

[54] **SAMPLING SUPPLY DEVICE HAVING
MAGNETIC MIXING**

[72] Inventor: William Selesnick, Shaker Heights, Ohio
[73] Assignee: Micro-Metric Instrument Co., Valley
View, Ohio
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[58] Field of Search.....259/63, 65, 66, 67, 102, 103,
259/107, 108, 13, 58

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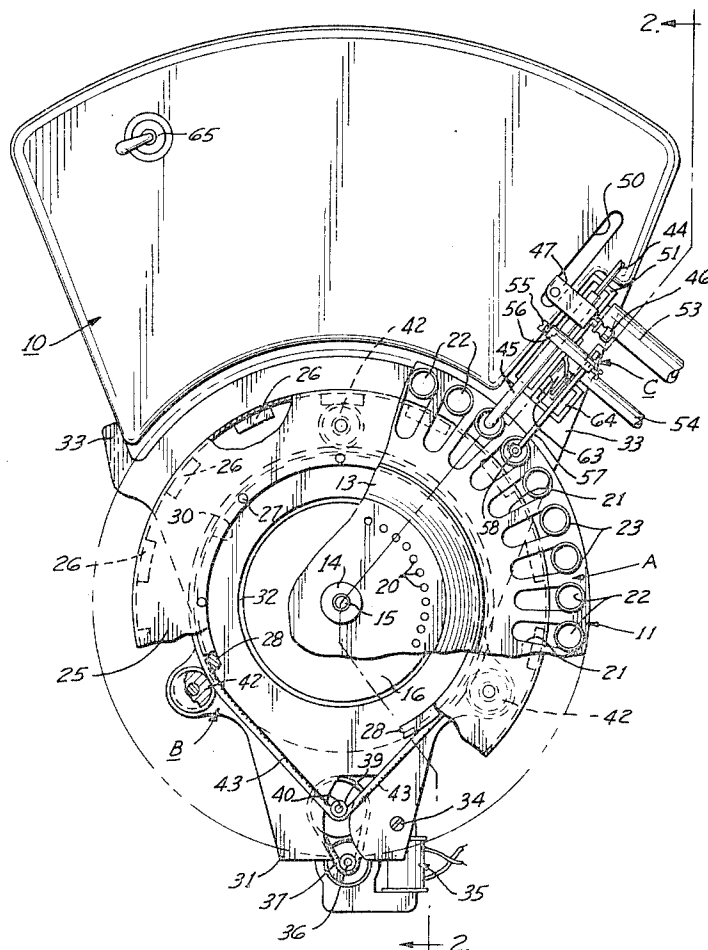
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Primary Examiner—Robert W. Jenkins
Attorney—Bosworth, Sessions, Herrstrom & Cain

[57] **ABSTRACT**

Process and apparatus adapted to supply sequentially a series of samples, normally liquid, at a sampling station for further processing such as by a conventional analyzer, wherein the samples are stirred or agitated magnetically to maintain them substantially in a homogenous condition. For this purpose, minute dipolar magnets are freely contained in the samples, and the supply device contains recovery means for recapturing the magnets after the samples have passed the sampling station. Dipolar master magnets are passed relatively to the freely-held magnets to induce their rotation. In a preferred form, a turntable carries the master magnets, and belt drive means jointly supports and rotates the turntable.

9 Claims, 22 Drawing Figures



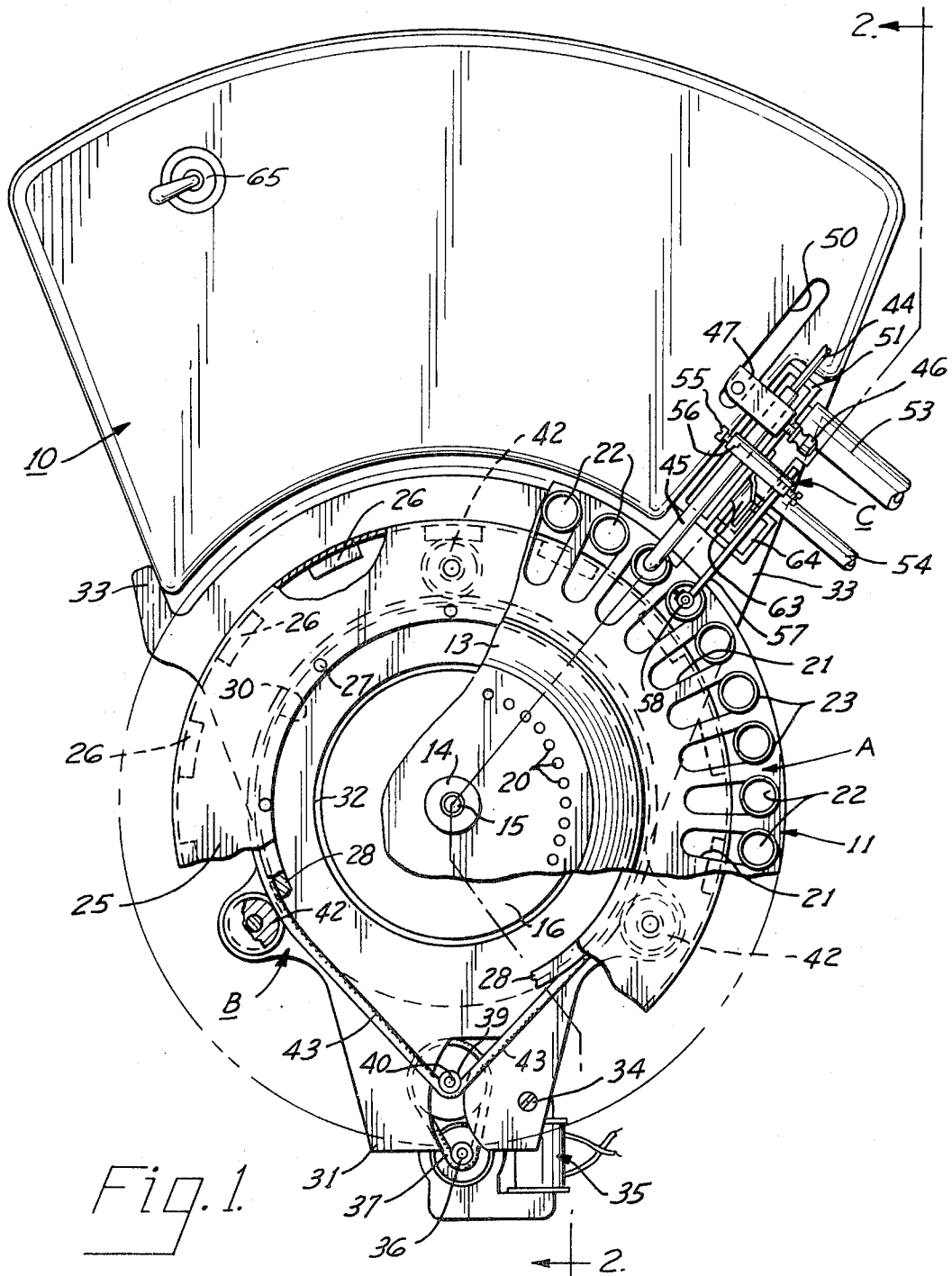
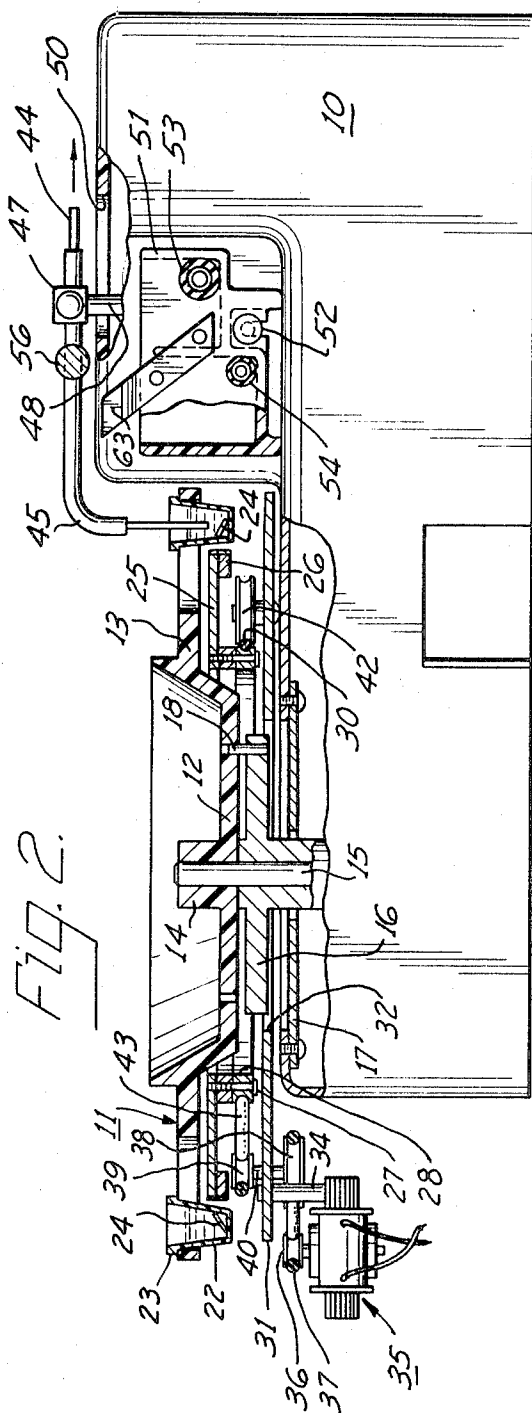
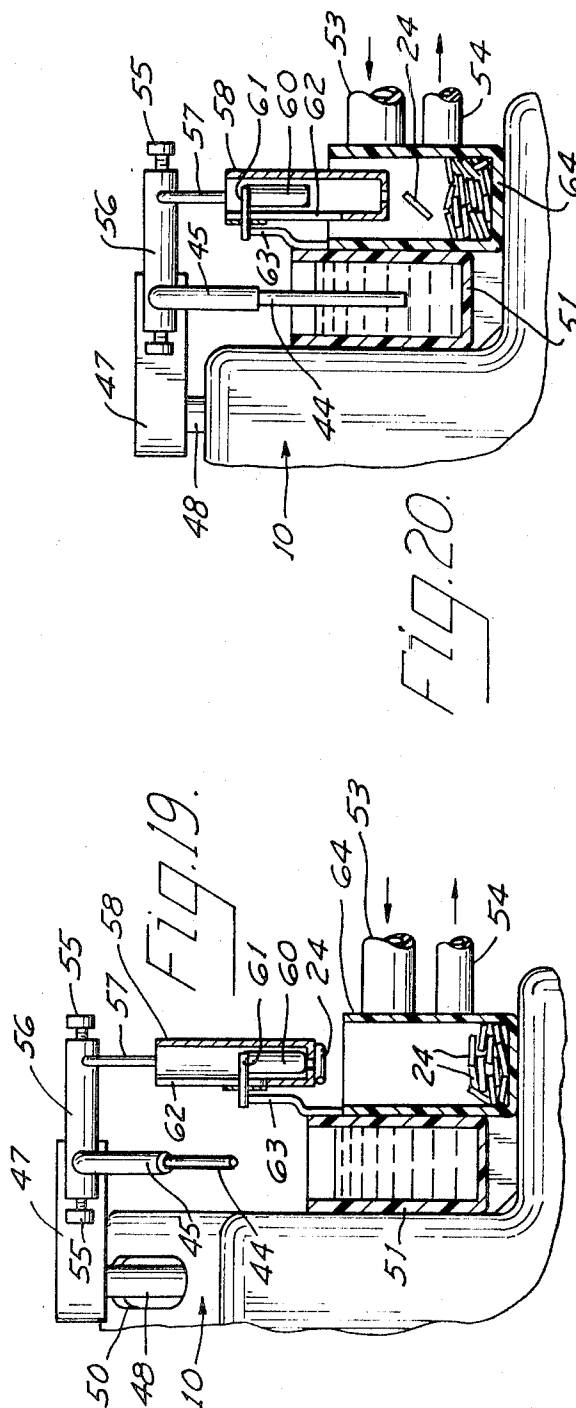
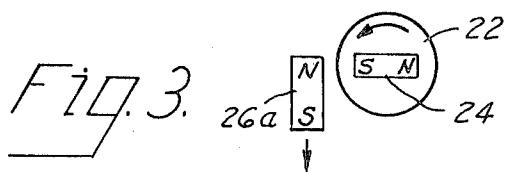
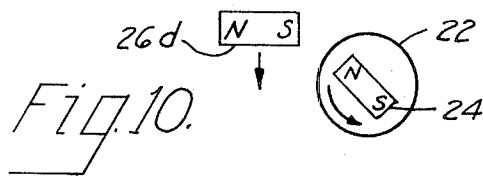
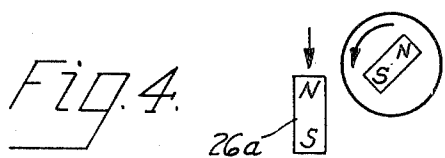
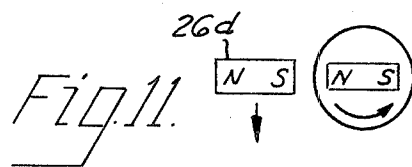
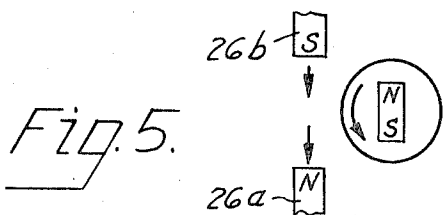
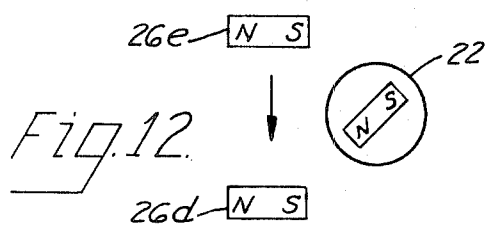
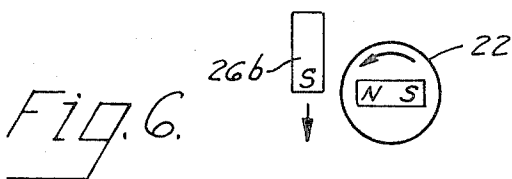
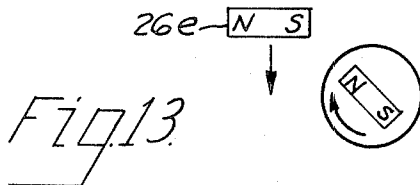
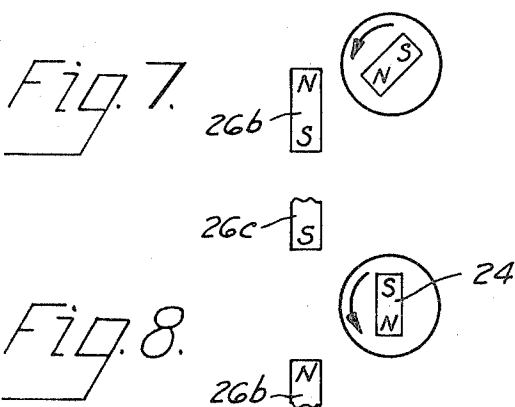
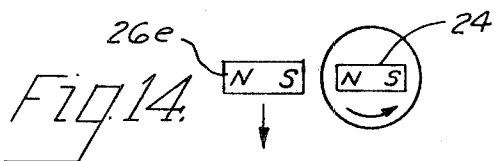
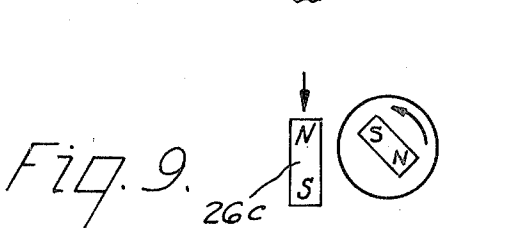
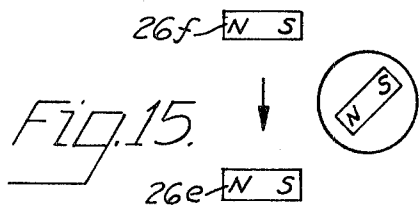
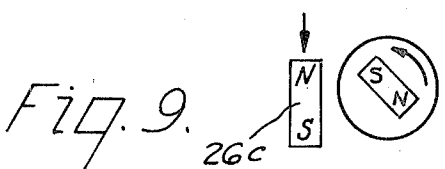


Fig. 1.

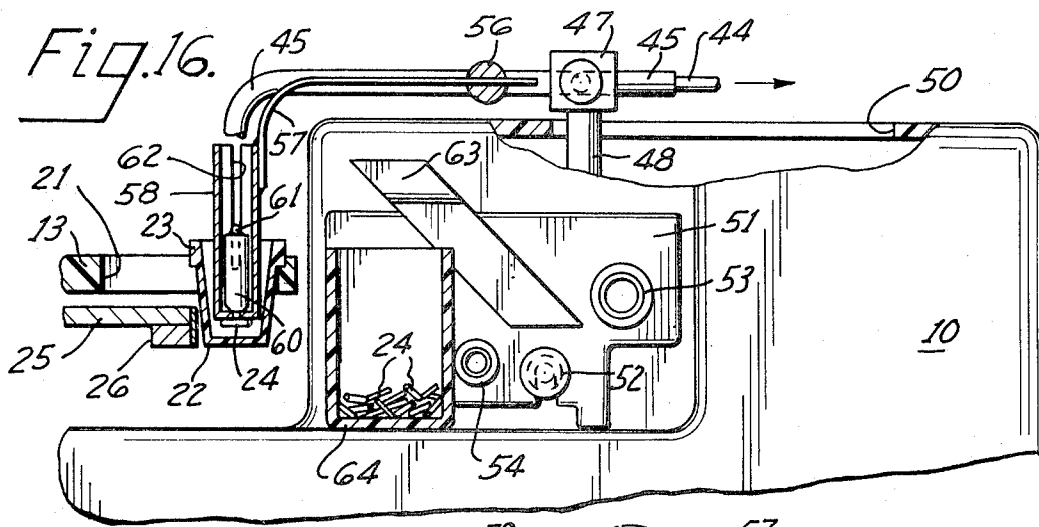
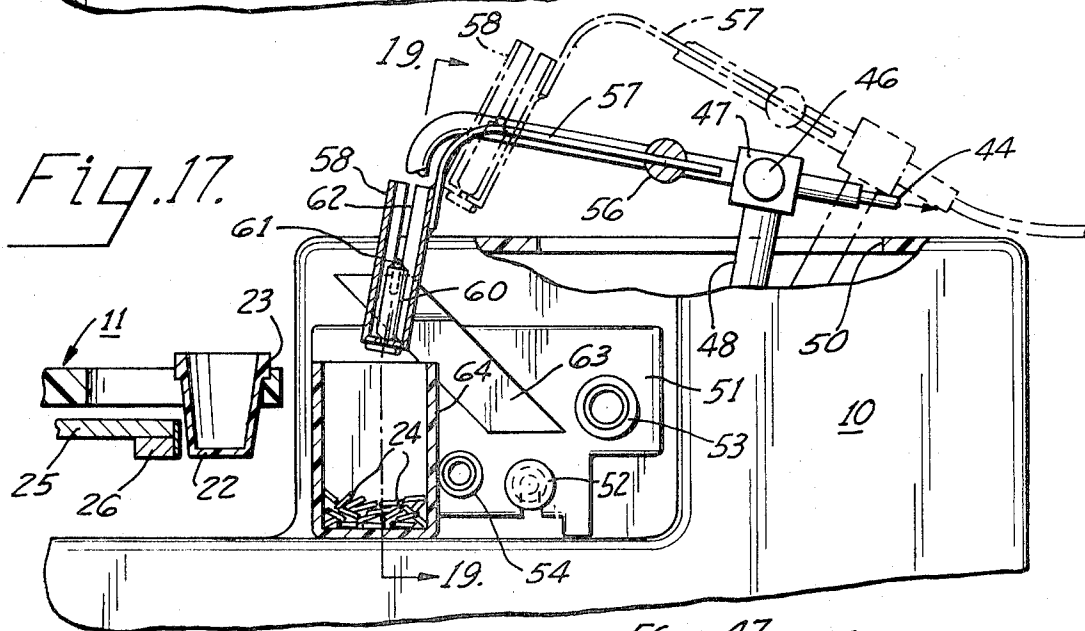
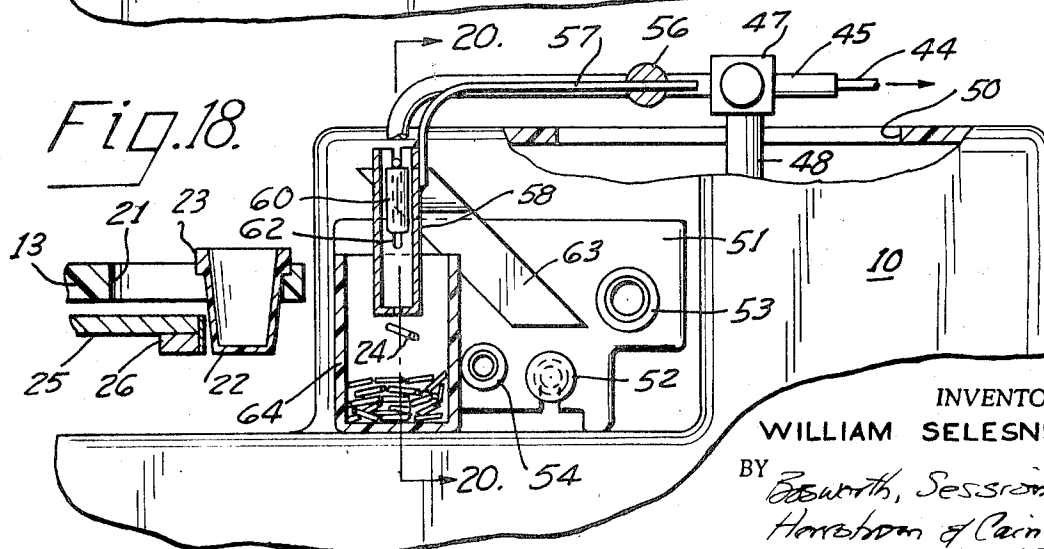
INVENTOR.
WILLIAM SELESNICK
BY *Bosworth, Sessions*
Hearshen & Cain
ATTORNEYS.



INVENTOR.
WILLIAM SELESNICK
BY *Beaumont, Seesons,*
Harshman & Cain
ATTORNEYS.



INVENTOR.
WILLIAM SELESNICK
BY *Bosworth, Selesnick,
Hornstrom & Cain*
ATTORNEYS.



INVENTOR.
WILLIAM SELESNICK
BY *Barth, Sessions*
Harriman & Cain
ATTORNEYS.

Fig. 21.

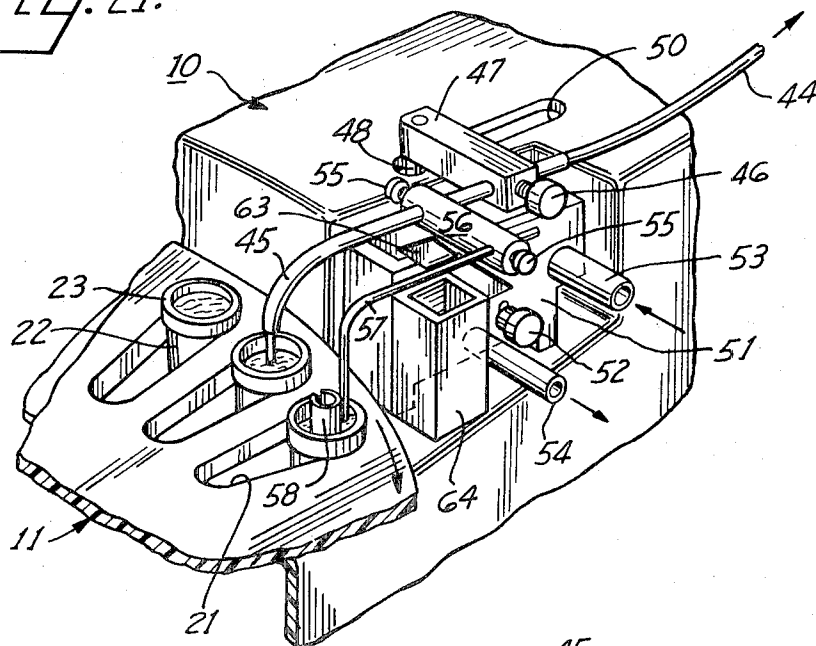
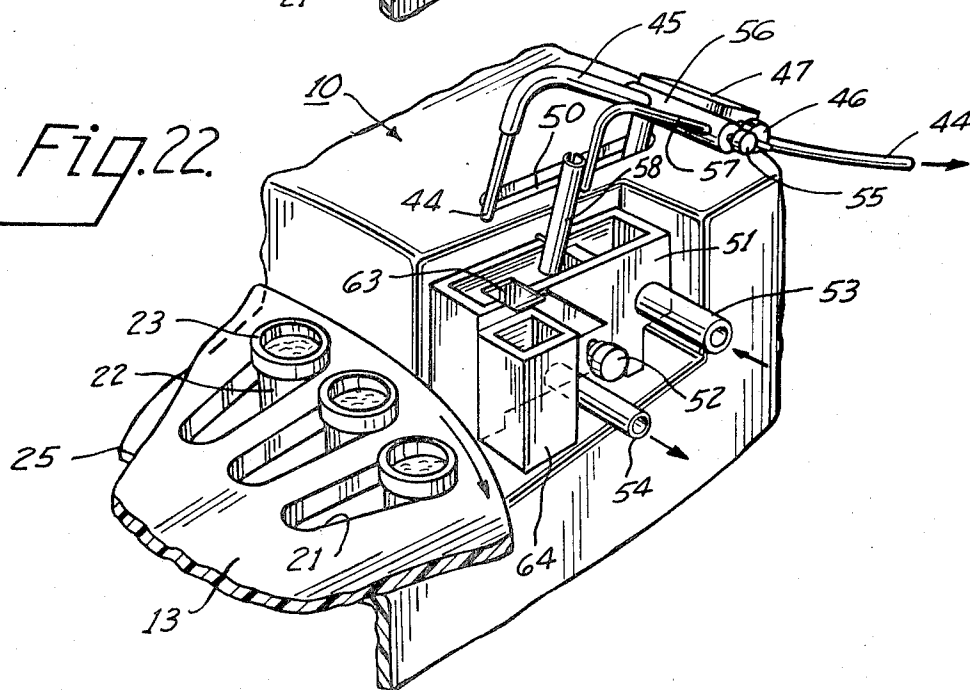


Fig. 22.



INVENTOR.
WILLIAM SELESNICK
 BY *Bozworth, Sessing, Henshaw & Cain*
 ATTORNEYS.

SAMPLING SUPPLY DEVICE HAVING MAGNETIC MIXING

BACKGROUND OF THE INVENTION

The present invention relates to a process and apparatus for presenting seriatim a series of samples at a sampling station for further processing, such as testing, analyzing, or the like, and more particularly to such process and apparatus wherein the samples are magnetically stirred to maintain them in a homogenous state so that representative portions may be withdrawn.

In many instances, such as in testing procedures, it is the practice to process a plurality of individual samples, usually of relatively small volume, by automatically advancing the samples in succession, as on an indexing table, to a sampling station. A portion from each individual samples is then aspirated or otherwise removed and further processed as may be desired. For example, as one instance, continuous determinations of the residue of an insecticide or pesticide in plant material may be made utilizing a cholinesterase bioassay procedure. Also such sequential sampling from a series of containers may be made to measure the photometric properties of samples.

One especially popular use of this general sampling technique occurs in hospitals, clinics and laboratories where samples of body fluids are analyzed for diagnostically significant factors, such as urea, sugar, etc. In particular, blood samples are often analyzed and tested by sequentially feeding portions of such samples to known analyzing apparatus. For instance, exemplary sampling supply apparatus of the type mentioned is disclosed in U.S. Pat. No. 3,038,340 to Israeli and U.S. Pat. No. 3,251,229 to Isreeli et al.

Regardless of the particular purpose for which the samples may be tested or analyzed, a common problem arises in that a representative portion must be drawn from each sample in order to obtain reliable, reproducible results. In the case of certain liquids which may contain matter that tends to settle, it is necessary or desirable to stir the liquid before or even while the liquid sample is being removed from cups or other containers at the sampling station. Particularly in the case of clinical analysis of blood hemoglobin, determinations are made on whole blood specimens which must be well mixed and in a homogenous condition when aspirated or otherwise withdrawn from the sample container for transmission to analysis apparatus. If left unattended, blood and blood serum samples can separate into plasma and red blood cells.

Various techniques have been suggested for stirring samples while still within their containers, so that the samples are in an homogenous condition at the time of their removal at the sampling station. For example, U.S. Pat. No. 3,107,536 to Ferrari discloses a stirrer comprising a metal spindle fitted within a polyethylene tube and rotated by a miniature electric motor. U.S. Pat. Nos. 3,107,537 and 3,230,766 both to Isreeli et al. teach the use of vibratory stirring means actuated by an electric solenoid and movable as a unit with the liquid-withdrawing device into and out of the containers of the samples at the sampling position. U.S. Pat. No. 3,252,327 to Ferrari discloses introducing air into liquid samples in containers during the sampling operation and also immediately before such operation to stir the liquids and prevent settling of particulate matter which may be suspended in the liquid.

All of these techniques are relatively cumbersome and unduly complicate the sampling apparatus. More significantly, in some cases the insertion of the same element, such as a stirrer, in all of the samples tends to introduce cross-contamination and leads to inaccurate test results. It would therefore advance the art if relatively simple stirring or agitating means could be effected which also acted individually and only for each container or sample so as to minimize the risk of contamination.

SUMMARY OF THE INVENTION

In accordance with the present invention, samples are maintained in essentially homogenous condition by stirring that is

induced magnetically. In one form, a rotary plate such as an indexing table, carries a series of containers of different samples in spaced relation along its periphery and advances the samples, seriatim, to a station equipped with sampling or takeoff means. Each container or cup freely holds a minute, subservient dipolar magnet. One or more master or controlling dipolar magnets are mounted to move relatively to the cups, such that the repeated attraction and repulsion between the respective poles of the two dipolar magnets, as they pass relatively to each other, causes the freely held magnets to turn within the containers and thereby stir or agitate the material contained therein. The turning or rotation of the freely held magnets is preferably unidirectional, although it can also be reciprocable.

The present process and apparatus also include recovery of the minute or subservient magnet from each cup after a sample has been withdrawn. Preferably, this is accomplished simultaneously with the drawing of a sample from an adjacent but succeeding cup, so that the samples are not contaminated by the magnet recovering means before a portion is taken. In a preferred form, the recovery means includes an additional magnet mounted to move substantially in unison with a sampling device or tube when it moves toward the rotary-plate-carrying sample cups and to the sampling position. Thus, at the same time a portion of one sample is withdrawn, the recovery magnet probes in a preceding, already tested sample and magnetically attracts and holds its subservient magnet. Further, when the recovery magnet returns with the sampling device to an original position away from the rotary plate, the minute or subservient magnet is automatically removed from the recovery magnet and collected with other like magnets for reuse.

The present invention further includes a novel drive arrangement for moving the master magnets relatively to the subservient magnets. In a preferred form, a turntable carrying the master magnets has an arcuate drive element. A plurality of pulley members are mounted for rotation essentially tangent to the arcuate path transcribed by translation of the drive element upon rotation of the turntable. A belt drive means is trained between and engages the pulley members and the arcuate drive element, so that, in motion, the belt drive means supports as well as rotates the turntable.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate a presently preferred embodiment wherein:

FIG. 1 is a plan view of one embodiment of the invention with parts broken away for purposes of illustration;

FIG. 2 is an offset section of FIG. 1 on the line 2-2;

FIGS. 3 through 9 are schematic, sequential views and illustrate diagrammatically one type of interreaction between master and subservient magnets to induce unidirectional rotation of the latter;

FIGS. 10 through 15 are schematic, sequential views and illustrate diagrammatically another type of interreaction between master and subservient magnets to induce reciprocal rotation of the latter;

FIGS. 16 through 18 are sequential, fragmentary side elevations of means for recovering a subservient magnet from a cup or container and show the joint action of the recovery means with a sampling device;

FIGS. 19 and 20 are sections on the lines 19-19 and 20-20 of FIGS. 17 and 18, respectively; and

FIGS. 21 and 22 are enlarged perspective views of the recapturing and sampling means of FIGS. 16 through 18.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A presently preferred embodiment comprises as principal components a rotary plate with sample cups and attendant parts, generally indicated at A (FIG. 1); a mounting and drive arrangement for master magnets generally represented at B; and magnet-recovering means shown in conjunction with a

sampling device and generally represented at C. The structure of these components and their manner of joint operation are as follows:

STRUCTURE

Referring initially to FIGS. 1 and 2, a sample supply device comprises a housing 10 of substantially triangular configuration in plan, a sample-containing plate 11 being mounted for rotation at the narrower end of the housing, and sampling and magnetic-recovery means, together with their attendant operating parts, being carried within the larger end. More particularly, plate 11 has a central dish-shaped portion 12 and an outer radial flange 13. The plate 11 is preferably made from nonmagnetic materials such as synthetic plastics like polymethacrylate resins or light metals like aluminum. The dish-shaped portion 12 has an upstanding boss 14 loosely fitted around a vertically disposed shaft 15 and seated upon a flanged collar 16 fixed to the shaft. The shaft 15 extends through an oversized opening in an underslung cover plate 17 riveted to the housing 10. The periphery of the flange of collar 16 has one or more holes to receive a fixed pin 18. The plate 11 has a series of holes 20 overlying and freely receiving the pin 18, so as to provide a driving connection with the shaft 15. Because of the loose fit between the boss 14 and shaft 15 and between openings 20 and pins 18, the rotary plate 11 can be easily removed from the shaft 15 or positioned thereover with a shaft-driving connection in any desired rotary position of the plate. The indexing means for periodically turning the shaft 15 through a desired angle and thereby presenting samples seriatim at a sampling device C does not form part of the present invention and is therefore not described in detail. Such indexing means are well known in the art. For example, the indexing means described in U.S. Pat. No. 3,230,776 to Isreeli et al. may be used.

The outer radial flange 13 of plate 11 has a plurality of slots 21 which gradually widen in an outward radial direction adjustably to receive cups or crucibles 22 having rims 23 which seat on the sides of the slots 21. In accordance with the present invention, each cup 22 has at least one minute, dipolar magnet 24 which acts subserviently to a controlling master magnet hereinafter described. The magnets 24 are rod-shaped and quite small, measuring about 0.25 inch in length for use in cups about 0.50 to 0.75 inch in diameter and preferably have a plastic coat, such as polytetrafluoroethylene, to minimize inadvertent adherence to a cup 22.

In order to induce magnetic rotation of the minute magnets 24, one or more controlling or master magnets are passed relatively to the former, the motion of the controlling magnets being independent of the motion of the rotary plate 11. In the embodiment illustrated, an annular turntable 25, disposed concentrically about the dish-shaped portion 12 of the rotary plate, carries a plurality of permanent dipolar master magnets 26 which are spaced circumferentially along the edge of the turntable 25 with their north-south poles alternately arranged. However, the master magnets can be otherwise arranged and still induce rotation of the subservient magnets. For example, as hereinafter described, like poles of the master magnets may be passed successively past the freely held magnets to induce reciprocable rotation of the latter. Bolts 27 secure a drive ring 28 concentrically to and beneath the turntable 25, the ring having an outer, circumferential groove 30 to receive a drive belt.

A mounting plate 31 of general triangular outline in plan, has a central opening 32 to avoid interference with shaft 15 and its flanged collar 16 and terminates in wings 33 which embrace a raised end of the housing 10 (FIG. 1) to center the plate 31 in position. If desired, the plate may be secured in place atop the housing, as shown in FIGS. 1 and 2, or even formed as an integral part of the housing. A fixed post 34 supports a motor 35 of standard construction. By means of a pulley 36 and drive belt 37, motor 35 drives pulleys 38 and 39 having a common shaft 40, pulley 38 being below and pulley

39 being above the mounting plate 31. Three additional pulleys 42 having grooved sheaves are mounted for rotation above the plate 31 in a position essentially tangent to an arcuate path described by the periphery of the drive ring 28 upon rotation of the turntable 25. A belt 43 of circular cross section is trained around drive pulley 39 and between the pulleys 42 and drive ring 28. It will be noted that the belt 43 is the only physical connection between the annular turntable 25 and the rest of the apparatus, such that the belt 43 both supports and rotates the turntable 25 and its drive ring 28.

The combined sampling and magnet-recovering station C serves to withdraw a portion of a sample from one cup while searching a previous, already sampled cup to retrieve its subservient magnet 24. Referring especially to FIGS. 16 through 22, the sampling device illustrated includes a plastic tube 44 slipped through a bent metal sleeve 45 and secured by a setscrew 46 within a transverse passage of a crook-mounting block 47. The tube illustrated is of the aspirating type, although the present invention does not reside in any particular takeoff means, and any of those known in the art may be used. In a like manner, the sample transmitted through tube 44 may be submitted to any testing procedure desired. U.S. Pat. Nos. 2,797,149 to Skeggs; 2,879,141 to Skeggs; and 3,081,158 to Winter describe various apparatus which may be used in treating and/or testing successively drawn samples.

A post 48 supports the crook-mounting block 47 and extends through a slotted opening 50 in the top of the housing 10. By conventional means, the post 48 is adapted to lift the tube 44 in a vertical plane, as illustrated by the solid and broken lines in FIG. 17, and to move the tube bodily to and from a sampling-withdrawal position with respect to a cup 22 on the rotary plate 11, as illustrated by the positions of FIGS. 16 and 18. Instead of moving substantially only in a vertical plane, the sampling device may have a horizontal component of motion as well. As indicated, the sampling device or what is generally referred to in the art as the "takeoff" means does not itself form part of the present invention and is not therefore described here in detail. The takeoff means may comprise any of those structures known in the art for this purpose. For example, other illustrated structures may be found in the following U.S. Pat. Nos. 3,038,349 to Isreeli; 3,127,773 to Blumenfeld; 3,134,263 to DeJong; 3,251,229 to Isreeli et al.; 3,252,329 to Heimann; and 3,282,651 to Ferrari et al.

In addition to necessarily removing the tube 44 to transpose it from cup to cup on the rotary plate 11, the described motion of the tube may also be for the purpose of dunking it in a washing receptacle 51 secured on the housing 10 by a setscrew 52. A wash liquid continually flows through the receptacle by means of inlet and outlet conduits 53 and 54, respectively, to cleanse the tip of the tube 44 and minimize crosscontamination of the samples.

After the contents of a cup 22 have been sampled, the minute dipolar magnet 24 is recaptured for further use. The structure for this purpose may be operated independently of the sampling device, but it generally is more convenient to operate the sampling and magnet-recovering means in unison and with the same or complementary motions.

For example, as shown in FIGS. 16 through 22, in one form, a cross arm 56 is secured by set screws 55 to both the sleeve 45 of the sampling tube and a rigid support wire 57. The wire supports a longitudinally slotted hollow column 58 having a partially closed bottom end. A permanent magnet 60 is freely carried within the column 58 and has a pin 61 extending through a longitudinal slot 62. The opening at the bottom of column 58 is not sufficiently large to lose the magnet 60 which is adapted by means of the pin 61 to move from an operative position at the bottom end of column to a retracted, inoperative position within the column. A striker arm 63 fixed to a side of the wash receptacle 51 engages the pin 61 of column 58 when the latter is positioned over a recovery box 64.

OPERATION

In operation, a power switch 65 (FIG. 1) energizes electrical components of the apparatus, including motor 35 and standard indexing means for the rotary plate 11, and other like electrically operated parts. The rotary plate moves only periodically and for a short angular distance, that is, approximately a circumferential distance from one cup 22 to another. On the other hand, motor 35 through the drive belt 43 continually rotates the turntable 25 through the drive ring 28. The net effect is that there is a relative side-by-side motion (note FIG. 2) between the master or controlling magnets 26 on the turntable and the minute, subservient magnets 24 in the cups. FIGS. 3 through 9 sequentially illustrate the preferred reaction obtained by passing a north and south pole successively by a subservient magnet 24, so that the latter comes alternately under the influence of poles of different polarity. This produces a continuous rotation of a magnet 24 in the same direction.

More particularly, as a trailing north pole, for example, of one master magnet 26a passes a subservient magnet 24, its south pole is attracted toward such north pole as illustrated by FIGS. 3 through 5. As the leading south pole of another master magnet 26b next passes the same subservient magnet, its north pole is similarly attracted toward that south pole of a master magnet as illustrated by FIGS. 6 and 7, thereby completing substantially a half-revolution of the rod-shaped subservient magnet. This action is continued as other master magnets pass in succession, such as magnet 26c as represented by FIGS. 8 and 9.

FIGS. 10 through 15 substantially illustrate another arrangement in which like poles of a series of dipolar master magnets are successively passed by a subservient magnet 24, so that the latter is always under the influence of poles of the same polarity. This produces a reciprocable rotation in a magnet 24.

For example, the dipolar master magnets may be placed transversely to the direction of movement with like poles arranged on the same side in the manner illustrated by FIGS. 10 through 15. The reverse position in which all north poles are on the right, as viewed in FIGS. 10 through 15, may also be used. As the south pole of one magnet 26d passes a subservient magnet 24, its north pole becomes magnetically "locked" to the master magnet and follows the movement of its south pole, thereby completing substantially a one-half revolution as illustrated by FIGS. 10 through 12. By the time controlling magnet 26d begins to lose its magnetic attraction for subservient magnet 26 because of increasing distance between them, another master magnet 26e becomes sufficiently close to magnet 24 to influence it. The magnet 24 then reverses its rotation in a direction back toward the entering magnet as shown by FIG. 13. This action is then repeated as still another magnet 26f becomes controlling so as ultimately to produce a back-and-forth, reciprocable rotation in the subservient magnet 24.

The speed of rotation of the subservient magnets is dependent in part upon the rate of relative motion between the two sets of magnets and upon the spacing of the master magnet poles and the cups 22. The spacing preferably is such that the subservient magnets contained within the sample cups turn continuously and at a relatively uniform rate of speed. Since each cup 22, for example, has a generally hemispherical lower end, a subservient magnet tends to ride with its ends in sliding engagement along a circular path with the hemispherical wall. Each subservient magnet is constrained in this manner generally to rotate about its longitudinal midpoint centrally of the lower end of the cup containing it. The continued rotation of the subservient magnets, whether unidirectional or reciprocable, imparts an effective stirring action to the material in the cups.

Meanwhile, as each cup is presented at the sampling station, post 48 moves the sampling tube 44 forwardly and into a cup 22 from which a sample is conventionally aspirated. At the

same time, column 58 moves forwardly because of its connection through crossarm 56 with the tube 44 and is immersed in an adjacent cup, specifically a preceding cup that has already been sampled, as illustrated best in FIGS. 16 and 21. The loosely held retrieving magnet 60 normally rests on the bottom of column 58 due to its weight and is free to attract and retain magnetically the subservient magnet 24 within a cup 22 through the open bottom end of the column.

When the tube 44 is retracted over the wash receptacle 51, column 58 naturally follows, as shown in FIG. 22. Similarly, when the tube is next pivoted downwardly and into the receptacle 51 to be cleansed, striker plate 63 engages pin 61 (FIG. 19), since the column 58 follows the same motion. Upon further downward movement of column 58, plate 63 forces pin 61 and the attached retrieving magnet 60 to a retracted, inoperative position within the column and thereby breaks the magnetic hold of magnet 60 on the recaptured subservient magnet 24 which drops into the recovery box 64 (FIG. 20). Thereafter, plate 11 moves one more cup position, and the sampling and recovery procedures as just described are repeated.

In place of the master magnets, other electrical components which produce and/or provide a succession of alternately north and south magnetic poles passing by the subservient magnets in sample cups may be employed to effect the stirring action. For example, a stator coil, such as one used in a conventional electrical induction motor, can be positioned along the path of the subservient magnets. The movement of positive and negative magnetic forces circumferentially of the coil causes the subservient magnets to stir material in the cups as previously described.

Those skilled in the art will appreciate that various other changes and modifications can be made in the preferred form described herein without departing from the spirit and scope of the invention.

I claim:

1. Stirring or agitating apparatus including a container adapted to hold material to be stirred or agitated, a first dipolar magnet freely held within said container for independent movement to provide a stirring action by such movement of the magnet itself, a plurality of second dipolar magnets supported seriatim and in fixed relationship to each other along a path, and means to move the container and said path of second dipolar magnets relatively to each other, so that the poles of said first dipolar magnet are magnetically coupled to the poles of successive ones of the second dipolar magnets along said path to induce said movement of the first dipolar magnet within the container.

2. The apparatus of claim 1 wherein said container is stationary, and said second dipolar magnets are so supported along said path to move the opposite poles thereof in tandem along said path successively to attract and repulse the poles of said first dipolar magnet and induce a rotary movement thereof.

3. The apparatus of claim 1 wherein said container is stationary, and said second dipolar magnets are so supported along said path to move like poles thereof in tandem along said path successively to attract the pole of said first dipolar magnet that is opposite to said like poles and induce a reciprocable movement thereof.

4. The apparatus of claim 1 wherein a plurality of said containers, each freely holding a first dipolar magnet, are arranged in essentially a circle, said plurality of said second dipolar magnets is carried on a periphery of a rotatable turntable mounted for rotation essentially concentric with and adjacent to said circle of containers, and said means to move the containers and second dipolar magnets relatively to each other rotates the turntable.

5. The apparatus of claim 1 wherein said first dipolar magnet is plastic-coated to minimize inadvertent adherence to said container.

6. A process for stirring material within a container comprising placing a first dipolar magnet in said container for free,

unimpeded movement therein, successively passing a plurality of second dipolar magnets relatively past the container, successively magnetically attracting the poles of said first dipolar magnet by the relative passing of the poles of said second dipolar magnets to induce movement of said first dipolar magnet within the container and thereby impart a stirring movement to said material.

7. The process of claim 6 wherein like poles of said plurality of second dipolar magnets are moved in tandem along said path successively to attract the pole of said first dipolar magnet that is opposite to said like poles and induce a reciprocable

movement thereof.

8. The process of claim 6 wherein alternately arranged north and south magnetic poles of said plurality of second dipolar magnets are moved along said path successively to attract and repulse the poles of said first dipolar magnet and induce a rotary movement thereof.

9. The process of claim 6 wherein a plurality of said containers is arranged along a predetermined path, each container having a first dipolar magnet, and said plurality of second dipolar magnets is moved along said path.

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