March 14, 1967 E. F. PERLOWSKI, JR. 3,308,599

VALVE SEALING METHOD

Filed June 12, 1964

2 Sheets-Sheet 1

FIG.1

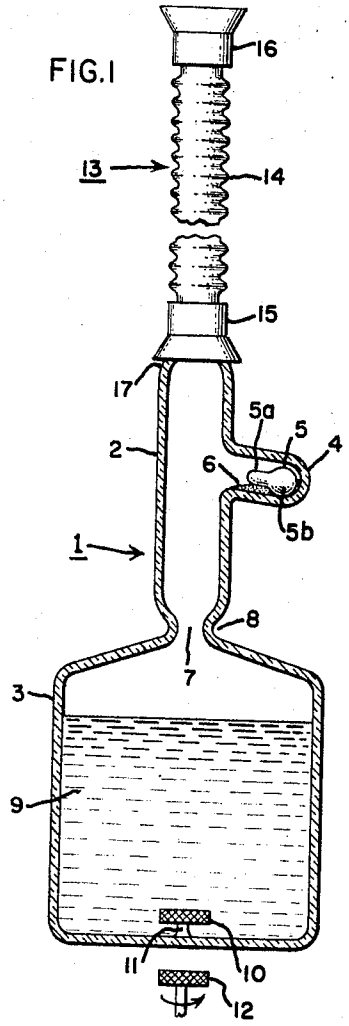


FIG.2

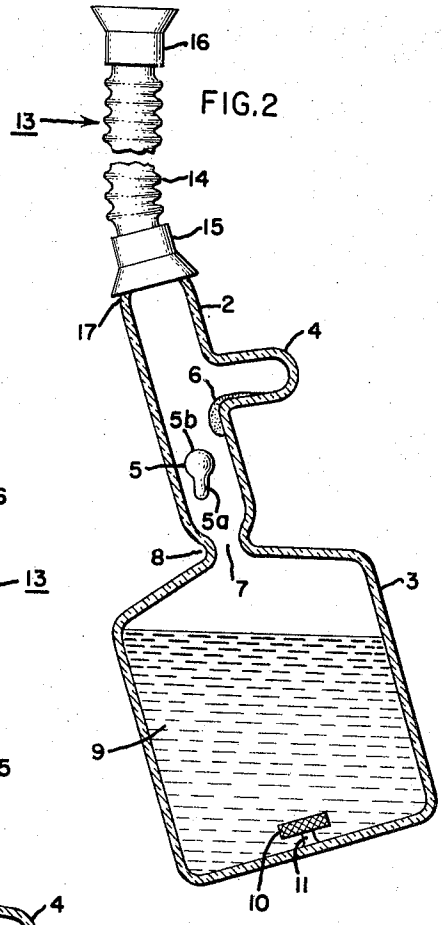
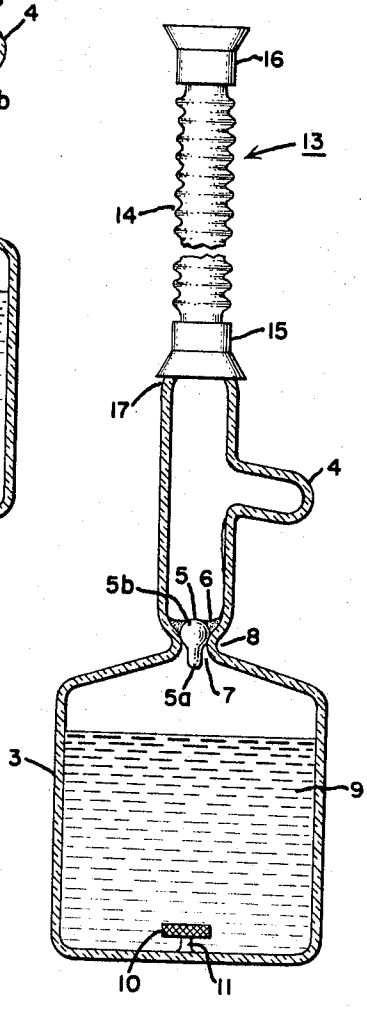


FIG.3



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VALVE SEALING METHOD

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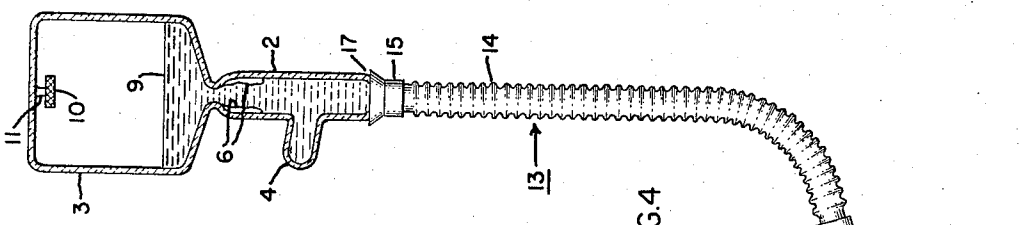


FIG.4

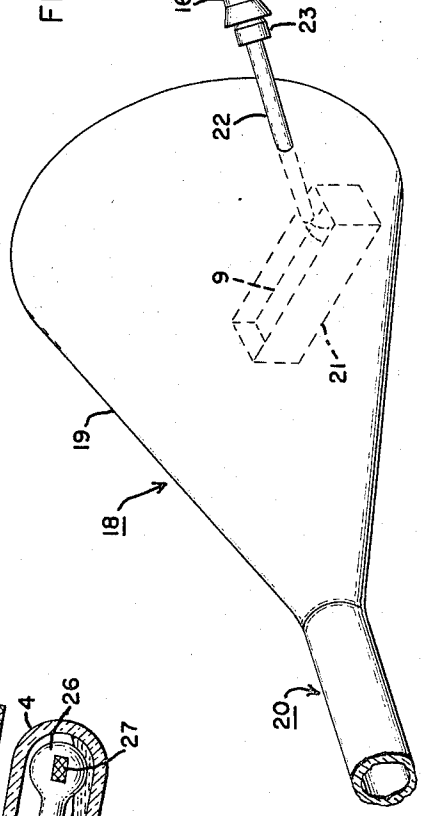


FIG.6

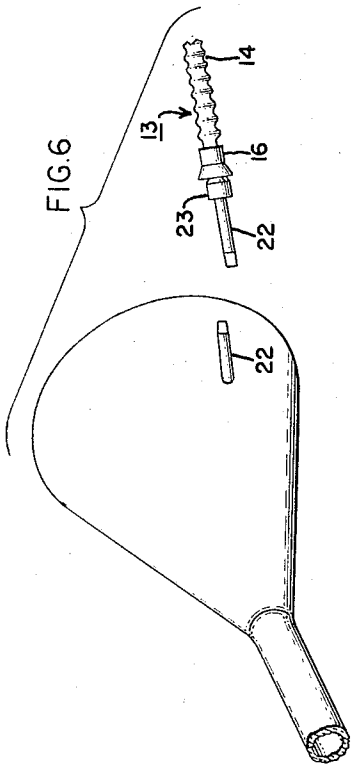


FIG.7

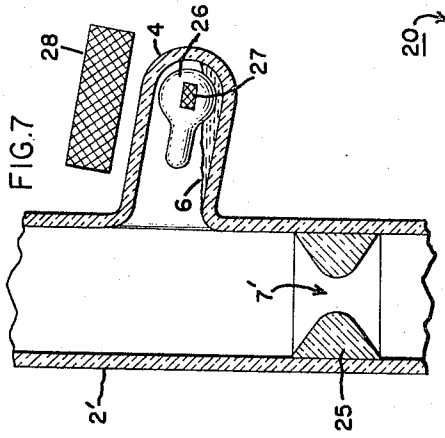
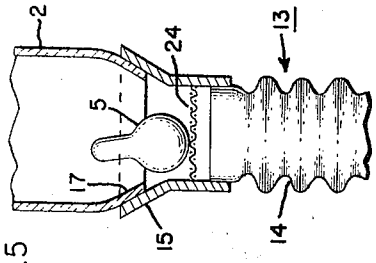


FIG.5



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3,308,599

VALVE SEALING METHOD

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Filed June 12, 1964, Ser. No. 374,692
4 Claims. (Cl. 53—22)

This invention relates to a valve sealing method and apparatus and, more particularly, to a thermoplastic valve seal and a method of operation thereof.

Prior art valves and the methods of operation thereof have proven unsatisfactory in applications requiring the handling of fluids in evacuated systems. A particular example of such fluid handling systems and the difficulties introduced thereby is found in the manufacture of light valve tubes for providing visual reproduction of television signals by a light projection system. In such light valve tubes, oil is stored within a reservoir within the tube and deposited as a thin film on a transparent, flat support member having a transparent conductive coating on the opposite, parallel surface thereof. The scanning electron beam performs a raster scan on the oil film, electrostatic charge attraction between the electrons thus deposited on the oil film and the conducting coating causing the oil film to be deformed. The light valve tube forms a portion of a Schlieren optical system wherein, by the projection of light through the optical system, the oil film, due to its deformation, diffracts the light rays passing therethrough for subsequent projection to a viewing screen for reproducing a television image.

Since light valve tubes employ a scanning electron beam, they must be degassed in the manner of standard cathode ray tubes, the degassing comprising a high temperature baking and evacuating of the tube. The oil film cannot be introduced into the light valve tube until completion of the degassing, since the high temperature would cause it to evaporate. Therefore, the oil must be kept in a second container, suitably a small capsule, introducing the further requirement that the oil capsule also must be degassed by an evacuating system, independently of the light valve tube.

It is desirable that the aperture or passage in the oil capsule through which it is evacuated during the degassing also provide the passage through which the oil flows from the capsule for introduction into the light valve tube. Therefore, valve means must be provided for sealing the oil capsule, following its evacuation, at the evacuating aperture. Further, the valve must permit interconnection of the oil capsule and the light valve tube while maintaining isolation therebetween during degassing of the latter. Finally, the valve must be operable, follwing the degassing of the light valve tube, to permit the oil to flow from the capsule into the reservoir of the light valve tube, preferably in a minimum amount of time, while avoiding, at all times, any contamination of the fluid.

Valve apparatus taught in the prior art, such as stopcock valves, generally are operated by a mechanical sliding or rotation of an element for engaging two surfaces at a sealing interface. Such surfaces must be accurately ground to assure a tight, hermetic seal, resulting in a relatively high cost of such valves. The frictional engagement of the surfaces at the sealing interface, a requisite of the tight hermetic seal, contributes to wear and deterioration of such valves and a resultant limited life-span. The high maintenance cost of such prior art valves is further compounded by their difficulty of replacement, requiring a mechanical severing from the chamber with which they are employed and the joining to the chamber of a new valve in hermetically-sealed fashion. Many prior art valves also require metal to glass interfaces, such interfaces not

only being difficult and expensive to form to assure the absence of leakage therethrough, but also being subject to fracture or rupture due to the unequal thermal coefficients of expansion of the two materials.

To operate a prior art valve, there is generally required a mechanical connection passing through the exterior walls of the valve to provide an operating arm or lever. This passage through the wall of the valve inherently introduces a leakage path, limiting the ability of the valve to withstand ambient pressures for maintaining a vacuum within a chamber.

Prior art valves of the internally-operated variety, such as rupture diaphragms and fracturable glass seals, are unsatisfactory in that they can be operated only to open, and not close or seal a passage or aperture. Since they have only this unidirectional mode of operation, they are unsatisfactory for the application contemplated by this invention and illustrated hereinbefore, inasmuch as the oil capsule would be required to have a second outlet for connection to an evacuating system. Further, the second outlet must still be provided with a valve if the capsule is to be capable of being removed from the evacuating system for use at a later date. To facilitate mass production of light valve tubes, it is essential that the oil capsules, following degassing, be hermetically sealed to permit their removal from the evacuating system so that they may be produced in advance and stored for subsequent use in a production line. In addition, the method of opening such rupture diaphragms and glass seals, namely the breaking or rupture thereof, as their name implies, introduces the foreign matter of the valve material into the fluid passing from the capsule into the reservoir in the light valve tube. Rupture diaphragms and glass seals are also undesirable in that they are inherently capable of only one operation and therefore are very expensive to employ.

In addition to the above-noted deficiencies, the valves provided by the prior art generally are neither capable of maintaining the isolation between the capsule containing the fluid and the light valve tube during the bake-out and degassing of the latter, nor do they permit the rapid transfer of the writing fluid into the light valve tube following the bake-out and evacuation thereof. Thus, the apparatus and methods of the prior art for effecting transfer of a fluid between two independently evacuated containers not only have been very expensive in costs of components and operation, but also have not been successful in maintaining the degree of evacuation and the contamination-free conditions which are essential for proper functioning of the completed light valve tube.

It is therefore an object of this invention to provide an improved valve sealing method and apparatus for effecting an hermetically-tight seal within an enclosed chamber.

Another object of this invention is to provide a valve sealing method and apparatus for employment within an enclosed chamber and operable from a position totally externally of the enclosed chamber for closing and opening and unsealing a defined aperture therewithin.

A further object of this invention is to provide a valve sealing method and apparatus for facilitating interconnection of first and second enclosed and independently evacuated chambers in an hermetically-isolated manner.

It is still another object of this invention to provide a valve sealing method and apparatus for effecting an hermetically-tight seal at a predetermined position within an enclosed chamber following evacuation thereof.

It is still a further object of this invention to provide a valve sealing method and apparatus for effecting an hermetically-tight seal at a predetermined position within an enclosed chamber following evacuation thereof and for providing opening of the valve seal from a position

totally externally of the enclosed chamber to provide communication with a second, independently evacuated chamber.

Still another object of this invention is to provide a valve sealing method and apparatus for facilitating interconnection of first and second enclosed chambers and operable for permitting communication therebetween with subsequent hermetic sealing of the second enclosed chamber.

Other objects and advantages of the present invention will be apparent to those skilled in the art from the following detailed description of the invention.

In accordance with a preferred embodiment of the invention there is provided a capsule having neck and tank portions, the neck portion being adapted for interconnection with a light valve tube. A hollow, depending side arm is formed on the neck portion, communicating with the interior thereof, a valve member and a small quantity of sealing fluid being received within the side arm. An aperture-defining constriction is provided in the neck portion intermediate the side arm and the tank portion and designed for receiving the valve member to seal the tank portion of the chamber. The side arm is heated to render the sealing fluid fluent, permitting the valve member to be released from the side arm upon appropriate tilting of the capsule. As the capsule is returned to an erect position, the valve member falls by force of gravity and is received within the constriction, the sealing fluid flowing about the valve member and the constriction to seal the aperture. Following the evacuation of the capsule and the sealing of the tank portion, the capsule is joined at its neck portion in hermetically sealed fashion to a feed tube extending through the envelope wall of a light valve tube. The feed tube extends within the light valve tube to provide communication with a reservoir therein. The valve sealing apparatus of the invention isolates the tank portion of the capsule from the light valve tube while the latter is degassed. Following the degassing, the light valve tube is cooled to ambient temperature and the valve sealing apparatus of the invention opened by externally heating the aperture-defining constriction. Following the bake-out and degassing of the light valve tube the latter is hermetically sealed and removed from the evacuating means and cooled to ambient temperature. The fluid contained within the tank portion of the capsule is transferred to the reservoir by opening the valve provided by the valve sealing apparatus of the invention which previously had maintained the isolation. This opening is effected by heating the constriction to render the sealing fluid fluent, whereby the valve member is released from the aperture and falls onto a suitable retaining screen. The writing fluid then readily flows from the capsule, through the neck portion thereof, and through the feed tube into the reservoir. The feed tube is pinched closed, providing an hermetic seal. The capsule subsequently is removed from the light valve tube, thus completing the operation.

For a better understanding of the invention, reference may be made to the following drawings in which:

FIGURE 1 shows the capsule and the valve sealing apparatus positioned in a preliminary step of the sealing method,

FIGURE 2 shows the capsule and the valve sealing apparatus in an intermediate step of the method,

FIGURE 3 shows the valve sealing apparatus in sealing position,

FIGURE 4 shows the capsule interconnected with a light valve tube at an intermediate step in the transfer of writing fluid therebetween,

FIGURE 5 shows a small portion of the apparatus of the invention in cross-section to illustrate a retaining screen for holding the valve member in the step of the method shown in FIGURE 4,

FIGURE 6 shows the final step in the method, and

FIGURE 7 shows alternative embodiments of the apparatus.

As shown in FIGURE 1, the valve sealing apparatus of the invention is adapted for employment in a capsule **1** including a neck portion **2** and a tank portion **3**. A side arm **4** is formed on the neck portion **2**, the hollow interior portion thereof communicating with the interior of neck portion **2**. The side arm **4** is oriented in depending relation to the neck portion **2** for the vertical orientation of the capsule **1** shown, the angle being approximately 5 to 10° below a horizontal plane.

Positioned within the side arm is a valve member or plug **5** and a small quantity of sealing fluid **6**. Valve member **5** may take various configurations, but is shown as being pear-shaped, including a narrow end **5***a* and a bulbous end **5***b*. Sealing fluid **6** is highly viscous, approximately the consistency of a solid, at room temperature, but becoming fluent upon sufficient heating.

An aperture **7**, defined by a constriction **8**, is provided intermediate the side arm **4** and the tank portion **3**, the constriction **8** interconnecting the neck portion **2** and the tank portion **3** in FIGURE 1. The constriction **8** establishes a valve sealing position within the capsule **1** by which the tank portion **3** thereof may be hermetically sealed. A quantity of fluid **9** is received within the tank portion **3**. The nature of the fluid **9** is determined by the system to which it is to be transferred, as explained more fully hereinafter. A stirring magnet **10** may be provided within the tank portion **3** and may be mounted therein by stud **11** affixed to the bottom of tank portion **3**. A driver magnet **12** is positioned externally of the tank **3** and adjacent stirring magnet **10** for rotation by suitable means (not shown) to drive stirring magnet **10** into rotation for stirring the fluid **9**.

An interconnecting means **13** is provided for joining the capsule **1** to other apparatus. Interconnecting means **13** includes a flexible tube **14** and ends **15** and **16**, each end **15** and **16** including an interior, or female taper portion. Neck portion **2** is provided with a tapered end section **17** to form a standard hermetically-tight taper joint with the end **15** of interconnecting means **13**. The female taper at end **16** provides an hermetically-tight joint with interconnecting means of associated apparatus (not shown).

In operation, following the reception of the fluid **9** within tank portion **3** as shown in FIGURE 1, interconnecting means **13** is attached to the capsule **1** and to suitable evacuating means (not shown) for evacuating the capsule **1**. Stirring magnet **10** assists in the evacuation by exposing air trapped within the fluid **9** at its surface.

Following the evacuation of chamber **1**, heat is applied to the side arm **4** to render the viscous sealing fluid **6** fluent. As shown in FIGURE 2, the capsule **1** then is tilted such that side arm **4** is angularly inclined slightly above a horizontal plane, permitting valve member **5** to drop into neck portion **2**. The angle of tilt is not critical, it being sufficient to raise side arm **4** approximately 5 to 10 degrees above a horizontal plane. Inasmuch as the sealing fluid **6** remains relatively viscous, even after heating, and since valve member **5** is partially immersed therein, a slight tapping on the side of neck portion **2** opposite to that of the side arm **4** may be necessary to assist in extricating valve member **5** from the fluid **6** and removing it from side arm **4**. Upon coming in contact with the cooler regions of neck portion **2**, the sealing fluid **6** is cooled and becomes more viscous, adhering thereto. A thin film of the sealing fluid **6**, formed on the valve member **5** while the latter was within the side arm **4**, remains in a fluent state thereon due to the heat retained by the valve member **5**.

Valve member **5**, by force of gravity, falls into the aperture **7**, the narrow end portion **5***a* thereof extending into the aperture and the bulbous end portion **5***b* engaging the interior walls of the constriction **8**. The thin film of

sealing fluid 6 retained in a fluent state on the valve member 5 flows about the interface thereof with the constriction 8 to form a preliminary seal. Since the majority of the sealing fluid 6 remains solidified on the neck portion 2, as shown in FIGURE 2, relative freedom is provided for manipulating capsule 1 to assure a proper orientation of the valve member 5 within aperture 7 in effecting the preliminary seal.

Following the positioning of valve member 5 within aperture 7 additional heat is applied to the neck portion 2 in the region thereof to which the sealing fluid 6 is adhering to render the latter fluent. The sealing fluid 6 then flows into the constricted region 8 as shown in FIGURE 3. After cooling to ambient temperature, the sealing fluid 6, in combination with the valve member 5, provides an hermetically-tight seal of the aperture 7. Interconnecting means 13 is now removed from the evacuating means (not shown), the valve sealing apparatus of the invention maintaining the evacuated condition of tank portion 3 of capsule 1 against ambient pressures.

The specific application of the valve sealing apparatus and method of the invention described herein is supplying a writing fluid to a light valve tube 18, as shown in FIGURE 4. Since the light valve tube forms no part of this invention, the only portions thereof which are shown include a flared envelope 19, a cylindrical neck portion 20, and a reservoir 21 within the envelope 19.

A feed tube 22 extends through the envelope 19, in hermetically sealed relationship therewith, to a position vertically above the reservoir 21. The feed tube 22 may be formed of copper or other suitable malleable material. Feed tube 22 is provided with end member 23 having a male taper end portion for forming an hermetically-tight taper joint with the end 16 of interconnecting means 13.

The light valve tube 18 includes a cathode gun section, generally included within the neck portion 20; it is therefore essential that the light valve tube 18 be subjected to a standard bake-out and degassing procedure to enable operation of the electron gun. The valve sealing apparatus and method of the invention maintain the writing fluid 9 in isolated condition within the tank portion 3 of capsule 1 during the bake-out and degassing of the light valve tube 18.

After the light valve tube 18 has cooled to ambient temperature, the valve apparatus of the invention is opened to permit the writing fluid 9 to flow into the reservoir 21. The valve member 5 and the sealing fluid 6 are removed from their sealing position within aperture 7 by applying heat to the exterior of constriction 8. The sealing fluid 6 is rendered fluent and begins to flow, thereby releasing valve member 5. Sealing fluid 6 continues to flow, by force of gravity, along the interior walls of neck portion 2 until it reaches the cooler portion thereof, whereupon it substantially solidifies and adheres thereto. The full dimension of aperture 7 is opened, thereby permitting the writing fluid 9 to flow readily therethrough.

As shown in FIGURE 5, a retaining screen 24 is provided within the end 15 of interconnecting means 13. Following its removal from the aperture 7, valve member 5 falls into the end 15 by force of gravity and is retained therein, as shown, by the retaining screen 24. The cross-sectional view of FIGURE 5 also illustrates the hermetically-tight taper joint formed by the male taper end portion 17 of the neck 2 and the interior female taper of the end 15.

Following the transfer of the writing fluid 9 to the reservoir 21, the feed tube 22 is pinched together, forming an hermetic seal. Feed tube 22 then is severed above the pinched position, and the capsule 1 and its associated apparatus is removed from the light valve tube 18. The stub of feed tube 22 which remains is preferably an inch to three inches in length, the collapsed end portion thereof being coated with an epoxy resin to assure the adequacy of the hermetic seal.

The valve member 5 may be retrieved from its retained

position within the end 15 on retaining screen 24 and employed with the capsule 1 in a subsequent operation. In addition, the sealing fluid 6 may be heated and caused to flow back into the side arm 4, whereby it, too is reusable.

Alternative embodiments of an aperture-defining constriction and a valve member are illustrated in FIGURE 7. Neck portion 2' has walls of constant diameter and includes therein aperture-defining members 25 for providing an aperture 7'. The members 25 may be hermetically sealed within the interior of neck portion 2' or, as a further alternative, may be formed integrally therewith.

FIGURE 7 also shows a valve member 26 having the same external configuration as the valve member 5 but including therein a permanent magnet 27. An external magnet 28 may be used to facilitate movement of the valve member 25 to its plugging position within the aperture 7'.

It is apparent that, if desired, separate side arms may be employed for independently retaining, or withholding the valve member such as 5 or 25 and the sealing fluid 6, the purpose of the withholding being to assure that the aperture 7 or 7', respectively, remains open.

In certain applications, such as the one illustrated, of supplying writing fluid to a light valve tube, it is essential that the transfer of the writing fluid be performed under contamination-free conditions. Therefore, the capsule 1, the interconnecting means 13, and the feed tube 22 preferably are selected to be of materials which are not soluble in the writing fluid 9. A suitable material for the capsule 1 and the valve member 5 is glass, and for the flexible tubing 14 and the feed tube 22 is copper. The use of copper for the tube 22 is also desirable in that it is sufficiently malleable so as to permit the metal in the walls thereof to collapse and flow together, when pinched, for providing the hermetic seal shown in FIGURE 6. Writing fluids which work effectively in light valve tubes comprise polybenzyl toluene, polybenzene benzene and polybenzyl biphenyl. Since the amount of writing fluid relative to the amount of sealing fluid 6 will be in the range of 250 gms. to $\frac{1}{10}$ of a gm., the possible percentage poisoning of the writing fluid during the transfer thereof from capsule 1 into reservoir 21 is relatively minute. However, to obviate any such poisoning which might occur, the sealing fluid 6 may be of the same chemical composition, but of a much higher viscosity than the writing fluid 9. In the alternative, the sealing fluid 6 may be selected from fluids which are insoluble in the writing fluid 9. In any event, the material constituting the sealing fluid 6 should either be substantially insoluble in the writing fluid 9 or, if soluble therein, of a non-poisoning or non-contaminating nature.

The valve sealing apparatus of the invention provides a substantial number of distinct advantages over the techniques and apparatus of the prior art. The utilization of the translatable valve member 5 assures an effective, strong, and highly reliable hermetic seal of the relatively wide-dimensional aperture. In one application employing the valve of the invention, 40 cc. of fluid was transferred in 1.5 minutes whereas periods of up to one hour were required for transferring the same quantity of fluid when employing prior art valves. Further, valve member 5 need not be accurately ground to form an hermetic seal with the interior walls defining the aperture 7 since sealing fluid 6 performs a dual function, not only mechanically retaining valve member 5 in the sealing position, but also hermetically sealing the interface. Vacuums attained in a system employing the valve sealing apparatus of the invention have ranged from 10^{-7} to 10^{-6} torr. The seal, once effected, is extremely stable and, in a series of applications, the change in the vacuum levels ranged from 0.7×10^{-6} torr to only 14×10^{-6} torr, for periods in excess of a month, clearly demonstrating the reliability and effectiveness of the valve sealing apparatus of the invention. Upon removal of the valve

member 5 from the sealing position within the aperture 7, however a relatively large orifice is provided through which the fluid may flow for rapid transfer thereof to a receiver within a second enclosed capsule or chamber.

In addition to being relatively low in initial cost of components and construction, the valve sealing apparatus of the invention is reusable for substantially an unlimited number of times. With the exception of accidental breakage, there are no parts subject to any substantial wear due to mechanical interaction or frictional engagement. Further, such wear which will occur is inconsequential since the sealing fluid 6 performs the hermetic sealing function at the interface of valve member 5 and the walls or construction defining the aperture 7. In addition, the simplicity of the apparatus enables its cleaning in a very easy manner, and also affords a minimal cost of maintenance and repair either in use, or in preparation of reuse.

Although shown in only one specific, preferred embodiment, the valve sealing apparatus of the invention is subject to numerous modifications, and the method and varieties of employment thereof will readily be obvious to those skilled in the art. Thus, it is intended by the appended claims to cover all such embodiments and applications thereof which fall within the true spirit and scope of the appended claims.

What I claim as new and desire to be secured by Letters Patent of the United States is:

1. A valve sealing method for selectively hermetically sealing or opening an aperture defined by a constriction located intermediate neck and tank portions of a capsule comprising the steps of:

(a) providing a hollow side arm on said neck portion in communication with the interior thereof,

(b) positioning a valve member and viscous sealing fluid in said side arm, said sealing fluid maintaining said valve member therein,

(c) heating said side arm for rendering said sealing fluid fluent for enabling release of said valve member from said side arm,

(d) tilting said capsule for releasing said valve member from said side arm,

(e) transferring said valve member to said constriction,

(f) heating said sealing fluid and causing it to flow into sealing relation with said valve member and said constriction, and

(g) cooling said sealing fluid for completing the hermetic valve seal.

2. A valve sealing method as recited in claim 1 wherein there are provided the following steps for opening the hermetic valve seal:

(a) inverting said capsule,

(b) heating said cooled sealing fluid at said constriction for rendering it fluent to enable release of said valve member from said constriction, and

(c) retaining said valve member following its removal from said constriction.

3. A valve sealing method for selectively hermetically sealing an aperture defined by a constriction located intermediate neck and tank portions of a capsule to provide interconnection of said capsule and a light valve tube while maintaining hermetic isolation therebetween and for removing said hermetic seal to enable the transfer of writing fluid from within said tank portion of said capsule to a reservoir within said light valve tube, comprising the steps of:

(a) providing a hollow side arm on said neck portion and in communication therewith at a position remote from said constriction,

(b) positioning a valve member and viscous sealing fluid within said side arm, said sealing fluid retaining said valve member within said side arm,

(c) introducing said writing fluid into said tank portion,

(d) connecting said capsule at said neck portion thereof to an evacuating means for degassing said capsule and said writing fluid,

(e) heating said side arm for rendering said sealing fluid fluent,

(f) tilting said capsule to extricate said valve member from said side arm,

(g) transferring said valve member to said constriction in plugging relationship therewith,

(h) heating said sealing fluid and causing it to flow into sealing relation with said valve member and said constriction,

(i) cooling said sealing fluid for completing the hermetic valve seal,

(j) inverting said capsule for positioning said neck portion thereof below said tank portion and connecting said capsule in hermetically sealed fashion with said reservoir,

(k) evacuating and degassing said light valve tube,

(l) heating said sealing fluid for rendering it fluent to enable release of said valve member from said constriction,

(m) retaining said valve member, following the removal thereof from said constriction, while transferring said writing fluid to said reservoir.

4. A valve sealing method as recited in claim 3 further including the steps of:

(a) providing a feed tube of malleable material extending through said light valve tube to provide communication between the reservoir contained therein and said capsule,

(b) mechanically deforming said feed tube following the transfer to said writing fluid to said reservoir to provide an hermetic seal thereof, and,

(c) removing said capsule from said light valve tube by severing said feed tube at the mechanically deformed portion thereof.

No references cited.

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