

[54] FLOW CUVETTE

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[51] **Int. Cl.** **G01n 1/10**

[58] **Field of Search**..... 356/246; 250/218

[56] **References Cited**

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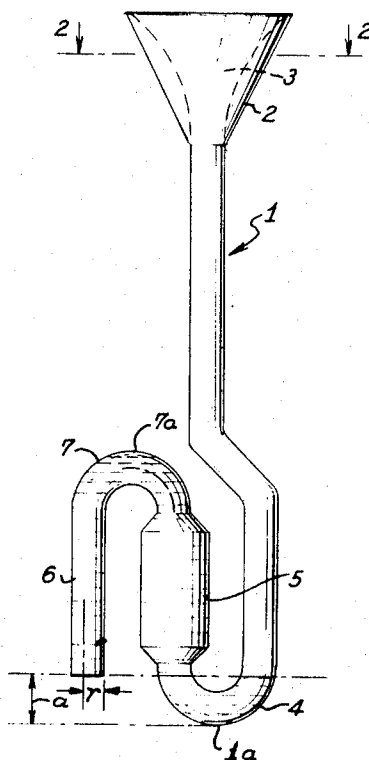
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[57]

ABSTRACT

A flow cuvette which is designed for use with photometric, fluorometric, turbidimetric, and nephelometric instruments. The cuvette holds the sample of liquid which is to be analyzed. A sample chamber is attached at the bottom to an upwardly directed U-shaped feed tube and at the top to a downwardly directed U-shaped drain tube. The feed tube extends above the highest edge of the drain tube and the lower end of the drain tube is positioned at a point above the lowest edge of the feed tube. A funnel is attached to the end of the drain tube to aid in the introduction of the sample. A means can be included in the funnel to prevent eddying or vortexing of the liquid sample and thus prevent entrainment of air bubbles in the sample.

17 Claims, 6 Drawing Figures



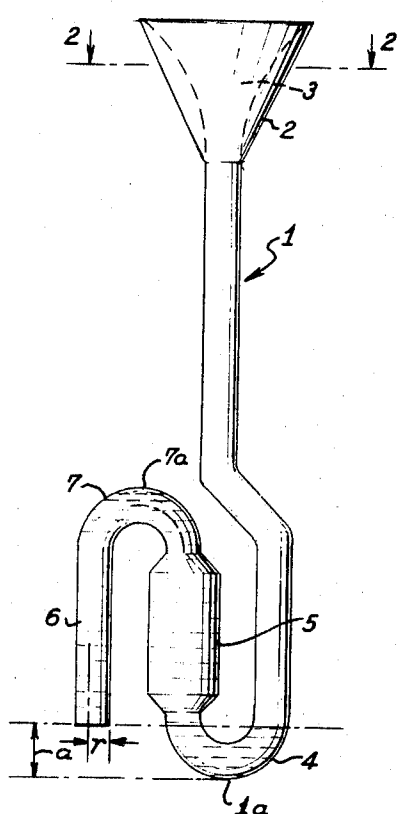


FIG. 1

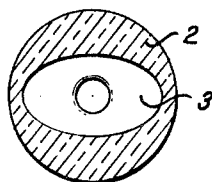


FIG. 2

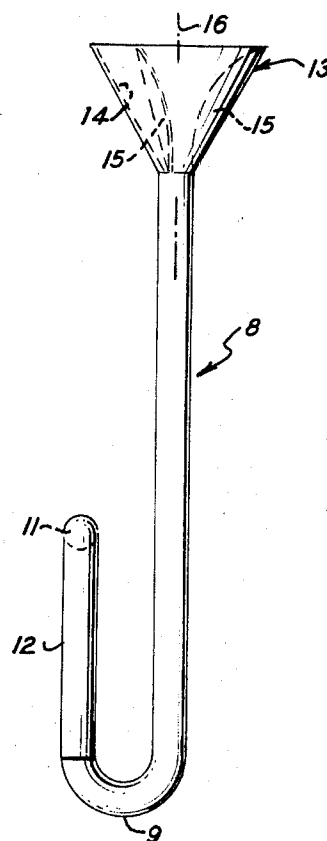


FIG. 3

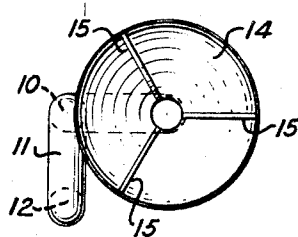


FIG. 4

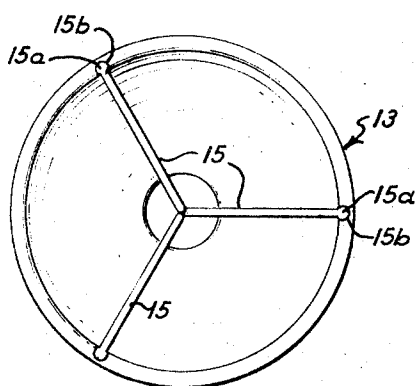


FIG. 5

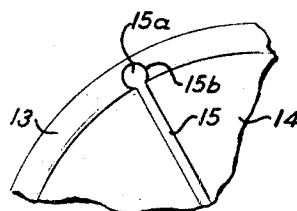


FIG. 6

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FLOW CUVETTE

BACKGROUND OF THE INVENTION

The present invention relates to a flow cuvette which is used for retaining and holding samples for photometric, fluorometric, turbidimetric, and nephelometric measurements. The flow cuvette provides a transparent measuring chamber for the reception of the liquid to be investigated.

Prior art flow cuvettes of this type have to be either connected to a pump, such as an air pump, or provided with a series of shutoff valves for the purpose of filling and emptying the samples from the cuvette. Operation of these cuvettes, therefore, is fairly cumbersome; and for this reason, the earlier models consisting simply of a glass or quartz chamber are usually still preferred. These devices were formed in various shapes, such as a hollow cylinder or a hollow prism. These simple cuvettes, however, have the disadvantage that for emptying and refilling they must be removed from the photometric-type instrument. Thus, each time a sample is changed, the cuvette must be removed from the instrument and replaced.

SUMMARY OF THE INVENTION

The present invention is intended to provide a flow cuvette which is simple to operate and which does not have to be removed from the photometric-type equipment when a change of sample is to be made.

Another object of this invention is that the sample of the liquid present in the flow cuvette automatically is removed and drained away by simply feeding in the next sample. With this apparatus, an air bubble divides the two samples, thus, preventing the samples from flowing together and becoming mixed.

Another object consists in the provision of a flow cuvette wherein the liquid to be investigated can flow into the sample chamber without the introduction of air bubbles even though the successive samples of liquid are separated by an air bubble.

The flow cuvette of the present invention is characterized in that the sample or measuring chamber is attached at the bottom to an upwardly directed U-shaped feed tube and at the top to a downwardly directed U-shaped drain tube. The feed tube is designed so that it extends at least above the upper end portion of the drain tube. The lower end of the drain tube, however, is positioned so that it does not extend beyond the lower or bottom end portion of the feed tube.

In one of the embodiments of this invention, a funnel is provided at the upper end of the feed tube, thus, facilitating the introduction of the liquid sample to the device. Vortexing or eddying in a funnel of this nature can cause the introduction of air bubbles to the liquid sample which is being introduced and, thus, render the sample unsatisfactory for the photometric-type process. To prevent this introduction of air, the funnel can be designed to prevent this vortexing by various means such as designing the inside surface of the funnel with an elliptical cross-section, providing longitudinal ribs on the inside surface of the funnel, or providing X-shaped cross ribs in the funnel. These ribs can be permanently attached or designed to be easily removed, as desired.

In certain types of measurements, such as those carried out with a fluorometric or a nephelometric instrument, it is convenient for the drain tube to project at

an angle of about 90° from the common plane which encompasses both the feed tube and the measuring chamber which is necessary in this type of instrument.

Other objects of this invention will appear in the following description and appended claims, reference being made to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the flow cuvette of the present invention;

FIG. 2 is a sectional view of the funnel portion taken on the line 2—2 of FIG. 1;

FIG. 3 is a side elevation of a second embodiment of this invention;

FIG. 4 is a top plan view of the flow cuvette shown in FIG. 3;

FIG. 5 shows an enlarged plan view of an embodiment of the feed funnel; and

FIG. 6 shows an enlarged detail view of the attachment of the rib to the inside surface of the feed funnel of FIG. 5.

DESCRIPTION OF SPECIFIC EMBODIMENTS

As seen in FIG. 1, the flow cuvette of the present invention is composed of a feed tube 1 which is provided in this embodiment with a feed funnel 2. The funnel 2, as can be seen in FIG. 2, has an elliptical cross-section 3 constituting a vortex preventing means so that eddying or vortexing of the inflowing liquid will be prevented. Vortexing in a funnel arrangement such as this allows the entrainment of air bubbles in the inner central portion of the liquid flow. This type of funnel cross-section is utilized to prevent such vortexing and consequently this air entrainment. It has been found that a liquid which contains air bubbles is not satisfactory for carrying out photometric-type measurements.

The feed tube 1 is formed at its end in a U-shape or 180° bend 4 which opens upwardly into a sample or measuring chamber 5. The measuring chamber 5 can have a somewhat larger diameter cross-section than that of the feed tube 1. This measuring chamber 5 is connected at its top end to a drain tube 6 which also has a U-shape or 180° bend 7, and thereafter is directed downwardly.

The feed tube 1 extends at least above the upper edge 7a of the drain tube bend; and in addition, the drain tube 6 is open at its lower end and terminates at a point which is above the lower edge 1a of the bend 4 of the feed tube 1. It has been found that the best results are obtained when the outlet orifice of the drain tube 6 is positioned at about the level of the inner radius of the bottom end portion or lower bend 4. The dimension designated as a in FIG. 1 is the distance the drain tube 6 terminates above the lower edge 1a of the bend 4.

As the liquid sample to be investigated is poured into funnel 2, it flows through the feed tube 1 and fills the measuring chamber 5 and the drain tube 6. The liquid thus obtains a hydrostatic equilibrium which is demonstrated by the shaded area in FIG. 1.

This hydrostatic equilibrium is obtained according to known laws of hydrostatics and specifically those laws relating to surface tension. The maximum permissible radius r of the drain tube may be calculated from the equation:

$$r = m g / 2\pi F$$

where

m is the mass of a drop of liquid detaching from the drain tube;

g is the acceleration of gravity; and

F is the surface tension of the liquid.

That is, in this manner the maximum permissible radius r is an amount effective to establish a hydrostatic equilibrium so that the liquid is maintained within the measuring chamber and the open ended drain tube 6.

After the photometric, fluorometric, turbidimetric, or nephelometric measurements have been completed, a second sample is poured into the funnel 2, and this sample, in turn, pushes out the previous sample from the cuvette. Mixing of the two samples is prevented by the entrapped air bubble which forms between the two samples of liquid during the introduction of the second sample. If an excess of the second sample is introduced, this excess will wash away any remainder of the previous sample which has adhered to the inner walls of the cuvette. Thus, any contamination of the first portion of the second sample can be flushed away with a minimum of liquid loss.

As shown in FIG. 3, for certain types of photometric investigations, such as fluorometric or nephelometric measurements, it may be desirable to reposition the drain tube in a direction of approximately 90° from the common plane of the measurement chamber and the feed tube 1. This permits different positioning and access of the measurement chamber 5 with respect to the measuring instrument.

Depending upon the space and design requirements, the feed tube 1 can be of a straight section as shown in FIG. 3 or of an offset arrangement as shown in FIG. 1. With the offset arrangement, the funnel 2 can be positioned over the measuring chamber 5 and, thus, provide a more compact unit.

In FIGS. 3 and 4, another embodiment of the flow cuvette of this invention is shown. In this embodiment, the cuvette includes a feed tube 8 which is joined through the bottom end portion or U-shaped bend 9 to a measuring or sample chamber 10. The measuring chamber 10 has the same diameter as the feed tube 8. It is to be understood that the measuring chamber 10 can be of any diameter that is desired. Usually this diameter is dictated by the type of instrument that is to be used. The upper end of the measuring chamber 10 then merges with a second U-shaped bend 11 which then extends into a downwardly directed drain tube 12. Again, the open end of this drain tube 12 is positioned above the lower bottom portion of the feed tube 8.

In contrast to the embodiment described above, the drain tube 12 does not lie in a common plane of the measuring chamber 10 and the feed tube 8, but is repositioned approximately 90° thereto. Thus, the desired access to the measuring chamber 10, as explained above, can be obtained.

The feed tube 8 has mounted at its upper end a feed funnel 13 whose inside surfaces define the shape of an inverted frustum 14. Three guide ribs 15, each displaced 120°, are positioned on the inside surface 14 of the funnel and project radially inward from the inside surface of the funnel 13. These ribs provide an anti-vortexing means to prevent the eddy or whirlpool effect during the introduction of the liquid sample to be inves-

tigated. The radial dimension of the guide ribs 15 may only be a portion of the radius or can extend the entire radius of the funnel, as shown in FIG. 5. In FIG. 5, each guide rib 15 is provided with a retaining bead 15a which is intended to be mated with an appropriate groove 15b formed in the side wall of the funnel. Thus, the guide rib 15 can be slid into the guide groove 15b and, thus, form an easy means of attachment. The guide ribs 15 are therefore easily installed and removed and may be used in any number of combinations desired based primarily according to the viscosity of liquid being investigated. It should be understood that these guide ribs could be permanently or integrally molded into the surface of the funnel and that any number of guide ribs could be integrally formed. As another possibility, all the guide ribs could be formed in one piece which is then simply inserted into the funnel when required. It is to be further understood that the funnel itself can be eliminated, if desired, and any form of device effective to aid in the introduction of the sample and to prevent vortices in the inflowing liquid can be used.

The cuvette described herein is preferably made from glass, such as quartz glass. Other materials may, however, be used for the manufacture of the cuvette provided they exhibit the ray transparency required of the photometric type equipment and are stable with respect to the liquid to be investigated. Plastics such as Plexiglass may also be used. If desired, it is possible to make only the measuring chamber 5 or 10 of a ray-transparent material and to use another material for the remaining parts of the cuvette. The choice of materials used will be governed mainly by the liquid to be investigated and the radiation, for example, visible light, infrared, or ultraviolet rays, used by the analyzing instrument.

While the flow cuvette of this invention has been shown and described in detail, it is obvious that this invention is not to be considered as being limited to the exact form disclosed and that changes in detail and construction may be made therein within the scope of the invention without departing from the spirit thereof.

Having thus set forth and disclosed the nature of this invention, what is claimed is:

1. A flow cuvette for retaining a liquid sample for photometric-type investigations comprising:

- a. a measuring chamber to receive the liquid sample;
- b. an upwardly directed inlet conduit means with one end connected to the bottom of said measuring chamber and there being an inlet at the opposite end thereof; and
- c. a downwardly directed outlet conduit means with one end connected to the top of said measuring chamber and there being an open outlet at the opposite end thereof;
- d. said inlet of the inlet conduit means being positioned above the highest level of the outlet conduit means and said outlet of the outlet conduit means being positioned at a level that is higher than the lowest level of the inlet conduit means;
- e. the maximum permissible radius of the drain conduit means being an amount effective to establish a hydrostatic equilibrium so that liquid may be maintained within the measuring chamber and the open ended drain conduit means.

2. A flow cuvette as defined in claim 1 wherein

said inlet conduit means includes a funnel means located at said inlet of said inlet conduit means to facilitate the introduction of the liquid sample.

3. A flow cuvette as defined in claim 2 wherein the funnel means includes a vortex preventing means so that the entrainment of air bubbles in the liquid sample will be prevented.

4. A flow cuvette as defined in claim 3 wherein the vortex preventing means comprises an elliptical cross-section configuration on the linear surface of the funnel means.

5. A flow cuvette as claimed in claim 3 wherein the vortex preventing means comprises one or more ribs located on the inner surface of said funnel means and which extend radially inwardly towards the center axis of the funnel means.

6. A flow cuvette as defined in claim 5 wherein each guide rib includes a bead and the inner surface of the funnel means includes a longitudinal groove which mates with said bead of the rib, said bead thereby constitutes an attachment means for said rib when it is located in said groove.

7. A flow cuvette as defined in claim 1 wherein the inlet conduit means is comprised of an elongated tube means including a U-shaped bottom end portion which is attached to the measuring chamber.

8. A flow cuvette as defined in claim 7 wherein the inlet conduit means is provided with an offset section which allows the inlet to be positioned generally above the measuring chamber.

9. A flow cuvette as defined in claim 1 wherein the outlet conduit means is comprised of an elongated tube means having a U-shaped bend which is attached to the measuring chamber.

10. A cuvette as defined in claim 9 wherein the maximum permissible radius of the outlet conduit means is defined by the formula:

$$r = m g / 2 \pi F$$

where

r is the maximum permissible radius of the outlet conduit means;

m is the mass of a drop of the liquid detaching from the outlet conduit means;

g is the acceleration of gravity; and

F is the surface tension of the liquid.

11. A flow cuvette as defined in claim 1 wherein the measuring chamber and the inlet conduit means lie in a common plane and the outlet conduit means is positioned at an angle from said common plane.

12. A flow cuvette for retaining a liquid sample to be measured comprising:

a. a measuring chamber to receive the liquid sample,
b. an upwardly directed feed conduit means having one bottom end portion connected to the bottom of said measuring chamber, and

c. a downwardly directed, tubular drain conduit means having an upper end portion connected to the top of said measuring chamber and a lower end thereof being open,

d. said feed conduit means extending upwardly at least to the level of the upper edge of said upper end portion,

e. said drain conduit means extending downwardly a distance which does not extend beyond the level of the lower most portion of the feed conduit means,

f. the maximum permissible radius of the tubular drain conduit means being an amount effective to establish a hydrostatic equilibrium so that liquid may be maintained within the measuring chamber and the open ended tubular drain conduit means.

13. A cuvette as defined in claim 12 wherein the maximum permissible radius of the drain conduit means is defined by the formula:

$$r = m g / 2 \pi F$$

where

r is the maximum permissible radius of the drain conduit means;

m is the mass of a drop of the liquid detaching from the drain conduit means;

g is the acceleration of gravity; and

F is the surface tension of the liquid.

14. A cuvette as defined in claim 12 wherein the bottom end portion of the feed conduit means is a U-shaped bend and

the upper end portion of the drain conduit means is a U-shaped bend.

15. A cuvette as defined in claim 12 wherein said feed conduit means includes a funnel means forming an inlet and having a vortex preventing means to prevent the entrainment of air bubbles in liquid placed in the cuvette.

16. A cuvette as defined in claim 15 wherein the vortex preventing means comprises an elliptical cross-section configuration on the inner surface of the funnel means.

17. A cuvette as defined in claim 15 wherein the vortex preventing means comprises one or more ribs located on the inner surface of said funnel means and which extend radially toward the center axis of the funnel means.

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