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[54] **PHOTOMETER CHAMBER UNIT**

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[51] **Int. Cl.** **G01n 1/14**

[58] **Field of Search** 356/180, 181, 244, 246; 250/576

[56] **References Cited**

UNITED STATES PATENTS

3,418,053	12/1968	Pelavin	356/181
3,689,164	9/1972	Riley	356/246
3,799,683	3/1974	Günner	356/246

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[57] **ABSTRACT**

A photometer chamber unit in which a liquid to be analyzed is sucked into a photometer chamber, comprises a channel system with a pipette tube which is to be inserted in a liquid and at least one photometer chamber which is to be passed by light. At the end of the channel system remote from the pipette tube the channel system ends with a damping capillary tube which opens into a chamber, whereas means are provided for achieving a first lower pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for sucking liquid into the channel system and for achieving a second higher pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for emptying the liquid from the channel system.

9 Claims, 3 Drawing Figures

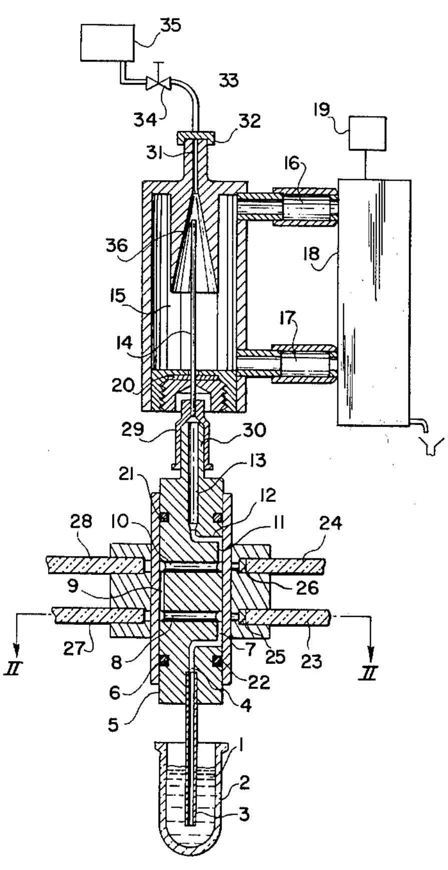
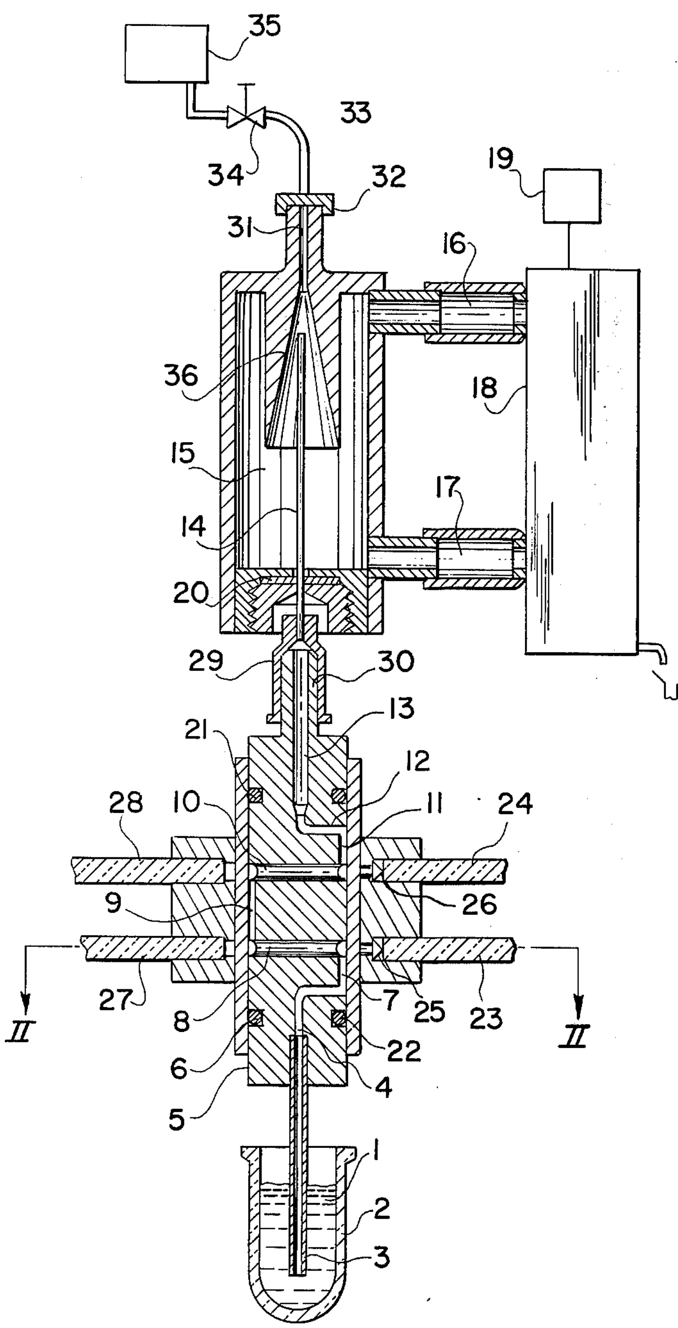


FIG. 1



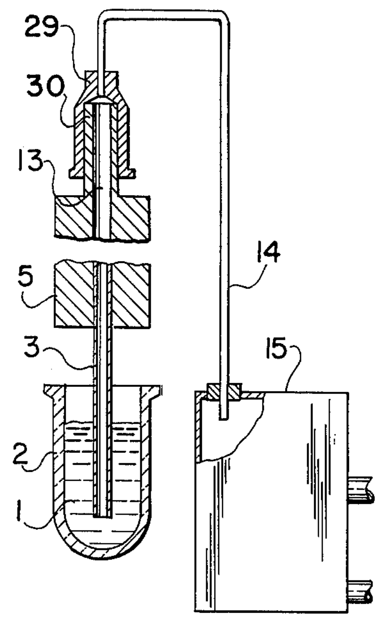
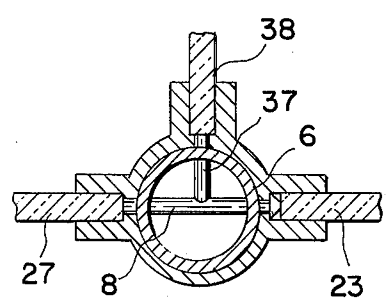


FIG. 3

FIG. 2



PHOTOMETER CHAMBER UNIT

The present invention concerns an arrangement in a chamber for the examination of fluids by means of colorimetric, photometric or similar methods. In this device one or several photometer chambers are filled with a sample liquid, on which said analysis is made, whereupon the photometer chambers are emptied so that a similar test can be made on another sample liquid in a succeeding test cycle. The photometer chamber is comprised in a channel system which begins with a pipette tube which is to be inserted in a liquid.

In previously known photometer chambers the liquid has been drawn into the chamber by means of a pump connected with the chamber and the supply of liquid to the chamber and the removal of liquid therefrom has been controlled by one or several valves. However, it is difficult to obtain a reliable function with elements such as pumps and valves and they also may cause a considerable contamination so that one sample liquid is contaminated by a preceding sample liquid that has passed through the apparatus.

These drawbacks are eliminated in the arrangement according to the invention, in which at the end of the channel system remote from the pipette tube the channel system ends with a damping capillary tube which opens into a chamber, whereas means are provided for achieving a first lower pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for sucking liquid into the channel system and for achieving a second higher pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for emptying the liquid from the channel system.

The invention will be described below with reference to the annexed drawing, where:

FIGS. 1 and 3 show two embodiments of the invention.

FIG. 2 shows a section along the line II—II in FIG. 1.

A liquid 1, which is to be analysed with regard to its optical properties is contained in a test tube 2. A pipette tube 3 is inserted into the liquid. This pipette tube is connected with a conduit 4 in a longitudinal, preferably circular body 5. This body is enclosed by a preferably circular tube 6 of a transparent material such as glass, in such a way that a sealing contact is present between the body 5 and the inner surface of the tube 6. The tube 3 is coaxial with the body 5 and the conduit 4 is diverted and opens out on the mantle surface of the body 5. In connection with the opening of the conduit 4 a recess 7 is made in the mantle surface of the body 5 which extends in the axial direction. The upper end of this recess 7 is connected with a first photometer chamber 8 in the body 5. This photometer chamber extends diametrically through the body 5.

The connection between the recess 7 and the photometer chamber 8 forms the entrance opening of this photometer chamber. The outlet opening thereof is connected with a second recess 9 in the mantle surface of the body 5. Also this recess extends in the axial direction and the upper end thereof is connected with a second photometer chamber 10. The outlet opening of the photometer chamber 10 is connected with a third axial recess 11 in the mantle surface of the body 5, and in the embodiment shown in FIG. 1 this recess is connected with an outlet conduit 12.

The body 5 can be provided with an arbitrary number of photometer chambers, accordingly either with only one photometer chamber or with two or several in dependence of the number of measurements which shall be made on the same sample liquid. The arrangement of several photometer chambers enables photoelectric measurements with a plurality of different wavelengths of the light.

The outlet conduit 12 is connected with a chamber 13 which is intended for receiving rinsing liquid and the function thereof will be explained further in the following. Finally, the chamber 13 is connected with a capillary tube 14 which opens out in a subpressure chamber 15. The chamber 15 is by means two conduits 16 and 17 connected with a source of subpressure 18. The subpressure generated in this source is variable and can be given suitable values by means of a control device 19.

The capillary tube 14 is thrust through a self-sealing rubber washer 20 in the lower end wall of the subpressure chamber 15. Accordingly, this chamber may be lifted away from the photometer chamber unit without influencing the subpressure in the chamber 15. This means that in an analyzing machine with a plurality of channels one and the same subpressure system may be used for all photometer chamber units.

As mentioned above a sealing contact is present between the body 5 and the transparent tube 6. At the end parts of the body 5 the sealing may be improved by means of O-rings 21, 22 which are mounted in annular grooves in the body 5 in a usual way.

The light which shall pass the photometer chambers 8 and 10 is supplied from lightsources not shown in the drawing by means of optical fibre bundles 23 and 24 which extend to such a distance from the tube 6 that collecting lenses 25, 26 for producing parallel light-rays to the photometer chambers 8 and 10 through the wall of the tube 6 may be inserted between the ends of the fibre bundles and the tube 6. The light which leaves the photometer chambers is conveyed by further optical fibre bundles 27 and 28 to photocells or similar means not shown in the drawing.

As described above the liquid is supplied to the photometer chambers 8 and 10 through axial recesses 7 and 9 in the mantle surface of the body 5. As a result of this design the inflowing liquid will rinse the inner surface of the tube 6 in the area in front of the corresponding photometer tube so that any impurities are removed from these parts. In spite of this it may happen that a coating will gradually be produced in these parts. When this has happened the tube 6 may be turned with relation to the body 5 so that a clean and previously not used part of the tube 6 will be brought in front of the photometer chambers 8 and 10. This procedure may be repeated a number of times and furthermore, the tube 6 may be displaced in the axial direction in relation to the body 5. The photometer chamber unit may accordingly function a very long time before it has to be dismounted for cleaning. Such a cleaning is simplified by the extremely simple design of the photometer chamber unit.

Due to reasons explained below, it may be advantageous that the capillary tube 14 be removably connected with the rest of the photometer chamber unit. For this purpose the capillary tube 14 is inserted in a socket 29, the length of which preferably is greater than the inner diameter of the socket. Furthermore, the socket has a conical cavity which has a larger diameter near the end of the socket **29**. Finally the socket **29** is put on a correspondingly designed stud **30** at the upper part of the body **5**. After the subpressure chamber **15** has been removed from the photometer chamber unit as described above the capillary tube **14** may accordingly be easily removed from the rest of the photometer chamber unit and a capillary tube having for instance another dimension may be put on the photometer chamber unit, whereupon the subpressure chamber **15** is again connected with the photometer chamber unit.

The upper part of the subpressure chamber **15** is provided with a conduit **31** which normally is closed by a cover **32**. The function of these elements will be described in the following.

The arrangement described above functions in the following way. When the subpressure in the subpressure chamber **15** has a first predetermined value the pipette tube **3** is inserted into a liquid **1**. As a result thereof liquid will flow into and fill the channel system which begins with the tube **3** and ends at the capillary tube **14** until the liquid has reached the upper end of the capillary tube **14**. The suction of liquid into the channel system takes place rather quickly until the liquid has reached the lower part of the capillary tube **14** since this tube has no noticable braking influence on the air which at first is exhausted from the channel system. When the liquid has reached the capillary tube, however, a braking occurs, so that the liquid comparatively slowly rises to the upper part of the capillary tube **14** which accordingly functions as a damping tube. The predetermined first value of the subpressure in the subpressure chamber **15** is so chosen that the liquid can rise to the upper part of the capillary tube **14** but cannot squeeze out from the tube. As a result of the capillary force in the capillary tube **14** and also as a result of the surface tension at the upper liquid surface, however, this value of the subpressure is not critical but a certain variation may be tolerated without the liquid in the capillary tube **14** sinking downwards or squeezing out. As a first result of this design always the same amount of liquid **1** is sucked into the photometer chamber unit. Accordingly, it has in a simple way been assured that the amount of sample liquid always is constant.

The part of the sample liquid which is first sucked into the photometer chamber unit flows through the two photometer chambers **8** and **10** and into the chamber **13**. This first part of the liquid accordingly functions as a rinsing liquid in order to remove possible rests of liquid samples previously sucked in. Since this amount of liquid remains in the chamber **13** the amount of liquid used for rinsing purposes is always constant so that the reproducibility is increased. Finally, the liquid which stays in the photometer chambers **8** and **10** and which is subjected to the analysis is accordingly very clean and is at rest during the measurement.

For emptying the channel system a predetermined second and higher subpressure is produced in the subpressure chamber **15**. This subpressure is so chosen that the liquid now may squeeze out of the capillary tube **14** into the subpressure chamber **15** from which the liquid is removed through the conduit **17**. Since this conduit may be obstructed by the liquid the source of subpressure **18** is connected with the subpressure chamber **15** as mentioned above by means of a second conduit **16** which is so located and designed that it always contains only air.

The damping capillary tube **14** causes the liquid to be sucked out of the photometer chamber unit comparatively slowly. This brings with it that the liquid column always is kept unbroken so that it is not divided into smaller drops which possibly might remain in those bends and transitions which are present in the channel system. The inner binding and the surface tension of the liquid accordingly results in that the channel system until the upper opening of the capillary tube **14** is entirely emptied from liquid. The extremely small drop which might possibly remain at this upper end can in no way reach the photomenter chambers **8** and **10** through the capillary tube **14** and the chamber **13**.

In view of the fact that the apparatus may be used for analysing liquids having mutually different internal friction the capillary tube **14** is interchangeable so that a suitable damping of the movements of the liquid may be obtained with regard to a certain internal friction.

In certain cases the analysis is made on a liquid of such a kind that a generation of foam may occur in the subpressure chamber **15**. In such case it might happen that also the conduit **16** was obstructed by the foam so that the free movement of the air could be prevented. This would result in an incorrect subpressure in the chamber **15**. In order to prevent the generation of foam a foam-quenching preparation may be supplied in such a way that it is slowly added through the narrow conduit **31**. For that purpose the cover **32** is removed whereupon a tube **33** is sealingly inserted into the conduit **31**. The tube **33** is connected with a container **35** for the foam-quenching preparation over a controllable valve **34**. Due to the subpressure in the chamber **15** the liquid is sucked into the conduit **31** and the flow is regulated to a suitable value so that an inverted funnel **36** which is connected with the conduit **31** is continuously damped by the foam-quenching liquid, so that an effective degradation of any generated foam is achieved. In order to meet different requirements some liquid of another kind may be used instead of the foam-quenching liquid such as a neutrualizing or a desinfecting liquid.

In the above description it has been assumed that the subpressure in the subpressure chamber may have either a first value or a second value corresponding to a greater subpressure. The apparatus may further on be so designed that at least a third value of the subpressure may be obtained and in such a case the subpressure is substantially greater than the subpressures mentioned before. This still greater subpressure may be needed if some impurity, for instance a solid particle has caused an obstruction of the channel system from the pipette tube **3** to the capillary tube **14**. This still greater subpressure can then cause an effective flushing of the channel system. If the said solid particle has such a magnitude that the lower opening of the pipette tube **3** has been obstructed, this solid particle may even be removed if a suitable overpressure is generated in the chamber **15**.

The photometer chamber device described may very well be used in connection with an automatic analyzing machine even if its use is not restricted to such a machine. Normally, an analyzing machine is connected with a recorder of some other similar means for recording the analysis results. In such a case it is valuable if an exact distinction may be made between successive samples so that a positive indication is obtained when a certain sample liquid is supplied to or removed from the photometer chamber unit. A positive indication of that kind is obtained in the photometer chamber unit according to the invention since the liquid which is sucked into the channel system and which is removed from it begins with and ends with a liquid meniscus. When such a meniscus passes either of the photometer chambers **8** and **10** a total reflection of the supplied light takes place which will be indicated as a distinct level change of the outgoing signal.

In the photometer chamber device according to the present invention the sample fluid to be examined always flows in one and the same direction. Furthermore, the sucking-in of the sample liquid and also the removal of this liquid is achieved entirely by the use of controllable subpressures. Thus, the apparatus does not comprise any piston pumps or any valves, which elements are of such a kind that difficulties with regard to sealing or contamination almost always are present.

From FIG. **2** it is clear that the impinging light normally passes the photometer chamber **8** in its longitudinal direction. Thereby an absorption measurement with regard to the passing light is made. It has been indicated in the drawing that also a light way can be achieved which is perpendicular to the photometer chamber **8** in that a light guiding rod **37** has been inserted in the body **5** in the same plane as the photometer chamber **8** and perpendicular to the chamber. The light which leaves the rod **37** passes through the wall of the tube **6** and further on to an optical fibre bundle **38.** In this way it is possible to make fluorescence measurements on the sample liquid as well as nefolometri.

In the above given description it has been stated that subpressure in the subpressure chamber **15** shall have such a magnitude with relation to the surrounding pressure i.e. the pressure on the liquid surface of the liquid **1** that the pressure difference between said lastnamed pressure and the subpressure in the chamber **15** is sufficient for forcing the liquid up through the channel system to the upper opening of the damping capillary tube **14.** For achieving this result it is of course not necessary that a subpressure prevails outside the upper opening of the damping capillary tube **14** in relation to the pressure of the surrounding. The same result can also be achieved if the pressure outside the opening of the damping capillary tube **14** is the same as in the surrounding, in which case the liquid surface of the liquid **1** has to be subjected to a corresponding overpressure. The invention covers also an embodiment of that kind.

In a working embodiment of the invention the pressure difference between the pressure on the liquid surface of the liquid **1** and the pressure in the chamber **15** is in the order of 120 millimeters water column. As has been mentioned above this pressure difference is not critical but a variation on some tenths millimeter water column may be tolerated without any harm to the function of the apparatus. With suitable dimensioning of the capillary tube **14** it can also be achieved that the liquid remains in the channel system even if the sample tube **2** is removed. After the measurement has been finished the liquid is sucked away as described above by increasing the subpressure. The apparatus may accordingly be used also in those cases when the different sample liquids are supplied manually, since it is only necessary to keep a tube with sample liquid under the pipette tube in order to start an analysis. After the channel system has been emptied after a preceeding analysis of a sample liquid and the subpressure in the chamber **15** has returned to the first-named lower value a continuous flow of air goes on through the channel system. As soon as a tube with a sample liquid is moved against the pipette tube **3** the liquid is sucked into the channel system and stops as described above so that the measurement can be performed.

With regard to the apparatus according to FIG. **1** it has been assumed that the free end of the capillary tube **14** forms the top of the channel system. Thus, the capillary tube **14** consists of a vertical and straight tube. However, it is clear that the free end of the capillary tube **14** which opens into the subpressure chamber **15** may be situated at a lower level. It is even possible that this free end may be substantially at the same level as the liquid surface of the liquid **1.** An example of this design of the capillary tube **14** is shown in FIG. **3.**

In order to suck the liquid from the sample tube **2** into the channel system a rather small pressure difference is needed between the pressure in the chamber **15** and the pressure on the liquid surface of the liquid **1.** As described above the liquid in the channel system stops when it has reached the free end of the capillary tube **14** and remains there due to the capillary force and also due to the surface tension of the liquid.

The design of the capillary tube **14** according to FIG. **3** may preferably be used in case various liquids having different specific gravity are to be examined in the apparatus. In the apparatus according to FIG. **1** it is necessary to give the capillary tube an inner diameter which is suitable with regard to the liquid in question which is to be examined in order to keep the upper liquid surface at the free end of the capillary tube **14.** In the embodiment shown in FIG. **3,** however, this inner diameter of the capillary tube **14** is not so critical.

In case the apparatus is used in an automatic analysing machine the conveying of tube with sample liquids, inserting of pipette tubes, measurement, recording of the measurement results and setting of the subpressures may be controlled in a known manner so that the desired working cycles are obtained.

What is claimed is:

1. In a photometer chamber unit in which a liquid to be analyzed is sucked into a photometer chamber, said unit comprising a channel system with a pipette tube for insertion into a liquid, and at least one photometer chamber which is to be passed by light, the improvement wherein the channel system is one single unbranched channel from the pipette through the photometer chamber, and at the end of the unbranched channel system remote from the pipette tube the channel system ends with a vertical damping capillary tube which extends into and opens into a chamber and constitutes a continuation of said single unbranched channel, and means are provided for achieving a first lower pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for sucking liquid into the channel system only until it reaches the upper end of said capillary tube in said chamber, and for achieving a second higher pressure difference between the pressure in the chamber and the pressure on the liquid around the pipette tube for emptying the liquid from the channel system and into the chamber.

2. Arrangement as claimed in claim **1** in which the chamber is connected with means for removing liquid from the chamber.

3. Arrangement as claimed in claim 1 in which the capillary tube is inserted into a hole in the wall of the chamber which is self-sealing upon removing of the capillary tube from the hole.

4. Arrangement as claimed in claim 1 and further comprising means for supplying a foam-quenching liquid to the chamber.

5. Arrangement as claimed in claim 4 wherein an inverted funnel is located above the free end of the capillary tube and wherein means are provided for damping said funnel with the foam-quenching liquid.

6. Arrangement as claimed in claim 1 wherein the photometer chamber in the channel system between the pipette tube and the capillary tube consists of a diametrical hole in a circular body, and each end of the hole is connected with an axial recess in the mantle surface of the body and the body is sealingly surrounded by a tube of transparent material.

7. Arrangement as claimed in claim 6 wherein optical fibre bundles are located coaxial with the diametrical hole for the conduit of light to and from the photometer chamber, and a collecting lens is inserted between the optical fibre bundle for the supply of light and the wall of the transparent tube.

8. Arrangement as claimed in claim 6 wherein the transparent tube is turnable and axially displaceable in relation to the body.

9. Arrangement as claimed in claim 6 wherein a light guiding rod is inserted in the body in the same plane as the photometer chamber and perpendicular to said chamber, and an optical fibre bundle is located outside the transparent tube coaxial with said rod.

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