

[54] **ROTOR FOR FAST ANALYZER OF
ROTARY CUVETTE TYPE**

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356/36, 180, 185, 197, 244, 246

[56] **References Cited**

UNITED STATES PATENTS

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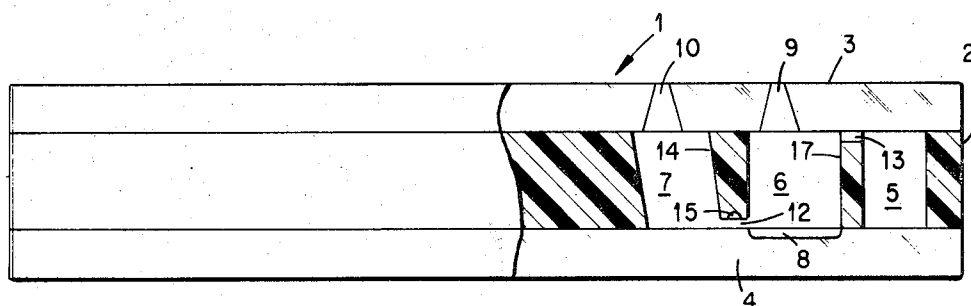
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[57] **ABSTRACT**

An improved rotor characterized by efficient premixing of sample and reactant liquids prior to their being discharged into a sample analysis cuvette is provided. Inner and outer concentric circular arrays of static loading cavities are disposed within the rotor on a one-to-one basis centripetal to an array of sample analysis cuvettes. The centrifugal walls of cavities in the inner array of loading cavities each slope downwardly and outwardly to a capillary-sized passage having a bubble trap. Liquid communication is provided by the capillary-sized passages between those cavities and respective cavities in the outer array of loading cavities upon rotation of the rotor while intercontact of the liquids in the respective cavities is prevented under static loading conditions. The centrifugal walls of cavities in the outer array of loading cavities each slope upwardly and outwardly to a cuvette loading passageway at an angle approaching the vertical in order to retain liquids in those cavities at preselected low rotor rotational speeds sufficient to cause liquid to flow through the capillary-sized passage and to discharge liquids through the cuvette loading passageways at preselected higher speeds.

8 Claims, 2 Drawing Figures



ROTOR FOR FAST ANALYZER OF ROTARY CUVETTE TYPE

BACKGROUND OF THE INVENTION

The invention described herein relates generally to photometers and more particularly to an improved rotor characterized by efficient premixing of sample and reagent liquids for use in a photometric analyzer of the rotary cuvette type. It was made in the course of, or under, a contract with the U. S. Atomic Energy Commission.

The design and operation of fast analyzers of the rotary cuvette type are generally described in U. S. Pat. No. 3,555,284, issued Jan. 12, 1971, to common assignee in the name of Norman G. Anderson. In the analyzer described in that patent, a central loading disk is provided for receiving liquid samples and reactants prior to an analysis operation. An annular array of sample analysis cuvettes is disposed about the loading disk for receiving the liquids from the loading disk and holding them for photometric analysis. Rotation of the loading disk and cuvette array causes the liquid samples and reactants to flow from the loading disk to cuvettes where they are photometrically analyzed while the entire system of cuvettes and loading disk is rotating.

The loading disk described in the aforementioned patent consists of three concentric annular arrays of chambers, the chambers in each array being interconnected, in series, with corresponding chambers in adjacent arrays. Rotation of the loading disk causes sample and reagent liquids in the two innermost arrays of chambers (loading chambers) to flow into the outermost array of chambers (mixing chambers) and then outward through a discharge passage into corresponding cuvettes. Such arrangement, although generally satisfactory, is characterized by relatively low mixing efficiencies since liquids in the innermost array of loading chambers must overtake the liquid from the radially intermediate array of chambers before mixing can occur.

In more recently developed fast analyzers of the rotary cuvette type, miniaturized rotors are used wherein the loading cavities and sample analysis cuvettes are provided in a single integral rotor. Such rotors are described in copending applications of common assignee Ser. Nos. 295,980 and 316,628. Due to the limited available space in the miniaturized rotors, separate mixing chambers cannot be used without a substantial reduction in the number of samples which can be accommodated in a single rotor. The small cavities and passages used in the miniaturized rotors also reduce turbulent mixing of the liquid samples and reagents because of the relatively greater effect of surface tension in the miniaturized rotors.

It is, accordingly, a general object of the invention to provide an improved rotor for a fast analyzer of the rotary cuvette type characterized by efficient premixing of statically loaded sample and reactant liquids.

Another, more particular, object of the invention is to provide an improved miniaturized multi-sample rotor for fast analyzers of the rotary cuvette type characterized by efficient premixing of statically loaded sample and reactant liquids.

Other objects of the invention will be apparent from an examination of the following description of a preferred embodiment and the appended claims.

SUMMARY OF THE INVENTION

In accordance with the invention, an improved rotor is provided for use in fast analyzers of the rotary cuvette type. The rotor defines inner and outer circular arrays of static loading cavities or chambers disposed on a one-to-one basis centripetal to a circular array of sample analysis cuvettes. The centrifugal walls of cavities in the inner circular array of loading cavities each slope downwardly and outwardly to a respective capillary-sized passage having a bubble trap to prevent liquid flow therethrough under static conditions. Liquid communication between cavities in the inner and outer arrays of cavities is provided by the capillary-sized passages upon rotation of the rotor at a first preselected low speed. Tangential discharge of flow by the capillary-sized passages at a point adjacent the lower ends of the cavities in the outer array causes vortex flow therein and facilitates mixing. The centrifugal walls of cavities in the outer array of loading cavities each slope outwardly and upwardly to a respective cuvette loading passageway at an angle approaching the vertical in order to retain liquids in those cavities at selected low rotational speeds sufficient to cause liquid flow through the capillary-sized passage and to discharge liquids through the cuvette loading passageways at preselected higher speeds. Such arrangement permits, by selective rotor acceleration, selective transfer of liquid from cavities in the inner array of loading cavities to respective cavities in the outer array and mixing with liquid retained in those cavities prior to transfer to respective sample analysis cuvettes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a cuvette rotor made in accordance with the invention.

FIG. 2 is a vertical section view of the rotor of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, initially to FIG. 1, a rotor 1 made in accordance with the invention is of laminated construction with a central, preferably opaque, plastic disk 2 sandwiched between top and bottom transparent plastic disks 3 and 4. The rotor is drawn enlarged to clarify construction details.

As further illustrated in FIG. 2, a multiplicity (only three shown) of sample analysis chambers or cuvettes 5 are disposed in a circular array within rotor 1 at an equal distance from the center of that rotor. Cuvettes 5 are conveniently formed by drilling axially extending apertures through disk 2 prior to sandwiching that disk between disks 3 and 4. Concentric annular arrays of sample and reactant loading cavities 6 and 7 are disposed on a one-to-one basis in general radial alignment with each cuvette 5. As shown in FIG. 1, loading cavities 6 and 7 are formed as apertures in disk 2 and are closed by top and bottom disks 3 and 4. Sample loading cavities 6 are extended below disk 2 by means of a depression 8 machined into bottom disk 3. Loading apertures 9 and 10 are provided in top transparent disk 3 in register with each cavity in the respective arrays of sample and reactant loading cavities. Static loading of reactants and samples through the loading apertures is possible using a hyperdermic syringe or automated dispensing equipment.

Successful operation of the invention depends upon the particular inclinations of the centrifugal surfaces used in the loading cavities 6 and 7 and the placement of connecting passages 12 and 13 used to connect respective reactant and sample loading cavities and sample analysis cuvettes.

As shown in FIG. 1, the centrifugal surface 14 of reactant loading cavity 7 extends downwardly and outwardly to a capillary-sized passage 12 containing a bubble trap 15. As used herein, a capillary-sized passage is one sized sufficiently small so as to block passage of liquid having a head equal to that of a full adjacent cavity under static conditions. Thus, passage 12 prevents contact between sample and reactant liquids placed in loading cavities 6 and 7 while the rotor is at rest as during a loading operation. Bubble trap 15 supplements the blocking action of passage 12 under static conditions. At a predetermined low rotational speed, rotation induced pressure in the reactant liquid overcomes the flow resistance of passage 12 and bubble trap 15 and causes reactant to flow from cavity 7 into the bottom of sample loading cavity 6 where it mixes with sample liquid loaded therein. As shown in FIG. 2, passage 12 intersects sample loading cavity 6 tangentially to facilitate vortex mixing of reactant and sample liquids. Sample loading cavity 6 is provided with a circular cross section so as not to interfere with the vortex flow pattern illustrated by the broken arrow 16 in FIG. 2. Depression 8 at the bottom of each sample loading cavity also enhances mixing by extending the sample loading cavity slightly below the discharge point of passage 12, thereby ensuring that reactant discharging from that passage will impinge upon the main body of sample liquid. The inclination of surface 14 aids in the rapid and complete transfer of reactant from cavity 7 through passage 12.

Centrifugal surface 17 of sample loading cavity 6 slopes upwardly and outwardly at a very slight angle (about 5° to 10°) from the vertical. This steep inclination acts to retain the sample and reactant liquids in cavity 6 until a predetermined higher rotational speed is reached wherein rotation induced acceleration forces overcome the gravitational, adhesive, and surface tension forces tending to retain liquid in the bottom of cavity 6 and cause it to flow upward and outward through passage 13 joining sample loading cavity 6 with a sample analysis cuvette 5. As shown in FIG. 2, passage 13 discharges into cuvette 5 tangentially to cause further mixing of the sample and reactant liquids in the cuvette.

In operation, sample and reactant liquids are introduced into respective loading chambers 7 and 6 with rotor 1 at rest. The combination of possible reactants and samples is limited in number only by the number of sample analysis cuvettes 5 available in a particular rotor. The liquids remain out of contact while the rotor is at rest as a result of the air lock in capillary-sized passage 12 and/or bubble trap 15. At a predetermined intermediate rotor speed, reactant flows from each chamber 6 through passage 12 and into a respective chamber 7 where it mixes with sample liquid. After a suitable mixing interval, the rotor speed is increased until the liquid in each chamber 7 passes through passage 13 to a respective sample analysis cuvette.

The above description of one embodiment of the invention should not be interpreted in a limiting sense. For example, sample and reactant liquids could be

loaded exactly opposite to the manner described with sample being placed in cavity or chamber 6 and reactant in chamber 7. It is intended rather, that the invention be limited only by the scope of the appended claims.

What is claimed is:

1. An improved rotor for a fast analyzer of the rotary cuvette type characterized by efficient premixing of sample and reactant liquids prior to their being discharged into sample analysis cuvettes for photometric analysis, the improved rotor comprising a generally disk-shaped member defining:

- a. a circular array of sample analysis cuvettes for accepting mixtures of liquid samples and reactants, said disk-shaped member having transparent walls above and below said sample analysis cuvettes;
- b. an inner array of static loading cavities equal in number and disposed centripetal to said sample analysis cuvettes, the centrifugal walls of said cavities in said inner array of cavities extending downwardly and outwardly;
- c. an outer array of static loading cavities equal in number and disposed radially intermediate said sample analysis cuvettes and said cavities in said inner array of static loading cavities, the centrifugal walls of said cavities in said outer array of cavities extending upwardly and outwardly with a steep inclination selected to retain liquids in said cavities at preselected low rotor rotational speeds;
- d. capillary-sized passages extending between respective cavities in said inner and outer arrays of cavities, said passages being sized to prevent flow between said cavities under static conditions while permitting flow from cavities in said inner array of cavities to cavities in said outer array of cavities at preselected low rotational speeds; and
- e. connecting passages extending between respective cavities in said outer array of cavities and said sample analysis cuvettes.

2. The improved rotor of claim 1 further including a bubble trap disposed intermediate the ends of each of said capillary-sized passages.

3. The improved rotor of claim 1 wherein cavities in said outer array of loading cavities are generally round in horizontal cross section and wherein said capillary-sized passages intersect said cavities in said outer array of cavities tangentially.

4. The improved rotor of claim 3 wherein said sample analysis cuvettes are generally round in horizontal cross section and wherein said connecting passages intersect said cuvettes tangentially.

5. The improved rotor of claim 1 wherein said capillary-sized passages extend between the lower ends of respective cavities in said inner and outer arrays of loading cavities.

6. The improved rotor of claim 5 wherein said capillary-sized passages intersect with the centrifugal walls of said cavities in said inner array of cavities.

7. The improved rotor of claim 1 wherein said connecting passages extend between the upper ends of respective cavities in said outer array of cavities and said sample analysis cuvettes.

8. The improved rotor of claim 7 wherein said connecting passages intersect with the centrifugal walls of said cavities in said outer array of cavities.

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