An automatically operated transporter apparatus which advances racks containing double rows of test tubes under a vertically movable aspirating and dispensing tip and tilts the tubes successively to a reference position allowing the tip to descend and engage the inner side wall of the tubes to perform its function. The tip is operationally in communication with a double pump metering and dispensing apparatus which includes a linearly adjustable eccentric mechanism which drives the pump pistons with a motion of adjustable sinusoidal amplitude. The apparatus also includes a pump valve switching mechanism which automatically switches the valves and the ports on the pumps between suction and compression strokes. The pumps may be adjusted to either work in parallel or alternating strokes. An automatic tip wiping mechanism is provided to insure precision in the processing. The apparatus can be set for continuous operation or for individual test tube processing cycle operation. Empty racks can be advanced without engaging the tip and pump apparatus. A trouble relay system gives a warning in case of any malfunction and stops the apparatus in most cases.

49 Claims, 40 Drawing Figures
FIG. 31

FIG. 32

MANUAL SWITCH
AUTOMATIC SWITCH
ADVANCE
TIP DOWN
TIP UP
TRANSPORTER
TEETH
20 TEETH
STOP INTERVAL
VALVE
PUMP
25 TEETH

IDLE GEAR ROTATION (DEGREES)/TIME (sec)
AUTOMATIC TEST TUBE TRANSPORTER AND SAMPLE DISPENSER

DESCRIPTION OF THE INVENTION

This invention relates to an automatically operated transporter apparatus for sequentially performing aspirating and/or dispensing functions on a plurality of test tubes which may contain liquid samples. It may entail drawing off, through a conduit, a volumetrically metered, freely adjustable, quantity of liquid and discharging this metered quantity through another conduit.

A major problem in the past in analytical testing of large number of sample liquids, such as blood, has been the large amount of time consumed in individually processing each sample-containing tube. For instance, where a tube having a sample liquid therein has to have reagent added thereto in order for certain tests to be performed and analytical conclusions drawn there, there are the problems of adding exactly the right amount of reagent, handling the sample tube so as not to spill or splash any sample liquid and the placing of the sample tube in upright position in a rack. In addition, the time consumed by such individual handling results in a serious time delay in hospitals and private analytical laboratories in getting the analytical results back to the physicians or, in the case of non-medical testing, the party requesting the analysis.

These same problems occur in performing other types of laboratory analysis. While metering and dispensing apparatuses to perform this function are known, they are mainly used in test laboratories, e.g., biochemical and clinical laboratories, and are intended either to deliver a predetermined volume of liquid to be analyzed (i.e., operating as a metering apparatus), or to deliver successively several metered quantities, all of identical volume, of the same liquid (i.e., operating as a dispensing apparatus), or else to deliver simultaneously both a volumetrically predetermined metered quantity of a liquid having to be analyzed and a metered quantity, also volumetrically predetermined but not necessarily of the same volume as the liquid to be analyzed, of a diluting liquid or of a reagent (i.e., operating as a diluting apparatus). The use of these apparatuses is becoming more and more widespread as the demand for large volume testing increases. However, the known apparatuses are often of low accuracy, inasmuch as the volumetric quantities they meter lack accuracy and are not readily reproducible, particularly when these volumetric quantities are small.

This defect in the known devices is largely due to the fact that, in these known forms of apparatus, adjustment of the metered quantity is not "digitalized." I.e., adjustment is continuous and such adjustment is often affected by errors in the reading of scales, these being human errors attributable to distraction, inattention or tiredness on the part of the operators. Moreover, the known forms of metering apparatus operate in a rather brutal way. First, an abrupt suction action occurs, then an abrupt stoppage of the suction action and finally an abrupt discharge of the metered quantity of liquid that has been sucked in. This often results in cavitation or breaks in the columns of liquid (hydraulic hammering effects) or in the formation of drops, both being a source of material errors also occurring in manual handling of the samples. The only way known to reduce the extent of the errors with these known forms of metering and dispensing apparatus, is by having them handle relatively large quantities of liquid. This, of course, is a major drawback when it is required to carry out a large number of different tests on a liquid from one source since, in order to do this, a corresponding number of samples is usually required of the liquid and this means that quite a sizable starting quantity will be needed. The only way in which this need for a sizable starting quantity of the liquid can be avoided is to reduce the greatest possible extent the volume of each sample.

Therefore, it is desirable to minimize all possible causes for inaccuracy in metering. This is particularly important in haematology where it is often desired to carry out a large number of tests without having to draw off large quantities of blood from the patients.

One of the most relevant examples is in pediatric haematology. According to the present invention there is provided an apparatus which comprises a unit having a novel test tube rack arrangement whereby the tubes are in staggered position and are alternately tilted under the dispensing tip. A rack advancement mechanism moves the racks under the tip which is actuated by a slide arrangement to lower it into the tube. After aspirating or dispensing the tip is withdrawn, may be simultaneously wiped clean, and an ejector mechanism ejects the processed racks.

The apparatus also incorporates a suction and forcing piston pump able, during a suction stroke, to draw off a predetermined volume and a switching valve associated with said pump and able cyclically to pass from one condition in which it causes said pump to communicate with one conduit to a second condition in which it causes the pump to communicate with another conduit. The apparatus also includes a drive mechanism able to cause said valve to pass from one condition to the other and able cyclically to actuate said pump by imparting to the reciprocating movement of the piston a substantially sinusoidal action, said mechanism being constructed so that the suction strokes of the pump occur when the valve is in said one condition and that the forcing strokes of the pump occur when the valve is in said other condition and so that each suction and forcing stroke may be followed by an idling pause during which the valve passes from one condition to another. Also featured is an adjustment means for selectively adjusting the volume of said metered quantity by varying the length of the stroke of the pump piston and display means for displaying to the outside a number indicative of said volume.

Accordingly, it is an object of this invention to provide an apparatus for automatically processing a plurality of tubes containing, or which may contain, sample liquids.

It is a further object of the present invention to provide an apparatus for automatically processing liquid samples wherein the samples may be continuously processed, individually processed or just run through the apparatus without processing and to provide the electrical and mechanical systems to accomplish this.

It is a further object of this invention to provide an improved test tube rack for use in an automatic processor of liquid sample tubes.

It is a still further object of the present invention to provide an improved dispensing and aspirating tip advance and retraction mechanism and an improved wipping mechanism for said tip.
A further object of the present invention is to provide an improved tube rack advancement mechanism for use in automatic processing of the samples contained in the tubes and to provide an improved ejection mechanism for ejecting said racks upon completion of the processing operation.

A further object of the present invention is to overcome the above-mentioned drawbacks by providing a metering and dispensing apparatus which is able to meter with great accuracy very small volumes of liquid and which will lend itself, because of the reproducibility of the metered quantities it delivers, to the automatization of testing.

It is a further object of this invention to provide a metering and dispensing apparatus having two piston pumps with selectively variable strokes in order to meter and/or dispense any predetermined volume of liquid.

A further object of this invention is to provide a novel valve-switching mechanism for a metering and dispensing apparatus.

A further object of this invention is to provide various novel improved metering and dispensing pumps.

Still another object of this invention is to provide an improved variable-stroke motion for a metering and dispensing apparatus.

The apparatus provided by the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of one embodiment of the transporter showing the working surface the component modules and the power panel.

FIG. 2 is a side view of the transporter shown in FIG. 1.

FIG. 3 is a perspective view of a half rack.

FIG. 4 is a plan view of two half racks assembled, cut away at two different planes to show details.

FIG. 5 is a cross-sectional view of a rack showing test tubes and the tilting of one tube.

FIG. 6 is a cross-sectional view of a rack showing an adapter for smaller tubes.

FIG. 7 is a plan view of the rack push bar.

FIG. 8 is a partial view of the push bar tensioning arrangement.

FIG. 9 is a plan view of the tilting post.

FIG. 10 is a rear view of the post of FIG. 9.

FIG. 11 is a cross-sectional side view of the post of FIG. 9.

FIG. 12 is a plan view of the working surface with parts broken away to show the rack-ejection mechanism and the rack-advancement mechanism.

FIG. 13 is a cross-sectional view taken along line 13—13 of FIG. 12.

FIG. 14 is a sectional view taken along line 14—14 of FIG. 13.

FIG. 15 is a sectional view taken along line 15—15 of FIG. 12.

FIG. 16 is a side view of the tip-advance and wiper mechanism.

FIG. 17 is a front view of the mechanism of FIG. 16.

FIG. 18 is a plan view of the mechanism shown in FIG. 16.

FIG. 19 is a plan view of the cast containing the wiper-paper feed.

FIG. 20 is a perspective view of the pump valve switching lever.

FIG. 21 is a side view of a version of the pump of the invention showing the piston stroke length adjustment mechanism in section.

FIG. 22 is a plan view of the embodiment of FIG. 21.

FIG. 23 is an enlarged sectional view of the stroke adjustment mechanism shown in FIG. 21.

FIG. 24 is a perspective view of the stroke adjustment mechanism shown in FIG. 21.

FIG. 25 is an exploded view of the crank arm and slide block arrangement of the stroke adjustment mechanism.

FIG. 26 is an exploded view of the pump valve actuating mechanism. FIG. 27 is a side sectional view of the pump and valve switching mechanism of the embodiment of FIG. 21.

FIG. 28 is a front view of the pump and switching mechanism in FIG. 27.

FIG. 29 is a sectional view taken along 29—29 of FIG. 27.

FIG. 30 is a sectional view taken along line 30—30 of FIG. 27.

FIGS. 31—34 are diagrammatic views of the various modes of operation of the present invention.

FIG. 35 is a graph showing the operation of various components in relation to the degrees of rotation of the idle gears.

FIG. 36 is a front view of the idle gear showing the arcuate sectors during which the valve and pump functions.

FIG. 37 is a sectional view of the module containing a flask of reagent.

FIG. 38 is a cross sectional view of the low reagent switch.

FIG. 39 shows a portion of the circuitry of the apparatus, and

FIG. 40 shows the remainder of the circuitry of the apparatus.

CABINET AND WORKING SURFACE

Referring now to FIGS. 1 and 2 there is shown the basic device generally designated as 100. It consists of a base 101 on which is mounted a main table member 102 having a working surface 119 and a raised portion 103. Mounted on top of portion 103 is a module-receiving member 104. It consists of power module 114, metering and dispensing module 128, tip module 129, and auxiliary modules 130—132. A slanted portion 105 overhangs the modules and contains a power panel 106. Panel 106 contains counters 107 and 108 for indicating the length of stroke set on the pumps or, i.e., the volumetric capacity of the pumps for a given cylinder size. Also contained by power panel 106 are a group of interlocked switches 110—113 and pump sequence switch 109. Switch 110 is the start switch; 111 is the reset switch; 112 is the buzzer switch and 113 is the power switch.

A translucent display 115 is used to indicate trouble in the system and has six trouble lights behind it. Below display 115 on module 114 are three switches; automatic mode switch 116; manual mode switch 117 and advance mode switch 118. Module 128 contains a space for receiving the pumps 500. Module 129 houses the tip lowering and wiper mechanism 600. Modules 130—132 house flasks used in diluting liquid samples with reagents, such as flask 700.

Tip 618 extends down from module 129.
On surface 119 are mounted guide walls 120, 121 and 123. Guide walls 120 and 121 have slots or grooves therein in which push bar 255 rides. A slot 125 under the module 129 and accommodates the rack-advance mechanism 300. Adjacent slot 125 and spaced from wall 121 which terminates short of portion 103 is tilting post 124.

Portion 103 has a slot 126 therein to accommodate the flippers of an eject mechanism 750. Forming part of wall 123, but not connected therewith, is an eject microswitchoff housing 133. When a processed rack hits housing 133, the eject mechanism operates to move the flippers to eject the processed rack.

**TEST TUBE RACKS**

The liquids to be metered or dispensed or analyzed are placed in test tubes which, in turn, are placed in racks generally designated as 200.

Referring now to FIG. 3 there is shown a rack 200. It is understood that 200 is merely one half of a completed rack and that all halves are identical. They are clipped or held together in any suitable manner. The rack 200 consists of back wall 205, end wall 201, top member 202, intermediate member 203 and bottom member 204.

Top member 202 has a series of round holes 206 adapted to receive test tubes such as 207. Holes 206 have notches 207 therein and are tapered on that side as at 208 in FIG. 4.

The intermediate member 203 has a series of elliptical shaped holes 209 underlying holes 206 in top member 202. The test tubes 207 are within these holes 209 also and are supported by bottom member 204. The holes 209 are also tapered as at 210. The bottom member 204 has a series of slots 212 which are adapted to be engaged by teeth in the rack advancement mechanism 300. Spacers 211 and 213 support the various members.

The end wall 201 has a rectangular notch 215 which accommodates the tilting post 124 as the rack is advanced under the siphoning and dispensing tip.

Referring now to FIG. 5 there is shown a cross-section of the rack 200. The test tubes 207 are shown received in the racks and are normally bailed upright by a spring 222 held against the back wall 205. Spring 222 maintains resilient pressure on tube 207. As post 124 passes through slots 215 and encounters the walls of the test tubes, it pushes them and they tilt into the position shown in FIG. 5. Part of the wiper and tip mechanism 600 is shown in FIG. 5 and the device is so arranged that the tip 618 hits the inner wall of test tube 207 at point X. This is important since if the aspiration and dispensing do not take place along this inner side splashing occurs which is not desired due to loss of liquid, agitation and bubble formation.

When a smaller test tube is used it is desirable to have the tip hit the inner wall thereof at approximately the same point. In these cases an adapter block 220 is used (FIG. 6). The block is shaped similar to test tube 207 so that it will tilt in the same manner. The smaller tube is received in a bore 221 of smaller diameter than adapter 220. Adapter 220 also has a projection 224 which is adapted to fit into notch 207. This is to insure that the smaller test tube is in proper orientation for the tip 618 to be received therein.

It should be noted that the taper 208 of hole 206 and the elliptical shape and taper 210 of holes 209 accommodate the tilting of test tube 207.

In the embodiments of the rack shown in FIGS. 5 and 6 the member 204 has recessed areas 212 which act in the same manner as slots 212.

Referring now to FIGS. 9, 10 and 11, there is shown a tilting post 124. Post 124 is received by the area formed by slots 215 and has a head portion 141 having angled beveled edges 142 and beveled sides 143. A circular bore 144 extends through the head portion and has a pin 145 slidable therein.

Head 141 is located on top of support member 146 (FIG. 10). Member 146 has a central bore 148 in which is received a metal sleeve 149. Bore 148 is in communication with relieved areas 147 and 151 (FIG. 11) in head 141, area 147 accommodating pin 145 and a resilient metal rod 154 which is located so that it coincides with the axis of sleeve 149 and passes out through the bottom of support 146.

Area 151 accommodates a raised portion of sleeve 149 to which is soldered or secured in any suitable manner a wire 152 which passes down through bore 150 in member 146 and out of the member.

When post 124 engages a tube, the edge of the tube slides against angled edge 142 and is tilted. When it reaches sides 143 it has achieved the maximum degree of tilt. When the tube hits pin 145 it pushes the pin inward until it is flush with the side 143 and springs rod 154. When the end of pin 145 is flush, rod 154 makes contact with sleeve 149 to complete a circuit and trip a relay which starts the tip mechanism and the tip is lowered. Other circuitry raises the tip after a stroke of the pumps 500 and advances the rack until the post starts to tip one of the tubes on the other side of the rack. In this instance the other side 142 of head 141 engages the outer tube wall and pin is pushed in the opposite direction until the contact is made with the sleeve. The contact also breaks a circuit in the rack advance mechanism 300 and stops the advance of the rack.

Thus, it is seen that the rack advances and stops for each test tube and each tube or adaptor is tilted so that the tip will engage the inner wall of a test tube at exactly the same point, X, for any given adjustment of the tip holder.

**RACK TRANSFER MECHANISM**

Referring now to FIGS. 1, and 7, 8, there is shown the rack transfer mechanism. The assembled racks 200, consisting of two half racks, are placed between guide walls 120 and 121 in front of push bar 255. Push bar 255 is in the form of an elongated parallel pipe and has studs 256 and 257 projecting from each end thereof. Stud 257 is longer than stud 256 for a reason to be described. Both studs ride in elongated grooves 250 and 251 located in the inner sides of guide walls 120 and 121, respectively.

Guide wall 121 has another relieved area 252 therein which houses a pulley wheel 253 secured to wall 121 by a pin 254. A wire 258 is wound around wheel 253 and passes through hole 259 to and is secured to stud 257 in any suitable manner.

Wire 258 may be wound on wheel 254 which is spring loaded. Any arrangement to provide a tension and pulling force on rack 200 is satisfactory.

The front surface of bar 255 has accurate cut out portions 260 in which are located bumper rollers 261,
mounted to bar 255 by pins 262. The rollers abut rack 200 and keep the racks and bar 255 from jamming as they are advanced through the apparatus. The rollers also aid the longitudinal advancement of the racks after they have been engaged by the rack transfer mechanism.

Several loaded racks complete with test tubes can be accommodated as well as just one rack. The bar keeps a biasing force on them and when one rack has been fully advanced by the mechanism 300, the bar 255 pushes another rack into place as the flipper mechanism 750 pushes the prior rack out between walls 121 and 123.

RACK ADVANCEMENT MECHANISM

Referring now to FIGS. 12, 13, 14, and 15, the rack advance mechanism is designated generally as 300.

The surface member 119 has a longitudinal slot 125 therein and mounted beneath the slot is a mechanism supporting platform 304. It is attached to and depends from member 119 by spacers 302 threaded into holes in member 119. Screws 303 secure platform 304 to spacer 302.

Mounted for rotation on platform 304 is shaft 309 in bearing 308 having flange 313. Shaft 309 has a cam member 315 thereon which has an indented portion 316 for activating a microswitch (not shown) in the timing circuitry. A bearing 314 supports the cam member 315 on shaft 309.

Shaft 309 terminates in a disc 310 having an eccentric pin 311 thereon to which is attached a crank arm 312.

Looking at FIG. 12, it is seen that platform 304 has a shorter slot 305 underlying and aligned with slot 125. Mounted beneath slot 305, and having a shorter slot 319 and a longer slot or guideway 319' aligned with slot 305, is guide member 317. Guide member 317 is held to the base of platform 304 by screw 318 and projection 306. Mounted for sliding movement in guideway 319' in member 317 is an elongated slide member 320.

Slide member 320 has a slot 322 therein underlying slots 319 and 305 and a threaded bore 323 adjacent the slot.

Member 317 has flanges 321' thereon which receive a retaining plate 321 for sliding movement. Plate 321 has a smooth-sided slot 321' therein. A screw 327 passes through a bearing member 325, through slot 321 and is engaged in threaded bore 323. A pivot arm 328 has a slot 329 which is eared by screw 327. Screw 327 is not fitted tightly so as to allow arm 328 to pivot around and slide relative to screw as arm 328 is swung on 339 extending therefrom to a socket thereabove secured underneath platform 304 (FIG. 12). As arm 328 pivots, screw 327 and slide 320 move slightly until screw 327 abuts the end of slot 321' in plate 321 thus causing it to move.

Plate 321 receives a threaded adjustment shaft 333 which is locked into a ratchet-supporting post 326. A locking nut 334 is used to lock shaft 333 and post 326 together at any desired elevation. Post 326 projects through slots 319 and 305 and into the area of slot 125.

As shown in FIG. 14, the post is slotted as at 321 and supports a balanced ratchet member 330. A pin 332 secures member 330 to post 326 for pivotal movement.

Ratchet member 330 has a solid portion 335 which is exactly counterbalanced by toothed portion 336. Toothed portion 336 has two teeth 337, 338 protruding upward therefrom. These teeth are adapted to engage the slots 212 or recessed areas 212' on the bottom of the racks and advance the racks.

Pivot arm 328 and crank arm 312 are joined in an adjustable manner as best illustrated in FIGS. 12 and 15. Arm 328 overlies arm 312 and is joined thereto by pin 341 passing through a smooth bore in pivot arm 328 and a slot 340 in crank arm 312. It has a flange 342 on one end thereof and a head 343 on the other end. Head 343 has a small diameter shaft 345 extending therefrom which is received in a smooth bore 347 in an adjustment block 344. A set screw 346 secures shaft 345 in the adjustment block. Adjusting the position of pin 341 in slot 340 determines the position of post 326 and teeth 337, 338.

The mechanism functions as follows: As shaft 309 rotates, eccentric pin 311 drives crank arm 312 which causes pivot arm 328 to pivot, the pivoting of arm 328 causing slide member 320 to begin a sliding movement until screw 327 hits the edge of slot 321' in retaining plate 321. When plate 321 begins its movement, post 326 and ratchet 330 move also. Because of this movement, portion 335 dips down and causes teeth 337, 338 to make firm engagement with the sides of rack slots 212. The ratchet advances the rack one cycle and then as disc 310 continues to rotate it disengages the teeth and moves backward. The back side of teeth 337, 338 are slanted so that the ratchet can ride over the slots.

TIP AND WIPER MECHANISM

Referring now to FIGS. 16, 17, 18 and 19 there is shown the tip and wiper mechanism generally designated as 600. It consists of a vertical mounting plate 601 secured to horizontal plate members 602 and 603. Spacer block 604 maintains members 602 and 603 in proper relationship. Additional spacers 605 support a motor support plate 606 on which is mounted motor 607. Motor 607 drives shaft 633 on which is mounted member 634 carrying camming discs 635 and 636 which are adapted to operate microswitches 637 and 638.

Disc member 639 raises a raised portion 640 which carries a first crank arm 641 which is pivotally pinned as at 642 to a second crank arm 643.

Crank arm 643 is pivotally connected by screw 644 to a slide block 645 which is mounted for sliding movement in slot 647 in member 602. Machine screws 646 secure the portions of block 645 together. An endless flexible cord 621 is clamped in block 645 and is engaged by pulleys 652, 653, 654 which are mounted on members 602 and 601 by pulley supports 655.

Member 601 has a slot 608 therein which accommodates a vertical slide 619 which is secured to tip holder 609. A shaft 620 and screw 620 secure cord 621 to slide 619 so that movement of block 645 causes tip holder 609 to move vertically in slot 608. Tip holder 609 has a central aperture (not shown) in which is received a tip enclosing member 610 which encompasses the tube 617 to which the tip is attached, and a wedging member 616 which locks the tube 617, the holder 609 and the enclosing member together. Thus, the position relative to holder 609 of the tip 618 may be adjusted.

Adjustably mounted on holder 609 is a wiper-actuating cam member 611. Cam 611 has camming surfaces 612, 613 which are adapted to act against L-shape pivot members 626 and 627. Cam 611 has a slot
614 therein and a screw 615 adjustably secured it to block 609.

Members 626 and 627 are pivoted by pins 628 and 629 to wiper pivot arms 624 and 625 which are centrally pivoted on pivots 622 and 623. At the ends of arms 624 and 625 are wiper elements 630 and 631, held on the arms by screws 632. Wiper elements can be formed of metal holders carrying a low density foamed plastic material such as polyurethane or polystyrene. When the block 645 moves, holder 609 carries tip 618 up or down, depending on the direction of movement of block 645. As the tip moves up, surfaces 612, 613 engage pivot members 626, 627 which cause the wiper elements to pivot inward to wipe the tip.

The portion of block 645 projecting beneath member 602 has a housing 648 projecting therefrom which contains a cam member 650 mounted for pivotal movement therein by pin 649. A spring 651 biases cam 650 into a normal position.

Mounted for rotation in member 603 is a shaft having serrated disk 656 mounted thereon for rotation above member 683 and serrated disc 657 mounted for rotation below member 663.

A ratchet member 659 is mounted for pivotal movement about pin 660 in member 663. It is biased against serrated disc 656 by spring 661. As the block moves to the left in FIG. 16, cam 650 engages disc 656 and rotates it a predetermined amount. Ratchet 659 merely rides on the serrated edge of the disc during this rotation. When block 645 moves in the opposite direction, ratchet 659 prevents disc 656 from counter-rotation when it is engaged by cam member 650.

Wiper case 665 is mounted underneath member 603 (FIG.16) and is held there by bracket member 662 and resilient clip 663 having a grasping knob 664.

Mounted under case 665 is a paper reel housing 666 which is held to case 665 by a projection 689 on case 665 receiving a flange 690 on housing 666 and by clip member 663 engaging a second flange member 688 on the housing.

Case 665 and housing 666 having aligned slanted slots 667 and 681, respectively. Housing 666 contains two reels 690 shown in FIG. 19. of paper 658. The rolls are spaced and fed up through slots 681, 667 into case 665.

As shown in FIG. 19, each strip of paper 658 is twisted 90° by two pairs of posts 668, 669. One strip is fed around posts 670, 671, 672 and 673, over fixed guide wheel 682, between guide plates 677, 678 and out of the casing through opening 679. The second strip is fed around posts 674, 675 and 676, around biased driven guide wheel 683 and out through opening 679. The dotted lines in FIG. 19 represent driven disc 656 with its serrated edge. Disc 656 is in engagement with wheel 683 also having serrated edges. A mounting member 665 holds a plunger 684 on which wheel 683 is mounted. Spring 668 biases wheel 683 into engagement with disc 656 and wheel 682. Both strips of paper are held between wheels 682 and 683 and when 693 is driven, the strips 658 are fed out and tension is put on rolls 680 which rotate within housing 666 to feed more paper. The friction between rolls 680 and the interior of the housing 666 prevents any backlash in the feed. A hole (FIG. 19) is located in the bottom of case 665 and allows tip 618 to pass therethrough on its down stroke. On the up stroke of tip 618, the wiper elements 630 and 631, which are located behind the two strips of wiping paper 658 converge and force the paper strips against tip 618 to thoroughly wipe it. The top of case 665 is open to accommodate the pivot arms and wiper elements. Due to the resilient nature of the pads carried by wiper elements 630, 631, the paper strips are conformed to the cylindrical shape of the tip 618.

The L-shaped pivot members 626, 627 prevent the wiper arms 624, 625 from wiping the tip on its down stroke. The paper is advanced during the beginning of the up stroke and the tip is wiped dry near the end of it. The time of wiping and the position of the tip can be adjusted to fit any particular situation.

A spring member 622a biases the tip member downward to remove any play in the mechanism during the up and down stroke of the tip. Hose 617 may be connected to either port of either pump 500.

IMPROVED METERING AND DISPENSING APPARATUS

The apparatus shown and generally designated as 900 (FIG. 21) is an improved version of the two piston, sinusoidal stroke metering and dispensing apparatus.

It consists generally of a base member 901 having support pads 902, 903. A rear support plate 904 extends upwardly therefrom and has a circular aperture 905 therein for accommodating a reduced diameter portion of the tubular housing 401 of a stroke adjusting mechanism 400. A support plate 800 extends upwardly from the base plate 901 and is parallel to a face plate 837 extending upwardly from the front of base plate 901. Lateral support members 937 nd 938 support the various members in conjunction with L-shaped brackets 938'. Support plate has a circular aperture therein corresponding to aperture 905 in plate 904 for receiving a reduced diameter portion of housing 401 of mechanism 400.

Members 919, 920 support a gear box 918. A support member 916 is attached thereto and supports a motor 915 which is connected to a gear box 918 by drive shaft 917. Gear box 919 contains reducing gears 921 which are connected to a pinion drive shaft 922. A coupling member 922 drives a pinion stud and pinion gear 806. Pinion gear 806 drives idler gears 807, 808 which are mounted for rotation on plate 800 by screws 929 and sleeves 928. Microswitches 923, 925 are mounted between plate 800 and the rear face of gears 807, 808. They can be activated by arcuate detents (not shown) in the rear face of gears 807, 808 acting in cooperation with spring-loaded contact members (not shown) to control the timing and operation of the device; in lieu of the contact members and detents, small insert magnets 936 may be inserted in the rear face of gears 807, 808 to activate the microswitches. Microswitches mounted on the front of face plate 837 is value switching mechanism 502 with pump members 500 depending therefrom.

At the rear of motor 915 is mounted a fan 935 having blades 936. Fan 935 is mounted to motor 915 by shaft 934. The fan 935 is operated only when motor 915 is on by the attraction of the electromagnet field of the motor attracting plate 933 pivoted to member 930. Plate 933 is maintained in position by spring 933'. A member 931 supports this mechanism. The contact of plate 933 with the motor 915 completes a circuit to set the fan running.

On the rear of plate 904 is an adjustment knob 909 and shaft 908 for setting the length of the piston stroke.
Knob 909 is mounted for rotation within a sleeve 907 which is adapted to rotate with the shaft 908. A wheel 910 is mounted for rotation with sleeve 907. Through an endless link drive 913, wheel 910, upon rotation of knob 909, moves drive 913, which, in turn, rotates wheel 912 connected to a counter 911 mounted on a support 906. A window 911* is located on top of counter 911 for viewing the number therein, which is usually from 0–100. The zero reading corresponds to zero stroke length and 100 corresponds to maximum stroke.

Of course, the counter 911 is illustrated as adjacent to the top of plate 904 only for purposes of illustration, it being understood that it may be located in the front of the metering and dispensing apparatus or in any location.

STROKE ADJUSTMENT MECHANISM

The device previously referred to is generally designated by 401 in FIG. 23. It is housed in a cylindrical casing 401 having annular internal grooves 402 at one end to receive snap rings 430. The opposite end has an annular internal groove 403 which is adapted to receive a snap ring 407. A tubular member 404 is mounted for rotary movement within casing 401 on bearing surfaces 405 and is prevented from sliding longitudinally within 405 by rings 407 and 407*.

There are two parallel juxtapositioned longitudinal slots or slideways 406 in the inner surface of member 404.

A solid cylindrical member 408 is mounted for longitudinal sliding movement within the casing. It is prevented from rotating relative to the casing by a screw 410 carrying a rider 411 threaded into a hole 409. Rider 411 cooperates with a slot 412.

A cylindrical bore 413 located in member 408 receives a hollow cylindrical insert 414, press fitted therein or screwed therein. The internal diameter of insert 414 is pinched as at 415. A flange 416 maintains the insert 414 against sliding movement within member 408. A jeweled ball 417 is received in the end portion of insert 414 and is maintained there by a spring 419 pushing against a member 418. A screw threaded stud 420 keeps the spring in compression within the insert member 414.

A coaxial bore 423 receives the end portion 422 of a threaded rod 421. Portion 422 is either press fitted into bore 423 or fastened therein for non-rotative movement. In internal threaded sleeve 424 engages a reduced diameter threaded portion 425 and a portion of the larger diameter section of 421. In the position shown in FIG. 23, the stroke would be adjusted to an intermediate length between zero and its maximum length. Sleeve 425 is mounted in a spherical portion 428 of a bearing having its outer race 429 between rings 430. The end of portion 425 has a slot 426 therein and a pin 427. Slot 426 and pin 427 are adapted to cooperate with sleeve 907 and shaft 908 which is inserted into slot 426 and retained therein by pin 427. By turning sleeve 424, rod 421 moves longitudinally in either direction, depending on the direction of rotation.

Ball 417 receives an extension member 432 of a crank-pin 431. The extension member 432 is offset from the axis of pin 431. Referring now to FIG. 23, crank-pin 431 is connected to a swivel member 432a having swivel studs or trunnions 433. Member 432a mounts in bearing member 434 in rectangular cut-out portion 435 and swivels therein on studs 433 which are received in holes 437. Member 434 has the general shape of a semi-circle but extends slightly over 180° for a reason to be explained. The outer circumference of member 434 has an arcuate raised portion 438 which is relieved as at 439 to accommodate the end of studs 433.

Member 434 is received within a slide member 440 which is generally rectangular with opposite parallel slide surfaces 443, 444. Member 440 has a generally semi-circular cut-out portion 441 which is slightly larger than a semi-circle or 180°. An annular groove 442 extends around the arcuate edge of the cut-out portion and is adapted to receive raised portion 439 of member 440. The reason that member 434 and cut-out portion 441 of member 440 are slightly larger than a 180° semi-circle is to allow member 434, usually made of steel or a like metal, to snap into member 440, usually made of bronze or like material.

The surfaces 443, 444 of member 440 are adapted to slide in longitudinal slots 406 of member 404.

Crank pin 431 is mounted for sliding movement within the central portion of a spherical bearing 445, the outer race 446 of which is grooved as at 447 to slidably fit between rods 448, 449. Rods 448 and 449 are fixed to cross pieces 450 and 451, respectively. Rod 448 extends through the cross pieces in order to hingedly accomodate arms 454 and 455 of member 456, shaped like a tuning fork. In FIG. 24, it is seen that member 456 has a lower depending portion 457 which has a rectangular aperture through which extends stroke bar 460. A set screw 458 in bore 457 of bar 460 maintains the relationship between bar 460 and member 456.

Bar 460 is mounted for rotative movement on pin 461 which is mounted in mounting block 462 in cut-out portion 463. Block 462 has a recessed area 464 which receives a machine screw 465. Screw 465 passes through a bore in the block and is threadably engaged in threaded bore 467 in the base of casing 401. An insert 466 spaces block 462 from the casing 401.

At the forward end of rod 460 is a small diameter bore 467 for receiving shaft 585 adapted to transmit the stroke to piston 500. A bore 468 receives set screw 588 for retaining shaft 585 in bore 466.

Mounted on the extending portion of member 404 is a gear 470. Gear 470 has teeth 472 and a circular slot which receives the end 471 of member 404. Gear 470 also has reduced diameter portions 473 and 474 which receive a cap member 475. Gear 470 and cap member 475 have the same diameter bores, 479 and 478, respectively. A set screw 480 secures cap member 475 to reduced diameter portion 474.

Crank pin 431 describes a cone in its rotation and is parallel to the axis of rotation of member 404 when at the top of its rotation position. To adjust the arc through which bar 460 moves sleeve 424 which is fixed in its longitudinal movement in either direction thus shortening or increasing the distance through which cross pieces 450 and 451 move. The arcuate movement of the end of bar 460 is sinusoidal due to the nature of the kinematic arrangement of the mechanism. The bar 460 is prevented from chattering or bouncing due to looseness or play by a constant force coil spring 483, shown in FIG. 24, one end of which is coiled about the bar as at 485 and the other end of which is bent, as at 484, and is received within a slot 482 in casing 401.
The device can be used to provide sinusoidal movement to any other device, such as a piston and cylinder. It is an improvement other straight reciprocal, linear movement which tends to start off quickly and diminish quickly. In the movement provided by the instant device, the maximum speed of movement occurs in the middle of the travel distance with acceleration and deceleration phases before and after this point of maximum speed.

And, more importantly, the length of travel, whether arcuate or linear can be linearly adjusted either before or during the movement of the device with a great degree of accuracy.

PUMP AND VALVE ARRANGEMENT

A preferred embodiment of the distributor pump is designated generally as 500. While two pumps are employed only one is described, it being understood that the pumps are identical except that the capacities may be varied. It consists of a cylindrical 501 connected to a valve actuating mechanism 502. Valve actuating mechanism 502 has mounting holes 503 for mounting the mechanism to switching assembly 800 to drive the valve arrangement. The lower surface of member 502 has a longitudinal slot 504 therein for a purpose to be described. Member 502 has a cut-out area or recess 505 for accommodating cylinder 501. As seen in FIG. 28, member 502 extends laterally away from cylinder 501, the purpose being to accommodate another cylinder. A bore 506 extends vertically from area 505 up into member 502. A lateral tapered bore intersects bore 506. A sleeve 508 and a washer 509 pivotally mount a valve actuating lever 510. Lever 510, referring now to FIG. 20, is an elongated member having a projection 511 for actuation by the pump valve actuating mechanism. Sleeve 508 passes through a figure eight type slot 513. The slot is made in this configuration so that the member 510 may pivot in either end of the slot about sleeve 508. The purpose of this arrangement is to allow an operator to pull on tab portion 512 of the member to slide the member forwards, thus disengaging projection 511 from assembly 800, hence where one pushes on tab 512, the pivot point of member 510 re-engages assembly 800 due to the change in pivot axis. Member 510 also has valve stud driving slots 514 and 515. A shaft 516 extends into bore 506 and has a relieved section 517 to accommodate a tapered locking pin 518. Locking pin 518 has a flattened tab portion 519 by which an operator may insert it into member 502.

The other end of shaft 516 terminates in a jewel bearing 520 which is held in a recess 522 of circular member 521. A flat plate member 523 having a central aperture therein for accommodating shaft 516 is secured to circular member 521 by a set screw 524 and is rigidly attached to the upper end of cylinder 501.

Member 521 is located in a circular aperture in rotary plug member 525 having valve driving studs 526, 527 located thereon. The top of cylinder 501 is open and studs 526, 527 engage in driving slots 514, 515, respectively, of member 510.

Member 521 is attached to valve member 532 and a spring bearing plate 531 by pin 533. When member 510 is driven reciprocally, the motion is translated to the valve member 532 to implement switching of the parts.

Member 501 does not rotate due to the action of slot 504 on pins 529, 530 which are rigidly attached in any suitable manner to the member 501. These pins limit the degree of entrance of member 501 in recess 505. A spring 528c biases member 521 upwards, and, through plate 521 is presses the lower face of valve member 532 against the upper face of stationary block 534, thus providing, by virtue of the rigid attachment of 521 to the upper rim of housing 501, a swivel connection on ball bearing 20 between member 502 and cylindrical member 501.

The valve arrangement is shown in FIGS. 27 and 29. The base of member 532 has a central aperture 539 connected with radially extending channels 540 and 541. The ends of these channels are adapted to alternately and respectively overlie port bores 542 and 543 (as shown in FIG. 30) in stationary block 534. Block 534 is fixed to a casing 535 by pins 537 in bores 536 extending through 535 and also into block 534 and has a central bore 538 in communication with aperture 539 in valve member 532. Port bores 543 and 542 are in communication with ports 544 and 545, respectively, which protrude out from casing 535 through a cut-away section 546 of member 501. Section 546, as seen in FIG. 28, has a notched cut-out portion 547 at the top thereof and has snap rings 536 holding pins 537 in place.

Thus it is seen that upon reciprocal rotation of member 532, (FIGS. 27 and 29), the bore 538 is alternately in communication with port 544 and port 545 (FIG. 30).

A circular coaxial recess 548 in the base of port block member 534 receives the end of a tubular glass cylinder 549. The opposite end of cylinder 549 is received in a like recess 551 in bleed block 550. Gaskets, such as 548, seal the ends of glass cylinder 549 into the recesses 548 and 551.

Bleed block member 550 is generally cylindrical in configuration and has a central bore therein receiving positive displacement piston 552 of constant diameter.

A manually operated bleed and priming knob 553 (FIG. 27) extends from the front of cylinder 501 through a cut-out portion 560 therein. Knob 553 has a circular bore therein which receives a priming port member 557. Port member 557 has a large diameter bore 554 tapering into a small diameter bore 555. Knob 553 and port 557 are fixed together for rotation by pin 556 and knob 553 has external threads 558 which engage a threaded circular insert member 559 in area 560 of member 550.

A channel and bore 563 extend down and out from the area enclosed by glass cylinder 549 and are in communication with the relieved area 560 in block member 550. A circular shaped sealing projection 562 keeps the end of port 557 away from the end surface of the relieved area 560, and breaks the communication between bores 555 and 563. A sealing ring 561 is located in an outer annular groove in port member 557 to prevent any leakage from occurring.

As knob 553 is rotated, the gap in the circular shaped projection rotates out of engagement with the end wall of the cut-out area 560 and bore 555 is in open communication with bore 563. The purpose of this arrangement is to allow a small volume piston and cylinder combination (the cylinder and pistons may vary in size) to be primed. Large volume piston and cylinder combi-
nations in some cases provide enough suction on the intake stroke so as to be essentially self-priming.

In the instances where the pump has to be primed, a hypodermic syringe (without the cannula) is inserted into the large diameter bore section 554 of the port 557 to provide suction within glass cylinder 549.

A washer 566 is positioned directly beneath member 550 and it and member 550 are held in place by an externally threaded insert member 567. The threads of insert member 567 engage internal threads 568 in the end of member 501 to hold the components of member 501 in place.

Insert 567 has internal threads 569 which are engaged by threads 571 of an adjustment member 570. Adjustment member 570, as shown in FIG. 27, has a central bore 573 through which passes piston 522. A reduced cylindrical portion 572 of adjustment member 570 abuts a washer 565 located at the base of a large bore 564 in the base of member 550. Between the washer and the end wall of the bore are V-shaped compression seals 566, their purpose being to prevent any leakage between the piston 552 and its bore in member 550. By turning adjustment member 570, provided with a roughened or serrated knob portion 574, compression is brought to bear on the seals 566. A guide sleeve 575 is located between adjustment member 570 and piston 552.

The end of piston 552 has a reduced diameter threaded portion 578 which is received within a threaded bore 577 in support member 576. Surrounding member 576 and attached thereto by screw 581 engaging internally threaded bore 582 is a resilient clip 579. The body of clip 579 is C-shaped and snaps onto support member 576 as shown in FIG. 7. An L-shaped resilient projection 580 extends downwardly from the clip body and cooperates with a relieved area 583 to maintain a jewel bearing 584 or any other suitable type of bearing. Bearing 584 is fixed on the end of a shaft 585 which, in turn, is received within a bore of crank arm 460. A set screw maintains shaft 585 in position. It is understood, of course, that any type of connection between piston 552 and reciprocating arm 460 may be used.

**VALVE SWITCHING MECHANISM**

Referring to FIG. 26 there is shown the driving arrangement for the eccentric stroke mechanism 400 and the valve switching mechanism. Mounted on support plate 800 are spacers 801, 802 aligned with mounting holes 803 to mount switching block mechanism 502 to face plate 837 which in turn is secured by bolts (not shown) and spacers 801, 802 to plate 800.

The bottom edge of plate 800 has two cut-outs as indicated by numeral 805 to allow the end of arm 460 to protrude threethrough. A pinion gear 806 is positioned approximately on the center line of the plate 800 and drives two idler gears 807 and 808. Gears 807 and 808 are identical and it is to be understood that the description of gear 807 applies equally as well to gear 808.

Gear 807 has teeth 808' therearound except in two relieved areas 809 and 810. Studs 811, 812 are mounted on the side of gear 807 for a purpose to be described. A raised reduced diameter member 813 forms a base for a cam 814 which are both mounted on a stud 815. Both member 813 and cam 814 may be either separate members or may be made an integral part of gear 807.

Mounted below and in engagement with the forward edge of gear 807 is drive gear 470. It is understood that an identical gear resides under idler gear 808 and that the description of gear 470 applies to said other drive gear. Drive gear 470, as previously described, has a cap member 475 attached thereto with protruding spokes 476, 477. Spokes 476, 477 are engaged by pins 811, 812 on gear 807 when gear 470 is out of engagement with teeth 808' of gear 807. I.e., the two relieved areas 809, 810 on gear 807 are to provide a pause between the intake and discharge strokes of the pistons. The purpose of spokes 476, 477 and pins 811, 812 is to start gear 470 moving before teeth 808' engage the teeth of gear 470 to insure a proper meshing of the teeth.

Adapted to be mounted over and ride on the surfaces of cam 814 and its counterpart on gear 808 is guide member 817. Generally, guide member 817 is a plate with two apertures 823 and 824. Aperture 824 has parallel internal edges 825, 826 and offset parallel edges 827, 828 and vertical end edge 829. Aperture 823 has an identical configuration. Both apertures cooperate with cam 814 and cam surface 816 to provide a vertically reciprocal movement to member 817 in a manner to be described. Member 817 has a depending portion 819 having a vertical notch 821 therein and two projecting studs 820, 820'. A second vertical notch 822 is provided in the upper edge of member 817 and is aligned with notch 821. A circular aperture 818 is located between apertures 823 and 824.

Mounted on member 817 for reciprocal pivotal movement are pivot plates 830 and 831, it being understood that the plates are symmetrically identical. Plate 830 has a projecting portion 832 with a hole 833 therein. The top of plate 830 has an arcuate edge 835 with a centrally located notch 836.

Hole 833 is adapted to receive stud 820 so that pivot plate 830 may be mounted to overlie aperture 824. Plate 830 has a central aperture 834 therein to accommodate the end of stud 814 which prevents it from pivoting 180° to a downward position. The shape of aperture 834 also limits the extent of reciprocal travel of plate 830.

To prevent member 817 from moving laterally, studs 834 and 844 are provided on the inner side of face plate 837. These mate with notches 821 and 822 which allow member 817 to move vertically in a reciprocal fashion.

Face plate 837 has mounting holes 838 which, when aligned with spacers 801, 802, and holes 803 in plate 800 accommodate bolts (not shown) which also pass through holes 803 in mechanism 502. Vertical slots 841, 842 are located in the base of face plate 837 and allow shafts 585, mounted in arms 460 to reciprocate therein.

Mechanism 502, previously described, mounts on the top front of face plate 837 and the projections 511 of pivot members 510 pass through horizontal slots 839 and 840 in plate 837 and reside in notches 836 in plates 830 and 831.

The operation of the valve switching mechanism is as follows. With valve member 532 in one position in cylinder 501, idle gears 807, 808 drive gears 470 to, e.g., move arm 460 downwardly, which retracts piston 552 for an intake stroke. Due to the shape of apertures 823, 824, no substantial vertical movement of member 817 occurs.
When the intake stroke is completed, gear 807 disengages gear 470 due to the position of one of the relieved areas 809, 810 and the stroke drive and adjustment mechanism 400 ceases to move arm 460. During the period in which gear 470 is not driven, however, the action of cams 814 on the edges of apertures 823, 824 drives the member 817 in a downward direction. Because plates 830, 831 are loosely pivoted about stud 815, the downward movement of member 817, through the stud 820 connection with hole 833 in pivot plate 830, the edge 835 of plate 830 moves arcuately laterally thus turning pivot member 510 due to the notch 836 engaging the projection 511. The pivoting of member 510 rotates the valve 532 so that another part is connected with bore 538 leading into the cylinder 549. The shape of apertures 823, 824 then provides for the cam 814 to rotate without any change in the position of member 817. At the same time, one of the spokes 476, 477 engages either pin 811 or 812 and start gear 470 to moving. Rotation of gear 470 then initiates the upward movement of arm 460 and the discharge stroke begins. The liquid, however, is discharged through a different part from which it entered.

If it is desired that the valve remain in one position, i.e., the intake and discharge occur through the same port, one simply pulls on tab 512 of either or both of the members 510 which disengages the projection 511 from being driven by notch 836.

**FLASK SUPPORTING MODULE**

Referring now to FIGS. 37 and 38, there is shown a module 130 for accommodating a supply flask support 700 used in various operations of the apparatus. The section shown in FIG. 37 is representative of the modules.

Generally, support 700 is a rectangular box with an opening 725 at the top thereof and fits inside module 130 in member 104. The bottom 702 of support 700 is provided with a depressed area 703 and has a raised punctured portion 704.

Secured to the top 705 of portion 103 is a fluid level sensing switch 722. Generally, it consists of a mounting plate 711 having mounting holes 712, 713 therein. A tubular member 714 depends from plate 711 and is secured thereto in any suitable manner. Member 714 is internally threaded as at 715 and receives a threaded adjustment member 716 having a knurled knob 717. Both plate 711 and member 716 have holes therein for receiving a projecting shaft 720. Shaft 720 has a rounded end and a collar 719. A spring 723 normally biases shaft 720 upwards.

Member 714 has a slot 716a therein for accommodating a contact member 721 which is adapted to make contact with a microswitch 722 mounted on the side of member 714.

Switch 722 can be adjusted by setting the amount of compression in spring 723 so that when the liquid in flask 724 is depleted sufficiently, thus making flask 724 lighter, contact member 721 breaks contact with microswitch 722 and the "low reagent" light will come on in the display 115.

The circuitry could also be set so that the apparatus will shut down when the reagent level attains a certain level.

The portion 103, the module 700 and the rest of the frame members are coated with Kydex, a plastic coating.

**OPERATION OF THE APPARATUS**

The circuitry for operating the apparatus is designated generally as 1000 in FIGS. 39 and 40. The device is adapted to be plugged into a 115 volt AC wall plug. It does not necessitate any special power source. The plug is shown in FIG. 39 as 1001. Line B is the ground. Line A has the main power switch 1003 and its accompanying fuse 1002. Between lines A and C are several motor circuits 1004, 1005, 1006, and 1007. Circuit 1004 contains the ejection motor 1008 which operates the flippers 750 (FIG. 12); circuit 1005 is the circuit for the tip actuating motor 1009, and 1006 is the rack advance motor circuit and 1007 is the pump motor circuit. Each circuit has conventional circuitry. Since the four circuits are substantially identical, only circuit 1004 is described.

Circuit 1004 has its motor running capacitance 1011, ejection motor relay open contacts 1012 and closed contacts 1013, resistor 1014, rectifier 1015 and and stopping capacitor 1016.

Motor circuits 1005, 1006 and 1007 are the same, each having a set of normally open and normally close contacts. The open contacts of 1005, 1006, and 1007 are designated 1132, 1133, and 1134 respectively.

A buzzer circuit 1017 is shown adjacent the pump motor circuit 1007. It consists of a buzzer relay 1018 connected to a parallel circuit containing momentary contact buzzer switch, open contacts 1020 of trouble relay 1047, normally closed contacts 1021 of start relay 1082, normally open contacts 1022 and normally closed contacts 1023 of buzzer relay 1018 and buzzer 1024.

The AC power lines are connected to transformer 1025 and bridge circuit 1026 to change the voltage to approximately 24 volts DC.

Shown adjacent bridge circuit 1026 are a series of lights 1028, 1030 and 1032. These lights illuminate translucent buttons of the advance mode switch 118, manual mode switch 117, and automatic mode switch 116 respectively. The lights are illuminated by closing of their normally open contacts 1027, 1029 and 1031, respectively, by the respective switches.

Trouble circuit 1033 is shown adjacent the above-described switch light circuitry. A tip alignment relay 1034 is connected to a normally open contact 1035 of a tip alignment switch and a silicon rectifier 1036. Adjacent the relay 1034 is a first trouble relay 1037 connected through normally open contacts 1038 of the reset switch 111 and its own contacts 1039. This parallel circuit also contains silicon rectifier 1040 and is connected across the main line by normally closed contacts 1041 of the advanced jam switch.

A circuit similar to that just described involves a second trouble relay 1042 connected through normally open contacts 1043 of reset switch 111 and its own contacts 1044. The normally closed contacts 1045 of tip alignment relay 1034 connect this relay across the power lines. A silicon rectifier 1046 completes the circuit.

A third trouble relay 1047 is connected across the main power lines in a circuit including silicon rectifiers 1048, 1049 and 1050. Also in the circuit are the normally open contacts 1051 and 1052 of the first and second trouble relays, respectively.
Referring now to FIG. 40 and matching the plus and minus signs of the circuitry shown in FIGS. 39 and 40, the remaining circuitry is illustrated.

A tip motor relay 1053 is connected via the open contacts 1054 of the tip limit switch (down position), which is normally held closed, and the open contacts 1055 of the start relay 1082 to the open contacts 1056 and 1057 of the automatic mode switch 116 and the manual mode switch 117 respectively. A silicon rectifier 1058 is connected across the tip motor relay 1053. Closed contacts 1059 of third trouble relay 1047 complete the circuit.

Shown adjacent relay 1053 is a pump motor control circuit 1060. It includes a pump motor relay 1061, silicon rectifiers 1062 and 1064, open contacts 1063 of the auxiliary start relay 1073 and dispensing apparatus 900 (FIG. 21), open contacts 1065 of the pump sequence switch 109 (momentary contact), the open contacts 1066 of the pump limit switch for the left position (momentary contact) the open contacts 1067, which are normally held closed, of the pump limit switch for the right position (momentary contact), closed contacts 1068 of the pump limit switch for the left position (momentary contact) and closed contacts 1069, which are normally held open, of pump limit switch for the right position (momentary contact).

Shown adjacent pump motor control circuit 1060 is start circuit 1070. It includes open 1071 of start switch 110 and closed contacts of manual mode switch 117. An auxiliary start relay circuit includes auxiliary start relay 1073, silicon rectifiers 1074 and 1076, capacitor 1081, resister 1080, closed contacts 1075, normally held open, of tip limit switch for the up position, the relay 1073 having open contacts 1077 and closed contacts 1079, open contacts 1078 of the tube sensing relay 1102 and closed contacts 1078a of tip motor impulse switch 637 (FIG. 16).

Also included within start circuit 1070 is start relay 1082, silicon rectifiers 1083, 1084, open contacts 1085 of tube sensing relay 1102, open contacts 1086, which are normally held closed, of tip limit switch for the up position, closed contacts 1087 for the auxiliary start relay 1073, open contacts 1088, which are normally held closed, of tip limit switch for the up position (momentary contact) and the closed contacts 1089, which are normally held open, of start limit switch for the right position (momentary contact).

A series of indicator lights are connected across the lines to indicate various conditions. These are all located behind display member 115. They include a sequence light 1092, an advance jam light 1093, a misaligned tip light 1094, a missing tube light 1095, a low paper light 1096 and a low reagent light 1097. Light 1095 is connected to closed contacts 1098 of tube sensing relay 1102. Light 1096 is connected to open contacts 1099 of low paper switch (indicating a short supply of wiping paper). Light 1097 is connected to low reagent switch contacts 1100.

A silicon rectifier 1101 is located between open contacts 1091 of ejection motor relay 1106, and the advancement circuit 1110. A tube sensing relay 1102 is connected across the lines with open contacts 1103 of the tube sensing switch (closed by a tube) and silicon rectifier 1104.

An ejection circuit 1105 contains an ejection motor relay 1106, silicon rectifier 1107, open contacts 1108 of the ejection motor cam switch and open contacts 1109 of the rack limit switch.

The last circuit, advancement circuit 1110, contains an advancement motor relay 1111, a silicon rectifier 1112, closed contacts 1113 of rack limit switch, open contacts 1114 are normally held open, of tip motor impulse switch 637.

Connected across contacts 1115 are closed contacts 1116 of ejection motor cam switch, closed contacts 1117, which are normally held open, of the tip limit switch for the up position, closed contacts of advancement relay 1130, closed contacts 1131 of the tube sensing relay 1102, closed contacts 1119 of the start relay 1082, silicon rectifier 1120 and open contacts 1121 of rack sense switch. Also included in circuit 1110 are open contacts 1122 of the advance mode switch 118, open contacts 1123 of the start switch 110, silicon rectifier 1124, capacitors 1125 and 1129, resistors 1126 and 1128, advancement relay 1130 and open contacts 1127 of the advancement motor cam switch.

For convenience sake, the relays are listed below with their accompanying numerical designations:

1061 — Pump Motor Relay
1106 — Ejection Motor Relay
1111 — Advancement Motor Relay
1053 — Tip Motor Relay
1082 — Start Relay
1073 — Auxiliary Start Relay
1102 — Tube Sensing Relay
1130 — Advancement Relay
1034 — Tip Alignment Relay
1037 — Trouble Relay No. 1
1042 — Trouble Relay No. 2
1018 — Buzzer Relay
1047 — Trouble Relay No. 3

Also listed are the manually operated switches as follows:

113 — Power Switch, Off-On
111 — Reset Switch, Momentary Contact
112 — Buzzer Switch, Momentary Contact
110 — Start Switch, Momentary Contact
109 — Pump Sequence Switch, Momentary Contact
116 — Automatic Mode Switch
117 — Manual Mode Switch
118 — Advance Mode Switch

The automatically operated switches are usually either simple contact switches or microswitches located in the various mechanisms to sense various conditions. They are inserted in the obvious locations. Some are shown and have numerical designations, while others are not. They are listed as follows:

Advancement Jam Switch
Tip Alignment Switch
Ejection Motor Cam Switch
133 — Rack Limit Switch
637 — Tip Motor Impulse Switch
Rack Sense Switch
Tip Limit Switch, Up Position
Tip Limit Switch, Down Position
Advancement Motor Cam Switch
145 — Tube Sensing Switch
Pump Limit Switch, Left Position
Pump Limit Switch, Right Position
Low Paper Switch
722 — Low Reagent Switch

The relays control the operation of the apparatus and are activated by either pushing one of the manually op-
erated switches or by the opening of a set of normally closed contacts in a switch or the closing of a set of normally open contacts in a switch. Automatic switches have one or more sets of contacts associated therewith. The operation of the relay is now described.

Trouble Relay No. 1 — 1037 — This relay is initially energized by the reset switch 111 through the normally closed contacts 1041 of the advanced jam switch. The relay 1037 is locked in through its own contacts. When an advancement jam condition occurs, relay 1037 will be energized and in turn will close contacts 1051 and thereby energize trouble relay No. 3, 1047 which closes contacts 1020 which sounds the buzzer 1024 through the normally closed contacts 1023 of the buzzer relay 1018. Contacts 1021 are opened by energization of start relay 1082 when start switch 110 is closed. The buzzer may be silenced by depressing the buzzer switch 112, which will energize relay 1018 causing it to lock-in through its own contact 1022. This in turn will open contacts 1023 and the circuit to the buzzer and silence it. Under normal operating conditions, the contacts 1020 shown in the buzzer control circuit open; therefore, when all trouble conditions have been cleared, the buzzer relay cannot be energized. This means that the buzzer relay will recondition itself to its normal condition after all trouble signals have been cleared.

Trouble Relay No. 2 — 1042 — This relay is initially energized by the reset switch 111 in like manner as relay 1037 through the normally closed contacts 1045 of relay 1042. The relay locks-in through its own contacts. Tip alignment relay 1034 is controlled by tip alignment switch which is normally open. Upon a misalignment of the tip, the switch contact 1035 will close energizing relay 1034 which in turn opens the circuit to trouble relay No. 2 which deenergizes and closes contacts 1052. This action sounds the buzzer in the same manner as trouble relay No. 1.

Trouble Relay No. 3 — 1047 — This relay is energized by either trouble relay No. 1 or 2 upon an advancement jam or a tip misalignment. The diodes shown going to the relay coil 1047 are used for isolation purposes only. Whenever relay 1047 is energized contacts 1059 open and all motor relay and control relays are deenergized.

Start Relay 1082 — This relay can only be energized when in the automatic or manual mode of operation (i.e., when either contacts 1056 or contacts 1057 are closed). The relay coil is energized by the start switch 110, through the normally closed contacts 1088 of the pump limit switch up position, the normally closed contacts, 1089 of the pump limit switch (right) in the pippet unit, and through the normally closed contacts 1087 of the relay 1073 which is the auxiliary start relay. The start relay 1082 will lock-in on its own contacts if the tip limit switch (up) contacts 1086 are closed, that is if the tip is in the up position. After the start relay 1082 has been energized, its contacts 1055 close, the tip motor relay 1053 will also become energized through the parallel connection of the following contact: pump limit switch (left) or pump limit switch (right) in the metering apparatus 900 or the tip limit switch down 1054, which is normally held closed. When the tip reaches the down position, the tip motor impulse switch (contacts 1115) which is normally held open will close charging capacitor 1081 through relay contacts 1079. When the tip returns to the normally up position, the contacts 1086 of tip limit switch (up) will close discharging the capacitor 1081 through relay 1073. This action will cause relay 1073 to be energized and to lock-in through its own contacts 1077 and 1079. After, the auxiliary start relay 1073, is energized, the pump motor relay, 1061, becomes energized which in turn closes contacts 1134 and operates the pump motor. This is the basic starting sequence for either the automatic or manual mode. The start relay 1082 will become deenergized any time the tip is in the up position and a tube is missing from the rack. A tube missing is determined by the tube sensing switch 145 (FIGS. 9 to 11) which is normally open as at 1103 but is closed by a tube. This tube closing operates the relay 1102. The TSR tube sensing relay 1102 keeps the start relay 1082 energized so long as a tube is present in the rack. Whenever a tube is missing in the rack, relay 1102 will be deenergized, opening its contacts 1085, in turn causing start relay 1082 to become deenergized. Noting the buzzer control circuitry, we see normally closed contacts 1021 of start relay 1082 therefore, when relay 1082 deenergizes, the buzzer will sound and can be silenced as described before.

Auxiliary Start Relay 1073 — The normal operation of this relay has already been indicated; however, it can also be energized by the start switch 110 when a tube is already present in the rack. This will permit starting in the middle of a rack.

Advancement Motor Relay 1111 — This relay is activated by the tip motor impulse switch 637 (FIG. 16) and contacts 1115. This switch is activated when the tip reaches the up position. The rack limit switch 133, shown in FIG. 1 inhibits advancement when a rack has been sensed or when a rack is being ejected. Since the operation of the tip motor impulse switch 637 is only momentary, a cam switch operated by the advancement motor is necessary to carry the motor through its one cycle of operation. When a partially filled rack is encountered during a normal run, the advancement circuitry is energized by the following: contacts 1121 of rack sense switch are closed, the start is 1082 relay deenergized because of a missing tube and therefore tube sensing relay contacts 1078 and 1085 are closed; the contacts 1118 of advancement relay 1130 are normally closed, the normally closed contacts 1086 on TLSU which is tip limit switch up, are closed, and the ejection motor can switch contacts 1116 are also closed. Advancement of the rack will continue until another tube is sensed in the rack and closes contacts 1103. At this time the start circuitry is reenergized through the ejection of the previous rack by the closing of contacts 1012 in the ejection motor circuit through the relay 1106. The relay 1106 is the ejection motor relay. This will automatically restart the next rack. Restarting will not occur however if the pump is out of sequence, that is the pump unit switch (right) on the pump unit is out of phase. It should be noted that advancement cannot occur if the tip is in the down position if ejection of a rack is occurring.

Advancement Relay 1130 — This relay causes the automatic advancement of the rack when in the advance mode (switch 118). Upon the depression of the start switch 110, the relay 1111 is energized through the normally closed contacts 1118, 1117, 1116 and 1113. This action will cause relay 1130 to become energized. This will cause the contacts 1118 to open and the contacts 1127 to close across capacitor 1125 and 1126. After the advancement motor has gone through
one complete cycle of operation, the contacts 1127 will again open. However, capacitor 1125 must discharge through 1130 which will remain energized for a time constant determined by 1125, 1126, and 1128. When relay 1130 does fall out, contacts 1118 close and the advancement circuitry is again energized for another cycle. This action will continue as long as start switch 110 and advance mode switch 118 are depressed. As noted before, this circuit is also called for when a partially filled rack is encountered.

Pump Motor Relay 1061 — This relay is energized only after the relay 1073 has been energized (which causes closing of contacts 1134 (FIG. 39) and is locked in through the limit switches on the pump unit which carry it through one complete cycle of operation.

The device is thus constructed for automatic operation or for semi-automatic operation.

The operator depresses the main power switch 113 and then selects the mode of operation. By pressing the automatic mode switch 116 and start switch 110, the device will begin to process the racks and dispense liquids until it has completed processing all the racks whereupon it shuts down. The depressing of manual mode switch 117 causes the apparatus to go through one complete cycle and then shut down. Pressing the advance mode switch 118 allows the rack to advance without the tip coming down. Depressing the pump sequence switch 109 operates the pump unit 900 and tip unit 600. It can be used to clear the tip of any remaining fluid after all the racks or tubes have been processed.

Reset switch 111 merely resets all the relays into their normal position after a trouble relay has stopped the device and the malfunction has been corrected. Buzzer switch 112 silences the buzzer which sounds when a malfunction occurs.

Referring now to FIG. 36 there is shown a view of an idler gear 807 (of FIG. 26) showing the time of operation of the pumps 500, the pause or stop interval and the period of valve operation for one cycle of the pump. Also shown are detents 1201 and 1202 which activate limit switches for the manual mode and automatic mode operation of the apparatus. The pump operates through approximately 125° and the valve through approximately 54°. There is an interval of 1° between the phases.

Referring to FIG. 35 there is shown a time chart plotting the rotation of idler gear 807 versus the operation of various components of the system. The valve plot is a linear representation of the arcuate chart of FIG. 35. The teeth plot and the pump plot represent the idler gear 807 and the drive gear 470 (FIG. 21) on the end of the pump. It is noticed that the gear 470 is rotating after gear 807 has stopped and that it commences again before gear 807 commences. This is due to the unmeshing and remeshing of the gears and the interaction of pins 811, 812 and spokes 476, 477.

The transporter plot is a combined plot of the advance, tip-up and tip-down period showing the individual periods where these circuits are energized.

While one embodiment of the transporter has been shown and described, it will be obvious to one of ordinary skill in the art to make changes and modifications within the scope of the appended claims.

We claim:

1. An automatic apparatus for processing samples contained in a plurality of tubes mounted in a support rack comprising a base having a planar surface, at least one conduit having an aspirating and dispensing tip, means to raise and lower said tip relative to the base, means supporting said tip and the tip raising and lowering means above said planar surface, pump means of adjustable volumetric capacity in communication with said conduit means and comprising at least two pumps each having a cylinder and piston means, said pistons being constant-displacement pistons of constant cross-section to provide accurate, positive displacement increments, stroke-adjustment means for individually varying the length of stroke of each of said pistons, motor means, eccentric means connecting said motor means to said stroke-adjustment means, said eccentric means being constructed to provide sinusoidal aspirating and dispensing pressures to said tip, rack advancement means to move a loaded support rack underneath said tip by increments so as to position each tube for lowering of said tip and cycling of said pump means, said pump means adapted to provide sinusoidal aspirating and dispensing pressures to said tip only when said tip is in the down position, and electrical means to control the operation of said motor means, pump means and said rack advancement means and to cycle said pump means and said tip means automatically upon operation of said rack-advancement means.

2. An apparatus as in claim 1 including guide means on said planar surface adapted to automatically feed said support racks to said rack advancement means, whereby a plurality of loaded racks may be automatically processed.

3. An apparatus as in claim 2 wherein said guide means comprises parallel rails on said planar surface, said rails having slot means therein, rack-pushing means between said rails and mounted for sliding movement in said slot means.

4. An apparatus as in claim 3 wherein a tensioning means is provided to put tension on said rack pushing means to bias it toward said rack advancement means.

5. An apparatus as in claim 1 including means associated with the stroke adjustment means and motor means whereby the pump pistons can be set to either pump in parallel or in alternately opposite directions.

6. An apparatus as in claim 1 wherein said eccentric means is linearly adjustable to set the pistons stroke from zero to a predetermined maximum.

7. An apparatus as in claim 6 including external indicator means on said apparatus to indicate the stroke setting on each eccentric mechanism.

8. An apparatus as in claim 1 wherein there are two ports in each cylinder, valve means in each pump capable of alternately placing said cylinder in communication with one port for the intake stroke and the other port during the exhaust stroke, said valve means being driven by said motor means.

9. An apparatus as in claim 8 wherein each pump is constructed so that said pistons and cylinders may be easily removed and replaced with cylinders and pistons of different constant cross section.

10. An apparatus as in claim 8 wherein at least one of said pumps has a bleed and priming means associated with its cylinder.

11. An apparatus as in claim 8 wherein each said valve means includes a rotary member and a valve switching mechanism in operative association with each said rotary member and said motor means.
12. An apparatus as in claim 11 wherein said valve switching mechanism includes a reciprocating lever means for slots therein, said rotary member having studs projecting into said slots whereby reciprocation of said lever means reciprocates said rotary valve member to shift ports between the intake and discharge strokes of said pump piston.

13. An apparatus as in claim 12 wherein said lever means is adapted to be disengaged to a position where it does not reciprocate whereby either or both pumps may intake and exhaust through only one port.

14. An apparatus as in claim 8 wherein said motor means includes motion translating means adapted to convert rotary motion into reciprocating arcuate motion and valve switching mechanisms connecting said motion translating means with said valve means.

15. An apparatus as in claim 14 wherein said valve switching mechanisms are adjustable to disengage from said motion translating means and leave either or both of said cylinders communicating with only one port during both the intake and exhaust stroke of its accompanying piston.

16. An apparatus as in claim 15 wherein said motion translating means comprises rotatable cams, vertically reciprocable members having aperture means receiving said cams and adapted to vertically reciprocate with pauses at the three major and bottom-most positions upon rotation of said cams, pivot members on said vertically reciprocable members and adapted to reciprocate in a vertical plane upon vertical movement of said vertically reciprocable member to drive said valve switching mechanism.

17. An apparatus as in claim 16 wherein said valve switching mechanism includes pivoted levers driven by said pivot members and adapted to reciprocate in a horizontal plane.

18. An apparatus as in claim 1 wherein each of said cylinder means has two ports and a valve means adapted to switch communication of said cylinder from one port to another between the intake and discharge strokes of the piston, said ports having fittings thereon adapted to accommodate flexible conduits.

19. An apparatus as in claim 18 wherein said electrical means includes a first motion translating means adapted to translate rotary motion into sinusoidal reciprocating motion, power transmitting means connecting said motor means and said first motion translating means to provide rotation to said motion translating means, a valve switching mechanism, means operatively connecting said valve means with said valve switching mechanism, a second motion translating means adapted to translate rotational movement of said power transmitting means into substantially reciprocating movement, said second motion translating means operatively associated with said valve switching mechanism and operating it to switch the valve means between strokes of said pistons, and reciprocating arm means connected to said pistons and said first motion translating means to provide strokes of sinusoidal amplitude to said pistons.

20. An apparatus as in claim 19 wherein said pump includes an elongated housing, said cylinder comprising chamber means within said housing, port containing means adjacent said chamber means, said port containing means including said two port bores, said valve means being a rotary member in said housing adjacent said port containing means and adapted to alternately place each port bore in open communication with said chamber means, adaptable means associated with said chamber and piston means to seal said pump against leakage, reciprocating rotating valve driving means connected to said valve means and having at least one driving stud projecting up beyond the end of said housing to engage said valve switching mechanism, said valve switching mechanism having reciprocating lever means engaging said driving stud to operate said valve means upon reciprocation thereof.

21. An apparatus as in claim 1 wherein said electrical control means includes means to advance the tube racks and incrementally upon completion of each pump cycle and means to advance the racks without any processing by the tip.

22. An apparatus as in claim 1 wherein said electrical control means includes means to operate the pump means alone without advancing the tube racks.

23. An apparatus as in claim 1 wherein said control means includes means to automatically shut down the operation of the apparatus if the rack advancement means is in a jammed condition or if the tip becomes misaligned.

24. An apparatus as in claim 1 wherein said base includes means to automatically eject a tube rack which has been processed from the path of a rack commencing processing.

25. An apparatus as in claim 1 wherein said electrical control means includes means to process only one tube at a time, whereby said control means has to be manually reactivated each time to process a plurality of tubes.

26. An apparatus as in claim 1 wherein said tip raising and lowering means includes a wiper means for wiping the tip clean during the upward stroke of said tip.

27. An apparatus as in claim 26 wherein said tip raising and lowering means also includes cam and crank arm operated reciprocating means, a first slot means, slide means holding said conduit and tip and mounted for vertical sliding movement in said first slot means and flexible cord means operatively connecting said slide means with said reciprocating means to raise and lower said tip.

28. An apparatus as in claim 27 wherein wiper means comprises pivoted wiping elements adjacent the vertical path of said tip, cam means on said slide means adapted to cause the wiping elements to converge on said tip during the raising thereof and a wiping means adapted to provide separate strips of wiping paper on opposite sides of said tip path, said wiper elements adapted to engage said paper strips and push them against said tip.

29. An apparatus as in claim 28 wherein said wiping means further comprises a paper supply means, means to advance said paper strips during each cycle of said tip raising and lowering means, said reciprocating means having a cam means thereon adapted to engage said paper strip advance means and advance said paper strips a predetermined distance during each stroke thereof whereby an area of dry paper is provided for wiping said tip during each operational cycle thereof.

30. An apparatus as in claim 1 wherein each of said pump means has two ports and a valve means adapted to switch communication of said cylinders from one port to another between the intake and discharge strokes of the pistons, said ports having fittings thereon adapted to accommodate flexible conduits, said electric-
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31. An apparatus for selectively or automatically processing a plurality of liquid sample containing tubes mounted in a support rack comprising a surface means, rack advance means cooperating with said surface means to advance said racks, a liquid metering and dispensing apparatus, a conduit means in communication with said metering and dispensing means and having an aspirating and dispensing tip, said apparatus adapted to provide sinusoidal aspirating and dispensing pressures to said tip only when said tip is in the down position, means adapted to raise and lower said tip into engagement with the samples contained in said tubes, rack ejection means adapted to eject processed racks from the path of a rack commencing processing, said tip raising and lowering means including a wiper means for wiping said tip as it is being raised.

32. An apparatus as in claim 31 including rack guide means adapted to successively guide a plurality of racks into engagement with said rack advance means to commence processing.

33. An apparatus as in claim 32 wherein said guide means comprises two parallel rails substantially perpendicular to the path of racks engaged by said rack advance means and being processed, and a rack push bar means mounted between said rails, a tensioning means connected to said push bar means and biasing the same to force unprocessed rack toward said rack advance means.

34. An apparatus as in claim 33 wherein said tensioning means comprises a pulley wheel mounted in one of said rails, a cord passing over said wheel with one end connected to said push bar means and the other end connected to a spring means.

35. An apparatus as in claim 31 wherein said rack advancement means includes a slot in said surface means and a rack engaging means mounted for reciprocal movement under said surface means and having aoothed means adapted to project through said slot and engage the bottom of said racks.

36. An apparatus as in claim 36 wherein said rack engaging means is mounted on a platform under said surface means, a slot in said platform underlying the slot in said surface means and generally parallel therewith, a slotted guide means mounted on the bottom side of said platform and a slide member mounted in said guide means and carrying said toothed means.

37. An apparatus as in claim 31 wherein said means for raising and lowering said tip includes a holder for adjustably holding said conduit means adjacent said tip.

38. An apparatus as in claim 31 wherein said wiper means comprises a wiper paper supply means, means providing two strips of said wiper paper on each side of said tip, means to advance said paper strips and means for pushing said strips against said tip.

39. An apparatus as in claim 38 wherein said means for pushing said paper strips against said tip comprises a pair of pivotally mounted wiper elements, said means for raising and lowering said tip includes cam means adapted to force said wiper elements against said tip as it is being raised.

40. An apparatus as in claim 31 wherein said surface means has a switch means therein adapted to control the operation of said tip lowering means through said electrical control means, said electrical control means adapted to prevent the lowering of said tip when said switch means senses the absence of a tube.

41. An apparatus as in claim 31 wherein said rack ejection means comprises a pair of flipper elements adapted to shove a processed rack laterally out of the path of a rack commencing processing, and means to power said flippers.

42. An apparatus as in claim 41 including switch means in the path of said racks being processed, said switch means adapted to activate said flipper means when said rack contacts said switch.

43. Apparatus for processing a liquid to be analyzed comprising a plurality of test tubes, a rack for supporting the test tubes upright at spaced intervals along the length of the rack, a stationary table having an upwardly facing planar surface on which the rack is slidable, a flexible conduit, a downwardly extending tip at the end of the conduit having an opening or bore communicating at its upper end with the passage of the conduit and open at its lower end to allow entry or discharge of liquid through the tip into or out of the conduit, means to support the tip movably above the table comprising means to raise and lower the tip relative to the table, means for intermittently moving the rack longitudinally over the table along a path extending under the tip, positive displacement pump means comprising a piston reciprocable in a cylinder communicating with the conduit, pump driving means for intermittently moving the piston in alternate suction and forcing strokes within the cylinder, said driving means having means for interrupting the motion of the piston at the end of each stroke to provide a pause for an appreciable time before the next stroke starts, and means for coordinating operation of the several means to carry out one or more cycles, each cycle including the following steps: the rack is moved to bring one of the tubes therein to a position under the tip, the rack is stopped with the tube in that position, the tip is moved down into the tube under the tip, the piston is moved through one of its alternate strokes while the tip is in the tube, the piston is stopped for its pause, the tip is raised out of the tube, and the piston is moved through the other of its alternate strokes.

44. Apparatus in accordance with claim 43 in which the cylinder has a common port for entry and discharge of liquid with respect to the cylinder, the apparatus comprises another conduit, a member having two fixed
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passages, one of the passages being connected to and communicating with the first-mentioned conduit and the other passage being connected to and communicating with the other conduit, valve means for selectively connecting the common port to one of the passages for communication therewith, and the operation coordinating means including means for operating the valve means when the piston is stopped for a pause.

45. Apparatus in accordance with claim 43 comprising means for sensing a tube in position below the tip for stopping the rack-moving means.

46. Apparatus in accordance with claim 43 comprising means actuated by a rack whose tubes have advanced beyond the tip-position in the path for ejecting such rack to an area of the table to one side of the path.

47. Apparatus in accordance with claim 43 comprising means for adjusting length of piston stroke and indicating means to indicate pump stroke volume.

48. Apparatus for processing a liquid to be analyzed comprising a plurality of test tubes, a rack for supporting the test tubes upright at spaced intervals along the length of the rack, a stationary table having an upwardly facing planar surface on which the rack is slidable, flexible conduit, a downwardly extending tip at the end of the conduit having an opening or bore communicating at its upper end with the passage of the conduit and open at its lower end to allow entry or discharge of liquid through the tip into or out of the conduit, means to support the tip movably above the table comprising means to raise and lower the tip relative to the table, means for intermittently moving the rack longitudinally over the table along a path extending under the tip from an initial rack-entry position in the path to a final eject-position therein, means for sliding the rack laterally on the table into the initial rack-position in the aforementioned path, means for pushing the rack laterally out of the path after the last tube in the rack passes beyond the tip position, positive displacement pump means comprising a piston reciprocable in a cylinder communicating with the conduit, pump driving means for intermittently moving the piston in alternate suction and forcing strokes within the cylinder, said driving means having means for interrupting the motion of the piston at the end of each stroke to provide a pause for an appreciable time before the next stroke starts, and means for coordinating operation of the several means to carry out one or more cycles, each cycle including the following steps: the rack is moved to bring one of the tubes therein to a position under the tip, the rack is stopped with the tube in that position, the tip is moved down into the tube under the tip, the pisto is moved piston one of its alternate strokes while the tip is in the tube, the piston is stopped for its pause, the tip is raised out of the tube, and the piston is moved through the other of its alternate strokes.

49. Apparatus for processing a liquid to be analyzed comprising a plurality of test tubes, a rack for supporting the test tubes upright at spaced intervals along the length of the rack, a table having an upwardly facing planar surface on which the rack is slidable, said table having an entrance area, large enough to accommodate several racks, to receive one or more racks to be processed, an exit area large enough to accommodate several racks to receive one or more racks after completion of processing, and an area, contiguous to the entrance and exit areas, comprising the rack-processing path, a flexible conduit, a downwardly extending tip at the end of the conduit having an opening or bore communicating at its upper end with the passage of the conduit and open at its lower end to allow entry or discharge of liquid through the tip into or out of the conduit, means to support the tip movably above the table comprising means to raise and lower the tip relative to the table, means for intermittently moving the rack longitudinally over the table along the rack-processing path extending under the tip from an initial rack-entry position in the path to a final eject-position therein, means for sliding the rack laterally on the table into the initial rack-position in the aforementioned path, means for pushing the rack laterally out of the path after the last tube in the rack passes beyond the tip position, positive displacement pump means comprising a piston reciprocable in a cylinder communicating with the conduit, pump driving means for intermittently moving the piston in alternate suction and forcing strokes within the cylinder, said driving means having means for interrupting the motion of the piston at the end of each stroke to provide a pause for an appreciable time before the next stroke starts, and means for coordinating operation of the several means to carry out one or more cycles, each cycle including the following steps: the rack is moved to bring one of the tubes therein to a position under the tip, the rack is stopped with the tube in that position, the tip is moved down into the tube under the tip, the piston is moved piston one of its alternate strokes while the tip is in the tube, the piston is stopped for its pause, the tip is raised out of the tube, and the piston is moved through the other of its alternate strokes.