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E. L. SCHULTZ
DIALYZER CONSTRUCTIONS

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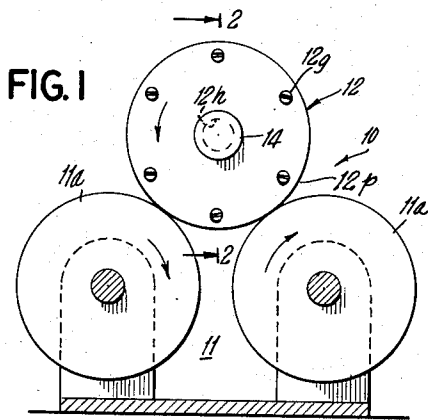


FIG. 2

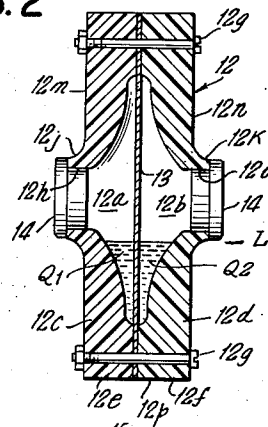


FIG. 3

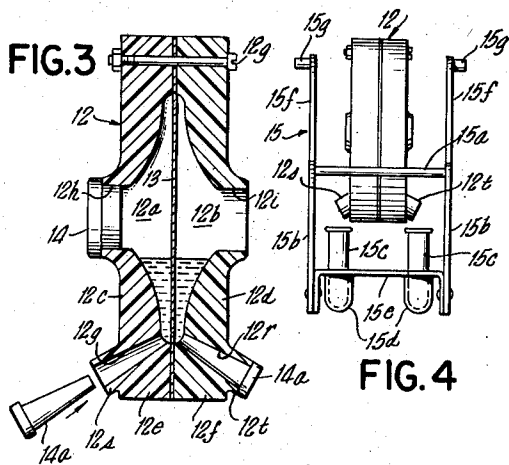


FIG. 4

FIG. 5

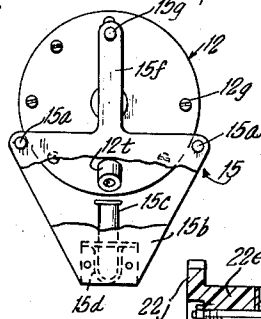


FIG. 6

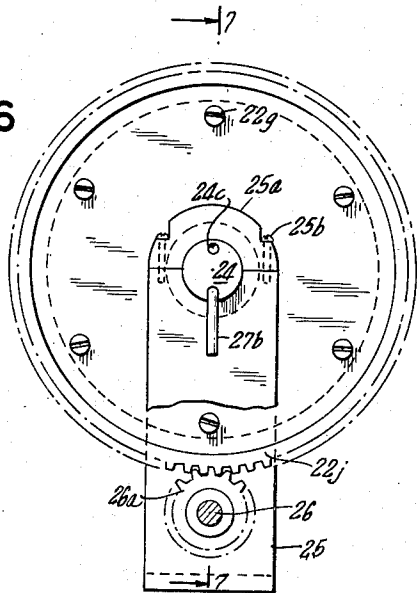
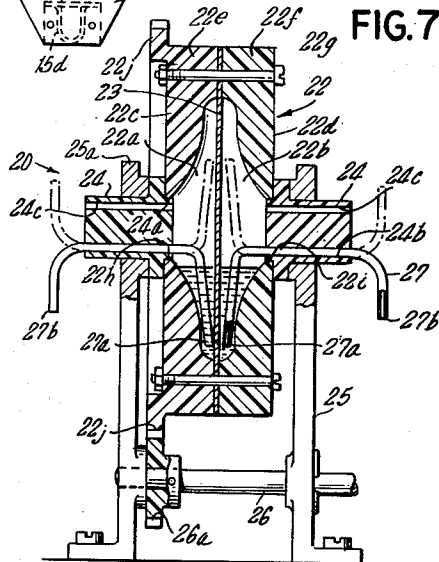


FIG. 7



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1

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DIALYZER CONSTRUCTIONS

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This invention relates to chemical and biochemical laboratory equipment and is more particularly directed to dialyzers for use in micro-analysis of a wide variety of solutions and colloidal suspensions such as whole blood.

Among the objects of the invention is to generally improve dialyzers of the character described which shall be capable of handling small quantities of fluids with the accuracy required by micro-chemical technique, which dialyzer shall comprise few and simple parts readily assembled into an operative unit capable of exposing a maximum area of fluid to the dialyzing process by rotation or oscillation of the unit on a horizontal axis, which shall provide for easy charging with small measured quantities of sample and extracting liquid, which dialyzer shall render efficient recovery of both sample and dialysate and permit easy and rapid cleaning for subsequent use by a variety of methods and using standard equipment commonly available in the laboratory, such as simple aspiration and centrifugation, which unit can be constructed of transparent resinous plastic material for resisting breakage in handling, corrosion by reagents and providing maximum visibility during operation and facilitating cleaning, which unit shall readily be adaptable for use as a component part of an automatic chemical analysis system, which shall be efficient and practical to a high degree in use.

Other objects of the invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists of features of constructions, combinations of elements and arrangements of parts which will be exemplified in the constructions hereinafter disclosed, the scope of the application of which will be indicated in the claims following.

In the accompanying drawing in which various embodiments of the invention are shown:

FIG. 1 is a side elevational view of a dialyzer unit constructed to embody the invention shown in operating position on a pair of power driven rollers forming a friction drive mechanism.

FIG. 2 is a sectional view taken on line 2-2 in FIG. 1 showing the interior construction of the dialyzer unit, the chamber being filled to the normal operating level with sample and extracting liquids.

FIG. 3 is a sectional view taken similar to FIG. 2 but of a modified form of dialyzer unit.

FIGS. 4 and 5 are front and side elevational views, respectively, of a trunnion mounting means for a centrifuge showing the dialyzer unit of FIG. 3 in position for removal of all liquid by centrifugal means particularly as a cleaning operation.

FIG. 6 is a front elevational view of another modified form of dialyzer unit with a gear driven mounting and having elements adaptable for use as part of an automatic or semi-automatic analysis system, and

FIG. 7 is a sectional view taken on line 7-7 in FIG. 6.

Referring in detail to the drawings, 10 generally denotes an apparatus comprising a power driven roller mechanism 11 mounting a dialyzer unit 12 for rotation thereon. As is clear from FIGS. 1 and 2, dialyzer unit 12, constructed to embody the invention, has a hollow casing structure supporting therein a suitable semi-permeable membrane 13 dividing, that is, separating the hollow into two chambers 12a and 12b.

2

Said casing structure may be formed of any suitable material, such as glass, a resinous plastic and the like, being chemically inert to the constituents of the samples and reagents to be used in the dialysis to be performed and also preferably transparent. Polystyrene is particularly suitable for its break resistant properties and may be molded by injection methods into a pair of mating halves 12c and 12d shown in FIG. 2 as having thickened rim portions 12e and 12f sandwiching membrane 13 therebetween. Suitable means for retaining mating halves 12c and 12d in assembly may be utilized, such as, a plurality of bolts and nuts 12g extending in spaced relation through rim portions 12e and 12f.

Chambers 12a and 12b may be of a uniform cross-section taken along planes parallel to that of membrane 13 (not shown) or as illustrated in FIG. 2, chambers 12a and 12b preferably may taper outwardly in curved fashion from a maximum cross-sectional area at membrane 13 to a minimum area terminating in central hub openings 12h and 12i. Annular pouring lips 12j and 12k may be integrally molded to extend beyond opposite end wall exterior surfaces 12m and 12n. Removable rubber or plastic stoppers 14 frictionally engage openings 12h and 12i for sealing chambers 12a and 12b.

The operation of apparatus 10 will now be apparent. Stoppers 14 are removed from hub openings 12h and 12i of a clean dialyzer unit 12 constructed to embody the invention as hereinbefore described. Then, holding unit 12 upright, that is, in the position shown in FIG. 2, measured quantities of an unknown or sample liquid Q1 and an extracting liquid Q2 are deposited into chambers 12a and 12b through openings 12h and 12i, respectively, chambers 12a and 12b preferably being filled to a level L just below openings 12h and 12i. Stoppers 14 are then replaced and unit 12 positioned upright on power driven roller mechanism 11 so that cylindrical surface 12p of unit 12 is supported for rotation on spaced rollers 11a. Upon applying power to rotate rollers 11a in one direction, e.g. clockwise, unit 12 rotates counter clockwise as indicated by the arrows in FIG. 1. Rotation of unit 12 causes liquids Q1 and Q2 to simultaneously flow along opposite sides of membrane 13 progressively bringing a fresh surface of said liquids into dialysitic relation thereby materially hastening the process.

The speed of rotation of unit 12 should be less than that speed required to centrifuge liquids Q1 and Q2 in chambers 12a and 12b. Where blood is used as the unknown liquid Q1 speeds of between 60 to 120 r.p.m. have been found to render satisfactory results by accomplishing approximately 95% dialysis in one hour of rotation as compared to about a day required to accomplish the same results when liquids Q1 and Q2 are permitted to stand in chambers 12a and 12b without rotation or when rotated at centrifuging speeds of 200 r.p.m. or more.

After dialysis has progressed for a predetermined time interval, liquids Q1 and Q2 may be transferred from chambers 12a and 12b by alternately removing stoppers 14 and decanting the liquid into test tubes or other containers, lips 12j and 12k serving as pouring aids in the well understood manner. Unit 12 is then washed as by filling and emptying chambers 12a and 12b several times with distilled water.

Where laboratory uses require substantially dry chambers 12a and 12b particularly in micro-analysis, dialyzer unit 12 may be provided with drain passageways 12q and 12r communicating the troughs of chambers 12a and 12b, respectively, with the exterior. As shown in FIGS. 3, 4 and 5 drain passageways 12q and 12r extend through rim portions 12e and 12f, respectively, being inclined laterally from the troughs of chambers 12a and 12b adjacent membrane 13, terminating in spouts 12s and 12t and having inwardly tapering bores for receiving

plugs 14a sized and shaped to occupy substantially the entire length of drain passageways 12q and 12r.

FIGS. 4 and 5 show a practical use of drain passageways 12q and 12r wherein dialyzer unit 12 is positioned in a trunnion cup 15 for use in a laboratory centrifuge of any well known design. Trunnion cup 15 may be of any suitable construction to support dialyzer unit 12 in an upright position as on spaced rungs 15a extending between side plates 15b and with spouts 12s and 12t extending downwardly in alignment above collecting tubes 15c which are supported in holders 15d formed in bottom plate 15e extending between said side plates 15b, vertical extensions 15f of side plates 15b terminating in outwardly projecting trunnion pins 15g.

Dialyzer unit 12 constructed with drain passageways 12q and 12r and having plugs 14a positioned therein are used in the manner hereinbefore described. After each use, chambers 12a and 12b are thoroughly rinsed and plugs 14a removed. Unit 12 is then positioned on rungs 15a of trunnion cup 15 so that spouts 12s and 12t extend downwardly for drainage into collecting tubes 15c, as indicated in FIGS. 4 and 5. Trunnion cup 15 carrying unit 12 is then placed in a centrifuge (not shown) of any conventional construction having bearing seats for pins 15g. Operation of the centrifuge will expel all liquid from chambers 12a and 12b and a clean and relatively dry dialyzer unit 12 is ready for use.

A modified dialyzer is shown as apparatus 20 in FIGS. 6 and 7 comprising dialyzer unit 22 formed with mating halves 22c and 22d having thickened portions 22e and 22f sandwiching membrane 23 therebetween to define chamber sections 22a and 22b and retained by bolts and nuts 22g.

In order to function as an element of an automatic or semi-automatic chemical analysis system, dialyzer unit 22 preferably is mounted for rotation on its axis in a positive manner as by spindles 24 having a bearing surface portion 24a extending into central hub openings 22h and 22i. Spindles 24 may be removably supported in axial alignment in a suitable frame 25 to locate ring gear 22j, which may be integrally formed with mating half 22c, to mesh with drive gear 26a mounted on drive shaft 26 suitably journaled in frame 25. Removal of spindles 24 and unit 22 from frame 25 may be provided for in any manner, as for example, by a split holder arrangement having detachable caps 25a secured to frame 25 by suitable screws 25b.

Sample liquid Q1 and extracting liquid Q2 may be introduced to chambers 22a and 22b, respectively, through delivery tubes 27 extending through passageways 24b extending longitudinally through spindles 24. Tubes 27 may have bent inner ends 27a positioned to reach down to just short of the bottoms of chambers 22a and 22b and may be arranged to swivel from said downward reaching position shown in full lines to an upwardly extending position shown in broken lines in FIG. 7. If desired, a second passageway 24c parallel to but separate from passageway 24b may be provided in each spindle 24 to serve as a vent in a manner hereinafter described.

In the operation of dialyzer unit 22, chambers 22a and 22b are filled to desired level L through tubes 27. Such filling may be accomplished by connecting the outer ends 27b of tubes 27 to liquid supply sources (not shown) and either by pumping or gravity flow through tubes 27 or application of suction to vents 24c delivering measured quantities of liquids Q1 and Q2 into chambers 22a and 22b, respectively. Tubes 27 may then be rotated 180° to extend upwardly and clear said liquids Q1 and Q2 to prevent any portion of measured liquids Q1 and Q2 from being siphoned back or drawn up by capillary attraction into tubes 27. Drive shaft 26, being connected to a suitable power source (not shown) and through gears 26a and 22j, will then be caused to rotate dialyzer unit 22 for a predetermined time interval to perform the required dialysis at an accelerated rate in the same man-

ner as described above for dialyzer unit 12. Dialyzed liquids Q1 and Q2 may then be removed from chambers 22a and 22b, respectively, by repositioning tube ends 27a to extend into the liquids and then either applying suction to tube ends 27b or pressure through vents 24c.

Where the extreme accuracy of micro-techniques is not required dialyzer unit 22 may function efficiently with delivery tube inner ends 27a remaining in the downwardly extending position shown in full lines in FIG. 7.

It will be understood that in actual practice and particularly in performing routine clinical tests, such as for blood sugar or blood urea nitrogen, standards may be set up for performing these various chemical analyses so as to require a much lower percentage of dialysis and thereby reduce the required time intervals of rotation of units 12 and 22 to about within a 5 minute range.

It will thus be seen that there are provided improved dialyzer constructions whereby the several objects of this invention are achieved and which are well adapted to meet conditions of practical use.

As various possible embodiments of the invention might be made, and as various changes might be made in the embodiments above set forth, it is to be understood that all matters herein set forth or shown in the accompanying drawing are to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. A dialyzer unit for use as an element of a chemical analysis system having means for imparting rotation thereto, said unit comprising a cylindrically shaped casing having an axis and opposite end walls enclosing a hollow interior, a semi-permeable dialyzing membrane extending in a plane substantially normal to said axis and spaced from said end walls within said casing interior dividing the latter into two chambers, each of said end walls having a central opening in coaxial alignment, means engaging each of said openings mounting said casing for rotation on said axis disposed horizontally, means associated with said mounting means for delivering liquids for dialysis into said chambers and removing dialyzed liquids therefrom, and means interconnecting said rotation imparting means with said casing for rotating said unit on said horizontal axis disposing said dialyzing membrane in a vertical plane causing said liquids when partially filling the chambers and separated by the membrane to progressively and simultaneously flow along the membrane in contact therewith for effecting dialysis.

2. The dialyzer unit defined in claim 1 in which said means for delivering and removing liquids are formed as tubes having bent ends within said chambers extending downwardly and terminating adjacent the bottom of the chambers.

3. The dialyzer unit defined in claim 1 in which said means for delivering and removing liquids are formed as tubes having bent ends within said chambers extending downwardly and terminating adjacent the bottom of the chambers, said tubes being independent of said casing rotation and rotatable from said downwardly extending position to an inoperative upwardly extending position.

4. A dialyzer unit of the character described comprising a hollow cylindrical casing formed with mating halves separating along a plane normal to the cylinder axis, each mating half having an end wall defining an end of said cylindrical casing and a thickened rim portion defining half of the cylindrical surface of the casing, a semi-permeable dialyzing membrane extending between said mating halves supportingly engaged by said rim portions dividing said hollow casing into two chambers, means for retaining said mating halves and membrane in engagement as a unit, each of said end walls having a central opening communicating each of said chambers with the exterior for introducing liquids therein for dialysis and removing dialyzed liquids therefrom, the cas-

5

ing cylindrical surface serving as means for supporting the casing on a pair of spaced horizontal rotating rollers for rotating the unit on said cylinder axis, and a removable plug for each of said openings.

5. The dialyzer unit defined in claim 4 in which each of said end walls tapers in thickness from a minimum at said end opening to a maximum adjacent said rim portion providing each chamber with a tapering cross-sectional area with maximum area at said membrane providing maximum surface area of said liquids when in the chambers in contact with the membrane.

6. The dialyzer unit defined in claim 4 in which said retaining means for the mating halves comprises spaced bolts extending through said thickened rim portions.

7. The dialyzer unit defined in claim 4 in which said end walls are formed with external annular lips surrounding said openings for non-spill pouring of the dialyzed liquids from said chambers into liquid receiving receptacles.

8. A pair of power driven rollers mounted in spaced parallel relation for horizontal rotation in combination with a dialyzer unit supported on a cylindrical surface thereof on said rollers for rotation thereby on a horizontal axis, said unit comprising a casing having said cylindrical surface and opposite end walls enclosing a hollow interior, a semi-permeable dialyzing membrane extending in a plane spaced from said end walls and normal to said horizontal axis within said casing interior dividing the latter into two chambers, each of said end walls being formed with an opening communicating each of said chambers with the exterior.

6

9. A dialyzing apparatus comprising a rotatable dialyzer unit formed with a pair of chambers and a semi-permeable dialyzing membrane extending as a common wall between the chambers, separate means communicating with each chamber from the exterior for introducing liquids therein for dialysis and removing dialyzed liquids therefrom, means supporting the unit with the membrane disposed in a vertical plane, and means for rotating said unit on an axis perpendicular to said vertical plane for causing said liquids when partially filling the chambers and separated by the membrane to progressively and simultaneously flow along the membrane in contact therewith for effecting dialysis.

10. The dialyzer unit defined in claim 4 including a second opening for each of said chambers located to extend through each end wall adjacent said cylindrical casing surface at an angle to said axis, and a removable plug extending into and through each of said second openings.

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