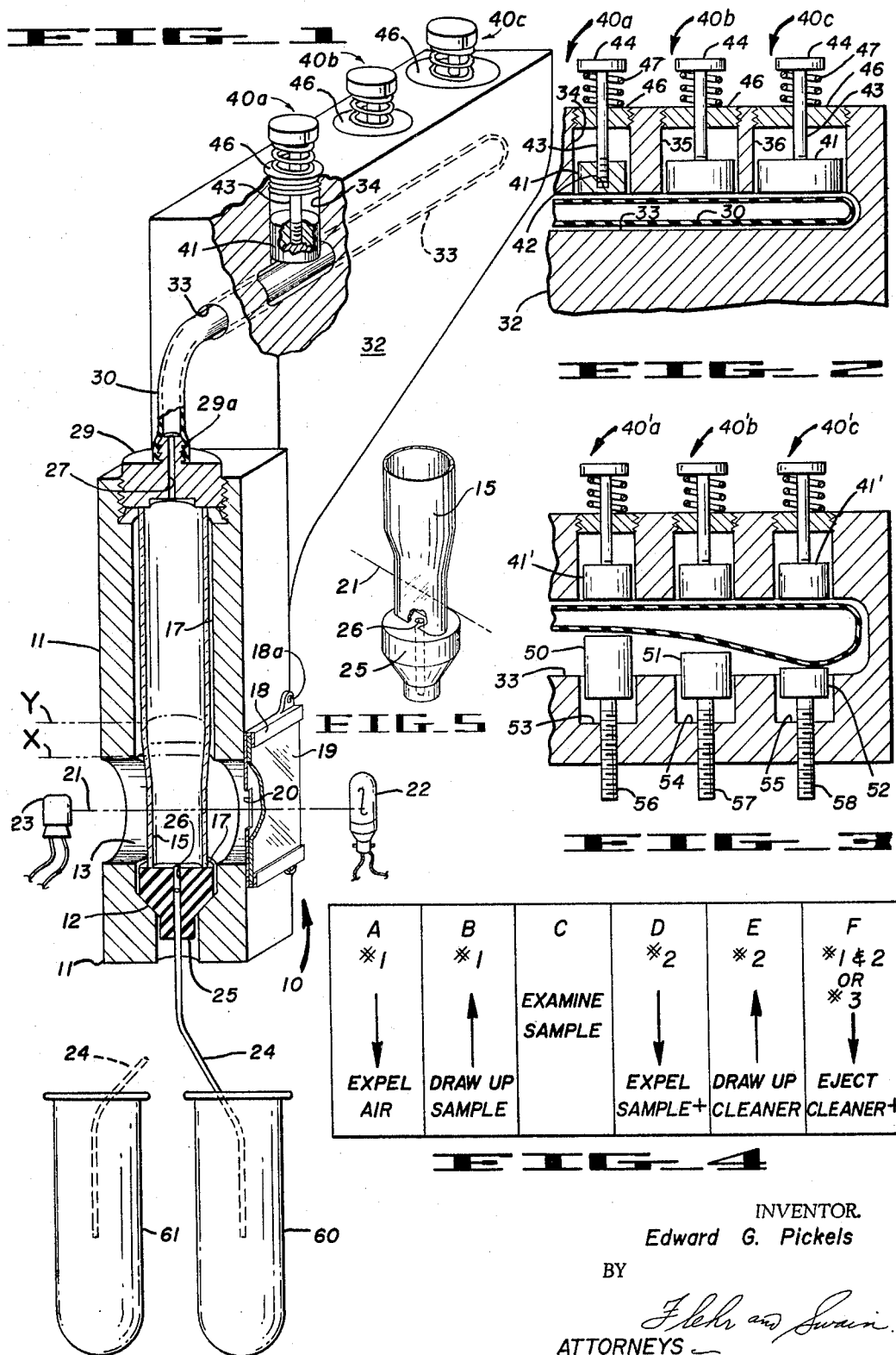


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VOLUMETRIC DISPLACEMENT
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**CUVETTE WITH MEANS FOR CONTROLLED
VOLUMETRIC DISPLACEMENT**

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This invention relates to analyzing apparatus and more particularly to a cuvette for such apparatus wherein small samples of fluid are deposited in the cuvette for optical analysis.

Originally, optical analyzing apparatus, such as colorimeters, were adapted to bodily receive successive test tubes which contained liquid samples to be analyzed. Each of the tubes contained a sample and the tubes were interchanged in the colorimeter to analyze the different samples. Generally the apparatus was calibrated for a particular test tube. However, since the tubes were interchanged to analyze various samples, errors due to variations in the positioning of the tube, glass materials, and changes in the light path were incurred.

An alternative apparatus was developed in which a fixed test tube or "cuvette" was permanently placed in the apparatus and the liquid samples to be analyzed were successively placed into the test tube or cuvette and removed therefrom. One type of such "cuvette" apparatus was filled from the top and the liquid sample removed from the cuvette via withdrawing the same from an opening formed in the bottom by connecting to the bottom of the cuvette a tube arranged to be subjected to a vacuum to remove the sample. The cuvette was cleaned by pouring a washing solution such as distilled water into the cuvette, followed by the application of a drying agent such as acetone to clean the test tube for the next successive sample, thereby removing all residue from the tube which might affect the reading of the succeeding sample.

The present invention contemplates an improved cuvette in which the analyzing chamber is arranged to be subjected to a vacuum wherein the liquid is sucked up into the cuvette via a connecting tube and expelled therefrom. The apparatus includes means whereby it is assured that each successive sample is completely expelled and that the washing is effected to remove all residue.

It is an object of the present invention to provide an improved cuvette of the above character.

It is another object of the present invention to provide a cuvette wherein a plurality of successive samples can be effectively and efficiently analyzed.

It is still another object of the present invention to provide a cuvette in which the samples and washing solutions are drawn into the cuvette and expelled therefrom through the same communicating passage and wherein means are provided for insuring an effective washing of the cuvette following an analysis of a sample.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawing which discloses, by way of example, the principle of the invention and the best mode which has been contemplated of applying that principle.

In the drawing:

FIGURE 1 is a perspective view partially broken away schematically representing the invention;

FIGURE 2 is a diagrammatic representation for purposes of illustrating the operation of one embodiment of the invention;

FIGURE 3 is a diagrammatic representation of an alternative embodiment of the invention;

FIGURE 4 is a chart wherein the successive operative steps of the invention have been itemized; and

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FIGURE 5 is a perspective view of the permanent transparent test tube, i.e., "cuvette" and bottom sealing plug.

Referring to FIGURE 1, the invention as schematically represented there includes a cuvette assembly 10 having a housing 11 which is axially drilled to form a bore 17, the lower end of bore 17 is tapered to form a conical seat 12 for receiving a resilient plug 25 of a suitable material, such as for example sold under the trademark "Teflon," which is a plastic described as consisting of a tetrafluoroethylene polymer.

Intercepting bore 17 normal thereto is a cylindrically shaped hole drilled through housing 11 to form a pair of open windows 13. A transparent permanent test tube or cuvette 15, shown best in FIGURE 5, is disposed within bore 17 with its open bottom end resting on the top of plug 25 to form a seal therewith. An externally threaded upper fitting 29 is screwed into the top of housing 11 until its under surface presses down upon the circular upper edge of cuvette 15. By applying appropriate pressure in this manner to cuvette 15, a water tight seal is provided between the lower edge of cuvette 15 and the upper surface of plug 25. Fitting 29 is provided with a hole 27 drilled coaxially therethrough and includes a boss portion 29a which is externally formed with several spaced circular ridges angled downwardly as shown in FIGURE 1. The ridges on portion 29a are provided in order to hold a resilient deformable squeeze bulb 30 of a suitable material such as rubber forced thereover.

A flexible capillary tube 24 of a suitable material such as plastic is slip fitted up into the axial hole 26 in plug 25 so as to open into the lower end of cuvette 15. Thus by drawing a fluid sample up into cuvette 15 via tube 24, the fluid sample can be interposed into an optical analyzing path such as 21 including, for example, a light source 22 and a photoresponsive device such as a photocell 23. It will be observed that the light path 21 incurs only the transparent wall of cuvette 15 and the fluid being analyzed. However, for certain purposes, it is sometimes necessary to filter the light path, and for this purpose, a bracket 18 having tabs 18a and an oblong masking slot 20 is secured, as by using screws to the side of housing 11. In this manner, a filter 19 shown in phantom lines in FIGURE 1 can be slipped into position to filter the light of path 21 as desired.

In order to manipulate the fluid level of both a sample and a washing solution, such as distilled water, within cuvette 15, the upper portion of the apparatus shown in FIGURE 1 includes a plunger housing 32 suitably attached to the side of housing 11 by means not shown. This connection can be either permanent or removable as desired. Bulb 30 is disposed into housing 32 and constrained in a bore 33 drilled therein. Intersecting bore 33 are three cylindrical openings 34-36 respectively, each of increasing diameter. Within each of bores 34-36 is a plunger assembly 40a-40c, shown best in FIGURE 2. Each plunger assembly includes a piston 41 of a suitable material, such as an epoxy resin, loosely fitted in the cylindrical openings 34-36. Pistons 41 include a central tapped hole 42 disposed to threadedly receive the lower end of an operating stem 43 which extends upwardly to a circular head portion 44. The top of each opening 34-36 is closed off by a threaded retaining ring 46 through which stems 43 pass. Finally, interposed between head portion 44 and retaining rings 46 there has been provided a spring 47.

As thus arranged and as shown in FIGURE 2, depressing any of plungers 40 will displace an associated volume from bulb 30 in increasing order of their positions as shown.

An alternative embodiment of the plunger arrangement is shown schematically in FIGURE 3. Plungers

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40 are represented by the same reference characters, together with a prime mark ('), wherein plunger 40a' displaces the least volume of air from bulb 30. It is to be noted that plungers 40' include pistons 41' of the same diameter. Their longitudinal displacement, however, is limited by the provision of a plurality of inserts 50, 51 and 52. Each insert 50-52 is generally cylindrical in shape, and made of a suitable material such as an epoxy resin and disposed in a cylindrical depression 53-55 respectively. Screws 56-58 are arranged to enter the bottom of each depression 53-55 so that each insert 50-52 can be raised into bore 33 to any degree desired.

As shown in FIGURE 3, it can be seen that the diameters of pistons 41 are the same, but their displacements vary by limiting their longitudinal travel.

OPERATION

Having the foregoing structure in mind, and referring to FIGURE 4, the handling of a small liquid sample will proceed as now to be described.

The first step (A) is to depress plunger 40a with capillary tube 24 preferably disposed in air, thereby expelling a small volume of air from bulb 30. If tube 24 is next inserted into a fluid sample as in test tube 60 for example, and plunger 40a released (B), the fluid sample will be drawn up into cuvette 15 to a level, for example, as shown by the line X. In this condition, the fluid sample can be optically analyzed by placing cuvette assembly 10 in path 21 so that light from source 22 can be passed through it to photocell 23. After suitably analyzing the fluid sample (C), the next larger plunger 40b is depressed (D) to expel the sample plus a small additional amount indicated by the plus sign (+) in step D. In this manner complete expulsion of the sample is assured.

Capillary tube 24 is then removed from test tube 60 and inserted into a container such as test tube 61 containing a washing solution, for instance, distilled water. With tube 24 disposed in test tube 61, the No. 2 plunger 40b can be released (E). This action introduces washing fluid into cuvette 15 to a degree exceeding the level previously indicated by the line X. For example, the water level may rise up to the line Y as shown. The final step (F) is intended to make sure that all washing fluid is expelled from cuvette 15, and this can be effected by either depressing the No. 1 and No. 2 plungers simultaneously or by depressing the No. 3 plunger. In either event, a still greater volume of gas such as air in bulb 30 is pressurized to expel all the liquid from cuvette 15 plus an additional amount.

As is known, it is desirable that formation of bubbles in the sample be avoided which would otherwise aerate the liquid being analyzed. In the above structure, pressure is controlled by means which can ordinarily be expected not to generate abrupt changes. Furthermore, the material of bulb 30 can be made with a wall thickness which gradually relieves itself to an unstressed condition slowly enough so that the quick release of plungers 40 is ineffectual in causing any abrupt reduction of the pressure within bulb 30.

Therefore, in the arrangement shown, the length of tube which is squeezed can be accurately controlled, and

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the amount of reduced pressure created can be made as small as desired. As mentioned, material for bulb 30 can be selected with an appropriate wall thickness so that reduction in pressure is limited to a gradual change which will not cause bubbles to form. It is further to be observed that the bulb tubing is always retained in its natural position whereby it will not develop a "set."

Accordingly, it is seen that there is provided a cuvette assembly which is adapted to operate with small volumes of a liquid sample and which does not aerate the sample being analyzed, and which includes means insuring proper washing between successive samples.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and detail of the device illustrated and in its operation can be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

I claim:

1. In a cuvette assembly having a transparent hollow fluid examining chamber and fluid conducting means leading into said chamber to supply fluid thereto, the combination of a resilient deformable tube closed at one end and coupled to lead into said chamber from the other, manually operable slidable plunger means disposed to selectively compress said tube and reduce the interior volume thereof in progressively increasing discrete degrees, said plunger means including a plurality of pistons of the same diameter but limited to move through different linear displacements, thereby each deforming said tube to a different related degree.

2. In a cuvette assembly having a transparent hollow fluid examining chamber and fluid conducting means leading into said chamber to supply fluid thereto, the combination of a resilient deformable tube closed at one end and coupled to lead into said chamber from the other, manually operable slidable plunger means disposed to selectively compress said tube and reduce the interior volume thereof in progressively increasing discrete degrees, said plunger means including a plurality of pistons having the same linear displacement while being of different diameter thereby each deforming said tube to a different related degree.

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