United States Patent [19]

Jordan

[11] 3,836,329

[45] Sept. 17, 1974

[54] METHOD AND APPARATUS FOR REMOVING LIQUID FROM CONTAINERS

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[73] Assignee: Damon Corporation, Needham Heights, Mass.

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[21] Appl. No.: 191,889

[52] U.S. Cl. ..... 23/230 R, 23/253 R, 23/259, 23/292, 73/423 A, 134/21, 134/22 C, 134/24, 134/37, 141/130

[51] Int. Cl. B08b 5/04, B08b 9/00, G01n 31/00

[58] Field of Search ..... 23/230 R, 253 R, 259, 292; 73/423 A; 134/21, 22 R, 22 C, 24, 37; 141/130

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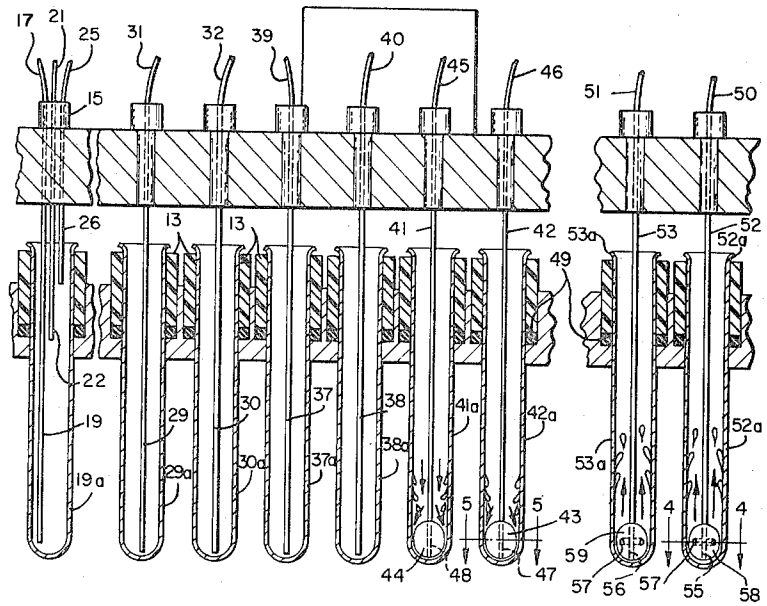
Primary Examiner—Joseph Scovronek
Attorney, Agent, or Firm—Kenway & Jenney

[57] ABSTRACT

An apparatus for removing a liquid from a container such as a test tube comprising a probe having a diameter slightly smaller than the container inside diameter. The probe has a bore connected to a source of gas at a superatmospheric or subatmospheric pressure which effects a gas flow between the probe and container to entrain liquid from the container into the gas stream.

19 Claims, 5 Drawing Figures



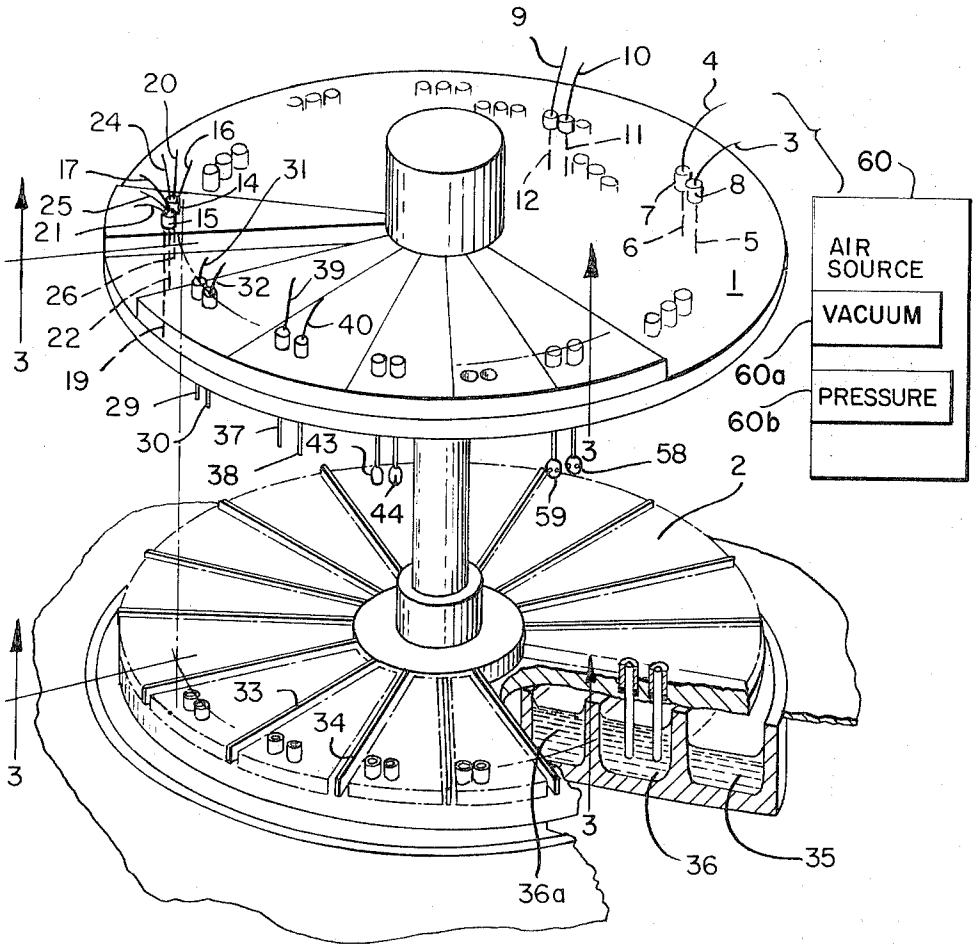


FIG. 1

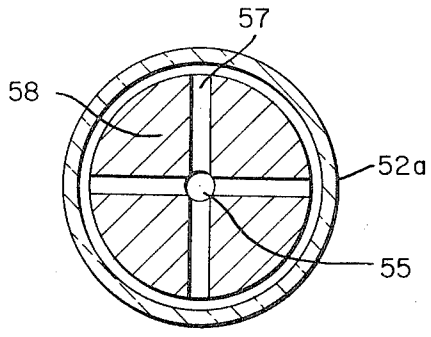


FIG. 4

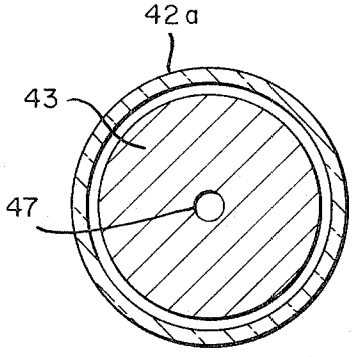


FIG. 5

FIG. 2

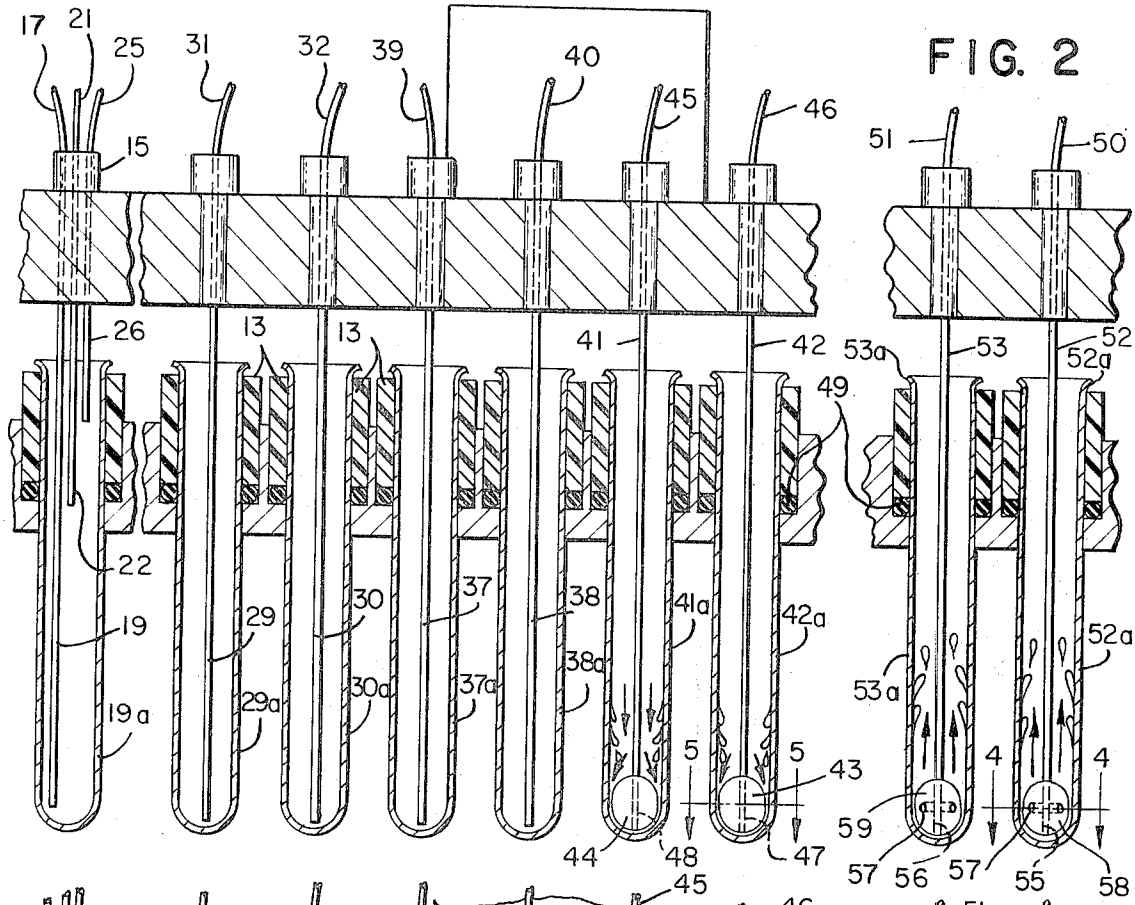

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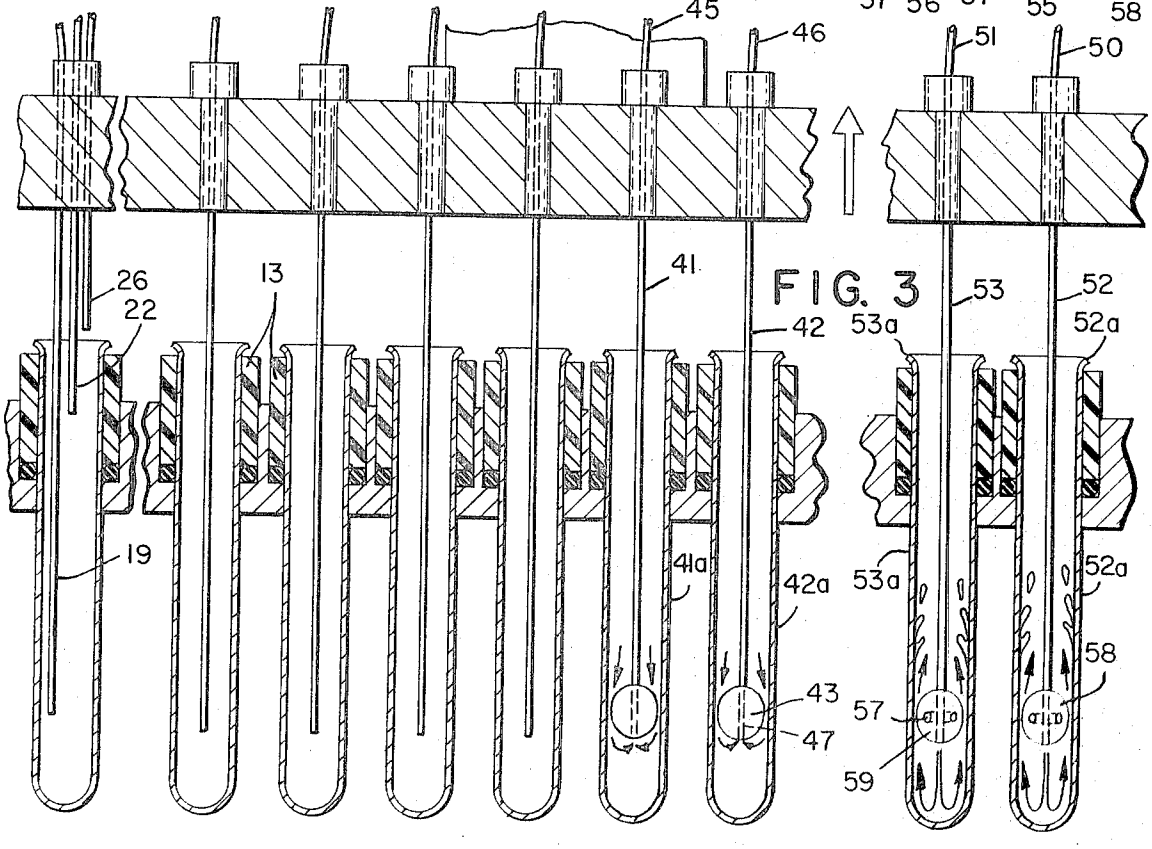
FIG. 3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METHOD AND APPARATUS FOR REMOVING LIQUID FROM CONTAINERS

This invention relates to a method and apparatus for removing liquids from containers particularly containers which must be cleaned repeatedly.

In some present automatic constituent analyzers of liquids, an aliquot is introduced into a container, such as a test tube, reacted therein and then removed therefrom for analysis to determine the degree of reaction. Prior to introducing the next successive aliquot, the container must be rendered free of any remaining liquid to prevent the contamination of the incoming aliquot. At the present time, the most common method employed involves aspirating the fluid by means of a hollow probe having a substantially smaller diameter than the container, introducing wash liquid into the container and then aspirating the wash liquid from the container with the same size probe. Since the wetting of the container wall generally is non-uniform, residual liquid remains thereon after aspiration. Thus, this method is undesirable since the removal of liquid from the walls and bottom of the container is incomplete. It has been proposed also to provide additional subsequent steps of introducing desiccated or heated gas such as air into the container after the wash fluid has been removed thereby to effect the desired liquid removal. However, the use of desiccated or heated air is expensive by virtue of the desiccated cost or heat control cost and therefore in most cases this solution is impractical. More importantly, removing the water from the vessel by evaporation may not produce the desired cleanliness since the contaminants dissolved in the water will not evaporate and will remain behind.

The present invention is based upon the discovery that a container, as for example a test tube, can be rendered free of liquid by employing a probe, the bottom end of which has a diameter only slightly smaller than the inside diameter of the container and having ports for passing fluids therethrough. In one aspect of the present invention, the enlarged portion of the probe has a port on the bottom surface thereof so that when inserted in the container, the port is adjacent the bottom surface of the container. In this aspect, a vacuum is applied to the probe chamber so that liquid in the container can be aspirated through the probe and out of the container. In another aspect of the present invention, the probe can also be provided with ports on the side walls, at a vertically intermediate height of the enlarged portion, to pass gas under pressure into the container. In the latter case, blowing is continued while withdrawing the probe from the container so that any liquid therein precedes the probe and exits from the top of the container.

It has been found that by employing the probe of this invention, substantial pressure drops can be generated between the top of the probe portion having the enlarged diameter and the fluid port or ports so that all of the liquid on the walls and on the bottom of the container can be entrained in the moving gas stream generated either through the probe or by being forced out of the top of the container. It is preferred that the top of the probe portion having the large diameter be convex to eliminate sharp edges which might damage the containers and to effectively maintain the pressure drop generated between the probe port or ports and the top surface of the enlarged portion of the probe.

This invention will be more fully understood with reference to the accompanying figures.

FIG. 1 is an isometric view, in partial cross-section, of a portion of a fluid analysis system in which test tubes periodically received liquids and periodically are cleaned.

FIG. 2 is a side view, in partial cross-section, of the system of FIG. 1 wherein the probes of this invention are located in the bottom of test tubes.

FIG. 3 is a side view, in partial cross-section, of the system of FIG. 1 while the probes are being withdrawn from the test tubes.

FIG. 4 is a cross-sectional view of a probe with side ports taken along the line 4—4 of FIG. 3.

FIG. 5 is a cross-sectional view of a probe taken along the line 5—5 of FIG. 3.

The fluid analysis system shown in FIG. 1, wherein aliquots of fluid are continually tested for various substituents and the containers in which the chemical reactions occur are continually cleaned, is more fully described in the commonly assigned copending application entitled "Constituents-Measuring Chemical Analyzer Having Sample Processing Conduit Feeding Aliquot-Processing Conveyor System" by David I. Kosowsky, Andres Ferrari and Carl R. Hurtig and filed concurrently herewith, i.e. on Oct. 22, 1971 and bearing Ser. No. 191,884, now U.S. Pat. No. 3,764,286, issued Oct. 9, 1973. The system for delivering and removing fluids from test tubes comprises a top tray 1 adapted to move vertically by vertical drive means (not shown) and having probes for delivering or removing liquids to or from test tubes retained in bottom tray 2. As shown in FIG. 1, the tray 1 is slightly thicker at the portion thereof employing larger probes extending to the bottom inside surface of the test tubes to improve axial stability of these probes when they register in the test tubes. The tray 1 is provided with a plurality of holes through its thickness to accommodate probes that extend through and beyond the thickness of the tray 2 and suitable connections for distributing samples, reagents and washing fluid as well as for delivering air or removing air for purposes of cleaning the test tubes in tray 2. In the system, all fluids are introduced into the test tubes located in tray 2 when tray 1 is moved vertically downward so that the probes in the various positions register within the tubes.

By way of example, samples are introduced into two test tubes in tray 2 through conduits 3 and 4 and probes 5 and 6 extending from probe holders 7 and 8. After the sample has been introduced into the two test tubes, tray 1 is elevated relative to tray 2 to the position shown in FIG. 1 and tray 2, having rotational drive means (not shown), is indexed counterclockwise to register the two tubes beneath reagent probes 11 and 12 connected with conduits 9 and 10. Tray 1 is then moved vertically toward tray 2 so that the reagent can be introduced through conduits 9 and 10 into the two test tubes on tray 2 into which the probes 11 and 12 extend. The vertical movement of tray 1 and the indexing of tray 2 counterclockwise is repeated until the two test tubes containing the reacted sample-reagent mixture are located beneath probe holders 14 and 15. Each probe holder 14 and 15 has three probes associated therewith, each connected to a conduit for passing fluids. Conduits 16 and 17 are connected to a source of vacuum, illustrated as the vacuum section 60a of a pressure source 60, and to probes, of which the one

probe 19 connected to conduit 17 is shown, so that the serum-reagent mixture is aspirated via these probes through conduits 16 and 17 into a means for determining the extent of reaction, such as a colorimeter (not shown). After the sample-reagent mixture has been aspirated, trays 1 and 2 remain juxtaposed and wash fluid is introduced through conduits 20 and 21 and through probes, of which the one probe 22 connected to conduit 21 is shown, to preliminary clean the two test tubes, as shown in FIG. 2 for the one test tube 19*a*. Conduits 24 and 25 are connected to a source of vacuum and to probes, of which the one probe 26 connected to conduit 25 is shown, that extend a short vertical distance within the test tube so that wash fluid introduced through the latter two probes will not overflow onto tray 2 but rather will be aspirated through these probes. Thereafter, wash fluid is aspirated to the colorimeter via the probes connected to conduits 16 and 17.

Tray 1 then is moved vertically upward and tray 2 is indexed counterclockwise so that the two test tubes now designated 29*a* and 30*a*, register with probes 29 and 30 connected to conduits 31 and 32 through which is introduced excess water. As the tray 2 is rotated, the test tubes contact heated liquid in troughs 36 and 36*a* which are maintained at different temperatures depending upon the type of reaction being carried out at the radial position corresponding to troughs 36 and 36*a*. Sufficient wash water is introduced through probes 29 and 30 so that the wash water in the test tubes will overflow the test tube onto tray 2 and be confined by walls 33 and 34 to flow into trough 35. All of the test tubes are maintained above the surface of tray 2 by walls 13 so that no liquid will flow into the test tubes from the tray surface. The test tubes filled with water then are indexed to register beneath probes 37 and 38 which are connected to a source of vacuum through conduits 39 and 40 to aspirate the water from the test tubes 37*a* and 38*a*. Since the probes 37 and 38 have substantially smaller diameters than the test tubes, all of the water in the test tubes 37*a* and 38*a* is not aspirated.

The operation of the probes of this invention will be described with reference to FIGS. 2 and 3. When trays 1 and 2 are juxtaposed, probes 41 and 42, having enlarged end portions 43 and 44 extend to the bottom of test tubes 41*a* and 42*a*. Conduits 45 and 46 are connected to a source of vacuum and to probes 41 and 42. During aspiration, through probes 41 and 42 and openings 47 and 48, air is caused to move downwardly through the test tubes 41*a* and 42*a* and into the small volume between the test tube inner surfaces and the outer surfaces of the probe extensions 43 and 44, thereby effecting a relatively large pressure drop between the top of the probe extensions 43 and 44 and the probe openings 47 and 48. Thus, any water in the small volume or adjacent the probe extensions 43 and 44 will be entrained by the moving air into openings 47 and 48. The test tubes are retained in positions during entry and removal of the enlarged probe extension by means of tight fitting "O" rings 49.

As shown in FIG. 3, when trays 1 and 2 are moved apart, air is blown under pressure e.g. from the pressure section 60b of air source 60 (FIG. 1) through conduits 50 and 51 into probes 52 and 53 and is caused to move through bottom ports 55 and 56 and side ports 57 so that when tray 1 is moved vertically upward, air passing between the outer surface of probe extensions 58 and 59, and the inner surface of the test tubes 52*a* and 53*a*, causes any entrained liquid to pass before the moving probes 58 and 59 upwardly and out of the test tubes 52*a* and 53*a*.

As shown in FIG. 4, the probes employed when blowing air into test tubes having a plurality of side ports 57 and a central bore 55 thereby causing the largest volume of air to pass through side ports 57 and upwardly through the tube during withdrawal of the probe 52 from the test tube 52*a*.

It has been found that the use of probes having a size only slightly smaller than the container that all of the liquid can be removed therefrom. Thus, it is not necessary to employ both of the larger size probes as shown in the figures.

Summarizing the foregoing description and the drawings, this invention thus provides an improvement for automated apparatus having at least one container with a closed end opposite an open end and which repeatedly receives a quantity of liquid material. The apparatus further has means for flushing the container with wash liquid and for emptying the container of the wash liquid, intermediate the delivery of successive quantities of the liquid material to the container. The improvement is in a probe having a fluid passage therein and arranged on such apparatus for extension into the container with the probe free end adjacent the container closed end. In particular, the improvement is to provide the probe with at least the portion at its free end contoured substantially to fill the cross section of the container. This large portion of the probe causes a fluid stream delivered to the probe from an external source to pass between the probe portion and the container inner wall with a wiping action. The outer end of the probe portion preferably is further contoured, as FIGS. 2 and 3 illustrate, to conform relatively closely with the closed end of the container.

The source of the fluid stream is a gaseous pressure source connected with the probe for creating the fluid stream as a gas stream. Where the gas stream is drawn into the probe, the aforesaid wiping action picks up fluid material from the container inner surface and removes it from the container by way of the probe. Where the gas stream is directed into the container from the probe, the wiping action removes fluid material from the container upward beyond the large probe portion toward the container open top for discharge therethrough from the container. With either or both of these arrangements, the wiping action which the invention provides removes residual fluidic particles from the container prior to the delivery of another quantity of liquid to it.

I claim:

1. The method of removing residual liquid from a container which comprises placing a probe adjacent the bottom inside surface of said container, said probe having an outside diameter slightly smaller than the inside diameter of the container, said probe having a bore extending between its top and bottom surfaces, and said bore being connected to a source of gaseous fluid, aspirating fluid through said bore to entrain any liquid in the container into said bore, removing said probe from said container, placing a second probe adjacent the bottom inside surface of said container, said second probe having an outside diameter slightly smaller than the inside diameter of the container, said second probe

having a central bore extending between its top and bottom surfaces and having at least one side bore extending between the central bore and a side wall of said probe, said central bore in said second probe being connected to a source of gaseous fluid, and forcing such fluid through the bores in said second probe successively into said container and outward from a top opening in said container.

2. The process of claim 1 wherein such gaseous fluid is forced through said second probe while said second probe is moved from the bottom inside surface of said container and outward through the top opening in said container.

3. In automated analysis apparatus which repeatedly delivers a quantity of liquid material to at least one container having an open end opposite a closed end, and having means for flushing said container with wash liquid and for emptying said container thereof intermediate the delivery of successive quantities of said liquid material thereto, the improvement comprising

a probe having a free end and arranged for extension into, and subsequent retraction from, said container intermediate said flushing and said delivery of liquid material to the container,

said probe having a first portion adjacent said free end therrof for disposition when said probe is so extended within said container adjacent the container closed end,

said probe further having port means in said first portion and having a fluid passage therein communicating with said port means and for connection to gas pressure source means for producing, via said fluid passage and said port means, a gas stream within said container and through said container open end and including through the annular space between the container inner surface and said probe portion, and

means on said probe portion enlarging the size thereof for constricting said annular space for thereby causing said gas stream to pass said constricted space with a wiping action against the container inner surface.

4. In automated apparatus as defined in claim 3 the further improvement wherein said container has a substantially circular interior cross section of uniform inside diameter, and said enlarging means provides said probe portion with a circular cross section having an outside diameter only slightly smaller than said inside diameter of the container.

5. In automated apparatus as defined in claim 3, the further improvement wherein

said probe has a further portion thereon spaced from said free end and said port means and of significantly lesser cross-sectional size than the cross-sectional size of said enlarging means, and

said enlarging means provides said probe first portion with a sufficiently large cross-sectional size relative to said container to produce a substantial pressure drop in said gas stream between said port means and said second portion.

6. In automated apparatus as defined in claim 3 the further improvement wherein said probe first portion

has an inner end removed from said probe end and of substantially lesser cross-sectional size than said enlarging means, and

has a convexly rounded surface between said inner end thereof and said enlarging means.

7. In automated apparatus as defined in claim 3 the further improvement comprising gas pressure source means connected with said fluid passage of said probe and producing a gas stream that exits from said fluid passage at said port means for passage through said constricted annular space and outward from said container through said open end thereof.

8. In automated apparatus as defined in claim 3 the further improvement comprising gas pressure source means connected with said passage of said probe and drawing said gas stream into said passage via said port means for drawing said gas stream into said container through said open end thereof and through said constricted annular space.

9. In automated apparatus as defined in claim 3 the further improvement wherein said probe first portion has an end surface contoured substantially like the contour of said container closed end.

10. In automated apparatus as defined in claim 3 the further improvement wherein said port means includes at least a port at the extreme free end of said probe first portion.

11. In automated apparatus as defined in claim 3 the further improvement wherein said port means includes a plurality of side ports passing through sidewalls of said probe first portion and communicating with said fluid passage.

12. In automated apparatus as defined in claim 3 the further improvement wherein said fluid passage extends along a first axis within said probe and

said port means includes an end port in line with said passage and a plurality of side ports extending transversely from said passage and exiting from said probe first portion along the sides thereof.

13. In automated apparatus as defined in claim 3 the further improvement comprising

means for selectively and alternately extending said probe into said container and withdrawing said probe from said container.

14. Clinical analysis apparatus for removing liquid residue from a container of selected interior cross section and having an open end opposite a closed end, said apparatus comprising

probe means

arranged for repeated extension into, and retraction from, said container through said open end thereof and without closing said open end,

having a free end arranged for disposition adjacent said container closed end when said probe means is extended into said container, and

having at least one port and having a fluid passage communicating with said port,

a source of gas pressure connected with said probe passage for producing, by way of said passage and port and when said port is within said container, a gas stream within said container and passing through said open end thereof, and

an enlarged end portion on said probe at said free end and through which said port is exposed, said enlarged portion having a cross-sectional size that is larger than elsewhere on said probe within said container when extended, and is sufficiently large relative to the interior cross-section of said container to constrain said gas stream to pass therearound with a wiping action on the container inner surface.

15. In the automated analysis of liquid material, an improvement in the process of removing such liquid from a container having a closed end opposite an open end and which repeatedly receives a quantity of the liquid material, said improvement comprising the successive steps of

introducing a gas stream into said container through said open end thereof and via a passage removably and replaceably extending into said container to adjacent said closed end thereof, and

constraining said gas stream to pass contiguously along the container inner surface through an annular space of small cross-sectional area relative to the cross-sectional area of said container, so that said gas stream removes liquid from the container inner surface.

16. In the automated treatment of liquid material, an improvement in the process of removing such liquid from a container having a closed end opposite an open end and which repeatedly receives a quantity of the liquid material, said improvement comprising the successive steps of

providing a passage-forming probe removably and replaceably extending into said container through said open end thereof with the passage end adjacent said container closed end, said probe having on at least a portion thereof an enlargement of the outer surface sufficient to leave only a space which is small relative to said container between said probe outer surface and said container,

introducing a gas stream into said container by means of said probe passage, and

constraining said gas stream to pass through said small space contiguous with said container inner surface, thereby to produce with said gas stream a wiping action of such fluid material from the container inner surface.

17. In a process as defined in claim 16, the further improvement comprising the steps of

gradually withdrawing said probe from said container, and

maintaining said gas stream through said passage during the withdrawal of said probe from said container.

18. In a process as defined in claim 16, the further improvement wherein said gas stream introducing step discharges gas into said container from said probe passage.

19. In a process as defined in claim 16, the further improvement comprising the steps of

moving said probe relative to said container to move said large probe surface between said container ends, and

maintaining said gas stream during said relative movement, thereby to constrain said gas stream to pass contiguous with said container inner surface along the length thereof between said container ends.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,836,329 Dated September 17, 1974

Inventor(s) Michael Jordan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

FIG. 1 should appear as shown on the attached page.

Signed and Sealed this

thirteenth Day of January 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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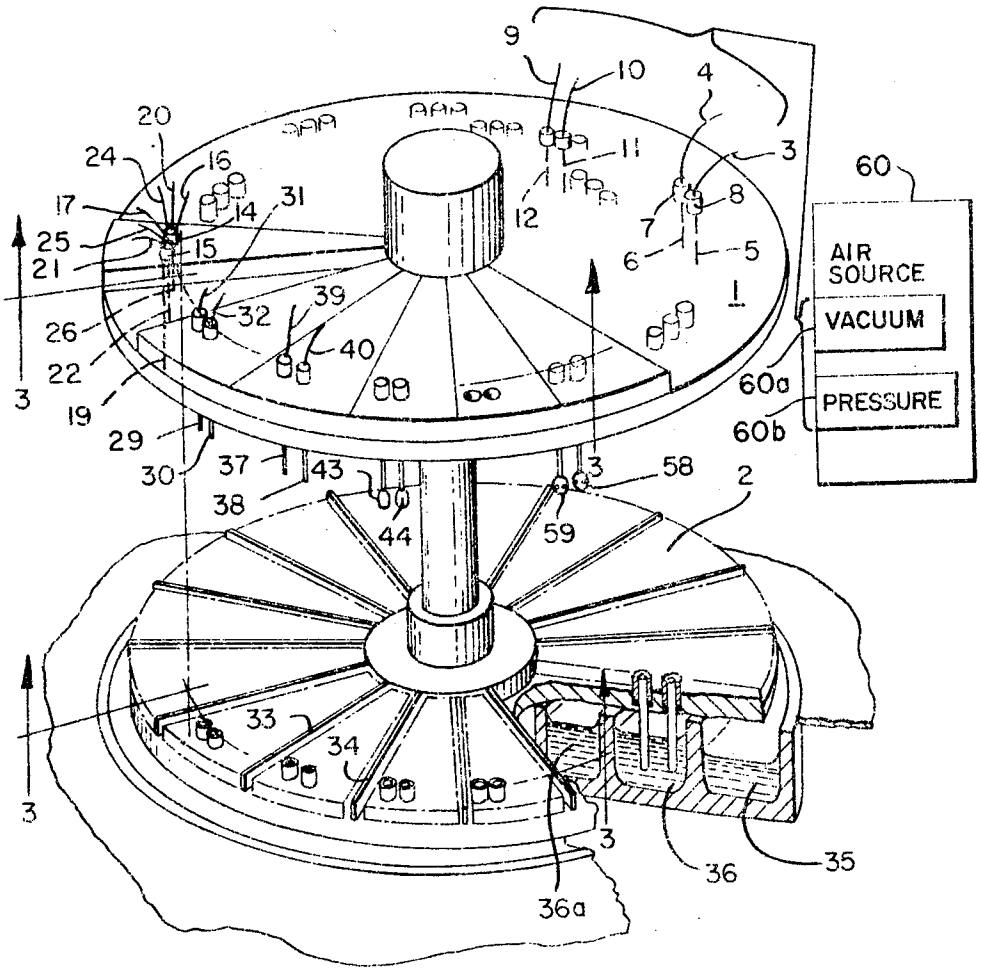
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FIG. 1