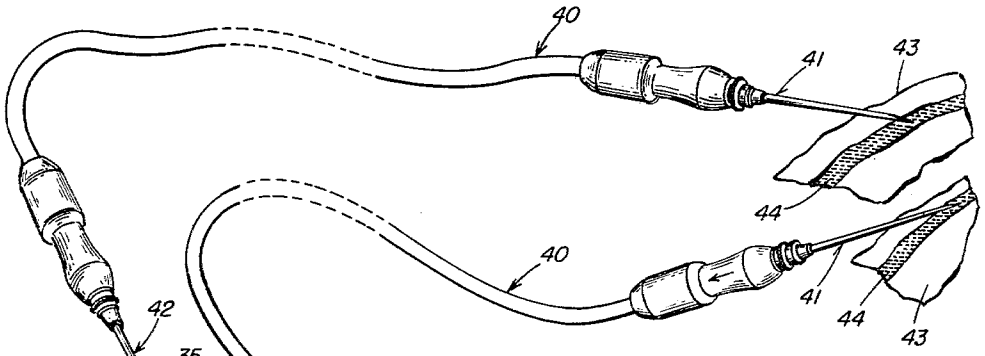
FIG. 6



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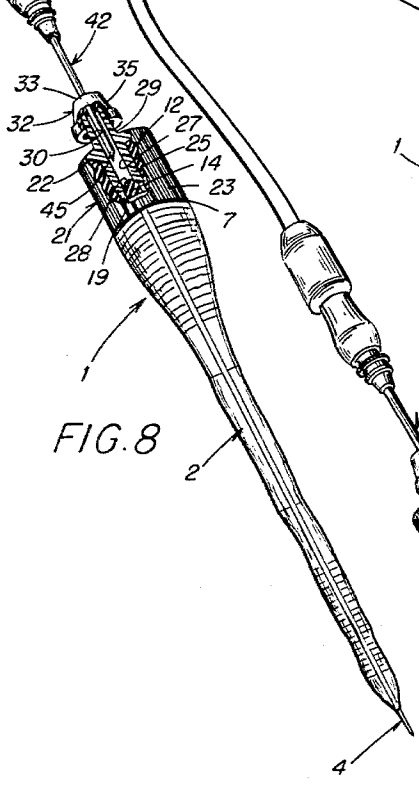


FIG. 8

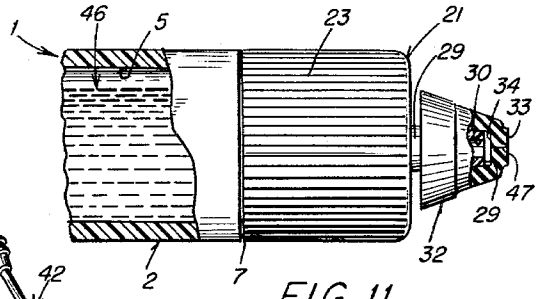


FIG. 11

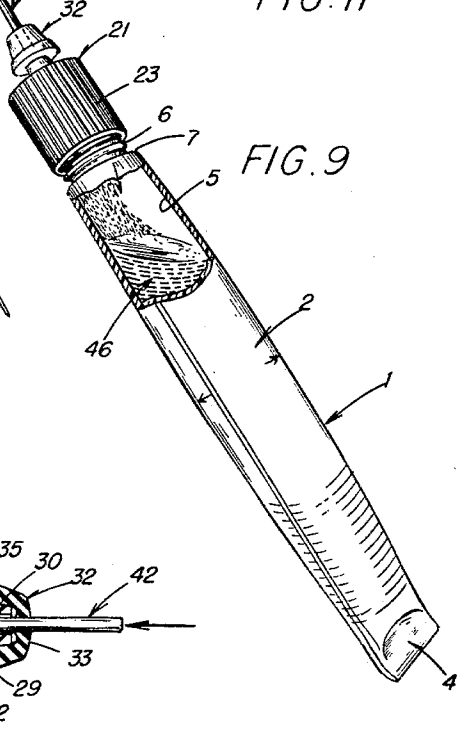
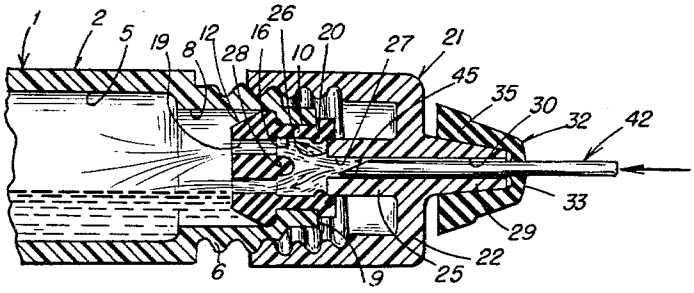


FIG. 9

FIG. 10



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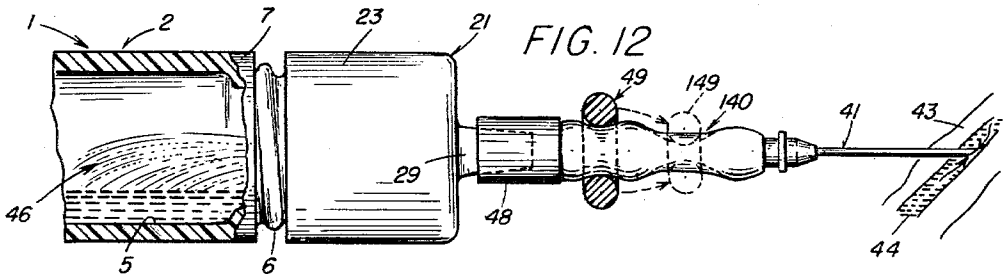


FIG. 12

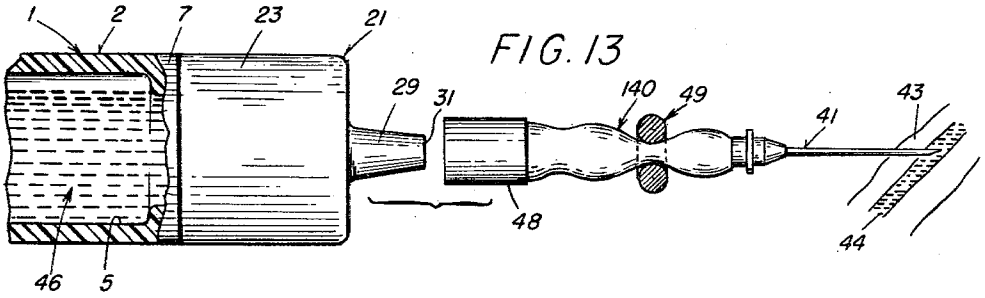


FIG. 13

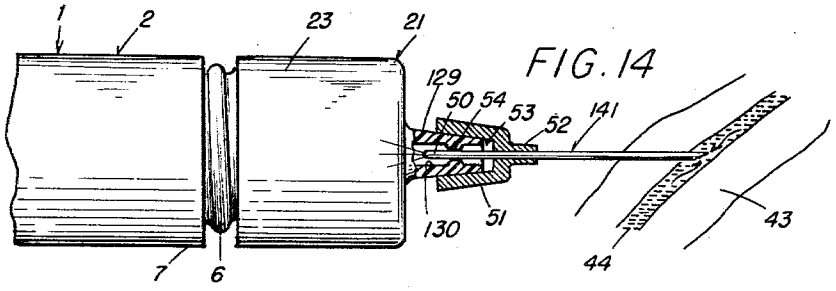


FIG. 14

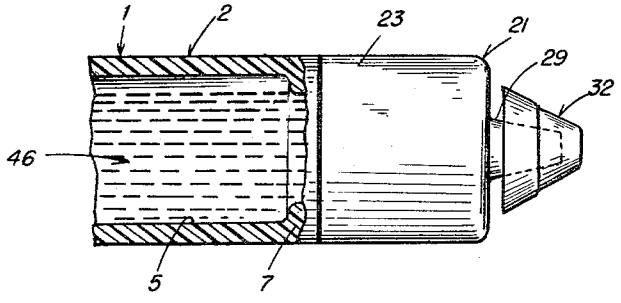


FIG. 15

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FIG. 16

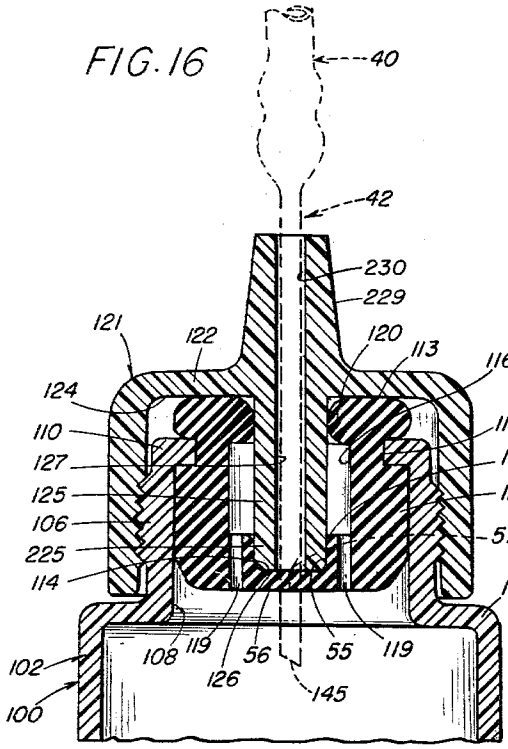
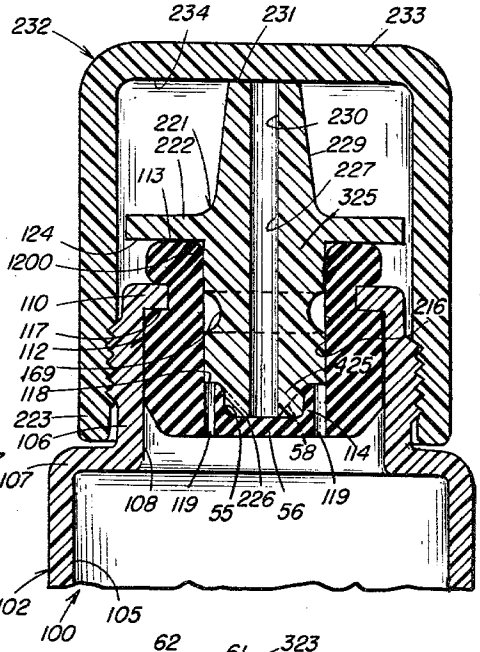


FIG. 17



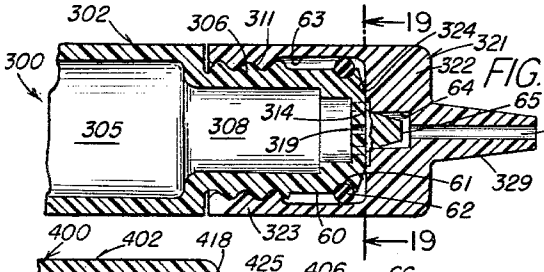


FIG. 18

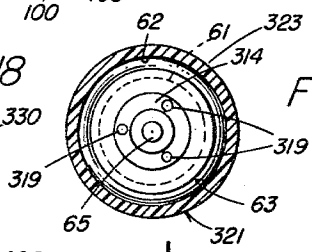


FIG. 19

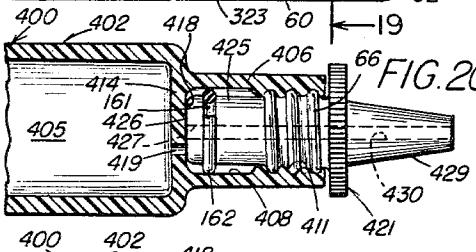


FIG. 20

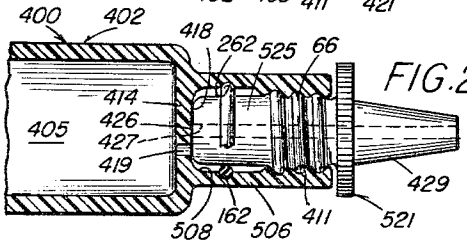


FIG. 21

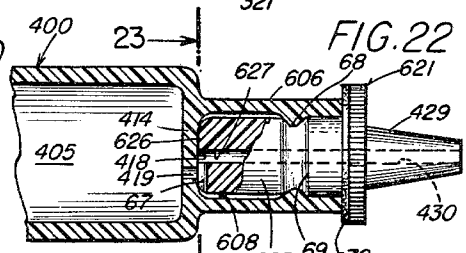


FIG. 22

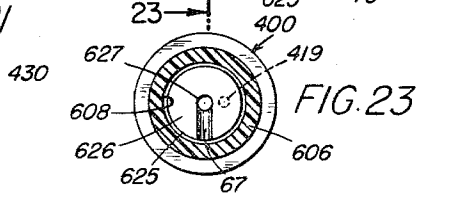


FIG. 23

United States Patent Office 3,181,529 Patented May 4, 1965

3,181,529

VALVED BODY-FLUID SAMPLING TUBES

Edgar H. Wilburn, Rutherford, N.J.
(Box 166, Highland Lakes, N.J.)

Filed July 30, 1962, Ser. No. 213,487
6 Claims. (Cl. 128—2)

The present invention relates to suction containers for taking samples of body fluids, such as blood, and is an improvement upon the plastic sampling tubes of the type disclosed in the United States Lockhart Patent No. 2,727,516 of December 20, 1955, for Medical Sampling Devices and Specimen Containers, as well as upon blood sampling evacuated glass tubes of conventional construction some of which are marketed as "Vacutainers."

It has been recognized that it is desirable that manipulations of such devices by an operator, such as a doctor or nurse, preparatory to taking samples of body fluids therewith, be simplified. This is particularly true with respect to the identified plastic tube type which require collapsing of the tube (which may involve folding it) to expel the sterilized air from its chamber for converting the latter to a suction chamber upon release of the tube. If the collapsed tube must be held collapsed or folded to maintain its chamber evacuated until its inlet or suction passage is equipped with a sampling needle and then the latter is thrust to communication of a patient's vein or fluid pocket in his body, or while the sampling tube is connected by the operator to such a needle which has remained in the patient's flesh in communication with a vein or such pocket, these required manipulations may be difficult or annoying to either the operator or the patient as well as dangerous. Thus, while for various reasons familiar to those who take such samples the collapsible plastic sampling tubes may be desired as offering certain advantages over previously evacuated and sealed glass sampling tubes, many hospitals and operators prefer the latter because they make the taking of the samples a simpler procedure. The present invention developed from a realization that the sampling procedure with such plastic sampling tubes could be simplified by equipping the tubes with closures having manipulative valves.

Many problems were encountered in the development of suitable valving structure and equipping such plastic tubes therewith. Leakage of air to the suction chamber in all positions of the valve had to be avoided. Also, the valve-equipped sampling tube had to be adapted to prevailing practices in the treatment and care of patients and the taking of one or successive samples of body fluids, such as blood, from them which may require association with or connection to equipment designed for other purposes, such as intravenous feeding or blood donor sets. Avoidance of contamination of withdrawn samples had to be assured to the complete satisfaction of all concerned. And the structure had to be versatile for ready adaptation to various habits of operators and differing requirements of hospitals and doctors. These and other problems are solved in efficient and acceptable manners by devices of the present invention.

Another object of the present invention is to provide various forms of the valved closures of the evacuated sampling tubes which embody fluid-tight sealing means effective in all mounted positions of the valves effectively to isolate the suction chambers from the ambient atmosphere.

A further object of the invention is to provide valving closures in forms readily mountable to such collapsible plastic or rigid evacuated tubes when each is provided with an open end equipped in a ready manner with simple closure engaging means.

Still another object of the invention is to provide forms

of the device which permit ready addition thereto of easily manipulative and protective supplemental external valving means.

An additional object of the invention is the provision of embodiments which permit ready communication to their suction chambers of sampling tubing by means of cannulas either connectable to the manipulative valves thereof or by thrust through the valved closures.

A still further object of the invention is to provide structural embodiments which are readily constructed and permit efficient use and operation.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is an exploded side elevational view, with parts broken away and in section, of an embodiment of the valved body-fluid sampling tube of the present invention, to about normal scale;

FIG. 2 is an enlarged axial section of the valved closure-equipped end of the sampling tube shown in FIG. 1, with parts broken away;

FIG. 3 is an axial section of an elastic valve seat unit or cup shown in FIG. 2, illustrating the relaxed condition thereof before mounting;

FIG. 4 is an inner or bottom end view of the valve body or cup shown in FIG. 3;

FIG. 5 is a perspective view graphically illustrating manipulative collapse of the sampling tube shown in FIG. 1 and the attendant expulsion of the gaseous fluid or sterilized air in its chamber;

FIG. 6 is an enlarged sectional view taken substantially on line 6—6 of FIG. 2, illustrating a valving action shown in FIG. 5 which permits expulsion of the contained gaseous fluid;

FIG. 7 is a perspective view of the body-fluid sampling tube illustrated in FIG. 5 after collapse thereof for substantial evacuation of its chamber and closing of its valves, readied for the taking of a sample of body fluid by suction to be performed by the collapsed chamber;

FIG. 8 is another perspective view of the collapsed body-fluid sampling tube illustrated in FIG. 7, with parts of the closure structure broken away and in section, depicting connection thereof to a patient's vein, by conventional suction tubing of a blood donor set, with the valved closure in its valve-closing position;

FIG. 9 is another perspective view of the structure shown in FIG. 8, with parts broken away and in section, showing the valved closure manipulated to valve-open position and showing, as a consequence, a sample of blood being sucked into the chamber;

FIG. 10 is an enlarged axial sectional of the closure end of the sampling tube shown in FIG. 9, similar to FIG. 2, and illustrating the action of taking a blood sample therewith;

FIG. 11 is an enlarged side view, with parts broken away and in section, of the same closure end of the sampling tube illustrated in FIG. 10, showing the parts in valve-closed positions after the completion of the taking of the blood sample and the attendant disconnection of the suction tubing;

FIG. 12 is an enlarged side view of the closure end of the blood sampling tube illustrated in FIGS. 10 and 11, with parts broken away and in section, illustrating the

taking of a blood sample with different suction tubing equipment;

FIG. 13 is a view similar to FIG. 12, illustrating the closure in its valve-closed position with the suction tubing separated therefrom;

FIG. 14 is a view similar to FIG. 12, but with chamber container parts shown only in side elevation and a closure neck in axial section connected to a different type of sample taking equipment;

FIG. 15 is a view of the closure end of the sampling tube as illustrated in FIG. 13 showing the mount of a protective cover cap on the tip end of the closure stem;

FIG. 16 is an enlarged sectional view of the head end of a sampling tube similar to that illustrated in FIGS. 1 to 15 incl., with parts broken away, illustrating another embodiment of the valving equipment thereof and depicting in dotted lines another method of communicating the suction chamber with suction tubing;

FIG. 17 is a sectional view with parts broken away, of a variation of the closure and valving structure of FIG. 16;

FIG. 18 is a sectional view, with parts broken away, of the head end of another embodiment of the collapsible sampling tubes illustrated in FIGS. 1 to 17 incl.;

FIG. 19 is a sectional view taken substantially on line 19—19 of FIG. 18;

FIG. 20 is an axial section of the head end of a modified form of the collapsible sampling tube illustrated in FIG. 2, showing in side elevation a different type of valving closure associated therewith;

FIG. 21 is a view similar to FIG. 20, with parts broken away, showing a modified form of the valving closure thereof;

FIG. 22 is a sectional view similar to FIG. 20 of a further modification of the valving closure and head end of the collapsible sampling tube, showing parts of the closure broken away and in section and illustrating it in valve-open position; and

FIG. 23 is a sectional view taken substantially on line 23—23 of FIG. 22 and showing valve parts in their valve-closed positions.

Referring to the drawings, in which like numerals identify similar parts throughout, it will be seen that the illustrated embodiments of the present body-fluid sampling tube invention comprise, in combination, the following associated elements and parts. These include a receptacle having a suction chamber and a tubular end defining an inlet passage communicating with the chamber. A closure is rotatably mounted to this tubular end and has a through passage for supply of body-fluid, such as blood, to the inlet passage. The closure includes a valve which has a ported valve seat carried by either the tubular end of the suction chamber or the closure, and a cooperating movable valve element is carried by the other of these two parts with the valve element cooperatively engaging the valve seat in a flow blocking relation in one rotational position of the closure. In another rotational position of the closure the valve element is located in flow permitting relation with respect to the valve seat. Fluid-tight sealing means are interposed between the tubular end of the receptacle and the closure rotatably mounted thereto, with this fluid-tight sealing means located at a point outward of the valve. The interposed fluid-tight sealing means includes interengaging structure maintained in fluid-tight engagement in all mounted positions of the closure so as to prevent leakage of external atmosphere inward thereof in open and closed positions of the valve while permitting free rotation of the closure relative to the tubular end of the receptacle.

It will be seen from FIGS. 1 to 15 incl. that an embodiment of the present invention may be in the form of a flexible, elastic collapsible tube or tubular receptacle 1, preferably formed of light-transmitting material to allow a person readily to see into the chamber thereof, such as a polyethylene composition. The elastic plastic collapsible tube 1 of the present invention preferably is molded from substantially transparent polythene with its back end open. The collapsible plastic tube 1 preferably is provided with a substantially cylindrical, flexible, elastic side wall section 2 provided with a head end 3, preferably molded integral therewith, and with its initially open back end 4 closed by pinching and sealing the opposite sides together, so as to form a collapsible receptacle or container having a closed internal chamber 5.

The head end 3 is in the form of a tubular end which is preferably provided as an integral, externally-threaded, tubular neck 6 connected to the container proper by an annular shoulder 7 and having a through bore 8 serving as an inlet passage communicating with the suction chamber 5. The tubular neck 6 terminates in a circular lip 9 with the neck bore 8 equipped with an annular, internal, constricting bead 10. The external threading of the neck 6 may, if desired, be limited to the root section thereof, such as is illustrated by threads 11.

The head end 3 of the container or receptacle 1 of the FIGS. 1 to 15 incl. embodiment is provided with valving mechanism which includes an elastic cylindrical cup 12 having an annular lip 13 at its outer end and, as will be best understood from FIGS. 2 and 3, a closing transverse wall 14 at its inner end and an intervening side wall 15 together defining a cylindrical well 16. The side wall 15 of the valve body or cup 12 is provided externally with an annular groove 17. The valve body 12 may be molded from any suitable elastic material, such as natural or synthetic rubber, and thus it may be inserted or forced snugly into the neck bore 8 to the position illustrated in FIG. 2 with the annular internal neck bead 10 snapped into the annular groove 17 and with the cup lip 13 lapping over the transverse neck lip 9. The closing transverse wall 14 at the inner end of the valve cup 12 has an outward side or face 18 within the well 16 which defines a valve seat, and a plurality of porting openings 19, such as a diametrically located pair thereof, extend through this transverse bottom wall. Thus, the interior of the well 16 is communicated with the neck bore 8 and by way of the latter with the suction chamber 5 through the valve ports 19. The side wall 15 of the well 16 is provided with a portion of fluid-tight sealing means, which may be in the form of an internal, annular, elastic bead 20, that may be located at the mouth of the well and formed as an integral part of the cup 12, as will be best seen in FIG. 3.

A closure 21 is provided in the FIGS. 1 to 15 incl. embodiment which is in the form of a cap having a transverse end wall 22 and an internally-threaded skirt 23 depending therefrom and threadably engaged on the externally threaded neck 6. The inside transverse face 24 can be snugly engaged against the outer transverse end 13 of the valve cup 12 when the closure cap 21 is threaded to an inward position, illustrated in FIG. 2, so as to provide a gasketing seal therebetween.

The closure or cap 21 is provided with an inwardly-extending extension 25, preferably in the form of a tubular stem, coaxially arranged in the skirt 23 and depending from the end wall 24 of the latter. As will be seen from FIG. 2, the inner end 26 of the tubular stem 25 engages or makes valve-closing contact with the outward side 18 of the transverse end wall 14 of the valve cup 12 in an annular zone to bridge over and close the mouths of the porting openings 19, so that this outward face of the transverse bottom wall of the cup serves as a valve seat and the inner end of this tubular stem serves as the cooperating valve element abutted together in fluid-tight engagement when the closure cap 21 is in its inward valve-closing position illustrated in FIG. 2. The threaded engagement of the closure cap skirt 23 upon the externally-threaded container neck 6 permits relative rotation and accompanying axial translation of the former relative to the latter between the inward valve-closing

position illustrated in FIG. 2 and an outer valve-open position, such as that illustrated in FIG. 10.

The tubular valve stem 25 has a longitudinal bore 27 extending through the cap end wall 22 to serve as a flow passage for supply of body fluid therethrough to the suction chamber 5, with the inner end of this bore being closed in the valve-closing position by an outwardly-extending, elastic nib 28 made integral with the transverse end wall 14 of the valve cup 12 and coaxially arranged on the outward face 18 thereof. For this purpose, the root of the elastic nib 28 preferably is of an O.D. slightly larger than the I.D. of the valve stem bore 27 so as to be jammed therein in fluid-tight manner, with its outer end being tapered or rounded to facilitate lead of the nib into the stem bore. Consequently, inner valve structure of the closure described may embody a valve in the form of ported seat 18 in the valve cup 12 and a cooperating valve element 26 in the form of the inner end of the closure-carried tubular stem 25, as well as a supplemental valve including a seat in the form of an annular zone of the cylindrical wall of the stem bore 27 at the inner end of this tubular stem and a cooperating valve element in the form of elastic nib 28 inserted therein. Thus, the first valve has its seat carried by the valve cup 12 and the cooperating valve element is carried by the closure 21 while conversely the second valve has its seat provided on the closure and its cooperating valve element carried by the valve cup.

The tubular stem 25 which is carried by the closure cap 21 has an outer diameter about equal to or slightly larger than the internal diameter of the well 16 of the valve cup 12 when the latter is in relaxed condition, as is illustrated in FIG. 3. Thus, since the constricted bead 20 at the mouth of the valve cup well 16 is of appreciably less internal diameter the elastic material of the latter is compressed by insertion of the tubular stem 25 therethrough, as is illustrated at 200 in FIG. 2, there to form a secure fluid-tight seal between this tubular stem and the valve cup. The compressed elastic bead 20 has wiping engagement with the external cylindrical surface of the tubular stem 25 in all positions of the closure cap 21 relative to the container neck 6, as will be understood from a comparison of FIGS. 2 and 10. This wiping engagement between the compressed elastic bead 20 and the tubular stem 25 at and between the inward valve-closing position of the closure 21 illustrated in FIG. 2 and the outer valve-open position thereof illustrated in FIG. 10 prevents leakage of the surrounding atmosphere or air to the suction chamber 5 when the latter is under evacuated conditions. While technically these valves may be considered separate and distinct they may be interpreted due to their proximity and locations on the opposed bottom 14 of the valve cup 12 and the inner end 26 of tubular stem 25 carried by the closure 21 to constitute an inner or master control valve structure.

The closure cap structure 21 may be molded from plastic material similar to that employed in the molding of the container or receptacle 1 and thus parts thereof may have a degree of flexibility and elasticity. However, the tubular valve stem 25 will have sufficient rigidity with respect to the valve seat structure, i.e., the bottom transverse wall 14 of the cup 12 and its central nib 28, as to provide the desired valving and fluid sealing action. It is to be understood that the closure cap structure 21 may be molded from plastic material of substantial rigidity, such as polystyrene.

The closure cap 21 has its transverse top wall 22 provided coaxially with an outwardly-extending, tubular neck 29 having a through bore 30 communicated with and preferably aligned with the bore 27 of the tubular stem 25, so that these communicated bores serve as a flow passage extending through the closure. Preferably the tubular neck 29 of the closure cap 21 is externally tapered to permit it to be jammed with a tight fit into the sockets of cooperating parts, such as connecting elements of body-fluid feed or suction tubing, suitable cap structure or a socketing hub of a cannula, as will be more fully explained hereinafter. The tubular neck 29 of the closure 21 has a tip end 31 which may be best seen from FIGS. 1 and 13.

A supplemental outer valve may be provided as a cover cap 32 of elastic material, which may be molded from any suitable elastic material, such as natural or synthetic rubber. The cover cap 32 has a needle-pierceable end wall 33 defined on the inner side by a face 34 opposed to and spaced from the tip 31 of the tubular neck 29 to provide an intervening space. The cap 32 includes an annular skirt 35 which is snugly engaged about the tapered tubular neck 29 so as securely to close the neck bore 30. As will be best understood from FIG. 6, if the cover cap skirt 35 be compressed or pinched on diametrically opposite sides, such as at opposed points 36 and 37, as by gripping between one's finger and thumb as is illustrated in FIG. 5, the cover cap skirt may be distorted to provide at diametrically located intervening or quarter points longitudinally-extending flow channels 38 and 39 (see FIG. 6) communicating the space between the inner face 34 and the tip 31 of the tubular neck 29 with the atmosphere. Thus, the outer closed valve is provided by the elastic cap 32 and the tubular neck 29 over which it is jammed, as is illustrated in FIG. 2, this valve being openable by pinching the cap in the manners illustrated in FIGS. 5 and 6, by distortion of the cap skirt 35 when pinched at diametrically opposite sides to form the intervening flow passages 38 and 39 between the neck and the skirt as an outlet for the closure through passage constituted by communicated bores 27 and 30.

In typical operation of the embodiment of the body-fluid sampling tube illustrated in FIGS. 1 to 15 incl. let it be assumed that it is to be employed for the taking of a sample of the blood of a patient. The sampling tube 1 will have its chamber 5 collapsed, such as in the manner illustrated in FIG. 5, with the inner or master control valve open as is attained by rotary retraction of the closure cap 21 to the valve-open position illustrated therein and in FIG. 10. Gaseous fluid, such as sterile air, contained in the chamber 5 will be expelled out through the tubular neck 29 and past the cover cap 32 by way of the relief channels 38 and 39 by the pinching procedure illustrated in FIG. 5. The operator will then release his grip upon the cover cap 32 so as to close the outer valve, thereby blocking the flow passage extending through the closure cap 21. The operator will then screw the closure cap 21 inward to the valve-closing position of FIG. 2. When the receptacle or container 1 is released the recovery characteristic of the plastic material employed in the formation of its walls 2 will cause it to straighten out with the side walls of the chamber 5 collapsed, to produce the prepared substantially evacuated sampling tube illustrated in FIGS. 7 and 8. This preparatory evacuating operation may be performed an appreciable time before the collapsed sampling tube 1 is to be employed in taking a blood sample.

For the purpose of taking a blood sample conventional feeding or suction tubing, such as that illustrated at 40 in FIGS. 8 and 9, may be employed. Such suction tubing may be equipped at opposite ends with single-ended needles or cannulas 41 and 42 with the first thrust into the patient's flesh, diagrammatically illustrated at 43 in FIGS. 8 and 9, to communicate its bore and the passage of the tubing 40 with a vein 44, also diagrammatically illustrated in FIGS. 8 and 9. When it is desired to take a blood sample with the use of the collapsed sampling tube 1 illustrated in FIG. 7, the tip 45 of the needle 42 may be thrust down through the end wall 33 of the cover cap 32 and inserted into the through passage of the closure cap 21 formed by the communicated bores 27 and 30, such as substantially to the position illustrated in FIGS. 8 and 10. When the operator then backs off the closure cap 21 by rotational unscrewing, such as to the position

of FIG. 10, the inner or master control valve will be open as therein shown, so that blood will be sucked from the vein 44 successively through the needle 41, the tubing 40, the needle 42, the bore 27, the well 16, the valve ports 19, the neck bore 8, and into the sampling tube chamber 5 to collect a pool 46 of blood in the latter, as is illustrated in FIGS. 9 and 10. The opening of the inner or master control valve by the backing off or retraction of the closure cap 21 permits the elastic recovery of the sampling tube side walls 2 to expand or separate substantially to their original molded forms, thereby creating the suction necessary to draw the blood sample 46 into the sampling tube chamber 5.

Thereafter, the operator will screw the closure cap 21 down to the valve-closing position of FIGS. 2 and 11 and withdraw the needle 42 from the end wall 33 of the cover cap 32. As a result, the slit 47 formed in the end of the cover cap 32 by the thrust of the needle 42 therethrough will close by elastic recovery and the filled sampling tube 1 will be securely sealed both at the inner or master control valve and at the cover cap. The cover cap serves not only as an outer valve, but also protects the flow passage through the closure 21 from contamination until such time as analysis procedure is performed.

If the analysis is to require substantially all of the contents 46 of the sampling tube chamber 5 it may be removed or expelled either by dismounting the closure cap 21 or by cutting off a corner of the bottom end seal 4 and then squeezing or flattening the side walls 2 of the sampling tube. In the event that it is desired to apply some of the blood sample 46 as smears to slides for microscopic examination or to produce a plurality of small examination pools, this may be accomplished by retracting the closure 21 to the valve-open position of FIG. 10 and removing the cover cap 32 to permit smearing flow or discharge by squeezing of successive quantities of the blood sample contained in the chamber 5 through the closure flow passage constituted by communicated bores 27 and 30.

Certain treatment technique may require the taking successively of a plurality of blood samples and for this purpose the suction tubing 40 may remain in mounted position with the bore of the needle 41 maintained in communication with the vein 44. The successive samples will be taken with the use of a plurality of the collapsed sampling tubes of FIG. 7, each being handled in the manner proposed in FIGS. 8, 9 and 10. Such procedure may be facilitated by employing a simpler type of suction tubing which has less tendency to detach from a patient's body during restless movement than the lengthy suction tubing 40 and equipment of FIGS. 8 and 9. For example, a relatively short section 140 of tubing may be equipped with needle 41 communicated to a patient's vein 44, as is illustrated in FIGS .12 and 13, with the opposite end of the tubing being connected to a hollow socketing hub 48 fitted in a fluid-tight manner over the tapered tubular neck 29 in a fluid-tight manner, so that the blood sample will be drawn into the sampling tube chamber 5 directly through the communicated bores 30 and 27. The suction tubing 140 may be provided with a conventional pinch clamp 49 which, when in the full line position of FIG. 12, does not restrict flow through the passage of the tubing, but when moved forward to the dotted line position 149 will pinch off the tubing and close its passage. Thus, when such simplified suction tubing equipment is left attached to the patient's body, as is illustrated in FIG. 13, blood drippage therefrom is prevented by the pinch clamp 49. Successive blood samples may then be taken when desired by consecutively connecting sampling tubes 1 to the suction tubing 140, with the tubular neck 29 of each securely socketed and jammed into the hollow hub 48 and the closure cap 21 thereof manipulated to the valve-open position to take the sample. After each sampling tube is filled in this manner, the closure cap 21 is then screwed inward to its valve-closing position, as is illustrated in FIG. 13, before disconnection of the tubular neck 29 from the suction tubing hub 48. Each filled sampling tube 1 may then be protectively closed by applying a cover cap, such as that illustrated at 32, to the tubular neck 29 thereof, as is illustrated in FIG. 15.

The suction equipment, which may be desirably left attached to a patient's body with its needle continuously communicated with a vein 44, may be in another form, such as that illustrated in FIG. 14. The needle 141 constitutes a cannula having an inner stub end 50 circumscribed by a socketing hub 51 provided with a neck 52 swaged about the cannula. The hub 51 may have a tapered socket 53 into which the tapered tubular neck 129 may be jammed for fluid-tight connection. The neck bore 130 may be provided with a constriction in the form of an internal annular bead 54 of an I.D. less than the O.D. of the cannula stub 50, so that when the latter is inserted therethrough, as is illustrated in FIG. 14, a fluid-tight seal will be assured.

Certain practices may dictate a desire to thrust the second needle of suction tubing equipment of the type illustrated in FIGS. 8 and 9 completely down through the valve closure of each sampling tube 1. In this case the tip 45 of needle 42 may be thrust completely through the communicated bores 30 and 27 to push the nib 28 out of the latter with inward flexure of the transverse valve cup wall 14, and then on down through the latter, such as adjacent to or at one of the ports 19 (when this transverse wall is sufficiently distorted), for direct communication to the evacuated chamber 5. Such practice may be facilitated by modified forms of the elastic valve cup and the closure cap, such as those illustrated in FIGS. 16 and 17. As is shown in FIG. 16, the well 116 of the valve cup 112 may be stepped at its bottom end to provide an annular shoulder 118 circumscribed about a relatively shallow socket 55 defined in the transverse bottom wall 114. The bottom of the socket 55 is closed by a needle-pierceable diaphragm 56 against which the bottom end 126 of the valve stem 125 is jammed in the valve-closing position of closure cap 121 for sealing off the flow passage through the closure constituted by communicated bores 127 and 230. The porting openings 119 may be provided in an annular zone about the valve seat socket 55, i.e., located to communicate with the well 116 at the annular shoulder 118.

In the FIG. 16 embodiment the inner or master control valve includes seat structure provided by the face of the bottom diaphragm 56 and the cylindrical socket side wall 55, with the former contacted in an annular zone by the transverse inner end face 126 of the valve stem 125 and the latter contacted by an annular zone of the cylindrical outer surface of the inner end section 225 of this valve stem. When the closure cap 121 is retracted by rotary unscrewing thereof the inner end section 225 which is socketed in the valve seat socket 55 will be withdrawn from the latter to beyond the shoulder 118 to communicate the bore 127 with the porting openings 119. In order to minimize the amount of blood which may be trapped in such a valved closure when the closure cap 121 is then screwed forward to the valve-closing position of FIG. 16, the socket may be provided in quite shallow depth while retaining the desired feature of contact between the cylindrical side wall 55 of the socket and an annular zone of the inner end section 225 of the valve stem.

It will be understood from FIG. 16 that the structure of such an embodiment permits suction tubing equipment, such as 40, to be communicated to the suction chamber 105 of the sampling tube 100 by thrust of the tip 145 of the needle 42 completely down through the communicated bores 230 and 127 and the pierceable diaphragm 56, to the dotted line position illustrated therein. The slit, indicated in dotted lines at 57 in FIG. 16, which is pierced through the diaphragm 56 by the needle inner end 145 will close by elastic recovery when the needle

is withdrawn, so that the inner or master control valve will effectively seal off the blood sample in the sampling tube chamber **105**. The valve cup **112** has the mouth of its well **116** provided with a constricted internal annular bead **120** to have continued wiping engagement with the cylindrical outer surface of the valve stem **125** in all mounted positions of the closure cap **121**, which is the full equivalent of the fluid-tight sealing means outward of the inner or master control valve of the FIGS. 1 to 15 incl. embodiment and provided therein by the internal bead **20**.

It will be noted from FIG. 16 that an annular space is provided between the cylindrical side wall of the valve cup well **116** and the cylindrical outer surface of the valve stem **125**, in which a small quantity of blood or sampled body-fluid may be trapped. If this is considered undesirable the structure of FIG. 16 may be slightly modified, such as in the manner of FIG. 17, to provide the tubular valve stem **325** with an O.D. substantially equal to or slightly greater than the I.D. of the intermediate main section of the valve cup well **216**, so as substantially to fill it. The fluid-sealing means will be embodied in this structure by the internal annular bead **120** which will be stretched for localized compression, as is indicated at **1200** in FIG. 17, by the insertion therethrough of this larger valve stem **325**. The inner end of the valve stem **325** will be stepped to provide a tip section **425** which is complementary in shape to the socket **55** for snug seating therein in the valve-closing position of the closure cap **121**. As is indicated in dotted lines at **58** in FIG. 17, the socket **55** may be frusto-conical in shape, and the end section **425** of the tubular valve stem **325** shaped complementary thereto so as to minimize tendency for entrapment of fluid. The attendant appreciable thickness of the transverse bottom wall **114** radially of the central diaphragm **56** opposite the passage bore **227** assures secure sealing of an extended annular zone of the inner end of the valve stem **325** to the opposed valve seat of complementary shape while assuring the provision of the pierceable diaphragm **56** in relatively thin section for ready puncture by a cannula when thrust down through the bores **230** and **227**.

The FIG. 16 structure may be further modified by omitting the internally-threaded skirt of the closure **121**, so that the transverse head wall thereof extends laterally as a circular flange. This further modification is proposed in FIG. 17 wherein it is shown that the skirt of the closure **221** is omitted to convert the transverse head wall into a circular lateral flange **222**. This valving closure is then supplemented by a separate cap member **232** which covers the entire valving closure in a protective manner and with its skirt **223** being internally-threaded for threaded engagement with the external threads on the container neck **106**. This converts the valve to a longitudinal sliding construction rather than a rotary one, for axial translation between the inward valve closing position and the outward valve open position. Thus, with the cover cap **232** screwed inward to the position illustrated in FIG. 17 the inner face **234** of the top or end wall **233** of the cover cap **232** jams tightly against the tip end **231** of the projecting neck **229** to hold the bottom end **425** of the valve stem **325**, serving as the valve element, snugly within the socket **55** which serves as the valve seat, in the valve closing position there illustrated. When the cap **232** is unscrewed and removed from the neck **106** the valve of the FIG. 17 construction may be opened by manual engagement of the circular flange **222** and application of pull thereon to withdraw the bottom end of the valve stem **425** from out of the socket **55**, thereby effecting communication between the closure bores **230** and **227** with the valve ports **119** by way of the space between the walls of the socket and the bottom end of the valve stem. This axial translation of the valving closure **221** and axial return thrust thereof thus effect the operation of the valve. Captive means may be provided between the valve stem **325** and the elastic valve cup **112**, to limit axial translation of the former through the constricted mouth or internal bead **120** of the well **216**. For example, the O.D. of the valve stem **325** may be reduced in its root section to a diameter similar to the root section of the valve stem **125** of the FIG. 16 structure, so that the inner valving end **425** is in the form of an enlarged head which limits axial translation through the internal bead **120**, and this reduced O.D. section should be at least long enough to raise the resulting enlarged valving head or inner end **425** completely out of the socket **55** in a valve open position. Such means for limiting the axial translation of the valve stem **325** in the well **216** may be an annular external bead on the valve stem, when the latter is of an O.D. similar to that of the valve stem **125** of FIG. 16, located a short distance above the shoulder **118**, so that this bead will jam up against the internal annular bead **120** of valve cup **112** during retraction. This axial travel of valve stem **325** further may be limited by an annular groove **169** therein, in the vicinity of its inner head end **425** (that may be in a form similar to annular groove **69** in valve stem **625** of the FIG. 22 embodiment), so that as the valve stem is retracted to a valve open position the internal constricting bead **120** in the mouth of the well **216** will snap thereinto to stop the outward travel. The internal constricting bead, which is shown in its compressed condition at **1200** in FIG. 17, thus provides the fluid-tight seal for the valve stem **325** in all axial positions of the latter, while also serving, in cooperation with annular groove **169**, as retraction limiting stop means. In these variations the closure **221** is translated axially by sliding motion without necessitating accompanying rotary motion after the cover cap **232** is removed.

The valved closures of FIGS. 1 to 17 incl. are well adapted to mounting in the mouths of evacuated rigid glass tube types of sampling containers, many of which resemble glass "test tubes." The edge of the open end or the lip of the mouth may be turned inwardly to provide an internal annular bead or flange to constitute the equivalent of the internal annular bead **10** of FIGS. 2 and 10 or that at **110** of FIGS. 16 and 17, to be located in the annular grooves **17** or **117** of the elastic valve cup members **12** or **112**, with the latter inserted in the bore of the tube. The skirt **23** of the closure cap **21** may be of an I.D. sufficient to telescope over the outer side of the end of the glass tube or omitted entirely, or the glass tube may be provided in any suitable manner with external threads to be engaged by the internal threads in the cap skirt.

In the embodiment illustrated in FIGS. 18 and 19, the sampling tube **300**, having flexible and elastic side walls **302** to define suction chamber **305**, is provided with a coaxially-extending tubular neck **306** which may carry external threads preferably located on the root section **311** thereof. Beyond the threaded neck section **311**, the neck **306** may be provided with a cylindrical section **60** terminating in a transverse wall **314** to close off neck bore **308**. The neck section **60** may have an annular groove **61** provided therein in which seats a fluid-tight sealing gasket **62** which may be in the form of an O-ring of elastic material, such as rubber.

Closure cap **321** of the FIGS. 18 and 19 embodiment has a skirt **323** provided with an internally-threaded section to be threadably engaged on the threaded neck section **311**, and a cylindrical section **63** opposed to the cylindrical neck section **60** for wiping contact by the O-ring **62** in all mounted positions of the closure cap.

Transverse end or top wall **322** of the closure cap **321** is provided with a tubular neck **329** having a longitudinally-extending bore **330** provided with a counterbore socket **64** at its inner end. The transverse end wall **314** at the tip of the neck **306** is to serve as a valve seat

and thus it is provided with porting openings 319. An annular zone of the inside face 324 of the closure cap top wall 322 makes secure contact with the transverse neck wall 314 in an annular zone radially outward of the porting openings 319 to serve as a valve. The transverse neck wall 314 is provided centrally with an outwardly-extending, tapered nib 65, preferably of elastic material, such as by being made integral with the neck 306 and sampling tube side walls 302 molded from elastic plastic material. The elastic nib 65 has a transverse cross-section of a diameter slightly greater than the I.D. of the mouth of the counterbore 64, so that the former will jam into the latter in the valve-closing position of the closure cap 321 to provide a second inner valving seal.

In the embodiment of FIG. 20 the sampling tube 400 is provided with elastic side walls 402 to define a suction chamber 405 closed off at the front end by a transverse circular wall 414, preferably made integral therewith, these parts preferably being molded from elastic plastic material. A tubular neck 406 extends coaxially from the transverse end wall 414 and the bore thereof has a cylindrical section 408 adjacent this crosswall while being provided with an internally-threaded section 411 therebeyond. Since the transverse crosswall 414 is to serve as a valve seat it is suitably ported, such as by providing an opening 419 therethrough at a point offset radially from the crosswall axis.

The closure 421 of the FIG. 20 structure is provided with a rotary plug 425 having a threaded root section 66 threadably engaged in the internally-threaded section 411 of the neck 406. The closure plug 425 has its inner end provided in the form of a cylindrical section in the external surface of which is formed an annular groove 161 in which is seated an O-ring gasket having wiping contact with the opposed inner surface of the cylindrical neck section 408 in all mounted positions of the closure plug. The closure plug 425 carries a tubular neck 429 having a through bore 430 extending to the inner end 426 of the closure plug, with the inner end or mouth 427 thereof opposed to an imperforate portion of the container crosswall 414. Thus, the inner stem end 426 serves as a valve element which will have sealing engagement with the crosswall 414 serving as a valve seat. When the closure plug 425 is retracted communication will be established between the inner end 427 of the bore or flow passage 430 and the offset port 419, for communication to the suction chamber 405.

In the FIG. 21 embodiment many of the parts are similar to those of the FIG. 20 embodiment except that the fluid-tight sealing means, in a form including O-ring 162 that is seated in an annular groove 262 formed on the inner face of the cylindrical section 508 of the neck bore. The O-ring gasket 162 has wiping contact with cylindrical section 525 of the closure plug in all mounted positions of the closure 521 carrying the latter. Valving action of the FIG. 21 embodiment is the same as that of the FIG. 20 embodiment.

In the embodiment of FIGS. 22 and 23, which is similar in many respects to those of FIGS. 20 and 21, the closure 621 has the inner end 627 of its through bore communicated to a transversely-extending, radial notch 67 in the inner end 626 of the closure plug 625. The neck bore 608 is provided with an annular internal rib 68 which is snugly seated in a fluid-tight manner in an annular groove 69 formed in the closure plug 625, there to provide a fluid-tight seal in all rotary positions of the closure plug. Elastic plastic material may be employed for molding the sampling tube 400, including its side walls 402 and the coaxially-extending tubular neck 606, so that the annular rib 68 when made integral therewith will be elastic for snugly engaging into the annular plug groove 69 to form a secure fluid-tight seal. This fluid-tight seal may be enhanced by also forming the closure plug from similar elastic plastic material, or relatively high durometer rubber. The elasticity of the neck 606 and its annular internal rib 68 permits the necessary stretching to allow the insertion of the closure plug 625 to the seated position of FIG. 22.

When the closure plug 625 of the FIGS. 22 and 23 embodiment is in the relative rotary position of FIG. 22, the radial notch 67 communicates the inner end 627 of the through passage 430 with the port or opening 419 for flow connection to the suction chamber 405. When the rotary closure plug 625 is rotated to another radial position, such as that illustrated in FIG. 23, wherein the radial notch 67 is no longer in communication with the valve port 419 (the position of which is indicated in dotted lines), an area of the inner end 626 of the closure plug is bridged over the port to close it and effect valve closure.

As will be understood from FIG. 22, an additional sealing gasket may be inserted in the embodiments of FIGS. 20 to 23 incl., in the form of an annular ring 70 interposed between the head 621 (or heads 421 and 521 of FIGS. 20 and 21) and the outer end of the tubular neck, so that it will be jammed therebetween in fluid-tight sealing engagement in the valve-closing positions of the closures.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A body-fluid sampling tube comprising, in combination,

(*a*) a receptacle having a suction chamber evacuated to a relatively high degree of evacuation sufficient to suck thereinto body fluid from a cavity in and the circulatory system of a person's body when communicated thereto,

(*b*) said receptacle having a tubular end defining a suction inlet passage communicating with the chamber for this purpose,

(*c*) closure means movably mounted to said tubular end for axial translation relative thereto and having a central through longitudinal passage for supply of body-fluid to the inlet passage,

(*d*) said receptacle tubular end and closure means having a pair of telescoped tubular parts respectively connected in fluid-tight manner thereto with one of said parts mounted in the other for relative axial translation between inward relative valve-closing positions and outward relative valve-open positions,

(*e*) said telescoped tubular parts carrying at the inner end of the closure supply passage complementary valve structures cooperatively engaged in flow blocking relation to form a closed valve in the inward valve-closing axial position of one of said telescoped tubular parts relative to the other preventing leakage of atmospheric air to said evacuated suction chamber through the closure supply passage and axially separable in flow permitting relation when one of said telescoped tubular parts is retracted to its outward valve-open position relative to the other to apply suction to the closure supply passage.

(*f*) fluid-tight sealing means interposed between said pair of telescoped tubular parts at a point outward of said valve in the form before assembly of parts of an annular transversely extending rib means of

relatively high elasticity carried by one of said pair of telescoped tubular parts in a fixed axial location thereon and confined after assembly of parts in distorted compressed condition between said pair of telescoped parts in a relatively narrow annular zone to limit drag resistance to relative longitudinal sliding action of said pair of telescoped parts, said compressed rib means being under appreciable compression of a degree sufficient to prevent leakage therepast of surrounding atmospheric air into the evacuated suction chamber while body fluid is sucked into the latter through the closure supply passage, said telescoped tubular parts being freely slidable manually relative to each other at all points of opposition axially offset from the location of said compressed rib means, and

(*g*) manually manipulative camming means temporarily locking said pair of telescoped tubular parts in their relative valve-closing positions and to permit release for relative retraction to their valve-open positions.

2. The body-fluid sampling tube as defined in claim 1 in which said suction chamber of said receptacle initially is in expanded form and filled with air, said chamber being partly defined by movable receptacle structure for inward movement to reduce the chamber capacity and expel therefrom air therein through said valve in its open position for attaining the evacuated condition, said closure having an exterior tubular neck terminating in a tip end section through which the supply passage extends, and a supply passage valving cover cap of material having appreciable elasticity including an integral relatively thin and readily needle-pierceable closed end wall through which a hollow needle may be easily thrust by hand and an integral pinch-distortable circular sidewall together defining a socket that initially when unmounted is of smaller transverse dimensions than those of said tip end section, said tip end section being jammed into the socket of said cover cap with stretch of the sidewall of the latter for closing off the supply passage in a fluid-tight manner, the cap sidewall being capable of being separated from said tip end section along at least one longitudinal line of mutual contact to define a flow channel leading from the supply passage to the surrounding atmosphere when said cap sidewall is pinched laterally against said tip end section for allowing evacuating expulsion of air from said chamber.

3. A body-fluid sampling tube comprising, in combination,

(*a*) an elongated, manually collapsible, tubular container of flexible and foldable plastic capable of self recovery from distorted shape sealed at one end and having a valve closure at the other end defining a suction chamber capable of evacuation with opening of the valve closure and manual collapse of said container;

(*b*) the valve closure-equipped end having an externally-threaded, tubular neck terminating in a circular lip

(*c*) with the bore of the neck equipped with an annular, internal, constricting bead;

(*d*) an elastic cylindrical cup having an annular lip as its outer end, a closing transverse wall at its inner end and an intervening cylindrical side wall together defining a cylindrical well,

(*e*) said side wall being provided externally with an annular groove in which said annular bead is seated with said cup inserted snugly into the neck bore and the cup lip lapping said neck lip;

(*f*) the outward side of said transverse end wall of said cup within the well defining a valve seat having at least one porting opening;

(*g*) a closure cap having a transverse end wall and an internally-threaded skirt depending therefrom and threadably engaged on said neck, said closure cap being capable of axial translation between an inward valve-closing position and an outer position upon rotation;

(*h*) a tubular stem coaxially arranged in the skirt of said closure cap and extending inward from the end wall of the latter, said stem being translatable axially between an inward valve-closing position and an outer valve-open position,

(*i*) said stem having a longitudinal through bore to serve as a flow passage for supply of body fluid therethrough to the suction chamber,

(*j*) the inner end of said stem serving as a valve element which makes valve-closing contact with said valve seat in an annular zone when said stem is in its inward valve-closing position to constitute the valve closing off communication between the porting opening and the stem bore; and

(*k*) annular fluid-tight sealing means located between the well sidewall and said stem fixedly carried by one thereof at a fixed location on the latter outward of said complementary valve element and seat and maintaining wiping engagement with the other in all longitudinal positions of said stem at and between the inward valve-closing and outer valve-open positions of the latter, said sealing means being before assembly of said stem into said cup in the form of an annular elastic and transversely extending rib means and being confined in distorted compressed condition between said well wall and said stem in a relatively narrow annular zone to limit drag resistance to relative longitudinal sliding action of said wall and stem, said compressed rib means being under appreciable compression of a degree sufficient to prevent leakage therepast of surrounding atmospheric air into the evacuated suction chamber while body fluid is sucked into the latter through said stem bore.

4. The body-fluid sampling tube as defined in claim 3 characterized by said annular, compressed fluid-tight sealing rib means being an internal, annular, elastic bead at the mouth of the well integral with said cup and of an internal diameter when relaxed appreciably less than the external diameter of said stem and having wiping engagement with the latter.

5. The body-fluid sampling tube as defined in claim 3 characterized by said closure cap having a tubular neck extending outwardly coaxially from the end wall thereof as an outer extension of said stem and terminating in a tip, said cap neck having a through bore communicating with the stem bore together serving as a body-fluid supply passage; and a supply passage-blocking cover cap of elastic material having an integral relatively thin and readily needle-pierceable closed end wall through which a hollow needle may be easily thrust by hand and an integral pinch-distortable circular sidewall together defining a socket therein in which the tip of said cap neck is engaged with stretch of said cap sidewall in a fluid-tight manner with said neck tip spaced inwardly from said cover cap end wall to allow evacuating expulsion of air from said suction chamber when said cover cap sidewall is pinched to separate it from said neck along at least one longitudinal line of mutual contact by there defining a flow channel communicating the neck bore with the surrounding atmosphere.

6. The body-fluid sampling tube as defined in claim 4 characterized by said valve seat being in the form of a coaxial socket in the outward side of said elastic cup end wall within its well with the bottom of the socket closed by an integral relatively thin and readily needle-pierceable diaphragm as a part of said cup through which a hollow needle may be easily thrust by hand, the inner end section of said stem being snugly seated in the socket in fluid-tight manner when said closure cap is in its inward valve-closing position with said needle-pierceable diaphragm extending across the inner end of the stem bore, the well being provided with an annular transverse shoulder at

the mouth of the socket and with a plurality of porting openings being provided in this annular shoulder and extending through the end wall to communicate the suction chamber with the bore of said stem when the inner end section of the latter is retracted from the socket.

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