United States Patent [19]

Burtis et al.

[11] **3,901,658**

[45] **Aug. 26, 1975**

[54] **WHOLE BLOOD ANALYSIS ROTOR ASSEMBLY HAVING REMOVABLE CELLULAR SEDIMENTATION BOWL**

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[22] Filed: **July 30, 1974**

[21] Appl. No.: **493,006**

[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

[56] **References Cited**

UNITED STATES PATENTS

3,744,974	7/1973	Maddox et al.	23/259
3,744,975	7/1973	Mailen	23/259
3,795,451	3/1974	Mailen	23/259 X

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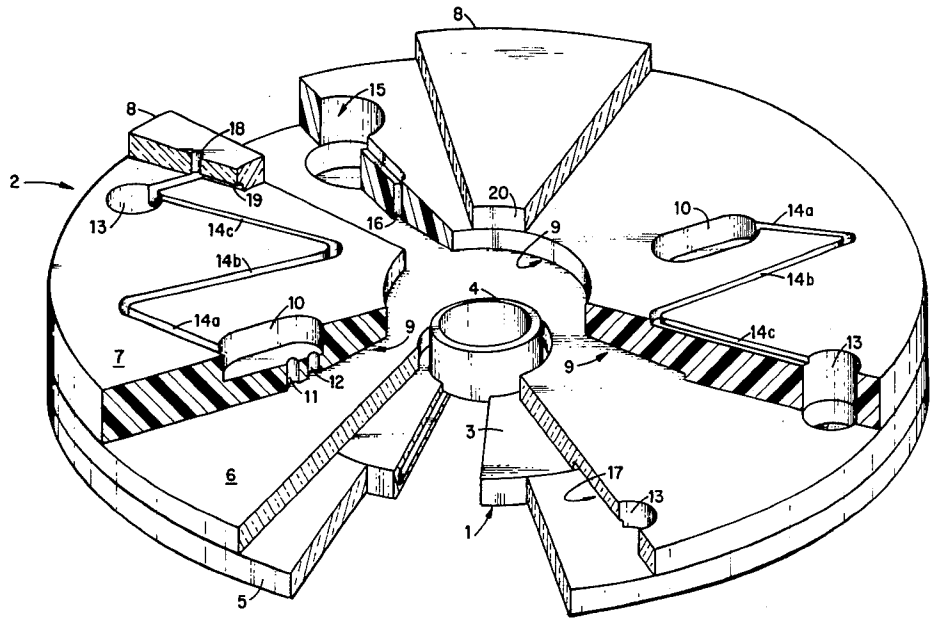
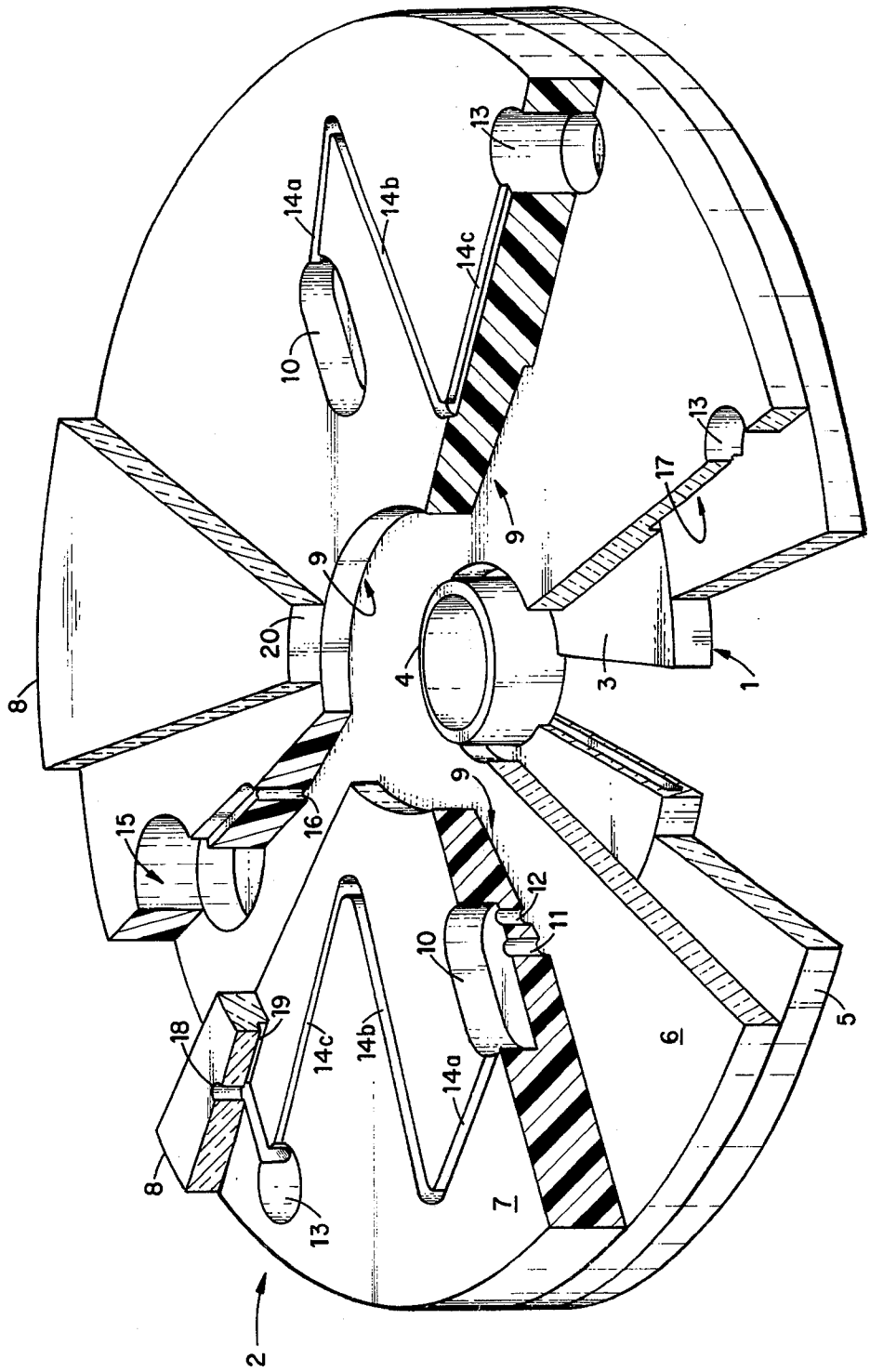
[57] **ABSTRACT**

A rotor assembly for performing photometric analyses using whole blood samples. Following static loading of a gross blood sample within a centrally located, removable, cell sedimentation bowl, the red blood cells in the gross sample are centrifugally separated from the plasma, the plasma displaced from the sedimentation bowl, 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.

7 Claims, 1 Drawing Figure

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WHOLE BLOOD ANALYSIS ROTOR ASSEMBLY HAVING REMOVABLE CELLULAR SEDIMENTATION BOWL

BACKGROUND OF THE INVENTION

The invention described herein relates generally to photometers and more particularly to an improved whole blood analysis rotor assembly for a multi-station 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 multi-station 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 from each sample analysis cuvette and transferring the subvolumes into respective cuvettes.

One rotor assembly which has been designed to accept and automatically process whole blood samples is described in copending application Ser. No. 489,305 of common assignee. That rotor is difficult to clean since red cells are closely packed within capillary sized passageways during a centrifugal separation operation designed to separate the plasma and cellular components. Also, because of its design which requires that part (about half) of a sample be wasted, blood volumes are required greatly in excess of that used in the actual analyses.

It is, accordingly, a general object of the invention to provide an improved rotor for a multi-station 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 multi-station photometric analyzer suitable for receiving a whole blood sample, centrifuging the whole blood sample to separate it into cellular and plasma components, measuring discrete plasma subvolumes, and transferring the subvolumes to respective sample analysis cuvettes.

Another particular object of the invention is to provide an improved rotor for a multi-station photometric analyzer suitable for receiving a whole blood sample wherein sedimented cellular components are readily removable following sample analysis.

Still another object of the invention is to provide an improved rotor for a multi-station photometric analyzer suitable for receiving a whole blood sample wherein the volume of blood required for analysis is minimized.

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 assembly is provided for use in performing whole blood analyses in a multi-station photometric analyzer. Included in the rotor assembly is a generally disk-shaped main rotor body and a removable sedimentation bowl nested within the main rotor body and adapted to rotate with that body as a unit. Features defined by the main rotor body include: an annular plasma distribution manifold for receiving plasma displaced from the sedimentation bowl, volume measuring chambers and passageways for receiving plasma from the distribution manifold, means for receiving plasma overflow from the distribution manifold, sample analysis cuvettes disposed in a circular array about the rotor periphery and means for loading reagents into the sample analysis cuvettes. The removable sedimentation bowl includes a hollow disk-shaped base portion and an upstanding annular neck portion through which whole blood samples are statically loaded into the base portion and through which separated plasma is displaced under dynamic operating conditions. Using the subject improved rotor assembly, cellular components are removed from whole blood samples and retained in the sedimentation bowl which can be cleaned between operations or disposed of and replaced with a new bowl.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, which is a top, cutaway, isometric view of a rotor assembly made in accordance with the invention, the rotor assembly is seen to include a sedimentation bowl **1** and a disk-shaped main rotor body **2**. The sedimentation bowl is shaped to nest concentrically within the rotor body at the level of the rotor body base and to rotate upon a turntable (not shown) with the rotor body as a unit. As shown, the sedimentation bowl comprises a shallow, hollow, disk-shaped base portion **3** and an upstanding annular neck portion **4** through which whole blood samples may be statically loaded into the base portion and separated plasma displaced under dynamic operating conditions. Neck portion **4** is provided with a slightly tapered inner surface having a larger diameter at its end which is fixed to base portion **3** to ensure movement of displacing liquid into the base portion during a plasma displacing operation. The main rotor body in the preferred embodiment is a vertically stacked, laminar construction comprising a base **5**, a divider plate **6**, a chamber plate **7**, and capping plate **8**. The base plate **5** is an annulus of transparent material which provides lower windows for the sample analysis cuvettes which is sized to provide an opening for receiving sedimentation bowl **1**. Divider plate **6** is annular shaped and extends centripetally beyond the inner periphery of the base **5**, permitting upward projection of the neck portion **4** therethrough. The divider plate **6** functions as a vertical retainer for the sedimentation bowl and as a lower wall for an annular plasma distribution manifold **9** formed in the centripetal region between divider plate **6** and a tapered portion of the chamber plate **7**.

The chamber plate **7** is, in comparison with the outer laminations, a thick annulus which provides a matrix defining the main functional chambers and inner connecting passageways as described below. The annular plasma distribution manifold **9** is formed by relieving a shallow conical portion of the matrix from the lower centripetal edge of the chamber plate. Plasma distribution manifold **9** extends from axially below to axially above the upper extremity of neck portion **4** when, as

shown, sediment bowl **1** is fully inserted within the main rotor body in operating position. A multiplicity (only one shown) of plasma volumetric measuring chambers **10** are disposed in a circular array and displaced axially above and radially overlapping the distribution manifold **9.** Plasma inlet ports **11** extend axially and provide liquid communication between distribution manifold **9** and each measuring chamber **10** to permit passage of plasma from the plasma distribution manifold to the respective measuring chambers. Ports **11** are precisely located on a common radius to facilitate equal filling of chambers **10** under centrifugal conditions. The measuring chambers **10** are vented to manifold **9** by means of vent ports **12** located centripetal to the plasma inlet ports **11.**

A circular array of sample analysis cuvettes **13** is located peripherally within the divider plate **6** and chamber plate **7.** Sample analysis cuvettes **13** are equal in number to, and are somewhat angularly offset from respective plasma measuring chambers **10.** One reference cuvette, which is not in communication with a plasma measuring chamber **10,** may be provided for photometric blank solutions. Corresponding measuring chambers **10** and sample analysis cuvettes **13** are in communication through corresponding folded passageways **14** which extend from the centrifugal extremity of each measuring chamber **10** and the centripetal extremity of each sample analysis cuvette **13.** Each passageway **14** comprises three interconnected, radially extended segments which describe an N shaped path with a first segment **14***a* extending from the measuring chamber radially outward to a point about equal to the radius at which sample analysis cuvettes **13** are disposed, a second segment **14***b* extending radially inward from the centrifugal end of the first segment to a point centripetal to the circle upon which commonly lie the plasma inlet ports **11,** and a third segment **14***c* extending radially outward from the centripetal end of the second segment to a sample analysis cuvette **13.** At least one plasma overflow chamber **15** is defined within the matrix of the divider plate **6** in a generally peripheral location. The overflow chamber **15** is in communication with plasma distribution manifold **9** by means of an overflow passageway **16** which enters the distribution manifold **9** at a point just centripetal to the circle upon which lie plasma inlet ports **11.** Overflow passageway **16** extends from plasma distribution manifold **9** upward to the top of the chamber plate **7,** and then centrifugally to enter the overflow chamber **15.**

As shown, each sample analysis cuvette **13** is provided with a cleanout passageway **17** extending from its lower centripetal extremity to the cavity which is formed in base **5** upon removal of sedimentation bowl **1** from its operating position. Plasma overflow chamber **15** may likewise be provided with a cleanout passageway.

Capping plate **8** is superimposed on chamber plate **7** partially to provide a top closure for the measuring chambers **10,** sample analysis cuvettes **13,** passageways **14,** plasma overflow chamber **15** and overflow passageways **16.** The capping plate also provides a matrix for forming reagent loading ports **18** (only **1** shown) which permit direct loading access to each sample analysis cuvette from the topside of the rotor assembly. Second cleanout passageways **19** extend between the reagent loading ports **18** and the centripetal extremity **20** of annular capping plate **8** to provide for fluid cleaning of the sample analysis cuvettes as do the first cleanout passageways **17.**

In operation, diverse test reagents are pipetted into the sample analysis cuvettes **13** through the reagent loading ports **18** while the rotor is kept stationary. Whole blood is statically loaded within sedimentation bowl **1** and then centrifuged at about 4000 RPM to sediment cellular components in the periphery of the hollow base portion of the bowl. A comparatively dense, water immiscible liquid, e.g., a halocarbon oil, is added to the sedimented blood under the same dynamic conditions to displace plasma centripetally and upwardly through the neck portion **4** of the sedimentation bowl. The volume of displacing liquid is predetermined to slightly exceed the total volume of the measuring system defined by chambers **10** and passageways **14,** in order that the measuring system will fill, yet not overflow in volume exceeding that of the overflow chamber **15.** The displaced plasma spills over the top of neck portion **4** and is caught within distribution manifold **9.** The plasma then passes through inlet ports **11** into plasma measuring chambers **10** and corresponding passageways **14** until it reaches the limiting centripetal level as defined by plasma overflow passagway **16.** Excess plasma flows through overflow passageway **16** into the overflow chamber **15.** The thus measured plasma subvolumes are displaced from the measuring chambers **10** and passageways **14** into respective sample analysis cuvettes by intermittent application of air pressure to the open center portion of capping plate **8,** while maintaining rotation of the entire rotor assembly at about 1000 RPM. It is necessary to predetermine the combined volume of reagent and plasma samples to be sufficient for photometric measurement, without overfilling the sample analysis cuvettes to the point where liquid could be lost by way of the cleanout passageways **17.**

The above described preferred embodiment and method of operation is intended to be illustrative 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. Also, the particular manner in which reagents are loaded into the sample analysis cuvettes could differ from that illustrated in that separate reagent loading cavities could be provided which communicate by means of suitable passageways with respective sample analysis cuvettes. It is intended rather, that the invention be limited in scope only by the following claims.

What is claimed is:

1. A rotor assembly for a photometric solution analyzer of the rotary cuvette type suitable for use in analyzing whole blood samples comprising:

a. a generally disk-shaped main rotor body defining:

i. an annular plasma distribution manifold;

ii. a plurality of volume measuring chambers distributed in a circular array, said volume measuring chambers being in liquid flow communication with said plasma distribution manifold;

iii. means limiting the centripetal level of plasma in said volume measuring chambers during operation of said rotor;

iv. a plurality of sample analysis cuvettes disposed in a circular array about the periphery of said main rotor body, said sample analysis cuvettes

being in liquid communication with said volume measuring chambers; and

v. means for loading reagents into said sample analysis cuvettes; and

b. a sedimentation bowl nested within said main rotor body and adapted to rotate with that body as a unit, said sedimentation bowl comprising:

i. a hollow disk-shaped base portion, said base portion having a centrally located top opening for receiving whole blood samples and discharging displaced plasma; and

ii. an upstanding, open-ended, annular neck portion integrally fixed to said base portion in register with said top opening, the top end of said neck portion terminating within the center of said annular plasma distribution chamber within a plane axially intermediate to the axial extremities of such chamber.

2. The rotor assembly of claim **1** wherein said sedimentation bowl is removably nested within said main rotor body.

3. The rotor assembly of claim **1** further including a plurality of passageways communicating between said sample analysis cuvettes and said volume measuring chambers, each of said passageways comprising three radially extending interconnected passageway segments; a first segment extending radially from a respective sample analysis cuvette to a point centripetal to the centripetal ends of said volume measuring chambers, a second segment extending from the centripetal end of said first segment to a point centrifugal to said volume measuring chambers, and a third segment extending from the centrifugal end of said second segment to the centrifugal end of a respective volume measuring chamber.

4. The rotor assembly of claim **1** wherein said volume measuring chambers are axially displaced from said plasma distribution manifold with the centripetal ends of said volume measuring chambers radially overlapping the centrifugal extremity of said plasma distribution manifold.

5. The rotor assembly of claim **4** wherein axially extending plasma inlet ports communicate between said plasma distribution manifold and respective volume measuring chambers, said inlet ports being disposed on a common radius about the center of rotation of said rotor assembly.

6. The rotor assembly of claim **5** wherein said means limiting the centripetal level of plasma in said volume measuring chambers comprises a plasma overflow chamber and a plasma overflow passageway communicating between said plasma distribution manifold and said plasma overflow chamber.

7. The rotor assembly of claim **6** wherein said overflow passageway communicates with said plasma distribution manifold at a radius centripetal to the common radius on which said plasma inlet ports are disposed.

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