

United States Patent

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[54] **CONSTANT FLOW RATE BURETTE**
5 Claims, 2 Drawing Figs.

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23/292, 222/158

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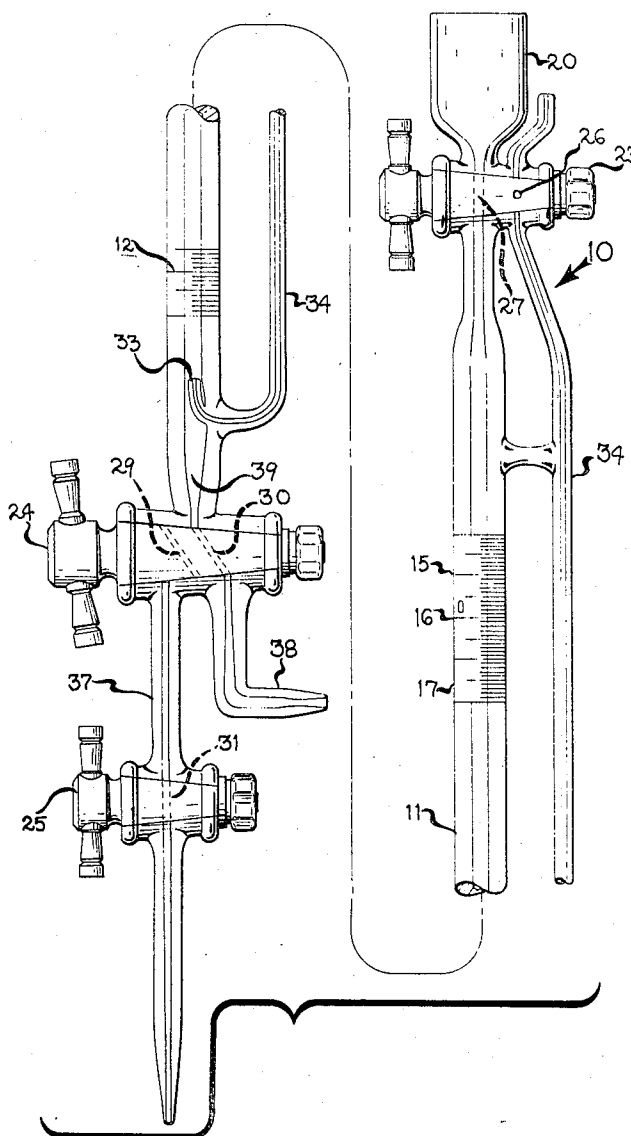
[50] Field of Search..... 23/253,
259, 292; 222/158; 73/426

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ABSTRACT: A burette assembly for discharging liquids at a constant flow rate regardless of the height of solution in the burette. This result is accomplished by attaching a capillary tube to the wall of a conventional burette. The tube is vented to the atmosphere at one end and terminates at the other end at a point on the inside of the bottom portion of the barrel the burette.



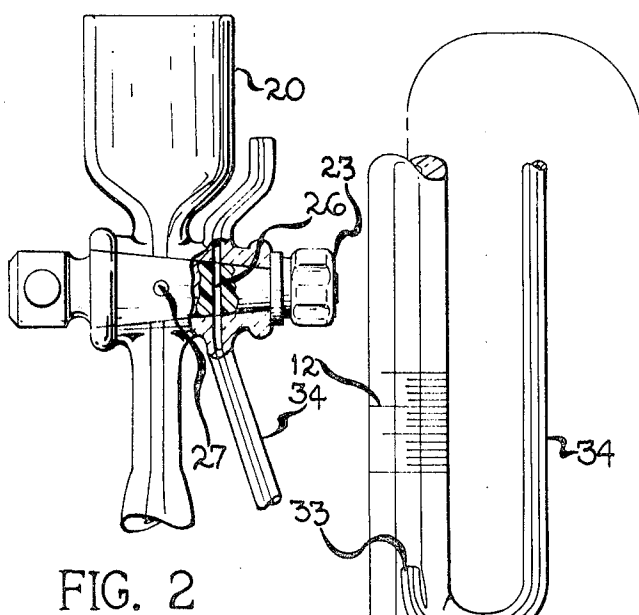


FIG. 2

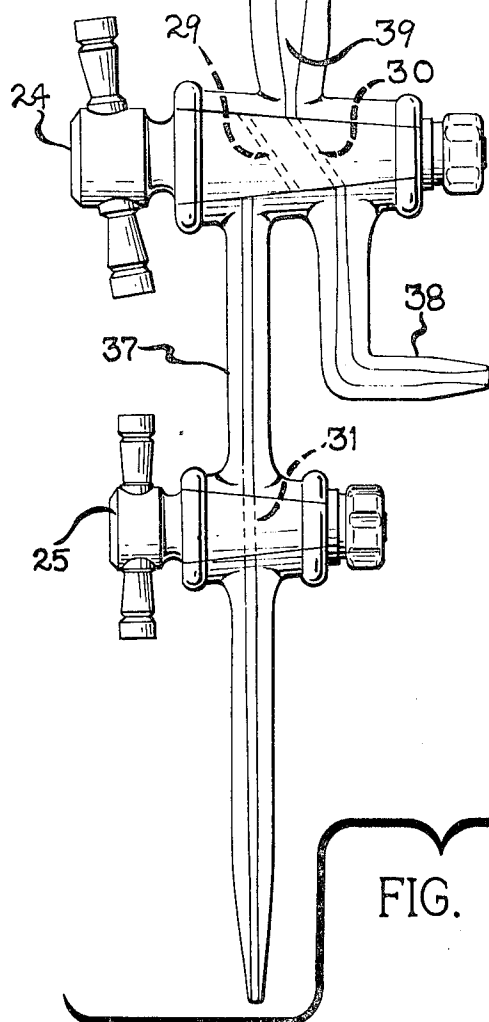
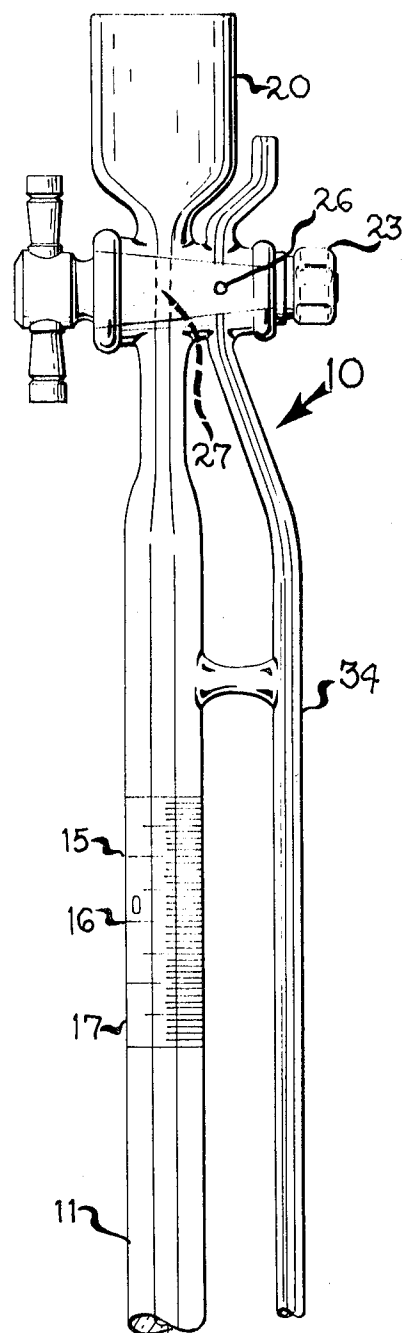


FIG. 1



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CONSTANT FLOW RATE BURETTE

THE INVENTION

This invention relates to a burette assembly, and more particularly, the invention relates to a burette which will discharge a quantity of liquid at a constant flow rate independent of the height of the liquid in the burette.

The common titration operation in performing volumetric and quantitative analysis involves the measurement of the amount of a standard reagent solution, one of known strength, required for reaction with a sample solution of known volume, but unknown strength. This operation is carried out with a burette comprising a long transparent cylinder of uniform bore for measuring the volume of standard solutions delivered therefrom.

Heretofore, burettes were designed to improve the accuracy and efficiency of the titration operation. To this end, burette construction included means to fill the barrel through attached funnels, means to pressure fill the burette, means to prevent evaporation of the liquid from storage reservoirs into the atmosphere, means to prevent stopcocks from sticking or leaking, means to make barrel graduations easy to read, means to prevent contamination of the stored liquid and means to release a predetermined volume of liquid. None of these burettes, however, have been constructed to discharge liquid at a constant flow rate.

Therefore, the primary object of this invention is to provide a burette for discharging liquid at a constant rate of flow.

An object of this invention is to provide a venting tube attached to the barrel of the burette, the upper end of which is vented to the atmosphere and the lower of which opens into the lower portion of the barrel of the burette.

Another object of this invention is to more accurately control the rate of flow of discharging liquid through the combination of a draw and fill stopcock and a separate rate of flow stopcock.

Another object of this invention is to provide a burette which may be connected to a pH meter or a millivoltmeter with a recording chart so that the amount of liquid discharged from the burette may be read directly from the chart.

An object of this invention is to provide a burette in which the rate of discharge can be adjusted to deliver a definite volume of liquid per scale division on the recorder chart independent of the height of the liquid in the burette.

Other objects and features of the advantages of the present invention will be found throughout the following description of the invention, particularly when considered with the accompanying drawings.

IN THE DRAWING

FIG. 1 of the drawings is a partial sectional view of the constant flow burette.

FIG. 2 is a partial sectional view of the venting stopcock of the constant flow burette in the open position.

FIG. 1 of the drawings shows a burette 10 made of glass or other transparent material with a barrel or cylindrical portion 11 of a uniform bore. Barrel 11 has imposed on the surface thereof uniformly positioned graduation lines 12 which are divided into a flow stability section 15 located above zero point 16 and a titration section 17 located below zero point 16.

Burette 10 contains an overflow funnel 20 integrally connected to the top portion of barrel 11. Immediately below the attached funnel, there is a venting stopcock 23 provided with passages 26 and 27 which are perpendicular to each other.

FIG. 2 of the drawings shows the position of stopcock 23 with capillary tube 34 vented to the atmosphere. In this position, passage 26 is axially aligned with the portions of capillary tube 34 above and below stopcock 23, while passage 27 is in the off position.

Referring to FIG. 1, capillary tube 34 with an internal diameter in the range of 0.01 to 0.40 inches is positioned along the wall of barrel 11 and funnel 20 and extends downwardly to a point in the bottom portion of the burette

just above the opening 39 leading to discharge tip 37. The height of the capillary tube 34 extending upwardly along the wall of barrel 11 should be greater than the height of the liquid in the barrel. Therefore, capillary tube 34 extends upwardly to a point along the wall of barrel 11 above venting stopcock 23.

In the preferred embodiment of this burette, capillary tube 34 is positioned outside of barrel 11. It is attached to the wall of barrel 11 at various points along the wall. Capillary tube 34 enters into the bottom portion of the barrel just above opening 39 leading to discharge tip 37 and extends upwardly within the barrel to facilitate the smooth emission of bubbles through the liquid in the burette. If capillary tube 34 has a very small inside diameter, then small bubbles are permitted to rise to the surface of the liquid in the burette, and the surface of the liquid is not constantly ajarred as it would be if large bubbles rose to the surface. The upper portion of capillary tube 34 is connected to passage 26, in stopcock 23. A portion of tube 34 extends above stopcock 23 and communicates with the portion below said stopcock 23 through passage 26, when passage 26 is in the open position.

The lower portion of burette 10 contains a fill and draw stopcock 24. Angularly disposed passages 29 and 30 of stopcock 24 respectively communicate between opening 39 and discharge tip 37 and tip 38. A rate of flow stopcock 25 with passage 31 is positioned within discharge tip 37 to control the flow rate of the emanating liquid.

The operation of the burette is as follows:

The burette 10 would be filled in the conventional manner through tip 38 which is connected to a supply of standard solution. During the filling process, stopcock 23 is opened to the air through passage 27 while passage 26 is in the closed position. This allows capillary tube 34 to fill partially with liquid. Stopcock 25 is also turned to the closed position during filling. After the burette is filled, with any overflow accumulating in funnel 20, stopcock 24 is rotated approximately 90° to the closed position so that passage 30 no longer communicates between opening 39 and tip 38. Stopcock 23 is then turned approximately 90° as shown in FIG. 2 so that passage 26 is in an open position communicating between the portions of capillary tube 34 above and below the stopcock. Passage 27 is now in a closed position. A column of entrapped air is thereby formed between the liquid level in the burette and the closed passage 27. Stopcock 24 is rotated approximately 90° to cause discharge through passage 29. A waste discharge receptacle containing a pH meter electrode or a millivoltmeter electrode connected to a recording chart is placed below discharge tip 37. When the rate of flow stopcock 25 is turned to the discharge position, liquid begins to exit tip 37. With the recording chart running, the rate of flow of discharging liquid is adjusted by means of stopcock 25 to deliver a definite volume of liquid per scale division on the recording chart, using the liquid in the upper flow stabilizing section 15 of the burette to adjust the flow.

The pressure exerted on the top of the liquid column in the burette by the entrapped column of air above the liquid is decreased while the liquid is discharging to a point where the pressure at the base 33 of the capillary tube 34 created by the sum of the atmospheric pressure exerted on the liquid in the capillary tube and the pressure exerted on the base 33 of the capillary tube by the liquid itself in the tube is greater than the pressure exerted on the base 33 of capillary tube 34 created by the sum of the pressure exerted by the trapped column of air on the liquid in barrel 11 of the burette and the pressure exerted on the base 33 of the capillary tube 34 by the liquid in the barrel of the burette. At that point, the height of liquid in capillary tube 34 rapidly decreases with respect to the height of liquid in barrel 11 of the burette. Finally, the tube is absent of liquid, and air begins to bubble through the tube, through the liquid in barrel 11 of the burette and up to the cylinder of entrapped air. When these bubbles begin to form within the liquid, the pressure at the base 33 of capillary tube 34 is equal to that of the atmosphere.

By making the diameter of the capillary tube very small with respect to the diameter of the burette, the liquid in the tube is quickly discharged until air bubbles begin to form at base 33 of the tube. So long as the height of the liquid in the burette is above that of base 33 of the capillary tube, air bubbles will displace the discharging liquid, and the liquid will flow from the burette at a constant rate.

After the rate of flow stopcock 25 is adjusted to deliver 1 milliliter of liquid or any other desired volume of liquid per scale division on the recorded chart and the liquid level within barrel 11 is made to coincide with zero point 16, fill and draw stopcock 24 is rotated to stop discharge. There should be no liquid in capillary tube 34 at this point, and the pressure at the datum of tip 33 will be that of the atmosphere.

The solution to be titrated is placed under discharge tip 37. Stopcock 24 is turned to direct liquid through discharge tip 37 at the same time a chart division on the recorded chart is under the recorder pen. If the rate of flow from discharge tip 37 has been properly adjusted, subsequent chart divisions will pass under the pen on the recording chart as the liquid level in the barrel of the burette passes each milliliter graduation.

If the end point of the titration in pH or millivolts is known, no further attention is necessary, and the end point of the analysis in milliliter titrated can be read directly from the recorder chart.

The following explanation is set forth to show how applicant believes the burette yields a discharge flow rate which is constant.

Definitions

P_t = Pressure exerted at the bottom of discharge tip 37 by the column of entrapped air in the burette and the liquid in the burette.

P_{air} = Pressure exerted by the entrapped air within burette upon the liquid in the burette.

P_1 = Pressure exerted at the base 33 of the capillary tube by the liquid in the burette.

P_c = Pressure exerted at the base 33 of the capillary tube from the column of entrapped air and the liquid in the burette.

P_{atm} = Pressure of the atmosphere.

H = Height of solution between the end of the discharge tip 37 and the base 33 of capillary tube 34.

r = Rate of flow at which liquid is emanating from discharge tip 37.

ϵ = Density of liquid within the burette.

The relationship between r , the rate of which liquid is leaving the discharge tip 37, and p_t , the total pressure at the bottom of the tip, is such that when p_t is constant, the rate of discharge r from the tip is also constant. Therefore, if it can be shown that the pressure p_t at the tip of the burette is constant, then the rate of flow, r , from the burette will also be constant.

The pressure P_c exerted at the bottom of the capillary tube by the air and liquid in the burette is the sum of the pressure exerted by the column of displaced air in the burette, P_{air} , and the liquid above the bottom of the capillary tube, P_1 .

$$(1) \quad P_c = P_{air} + P_1$$

When the burette is operated in the conventional manner, there is no liquid in the capillary tube. As liquid is discharged from the burette, tiny bubbles of air pass from the bottom of the capillary tube through the liquid in the barrel of the burette and then diffuse into the air column above the liquid in the burette. Therefore, the pressure at the bottom of the capillary tube must be equal to atmospheric pressure, since there is no liquid in the tube. (2) $P_c = P_{atm}$

But for the short length of time necessary to perform a titration operation, P_{atm} is constant. (3) $P_{atm} = K_1$

Now, substituting equation (3) back into equation (2), (4)

$$P_c = K_1$$

The pressure P_t at the bottom of discharge tip 37 is determined from the summation of the pressure P_{air} exerted by the entrapped air, the pressure P_1 exerted by the column of liquid above the base of the capillary tube, and the pressure of the column of liquid between the discharge tip and the base of the capillary tube.

Since the pressure exerted by the liquid column between the discharge tip and the bottom of the capillary tube is determined by the density of the liquid and its height,

$$(5) \quad P_t = P_{air} + P_1 + \epsilon H$$

Substituting equation (1) into equation (5),

$$(6) \quad P_t = P_c + \epsilon H$$

But from equation (4), $P_c = K_1$.

Therefore, (6) becomes

$$(7) \quad P_t = K_1 + \epsilon H$$

Since both ϵ , the liquid density, and H , the height of solution between the end of the discharge tip and the bottom of the capillary tube are constants, then

$$(8) \quad P_t = K_2$$

Since P_t is constant, the rate of discharge, r , from the burette is also constant.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will become apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An apparatus for discharging liquid at a constant flow rate comprising in combination:

- a reservoir for holding a quantity of liquid to be discharged,
- a first stopcock connected to the bottom portion of said reservoir and having a transverse passage therethrough to permit the discharge of liquid from said reservoir,
- means connected to the top portion of said reservoir to vent the liquid in the reservoir to the atmosphere during filling and to close the top portion of the reservoir from the atmosphere during discharge,
- a capillary tube open at both ends attached to said reservoir and extending in an upward direction to a point above the upper end of said reservoir, and
- the upper end of said capillary tube having means for closing said tube from the atmosphere during filling of the reservoir and the lower end opening into the lower portion of said reservoir above the stopcock, thereby permitting said reservoir to discharge liquid at a constant flow rate.

2. The apparatus as claimed in claim 1, wherein said reservoir comprises a tube having graduations thereon indicating the volume of liquid discharged.

3. The apparatus as claimed in claim 1, including a second stopcock positioned below said first stopcock and integrally connected to a discharge tip that is in turn connected to said first stopcock, said second stopcock having a transverse passage therethrough, thereby controlling the rate of discharge of liquid from the discharge tip.

4. The apparatus as claimed in claim 1 wherein the lower end of said capillary tube is U-shaped and is positioned within said reservoir so that the opening of said capillary tube is within said reservoir and is directed toward the top portion of the reservoir.

5. The apparatus as claimed in claim 1, including:

- a funnel connected to said reservoir for storing liquid,
- a third stopcock connected integrally to the funnel, the reservoir and the capillary tube, said third stopcock containing passages for directing liquid into said funnel and for venting said capillary tube to the atmosphere.