

- [54] **WHOLE BLOOD ANALYSIS ROTOR FOR A MULTISTATION DYNAMIC PHOTOMETER** 3,744,975 7/1973 Mailen..... 23/259
3,795,451 3/1974 Mailen..... 23/259 X
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- [52] U.S. Cl. **23/259; 233/26; 356/39; 356/246**
- [51] Int. Cl.².....**B04B 5/12; G01N 33/16; G01N 21/00; G01N 1/10**
- [58] Field of Search..... **23/253 R, 259; 356/39, 356/197, 246; 233/26**

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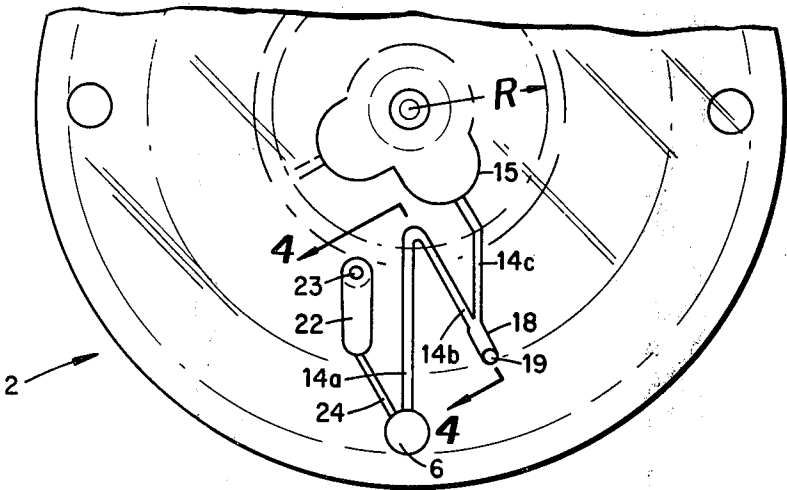
ABSTRACT

A rotor for performing photometric analyses using whole blood samples. Following static loading of a gross blood sample in the rotor the red blood cells in the gross sample are centrifugally separated from the plasma and measured subvolumes of plasma distributed to respective sample analysis cuvettes positioned in an annular array about the rotor periphery. Means for adding reagents to the respective cuvettes are also described.

References Cited
UNITED STATES PATENTS

3,744,974 7/1973 Maddox et al..... 23/259

5 Claims, 4 Drawing Figures



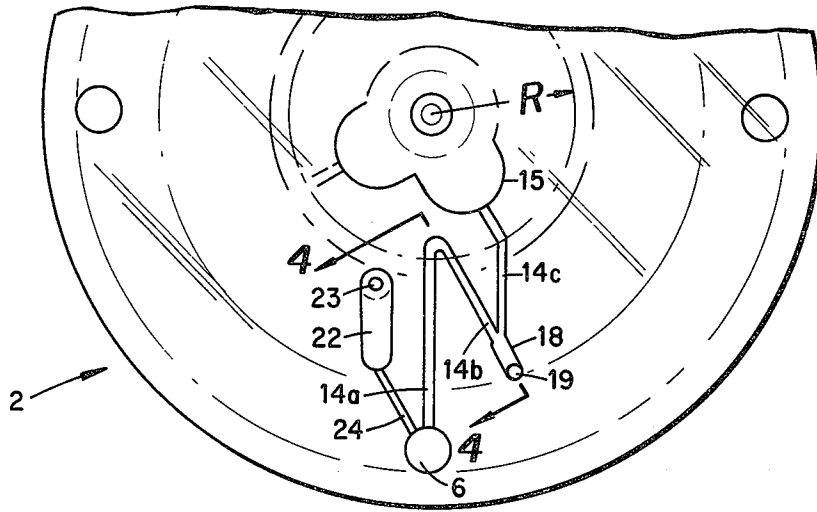


Fig. 3

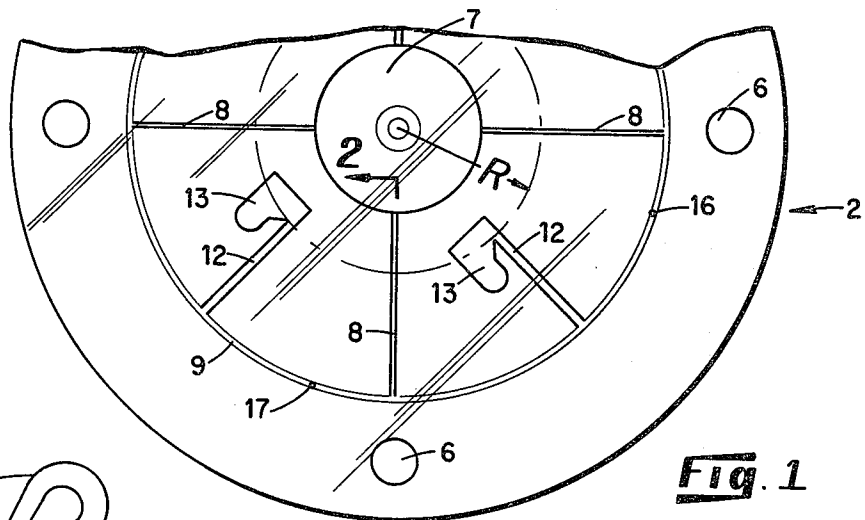


Fig. 1

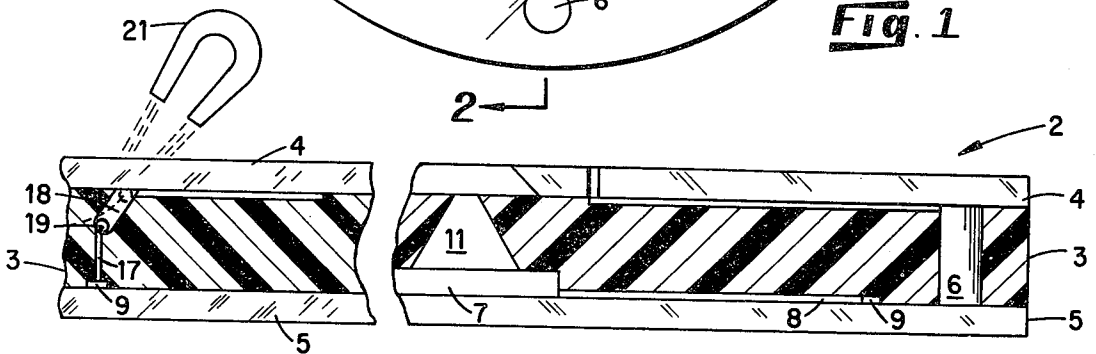


Fig. 4

Fig. 2

WHOLE BLOOD ANALYSIS ROTOR FOR A MULTISTATION DYNAMIC PHOTOMETER

BACKGROUND OF THE INVENTION

The invention described herein relates generally to photometers and more particularly to an improved whole blood analysis rotor for a multistation dynamic photometer of the rotary cuvette type. It was made in the course of, or under, a contract with the U.S. Atomic Energy Commission.

Fast photometric analyzers incorporating multistation rotary cuvette systems are becoming widely used in various laboratories because of their ability to rapidly and accurately analyze large numbers of samples. Of particular interest are blood tests including glucose, LDH, SGOT, SGPT, BUN, total protein, alkaline phosphatase, bilirubin, calcium, chloride, sodium, potassium and magnesium. Since such tests are normally performed on blood plasma, blood cells must be removed from whole blood samples prior to analysis. Cuvette rotors designed to accept and automatically process whole blood samples must, therefore, be capable of separating plasma from cellular material. In addition, such rotors must be designed for receiving a sample in a loading operation, measuring discrete subvolumes of separated plasma for each sample analysis cuvette and transferring the subvolumes into the respective cuvettes.

It is, accordingly, a general object of the invention to provide an improved rotor for a multistation photometric analyzer which is suitable for use in performing whole blood analyses.

Another more particular object of the invention is to provide an improved rotor for a multistation photometric analyzer suitable for receiving a whole blood sample, centrifuging the whole blood sample to separate its plasma and cellular components, measuring discrete plasma subvolumes and transferring the subvolumes to respective sample analysis cuvettes.

Other objects of the invention will be apparent from an examination of the following written description of the invention and the appended drawings.

SUMMARY OF THE INVENTION

In accordance with the invention, an improved rotor for a multistation photometric analyzer is provided which is suitable for use in performing whole blood analyses. The rotor is a generally disk-shaped body defining: a circular array of peripherally-located sample analysis cuvettes; a centrally located static loading chamber having a central loading port for receiving gross whole blood samples; a continuous capillary-sized annulus positioned on a radius intermediate said cuvette and said static loading chamber; at least one first capillary-sized passageway communicating between said static loading chamber and said annulus; at least one second capillary-sized passageway communicating between said annulus and a centrifugal overflow chamber positioned centripetal to said annulus; third capillary-sized passageways radially folded to form three radially-extending interconnected passageway segments, a first segment extending radially from each cuvette to a point centripetal to said overflow chamber, a second segment extending from the centripetal end of the first segment to a radius about equal to that of the annulus and a third segment extending from the centrifugal end of the second segment to a central fluid trans-

fer cavity in open communication with the central loading port; and valve containing connecting passageways extending between the annulus and the centrifugal ends of the second and third segments of the third capillary-sized passageways. Rotors made according to the invention accept whole blood samples, separate plasma from cellular material, measure subvolumes of the separated plasma, and transfer the measured subvolumes to respective sample analysis cuvettes where they are mixed with suitable reagents and photometrically analyzed.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a vertical sectional view taken along line 2—2 of FIG. 1.

FIG. 3 is a top plan view of the rotor of FIG. 1.

FIG. 4 is a vertical sectional view taken along line 4—4 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, initially to FIGS. 1 and 2, the bottom side and a first sectional view of a disk-shaped rotor 2 are shown, respectively. In construction, the rotor is of laminated design with a central, preferably opaque, plastic disk 3 sandwiched between top and bottom transparent disks 4 and 5. A circular array (only three shown) of axially extending apertures are provided through disk 3 to serve as sample analysis cuvettes 6. As shown, the bottom side of disk 3 is provided with a central circular static loading chamber 7 which communicates via a plurality of first radially extending capillary-sized flow passageways 8 with a continuous capillary-sized annulus 9. Capillary-sized passageways, although not essential to the operation of the invention, are used to reduce the total blood sample volume requirement of the rotor. Larger passageways may be used in rotors designed to test samples, such as sewage effluents, which are not subject to the volumetric restrictions of blood samples. An axially extending loading port 11 provides access to loading chamber 7 through the top of the rotor. Also shown in FIG. 1 are second radially extending capillary-sized passageways 12 communicating between annulus 9 and respective overflow chambers 13 designed to limit the centripetal displacement of blood within passageways described in later reference to FIGS. 3 and 4.

Turning now to FIGS. 3 and 4 wherein the top side and a second sectional view of the rotor of FIG. 1 are shown, a third capillary-sized passageway 14 is radially folded to form three radially-extending interconnected passageway segments. A first segment designated 14a extends radially from each cuvette to a point centripetal to overflow chambers 13. A second segment designated 14b extends from the centripetal end of the first segment to a radius roughly corresponding to that of annulus 9. The third segment designated 14c extends from the centrifugal end of the second segment to a central fluid transfer cavity 15 in open communication with central loading port 11 and the top surface of top transparent disk 4.

As shown in FIGS. 1, 3 and 4, annulus 9 communicates with passageways 14 by means of valve containing connecting passageways 17 extending between the annulus and the centrifugal ends of passageway seg-

ments 14b and 14c. A magnetically opened ball check valve includes a ball traverse chamber 18 of larger diameter than the capillary-sized passageways 14 and 17 to permit ball 19 to close off passage of liquid between the annulus and passageway 14 during centrifugation, except when an axially located magnet 21 (shown schematically) is brought into position or activated to hold the valve open by drawing ball 19 (of magnetic material) to the centripetal ends of ball traverse chamber 18. Chamber 18 extends radially so that rotation-induced inertial forces press ball 19 against the opening of passageway 17 at the centrifugal end of that chamber.

Also shown in FIG. 3 is a reagent loading chamber 22 which may be statically loaded through loading port 23. A reagent transfer passageway 24 extends radially between each chamber 22 and a respective cuvette 6 to permit rotation-induced transfer of reagent from the chamber to a respective cuvette where it mixes with blood plasma and is photometrically analyzed.

OPERATION

In operation, a rotor as hereinbefore described is placed in a turntable such as that shown in U.S. Pat. No. 3,798,459 which issued Mar. 19, 1974, in the name of Anderson et al. A gross whole blood sample is loaded, preferably by a hypodermic needle extending through loading port 11 into loading chamber 7 while the rotor is at rest. Suitable reagents are likewise loaded into loading chambers 22 through loading ports 23. Although not shown in FIG. 3, one complete set of loading chamber 22, passageways 14 and 17, etc., is provided for each sample analysis cuvette 6. Only one set of those features is illustrated to simplify the drawing without detracting from a full understanding of the invention.

Once static loading of the whole blood sample and reagents has been completed, the rotor is accelerated to a low speed, typically 300 to 500 rpm, and magnet 21 activated to open the ball check valves by drawing check balls 19 to the centripetal ends of the respective ball traverse chambers 18. Reagents contained in loading chambers 22 pass immediately through passageways 24 to respective sample analysis chambers 6 under the influence of rotation-induced inertial forces. During this initial low speed rotation, the whole blood sample in loading chamber 7 flows outward through passageways 8 into annulus 9 from which it flows radially inwardly into passageways 12, 17 and segments 14b and 14c of passageways 14 to a common radius as determined by radius R where overflow occurs into overflow chambers 13. The gross volume of the statically loaded whole blood sample is selected to cause overflow into chambers 13 without filling those chambers. As indicated above, the common centripetal end of interconnected passageway segments 14a and 14b is centripetal to the radius R defining the overflow level so that no blood spills into the sample analysis cuvettes during this initial low speed centrifugation step.

Following the initial low speed centrifugation step wherein whole blood is caused to rise within passageway segments 14b and 14c to a level corresponding to radius R, magnet 21 is removed or de-energized and rotational speed increased to about 4000 rpm. Ball check 19 moves to the centrifugal end of ball traverse chamber 18 where it blocks passageway 17 as shown in FIG. 4. High speed centrifugation is continued until all red

blood cells within passageway segments 14b and 14c sediment into chamber 18 which is sized to hold all the red blood cells in a normal blood sample contained within passageway segments 14b and 14c. The plasma-red cell interface following sedimentation of the red cells will thus normally be within ball transfer chamber 18 leaving passageway segments 14b and 14c containing a measured volume of plasma only. The plasma volume is determined by the length and cross section of segments 14b and 14c and the selection of radius R which limits the centripetal level to which the segments are filled.

The volume of clarified plasma contained in passageway segments 14b and 14c is transferred to a respective sample analysis cuvette 6 with the rotor spinning at reduced speed, typically about 1000 rpm, by applying a slight positive air pressure to the central opening in disk 4 to pressurize fluid transfer cavity 15. This slight pressure forces the plasma to flow from passageway segments 14b and 14c through segment 14a and into a sample analysis cuvette where it mixes with reagent previously transferred to the cuvette upon initial rotation. Alternatively, a rinse solution of distilled water could be injected into fluid transfer cavity 15 to displace plasma from passageway segments 14b and 14c. Photometric analysis of the cuvette contents is then made while the rotor continues to rotate at about 1000 rpm in accordance with the techniques and principles taught in U.S. Pat. No. 3,555,284 issued Jan. 12, 1971, in the name of Norman G. Anderson.

The above described preferred embodiment and method of operation are intended to be illustrative only and should not be interpreted in a limiting sense. For example, particulate suspensions other than whole blood could be processed to remove particulates and the clarified supernatant analyzed. It is intended rather, that the invention be limited in scope only by the following claims.

What is claimed is:

1. An improved rotor for a photometric solution analyzer of the rotary cuvette type suitable for use in analyzing whole blood samples comprising a generally disk-shaped member defining:
 - a. a plurality of sample analysis cuvettes disposed in a circular array for receiving liquid samples and reagents, said disk-shaped member having transparent walls adjacent said sample analysis cuvettes for permitting the passageway of light therethrough;
 - b. a centrally located static loading chamber having a loading port for receiving gross whole blood samples;
 - c. a central fluid transfer cavity in open communication with the outside of said disk-shaped member;
 - d. a continuous annulus positioned on a radius intermediate said cuvettes and said static loading chamber;
 - e. at least one first passageway communicating between said annulus and said static loading chamber;
 - f. at least one overflow chamber positioned intermediate said annulus and said static loading chamber;
 - g. at least one second passageway communicating between said annulus and said at least one overflow chamber;
 - h. a plurality of third passageways each of which is radially folded to form three radially extending interconnected passageway segments; a first segment

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extending radially from a respective sample analysis cuvette to a point centripetal to said overflow chamber, a second segment extending from the centripetal end of said first segment to a radius about equal to that of said annulus, and a third segment extending from the centrifugal end of said second segment to said central fluid transfer cavity;

i. a plurality of connecting passageways extending between said annulus and the centrifugal ends of respective second and third segments of said third passageways;

j. a magnetically actuated ball trap valve disposed in each of said connecting passageways; and

k. means for injecting reagents into said sample analysis cuvettes.

2. The improved rotor of claim 1 wherein said annulus and said first, second, third and connecting passageways are capillary sized.

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3. The improved rotor of claim 1 wherein said second and third segments of said third passageways define a preselected sample volume.

4. The improved rotor of claim 1 wherein said magnetically actuated ball trap valve includes a radially oriented ball traverse chamber and a ball of magnetic material disposed within said ball traverse chamber; the centrifugal end of each of said ball traverse chamber being in communication with a respective connecting passageway.

5. The improved rotor of claim 1 wherein said means for injecting reagents into said sample analysis cuvettes includes a static reagent loading chamber disposed centripetally to each cuvette, and a radially-extending reagent transfer passageway communicating between the centrifugal end of each reagent loading chamber and a respective cuvette.

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