June 17, 1969 J. F. GRIMSHAW 3,449,959

SAMPLE CONTAINER FOR AUTOMATIC SAMPLING APPARATUS

Filed June 27, 1966

Sheet 1 of 3

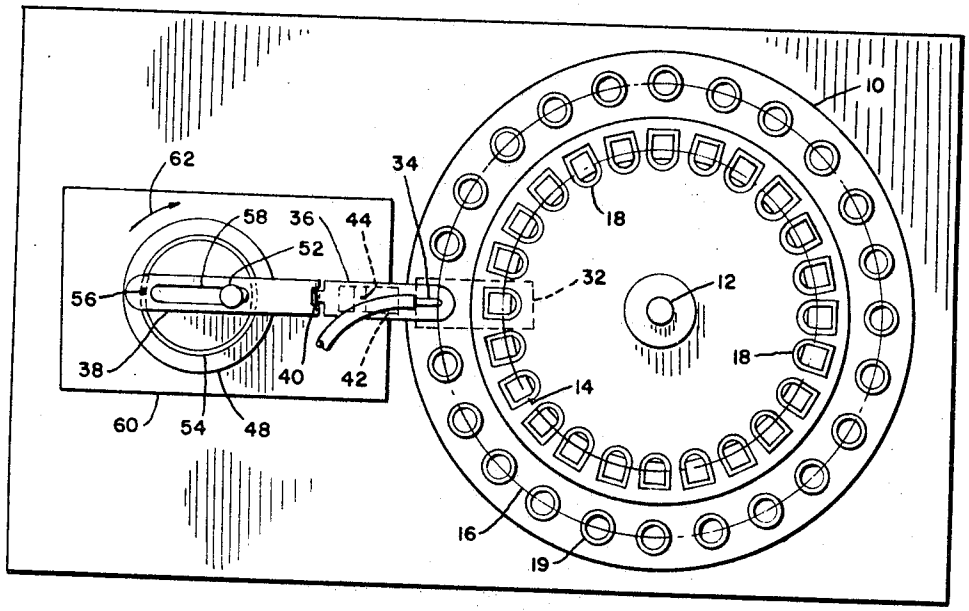


FIG. 1

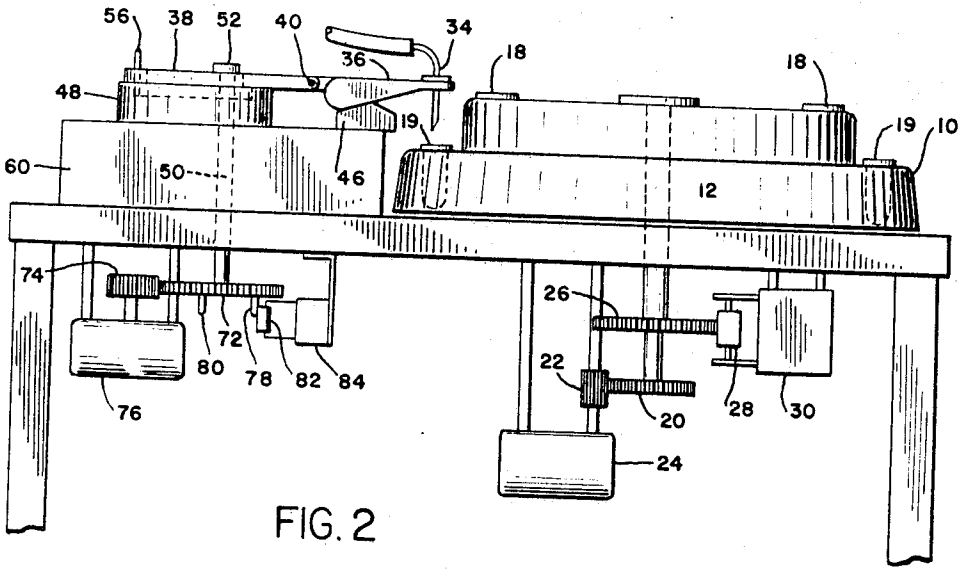


FIG. 2

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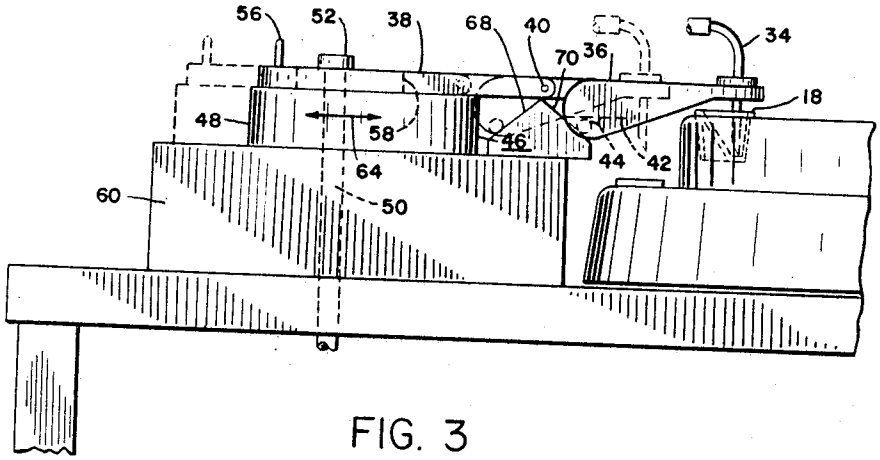


FIG. 3

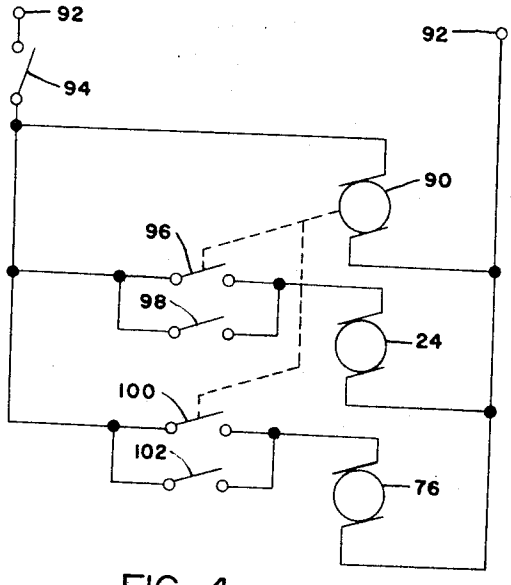


FIG. 4

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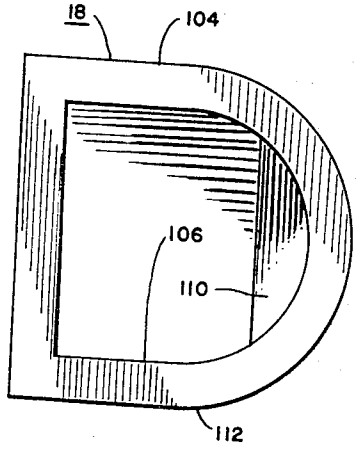


FIG. 5

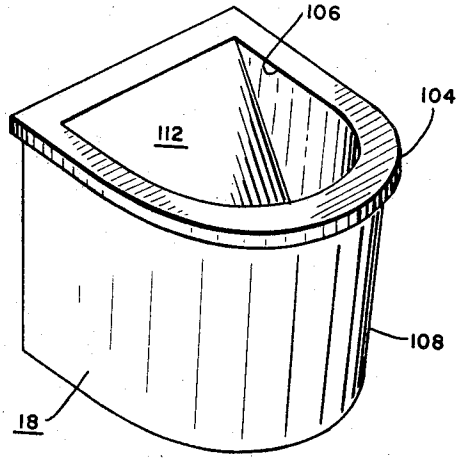


FIG. 6

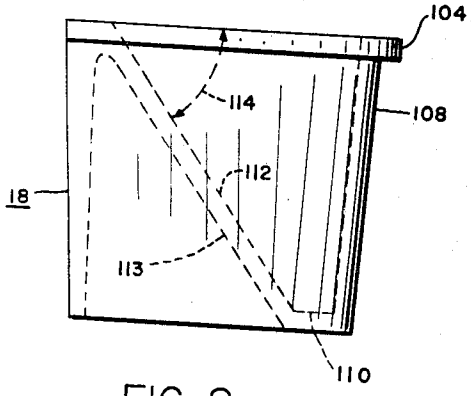


FIG. 8

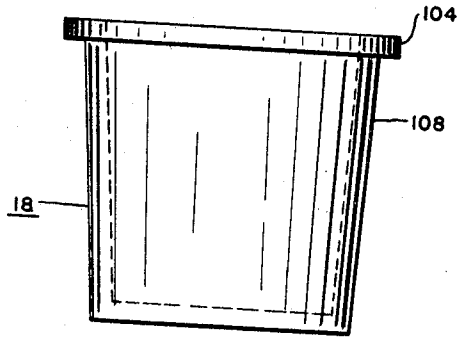


FIG. 7

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3,449,959

SAMPLE CONTAINER FOR AUTOMATIC SAMPLING APPARATUS

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Int. Cl. G01n 1/10
U.S. Cl. 73—423
4 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for supplying samples to an analyzer wherein sample containers are mounted on a turntable which is turned so that samples may be sequentially removed by a probe. The disclosure relates to a particular shaped container and a particular mechanism for manipulating the probe.

This invention relates to containers for receiving liquid samples and more particularly to containers for automatic mixing apparatus adapted to receive small volumes of liquid samples and shaped to cooperate with withdrawal means to provide for the maximum removal of the liquid sample therein.

In certain types of analytical procedures, large numbers of routine determinations must be carried out. Particularly applicable are those employed in biochemical, physiological and medical laboratories where materials such as blood serum, spinal fluids, tissue serum, urine, or other materials are tested and/or analyzed. Such tests are particularly suited for automation because the analytical procedures are repeated a large number of times.

In accordance with many of these procedures, a measurement is made by a suitable sensing device capable of measuring a physical or chemical property which is indicative of the analytical results to be found. For example, many procedures call for the accurate mixing of a predetermined volume of a test sample with other reagents to develop a reaction resulting in a change in optical density in an amount depending upon the concentration of a constituent in the test sample. Apparatus designed to automatically provide the mixing sequence generally includes a plurality of sample containers adapted to receive liquids to be tested. The sample containers are sequentially moved to a withdrawal position wherein a transfer device including a probe educts a predetermined volume of the test sample.

In many cases, the available amount of test samples is small, such as in the case of spinal fluids, etc., requiring efficient processing of the sample. This presents a particular problem in automated apparatus wherein it is highly desirable to transfer substantially all of the liquid in the container so that the amount of fluid required per test can be minimized.

It is therefore an object of this invention to provide a new and improved sample container for automatic analyzing apparatus.

It is also an object of this invention to provide a new and improved sample container for automated apparatus adapted to cooperate with a transfer device for the efficient transfer of liquid therein.

It is still a further object of this invention to provide a new and improved sample container for automated apparatus particularly adapted to receive small volumes of test sample and cooperates with a transfer device for the maximum transfer thereof.

The sample container of the invention is adapted to be used with automatic sampling apparatus including a carrier means for receiving a plurality of the sample containers and moves the containers in a step by step motion and includes means for sequentially moving an intake probe into and out of the plurality of containers for withdrawing the contents therein during dwell periods. The sample containers include a top portion having an opening therein for receiving the probe, an elongated bottom portion that is substantially smaller than the opening in the top portion and side portions connecting the top and bottom portions to form a highly tapered cavity for receiving liquid samples. The containers are mounted on the carrier means so that the probe moves into the containers to engage the bottom portion and the larger dimension of the bottom portion lies along the path of movement of the carrier means. The highly tapered cavity provides for the maximum withdrawal of the liquid sample therein, thereby providing for the efficient use of smaller test samples. The elongated bottom portion provides for a wide degree of tolerance for the step by step motion of the carrier means.

A further feature of the invention includes the cooperation of the highly tapered cavity to guide a gravity biased probe to engagement with the bottom portion when said probe or container is misaligned.

The novel features which are considered to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings in which:

FIGURE 1 is a plan view of an automatic sampling apparatus adapted to be used in conjunction with the sample container including the invention.

FIGURE 2 is a side view of the sampling apparatus of FIGURE 1.

FIGURE 3 is an enlarged side view of the transfer device of FIGURE 1 and its relation to a sample container.

FIGURE 4 is an electrical schematic diagram for controlling the operation of the automatic sampling apparatus.

FIGURE 5 is a top view of the sample container for the automatic sampling apparatus of FIGURE 1.

FIGURE 6 is a perspective view of the sample container of FIGURE 5.

FIGURE 7 is a front view of the sample container of FIGURE 5.

FIGURE 8 is a side view of the sample container of FIGURE 5.

Referring to FIGURES 1, 2, and 3, an automatic sampling system includes a circular turntable **10** mounted to rotate about a shaft **12**. Two groups of holes are formed in concentric circular rows **14** and **16** about the shaft **12**. The holes in the circular row **14** are unsymetrically shaped about the row **14** (as illustrated by the hole **15**) and include a curved portion and several connecting straight portions. The holes receive a plurality of small containers **18** (including test samples to be analyzed) having an outer shape to fit in the unsymmetrical holes in a predetermined aligned manner. The holes in the circular row **16** are in fixed radial relation with the containers **18** in row **14** and receive a plurality of cuvettes **19** (one for each container **18**). The cuvettes **19** are adapted to receive a portion of test samples mixed with a plurality of reagents.

The turntable shaft **12** is coupled through the gears **20** and **22** to a motor **24** (FIGURE 2). A timing gear **26** is also coupled to the shaft **12**, the teeth of which are adapted to engage the roller **28** of a snap action switch **30** to provide an indication when the turntable **10** has rotated a preset angle. The motor **24**, by way of example, can be a

commercially available slow speed stepping motor that can be energized momentarily to close the switch **30** and then held energized (sealed in) by the switch **30** until the turntable **10** has rotated a required angle. Each time the motor **24** is energized a new sample container **18** and cuvette **19** are positioned in a sampling site (illustrated by a dashed block **32**).

A probe **34** is mounted to form a portion of an automatic sampling mechanism or transfer device adapted to be connected to suitable pump mechanism to remove a preset volume of the test sample from the containers **18** and translate the preset volume of the test sample along with a given volume of a second reagent into a corresponding cuvette **19** in the sampling site **32**. Probe **34** is a hollow tube extending through a movable probe arm **36**. The movable arm **36** is pivotally coupled to a sliding member **38** through a pivot connection **40** and includes an elongated guide slot **42** (shown dashed) formed therein with a pin **44** (shown dashed) extending across the slot (FIGURES 1 and 3). The guide slot **42** fits over a stationary cam **46** having a triangular shaped surface that engages the pin **44** to control the vertical motion of the arm **36**.

The slidable member **38** is mounted on a circular cam **48** through a cam drive shaft **50** (shown dashed) and held in place by a cap **52**. The cam **48** includes a circular groove **54** (FIGURE 1) formed eccentric with the drive shaft **50**. A guide pin **56** extends through the slidable member **38** into the circular groove **54**. The shaft **50** passes through a slot **58** formed in the slidable member **38** (FIGURE 1) and extends through and makes connection with the circular cam **48** at a point off center.

The cam **48** is rotated by the shaft **50** to slide along a base **60** in a counterclockwise direction (as indicated by the arrow **62**, FIGURE 1) so that the slidable member **38** slides back and forth (in the direction as indicated by the arrows **64**, FIGURE 3) causing the pin **44** to ride along the surfaces **68** and **70** of the stationary cam **46** and forcing the arm **36** to follow a curved path having the form of an arc. For example, if the arm **38** is forced to move in a direction towards the turntable **10**, the pin **44** rides up along the surface **68** causing the arm **36** to tilt upwards above the container **18** in circular row **14** (as shown in phantom in FIGURE 3). After the pin has passed the peak in the cam **46** (with the arm still moving in the same direction) the pin **44** slides along the surface **70** causing the arm to be tilted down toward the turntable **10** so that the probe **34** dips into a sample container **18** in the sampling site **32** providing a first operative position for withdrawing the test sample (FIGURE 3). As the cam **48** is rotated further, the direction of movement of the slider **38** and the arm **36** reverses, forcing the pin **44** to slide back up the surface **70**, tilting the arm **36** up away from the turntable **10** and over the peak onto the surface **68**. While returning over the surface **68** the arm **36** tilts back down towards the turntable **10** so that the probe **34** extends over the corresponding cuvette **19** in the circle **16** providing a second operative position for delivery of a liquid to a cuvette **19**.

The cam shaft **50** is coupled through the gears **72** and **74** to a drive motor **76** (FIGURE 2). Two pins **78** and **80** are mounted on the gear **72** to engage a roller **82** of a snap action switch **84** to provide a signal when a half revolution of the cam **48** has been completed.

The operation of the automatic sampling apparatus of the figures is controlled by a suitable timer device, such as a motor driven cam timer. A cam motor **90** (FIGURE 4) is connected to a pair of power terminals **92** (adapted to be connected to the 60 cycle line mains) through a switch **94**. When the motor **90** is energized, a cam periodically closes a switch **96**, momentarily energizing the turntable motor **24**. The motor **24** is held energized by the contacts **98** of the snap action switch **30** until the next sample container **18** and cuvette **19** move into the sampling site **32**.

Shortly thereafter, the timer device momentarily closes the contacts **100** to energizing the motor **76** to drive the pin **78** away from the roller **82** of the snap action switch **84**. The contacts **102** of the snap action switch **84** are closed to keep the motor energized until the pin **80** actuates the switch **84**. At this time the probe **34** is inserted into a sample container **18** as illustrated in FIGURE 3. The probe **34** is adapted to be connected to suitable pump means for removing the sample therein. The switch contacts **100** are again momentarily closed and the motor **76** is energized by the switch contacts **102** (snap action switch **84**) until the pin **78** engages the roller **82** to actuate the switch **84**. At this time the probe **34** is positional over a cuvette **19** in the sampling site **32** as illustrated in FIGURE 2.

The liquid sample can now be transferred to the cuvette **19** along with other reagents by suitable pump means. The sequence is automatically repeated until all the samples are removed and transferred, at which time apparatus is deenergized by opening the switch **94**.

It should be noted that the combined action of the cam **46**, the pin **44** and the slide **38**, moves the probes **34** into and out of the sample container **18** in a path within a plane substantially normal to the plane of the turntable **10**. The shape of the sample container conforms with the path of movement of the probe **34** to provide for free movement therein and also allows the maximum withdrawal of the liquid sample therein.

Referring now to FIGURES 5–8, the sample container **18** is formed with a top portion **104** having three substantially straight sections and a fourth curved section connected to form an enlarged cap with an opening **106** for receiving the probe **34**. The sides **108** of the container **18** extend away from the top portion **104** and follow substantially the same shape, slightly reduced in size, and include a slight taper toward each other. The holes in the row **14** have the same general shape as the outer perimeter of the sample container **18** and receive the container so that the curved portion of container extends toward the shaft **12** and the bottom of top portion **104** rests on the turntable **10**. The container **18** also includes an elongated bottom portion **110** facing the opening **106** which is substantially smaller than the opening **106**. In the present embodiment, the area of the bottom portion **110** is in the order of 15% of the size of the opening **106**. The bottom portion is connected to the curved portion of the container sides **108** and an inclined panel **112** extending from an opposite portion of the top portion **104** disposed at an angle **114** in the order of 50° with respect to the plane of the top portion **104**. The bottom portion **110**, the sides **108**, and the inclined panel **112** define a highly tapered cavity for receiving the liquid sample. The bottom edges of the sides **108** lie in a plane substantially parallel to the plane including the top portion **104** and thereby provide a stable surface for setting the container **18** when filling. A void **113** is included merely to save material in the manufacture of the container **18**.

When the container **18** is placed in the turntable **10** and subsequently rotated into the sampling site **32**, the inclined panel **112** is located in a plane substantially normal to the plane of movement of the probe **34**. The inclination of the panel **112** provides sufficient clearance for the probe **34** to reach the bottom portion **110** of the container **18** as shown in FIGURE 3. The highly tapered cavity of the container **18** allows the probe **34** to remove substantially all the liquid sample therein. By minimizing the area of the bottom portion **110** and correspondingly increasing the sample depth, the amount of sample waste is minimized in an inverse relation to the size of the bottom portion **110**.

The size of the opening **106** is sufficiently large to provide a large tolerance for the relative movement or positioning of the turntable **10** and for the movement of the probe **34** into the sample container. The bottom por-

tion **110** has an elongated shape with the larger dimension disposed in or along the direction of movement of the turntable **10** thereby providing a wide tolerance in the positional step by step movement of the turntable **10**.

The sample containers **18** may be inexpensively made of plastic by injection molding with a wide manufacturing tolerance range. If the sample container **18** is built with undesirable projected portions or other defects that prevent the seating of the top portion **104** on the turntable **10**, the probe **34** cooperates with the panel **112** to reach the bottom portion **110**. As previously mentioned, the arm **36** is gravity biased so that the pin **44** rides on the cam **46**. If the container **18** is not properly seated, the movement of the probe **34** engages the inclined panel **112** and slides down the panel (due to the movement of the slide **38**) until the probe **34** reaches the bottom portion **110** thereby providing for maximum withdrawal of the liquid sample.

I claim:

1. A liquid sample container for automatic sampling apparatus including a carrier formed with a plurality of openings in a plane, each of said openings being adpated to receive a sample container to move said containers in a step by step motion along a predetermined path and means for sequentially moving a probe in an arcuate path along a plane substantially normal to the plane of the carrier into and out of the containers for withdrawing the contents therein during the dwell period of said carrier, said plurality of openings are unsymmetrically formed with reference to said predetermined path, said container comprising:

a top portion formed with an opening therein for receiving said probe;

side portions connected to said top portion and shaped to conform with said openings and adapted to be mounted therein in a preset arrangement with respect to said arcuate path so that said top portion engages said plane of said carrier;

an elongated bottom portion substantially smaller than the size of said opening in said top portion, connected to said side portions, the greater dimension of said bottom portion being positioned substantially parallel to said predetermined path of movement, and is substantially larger than the largest dimension of a cross-section of said probe taken along a plane parallel to said carrier, and

an inclined panel connected to said top, bottom and side portions defining a highly tapered cavity for receiving liquid samples therein, said panel extends upwardly and outwardly from said bottom portion toward said arcuate path providing clearance for the movement of said probe for engagement with said bottom portion and provides for the withdrawal of substantially all of said liquid test sample therein.

2. A liquid test sample container as defined in claim **1** wherein the area of the bottom portion is in the order of 15% of the size of the opening in the top portion.

3. A liquid test sample container as defined in claim **2** wherein the panel is inclined at an angle in the order of fifty degrees with respect to the plane of said top portion.

4. A liquid test sample container as defined in claim **3** wherein said probe is gravity biased for movement into and out of said containers, and said incline plane acts as a guide for directing said probe to said bottom portion when a container is improperly seated in said unsymmetrical opening.

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