Jan. 6, 1970 O. SODERBLOM 3,487,862

LIQUID TRANSFER APPARATUS

Filed June 19, 1967 2 Sheets-Sheet 1

FIG. 1

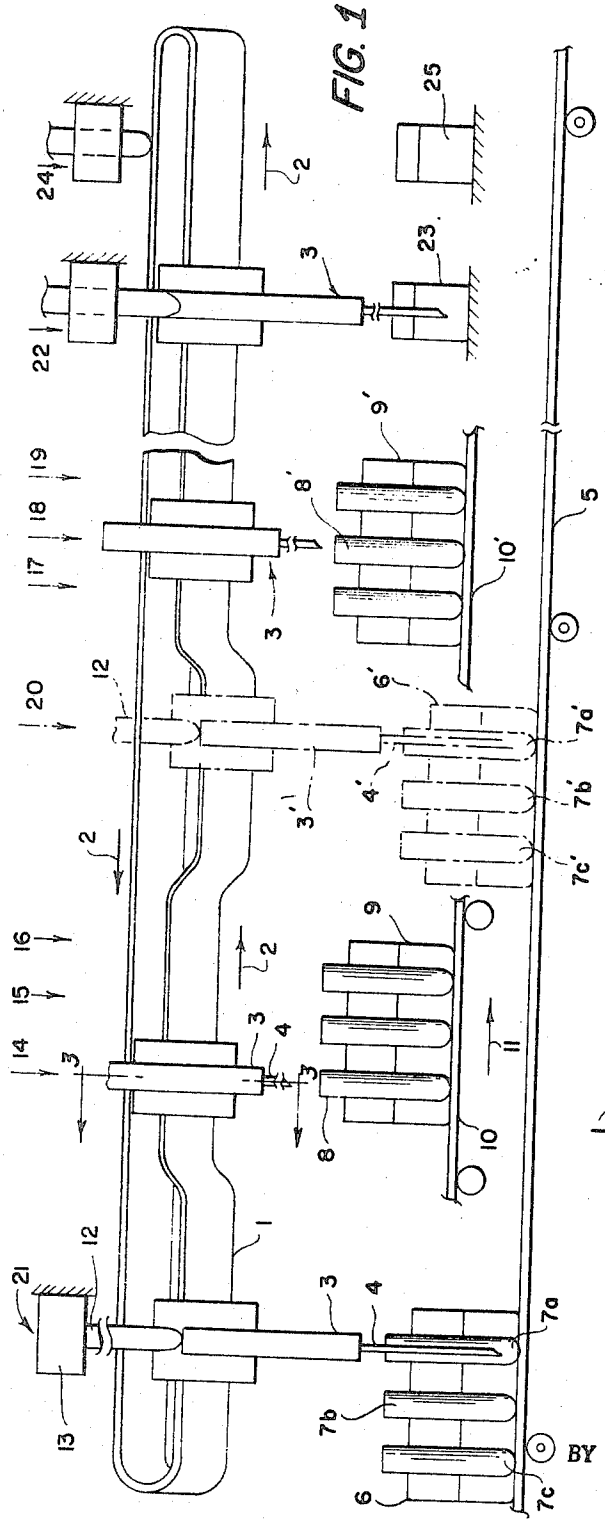
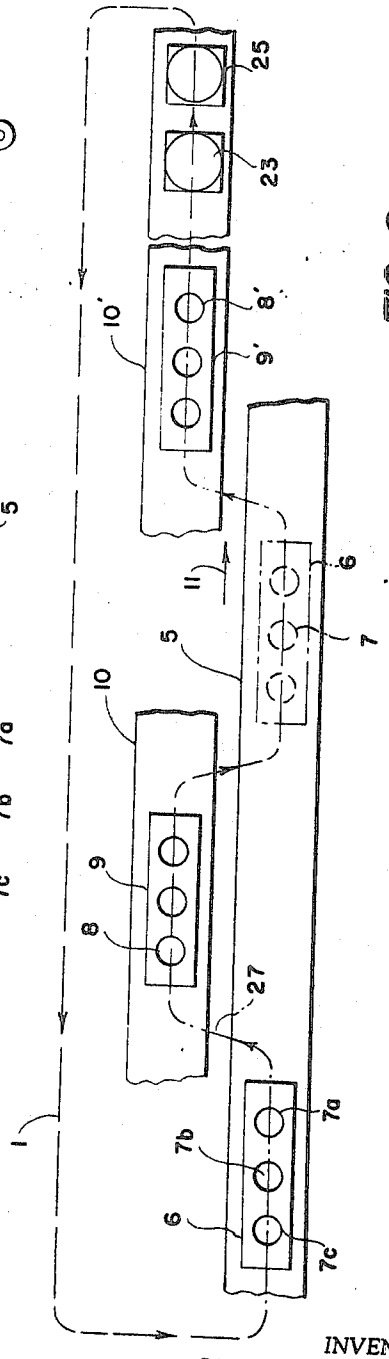


FIG. 2



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Filed June 19, 1967 2 Sheets-Sheet 2

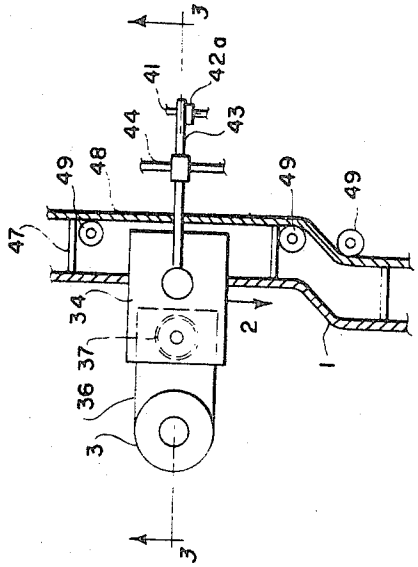

FIG. 4

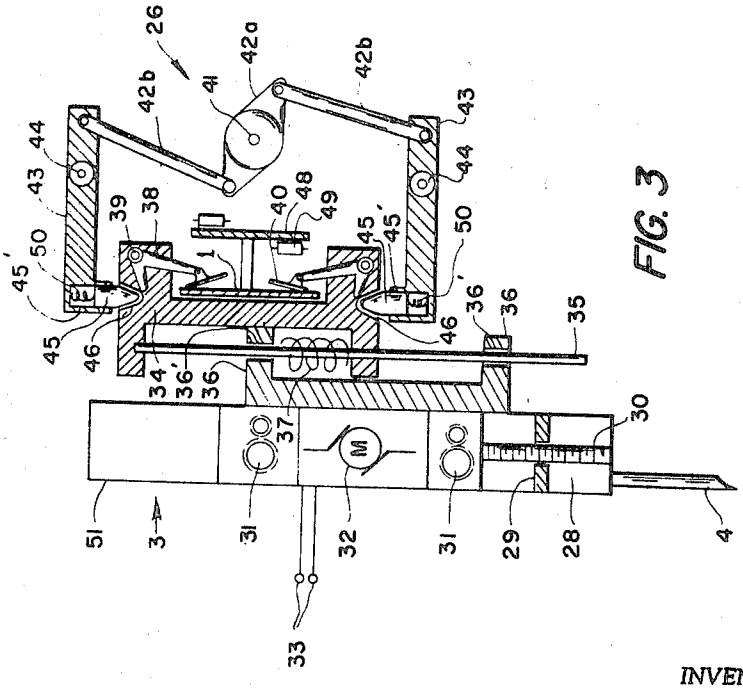

FIG. 3

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LIQUID TRANSFER APPARATUS

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U.S. Cl. 141—232 13 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for transferring a liquid sample from a primary container on a first conveyor to a plurality of secondary containers on a second conveyor. A transfer device follows a path over the primary container to receive the sample liquid, and then over the secondary containers to discharge measured amounts of the liquid into each secondary container. The transfer device includes a support member releasably attached to a constantly moving rail, and another member including a pump, the latter member being movable downwardly relative to the support member for liquid transfer between a container and the transfer device. An actuating device at each fluid transfer position releases the transfer device from the moving rail and holds it in place while liquid is being transferred.

Background—Field of the invention

This invention relates to apparatus for automatically transferring predetermined quantities of a liquid sample from a primary container to a plurality of secondary containers for enabling numerous analytical tests to be conducted on the sample liquid.

Background—Description of the prior art

In automatic analyzing machines, a liquid sample such as a blood sample is first placed in a primary container from which the liquid sample is transferred to a plurality of secondary containers, such as test tubes, in which the liquid sample is carried to the various test stations whereat the tests are conducted.

In this type of analyzing apparatus problems are encountered in the design and operation of a suitable transfer means for transfering the liquid from the primary containers to the plurality of secondary containers. A plurality of separate and distinct liquid samples, each in a different primary container, are continuously conveyed into the apparatus. The transfer means must continuously transfer liquid from each primary container to a plurality of secondary containers in small and accurately determined quantities and in a fairly rapid manner, while avoiding the possibility of contaminating any given liquid sample with traces of a foregoing liquid sample.

In the conventional automatic liquid analyzing apparatus the problem of conveying liquid from each of a large number of primary containers to a plurality of secondary containers has been solved in the following manner. A rack with a batch of primary containers, each with a separate liquid sample, is placed alongside a rack of secondary containers and liquid is transferred from each primary container to one secondary container. The rack with the primary containers is then moved longitudinally one step and a new rack with a second batch of empty secondary containers replaces the first batch of secondary containers alongside the primary containers. The same transfer means then transfers liquid from the batch of primary containers to this second batch of secondary containers. The rack with the batch of primary containers is then moved longitudinally one more step and a third batch of empty secondary containers replaces the second batch. This procedure is carried out until liquid has been transferred from each primary container to the prescribed number of secondary containers. The secondary containers are then arranged in a predetermined manner so that all of the secondary containers associated with any given primary container may be readily identified.

While the above transferring means accomplishes the object of transferring liquid from each of a plurality of primary containers to a plurality of secondary containers, the procedure is such that the step of cleaning the transfer means to avoid contamination of any container with traces from another sample is unduly complicated. The liquid transfer tubes of the transfer means must enter a different primary container before each pass over a rack of secondary containers. Consequently, each transfer tube of the transfer means must be cleaned after each pass over the rack of secondary containers. This constant cleaning procedure, while necessary, tends to complicate the operation of the automatic liquid analyzing machine.

Summary of the invention

It is a purpose of the present invention to provide a liquid transfer apparatus, suitable for use with an automatic liquid analyzing machine, for transferring liquids from each of a plurality of primary containers to a plurality of secondary containers, while at the same time vastly simplifying the procedure for cleaning the interior of the transfer means to avoid contamination of the liquid samples.

According to the present invention there is provided a liquid transfer apparatus designed so that the liquid transfer means may receive all of the liquid of a given sample required for testing purposes from a primary container and then discharge predetermined quantities of the liquid sample into a plurality of secondary containers before the liquid transfer means arrives at a different primary container to receive a different liquid sample. Therefore, cleaning of the transfer means may be performed only once during each complete cycle of the transfer means. This cleaning would occur, of course, after the liquid sample has been discharged and before the transfer means arrives at a new primary container.

According to one embodiment of the present invention there are provided a first conveyor for moving the primary containers, a second conveyor for moving the plurality of secondary containers and a transfer means movable along a path which passes over both the first and second conveyors whereby the transfer means withdraws liquid from a primary container on the first conveyor and delivers the same to a plurality of secondary containers on the second conveyor.

The transfer means may be mounted to move along an endless belt over the two conveyors; it may include a liquid pump and a pipette and a means for selectively lowering the pipette into and raising it out of the containers. The endless belt may move along the said path continuously and the transfer means may include a clutch for selectively coupling or releasing the transfer means with the movable belt. An actuating means may be provided at each liquid transfer position to release the clutch and hold the transfer means in the place during a liquid transfer operation. When the transfer means has completed its discharge of a liquid sample into a plurality of secondary containers it may then pass along the endless conveyor to a cleaning station where the pipette and the pump may be cleaned before the transfer means moves to a position to receive a new charge of a different liquid sample.

Thus, it is an object of this invention to provide a liquid

transfer apparatus which overcomes disadvantages of liquid transfer apparatus known heretofore.

It is another object of this invention to provide a liquid transfer apparatus for an automatic liquid analyzing machine which withdraws a liquid sample from one container after which it discharges predetermined quantities of the said sample to a plurality of secondary containers.

It is still another object of this invention to provide an apparatus of the character described in which the amount of liquid discharged to the secondary containers is automatically varied and controlled to within exceedingly accurate limits.

A further object of the invention is to provide a liquid transfer apparatus for use in automatic analyzing machines wherein the transferring means is cleaned after it has discharged sample liquid into the desired number of secondary containers and before it withdraws a new sample from a different primary container.

Another object of this invention is to provide a liquid transfer apparatus in which a number of transferring means operate simultaneously thereby allowing the distribution of a large number of liquid samples from primary containers to secondary containers at a high rate.

It is still another object of this invention to provide a liquid transfer apparatus wherein the time during which the transfer means stops at the various charging and discharging stations is individually and automatically variable for each station, whereby the number of such transferring means required to serve a given number of containers is greatly reduced.

It is still another object of this invention to provide a liquid transfer apparatus of the type described wherein the transferring means may draw samples from the same primary container at a plurality of charging stations and discharge sample liquid to secondary containers between these charging stations, whereby a large number of discharge stations can be incorporated in the apparatus without the requirement of a prohibitively large capacity of the transferring means.

Other objects and the attendant advantages of the present invention will become apparent from the detailed description to follow together with the accompanying drawings.

Brief summary of the drawings

There follows a detailed description of the present invention together with accompanying drawings. It is to be understood, however, that the detailed description and the accompanying drawings are intended merely to describe and illustrate a preferred embodiment of the invention, and that the invention is capable of numerous modifications and variations apparent to one skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims.

In the drawings:

FIGURE 1 is an overall schematic view of the liquid transferring apparatus of the present invention.

FIGURE 2 is a plan view of a portion of FIGURE 1.

FIGURE 3 is a sectional view of a liquid transferring means taken along line 3—3 of FIGURES 1 and 4.

FIGURE 4 is a plan view of a liquid transfer means shown in FIGURE 3.

Description of the preferred embodiment

Referring to FIGURE 1 there is shown a liquid transfer apparatus including a transporting means **1**, for example, an endless belt continuously movable in a direction indicated by arrow **2**. A plurality of liquid transfer means **3** are mounted on the transporting means and are adapted either to engage the endless belt to move therewith or to be released from the endless belt and held stationarily in place by suitable holding means. Each transfer means **3** includes a pipette **4** extending downwardly therefrom and adapted to enter a liquid container located beneath the transfer means **3** for liquid transfer therewith.

Referring to FIGURES 1 and 2 it can be seen that a first conveyor **5** and a second conveyor **10** are movable along separate paths beneath the transporting means **1**, both being movable in the same direction as indicated by the arrow **11**. The first conveyor **5** supports a rack **6** having a plurality of primary liquid containers **7***a*, **7***b* and **7***c* mounted thereon. In the normal course of operation each of the containers **7** would contain a different sample liquid.

The second conveyor **10** supports a rack **9** having a plurality of secondary containers **8** mounted therein.

FIGURE 2 illustrates, schematically, the path **27** taken by a typical transfer means **3** as it passes over the rack **6** and then over the rack **9**. FIGURES 1 and 2 illustrate that the path **27**, after passing over the first conveyor **5** and the second conveyor **10** may return again to the first conveyor **5** and then again over another second conveyor **10'** before arriving at the cleaning stations **22** and **24**. The purpose of this arrangement will be described in detail below.

Any conventional power actuated means may be employed to move the belt **1** and the conveyors **5** and **10**. Actuating means to be described in more detail below are employed to selectively couple or release the transfer means **3** from the continuously moving belt.

FIGURE 1 shows a first charging station **21** mounted over the first conveyor **5**; discharging stations **14, 15** and **16** over conveyor **10** and spaced apart by intervals equal to the distance between the second containers **8** on the rack **9**; and optionally, if desired, a second charging station **20** located over the conveyor **5** and additional discharging stations **17, 18** and **19** positioned over conveyor **10'**; and finally, cleaning stations **22** and **24** through which the transfer means **3** passes before returning to the first charging station **21**. At stations **22** and **24** the cleaning liquid from containers **23** and **25** would be drawn into the pipette **4** and the pump of the transfer means **3** and the cleaning fluid would be discharged at additional stations, not shown.

At each of the stations **21, 20, 22** and **24** there is provided a push rod **12** selectively actuated by a push rod actuating means **13**. The rod **12** acts upon a portion of the transfer means **3** to lower the same so that the pipette **4** enters the container mounted therebelow.

FIGURES 3 and 4 illustrate, in detail, a typical transfer means **3** and an actuating means **26**. An actuating means similar to that shown in FIGURES 3 and 4 would be stationarily mounted at any point along path **27** where the movement of the transfer means **3** would have to be interrupted. Thus, an actuating means would be provided at liquid charging and discharging stations **14–22** and at each of the cleaning stations **22** and **24**.

The transfer means **3** includes two main portions, a slidable member **51** and a support member **34**. The slidable member **51** is vertically movable relative to support member **34**. Flange portions **36** include bores **36'** through which a guide rod **35** passes. The upper flange **36** is urged upwardly by a spring **37** which acts against the support member **34**. Thus, downward movement of the slidable member **51** is provided by downward movement of the push rod **12** while upward movement of the slidable member **51** is provided by the force of spring **37** when the push rod **12** is withdrawn upwardly by the drive means **13**.

As illustrated in FIGURE 3 the slidable member **51** includes a pump having a cylinder **28** in fluid communication with pipette **4** and controlled by a piston **29**. The piston **29** is slidable within the cylinder **28** and is threadedly mounted on a screw **30** whereby turning of the screw causes vertical movement of the piston **29**. The screw **30** is driven by gears **31** which are in turn driven by a reversible electric motor **32** controlled by current received at terminals **33**.

As indicated above the transfer means **3**, including the support member **34** and the slidable member **51**, is normally coupled to the continuously moving belt **1** for movement therewith. This engagement between the sup-

port means 34 and the belt 1 is provided by clutch pads 40 which are normally urged into frictional engagement with the moving belt 1 by a spring force or the like acting upon two armed levers 38 which are pivotable about axes 39 passing through the support member 34.

At each of the stations 14–22 and 24 there is provided an actuating means 26 including a first link 42*a* fixed to a rotatable shaft 41 and pivotally connected, at its outer ends, to parallel links 42*b*. The latter are in turn pivotally connected to horizontal lever members 43 which are mounted for pivotal movement about axes 44. Cam members 45 are located in recesses 45′ located at the ends of levers 43 and are urged outwardly by springs 50 to an extent limited by a retaining edge formed by the outer end of recesses 45′.

Each support member 34 includes two recesses 46 into which the cam members 45 are urged by spring members 50 when the transfer means 3 moves to the liquid transfer station of the actuating member (assuming that the shaft 41 is so turned that the levers 43 are in the position shown in FIGURE 3). The cam members 45 serve two purposes. First, the cam members act against the two armed levers 38 offsetting the normal spring force and thereby disengaging the clutch pads 40 from the moving belt 1 so that the support member 34 is no longer movable therewith. In addition, the cam members 45, by their engagement in recesses 46, firmly hold the support member 34 in place during a liquid transfer operation.

As illustrated in FIGURES 3 and 4 the moving belt 1 includes cross-members 47 and an inside belt 48 against which pulley members 49 are in driving engagement. Of course, some of these pulleys 49 will be idle pulleys intended merely to guide the direction of the movable belt 1 while others will serve to drive the movable belt.

The invention operates in the following manner. A rack 6 having a plurality of separate primary containers 7*a*, 7*b* and 7*c*, each with a different liquid sample, is moved by conveyor 5 so that container 7*a* is positioned beneath charging station 21. A second rack 9 having a plurality of secondary containers 8 mounted therein is moved by conveyor 10 so that its secondary containers are located beneath discharging stations 14, 15 and 16. Of course, additional secondary containers 8 and additional discharging stations can be provided at this point. A transfer means 3, driven by belt 1 in the direction of the arrow 2 to charging station 21 would then be held at station 21 by an actuating means 26. The driving means 13 would then be actuated to urge the push rod 12 downwardly so that pipette 4 would enter the first primary container 7*a*. Electrical current would then be supplied through terminals 33 to operate motor 32, gear 31, screw 30 and pump piston 29 to cause the pump to withdraw liquid from the container 7*a*. Drive means 13 would then allow the push rod 12 to move upwardly thereby allowing slidable member 51 to move upwardly relative to support member 34 under the action of spring 37. Once the slidable member 51 has been raised to its normal position, the shaft 41 could be turned counterclockwise (as viewed in FIGURE 3) thereby separating the cam member 45 from the recesses 46, permitting the clutch pads 40 to engage the movable belt 41.

The charged transfer means 3 will then be stopped at stations 14, 15 and 16 by separate actuating means located at each of those stations. At each station predetermined, accurately measured quantities of liquid in the cylinder 28 will be discharged into each of the secondary containers 8. However, since the secondary containers may contain different reagents which could contaminate the pipettes, the transfer means 3 are not lowered into the secondary containers 8 during the liquid discharge operation.

The said transfer means 3 could then move to stations 22 and 24 for cleaning. At station 22 the empty transfer means 3 would be charged with a suitable cleaning fluid located in container 23 and at station 24 the cleaning liquid would be discharged into the receptacle 25 after which the said transfer means would be ready to return to the charging station 21 to receive a new charge of a different liquid sample. Alternatively, each of the containers 23 and 25 may contain liquid which is withdrawn at stations 22 and 24 and discharged at additional stations not shown.

Referring now to FIGURE 1, the path of the transfer means 3 may return to the conveyor 5 to receive more of the same liquid sample from the same container 7*a* from which it withdrew liquid at station 21. The transfer means 3 then returns to a second discharging station having positions 17, 18 and 19 to discharge liquid into fourth, fifth and sixth secondary containers 8. This position of the transfer means 3, the rack 6 and the primary containers 7 at this optional position 20 are shown in dotted lines in FIGURE 1 as indicated by the numerals 3′, 6′ and 7′. Thus, by returning the transfer means to a new charging position 20 for a second charge it is possible to keep the size of the pipette and cylinder 28 small. Since the transfer means 3 is returning to and withdrawing liquid from the same primary container 7*a*, there is no need to clean the pipette 4 and cylinder 28 between stations 16 and 20.

After the transfer means 3 has withdrawn liquid from the first primary container 7*a*, and after the transfer means 3 has moved on to the positions 14, 15 and 16 to discharge that liquid into the secondary containers, the transfer means 3 is moved one step so that second primary container 7*b* moves beneath position 21. A new clean transfer means 3 is then moved into position 21 for receiving the new liquid sample from container 7*b*. This new clean transfer means 3, charged with fluid from primary container 7*b* then moves to discharging positions 14, 15 and 16 where a completely new rack 9 having a completely new set of secondary containers 8, has been brought into place beneath belt 1 at discharging stations 14, 15 and 16. Once the transfer means charged with liquid from container 7*b* has moved onward to the discharging positions, the conveyor 5 moves one more step so that the new, separate sample 7*c* moves beneath position 21 to supply a new third transfer means 3 with the liquid sample contained therein.

In a preferred embodiment of the invention the transporting means 1 is an endless belt. Thus, after a transfer means 3 is cleaned at stations 22 and 24 it simply returns around the back of the belt 1 to the charging station 21. In this manner the process can be continued indefinitely.

The power and control means for driving the various conveyors, the push rods, the pumps and the actuating means have not been shown in detail since these details are believed to be readily apparent to one skilled in the art. For example, the drive means 13 may comprise a simple motor and gear connected to push rod 12. Similarly, the shaft 41 may be connected through a gear to a suitable electric motor. These drive means could also be pneumatic, hydraulic, etc.

It is also within the scope of the invention that the movement of the various features be correlated with each other and operated automatically. For example, the relationship between the movement of the conveyors 5 and 10 is readily apparent. As the conveyor 5 moves one step the conveyor 10 would move a sufficient distance to place a new rack 9 beneath positions 14, 15 and 16. Similarly, the electric current or other power means supplied to drive means 13, pump 28 and actuating means 26 could very easily be controlled and operated in a predetermined sequence. It is also apparent that if the optional mode of operation is employed whereby the transfer means 3 returns to a position 20 over the conveyor 5, then movement of the rack 6 along conveyor 5 would have to be synchronized with movement of the transfer means 3, so that the same first container 7*a* would be located below position 20 when the transfer means 3 was lowered to pipette 4 for further charge of the same sample liquid.

Although the invention has been described and illustrated in considerable detail with respect to a preferred embodiment thereof, it should be apparent that the detailed description and the drawings are intended merely for pur-

poses of illustration and that numerous modifications would be apparent to one skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An apparatus for transferring liquid samples from a primary container to a plurality of secondary containers comprising: a first support means for supporting the primary container, a second support means for supporting the secondary containers, a transfer means for withdrawing liquid from said primary container and discharging predetermined quantities of the liquid into the plurality of secondary containers, a transporting means movable along a predetermined path at a substantially constant speed for transporting said transfer means along said path which passes by both the primary container on the first support means and the secondary containers on the second support means, a coupling means for releasably coupling said transfer means to said transporting means to move the transfer means along said path, and an actuating means for operating on the coupling means for selectively releasing the transfer means from the transporting means and for holding the transfer means at a given place so that liquid transfer between the transfer means and a container can be carried out with the transfer means stationary at said given place while the transporting means continues said movement along said path at said substantially constant speed.

2. An apparatus as claimed in claim 1 wherein said transfer means includes a variable displacement pump means for withdrawing and discharging liquids, and a pipette for placing the pump and a container in fluid communication with each other.

3. Apparatus as claimed in claim 2 wherein said transfer means includes a support member and a slidable member, the latter being slidable vertically relative to the support member, said support member being mounted on said transporting means.

4. An apparatus as claimed in claim 3 wherein said coupling means includes at least one clutch element on said support member, said clutch element movable at least between a first position coupling the support member to the transporting means and a second position to release the support member from the transporting means, and wherein said actuating means includes, at least one liquid transfer position, a linkage means for both moving the said clutch element to the second position and for holding the transfer means in place while the clutch element is in the said second position.

5. An apparatus as claimed in claim 4 wherein the said coupling means includes a lever means pivotally mounted on the support member and spring biased to said first position, said support member including a recess, and wherein said linkage means includes a cam member engageable in said recess when the support member arrives at the corresponding liquid transfer position, to move the said lever means to the said second position and to hold the support member in place.

6. Apparatus as claimed in claim 5 including a driving means, mounted above at least one liquid transfer position along the said path whereat liquid withdrawal is to take place, for lowering the said slidable member of the transfer means relative to the support member thereof thereby placing the said pump into communication with the liquid in a container through the said pipette.

7. An apparatus as claimed in claim 1 wherein said transporting means is movable at a substantially constant speed during both coupling and release of said coupling means.

8. An apparatus as claimed in claim 7 wherein the said transporting means is a continuously moving rail and follows a path over the first support means, then over the second support means, then back over the first support means and then back over the second support means, whereby the speed of the first support means and the speed of the transporting means are synchronized so that when the transporting means passes over the first support means the second time it is positioned relative to the said primary container on the first support means for withdrawing liquid therefrom.

9. An apparatus as claimed in claim 1 including at least one driving means, mounted above a liquid transfer position along the said path whereat liquid withdrawal is to take place, for lowering the transfer means into a container located at that liquid transfer position.

10. An apparatus as claimed in claim 9 wherein said transfer means includes a support member and a slidable member, the latter being slidable vertically relative to the support member, said support member being mounted on said transporting means, and wherein the said lowering movement of the transfer means is constituted by lowering the said slidable member relative to the said support member.

11. An apparatus as claimed in claim 10 wherein said coupling means includes at least one clutch element on said support member, said clutch element movable at least between a first position coupling the support member to the transporting means and a second position to release the support member from the transporting means, and wherein said actuating means includes, at least one liquid transfer position, a linkage means for both moving the said clutch element to the second position and for holding the transfer means in place while the clutch element is in the said second position.

12. An apparatus as claimed in claim 11 wherein the said coupling means includes a lever means pivotally mounted on the support member and spring biased to said first position, said support member including a recess, and wherein said linkage means includes a cam member engageable in said recess when the support member arrives at the corresponding liquid transfer position, to move the said lever means to the said second position and to hold the support member in place.

13. An apparatus as claimed in claim 1 wherein the transfer means includes means for varying the said predetermined quantity of liquid discharged into the secondary containers and including a pump means for discharging the said liquid.

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U.S. Cl. X.R.

23—259; 73—423; 141—130, 167, 284