

[54] **AUTOMATED HANDLING AND TREATING APPARATUS**

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[22] Filed: **June 1, 1972**

[21] Appl. No.: **258,517**

[52] U.S. Cl. **23/253 R, 23/259, 141/238;242**

[51] Int. Cl. **G01n 31/00**

[58] Field of Search..... **23/253 R, 259; 141/130, 141/234, 237, 238, 242**

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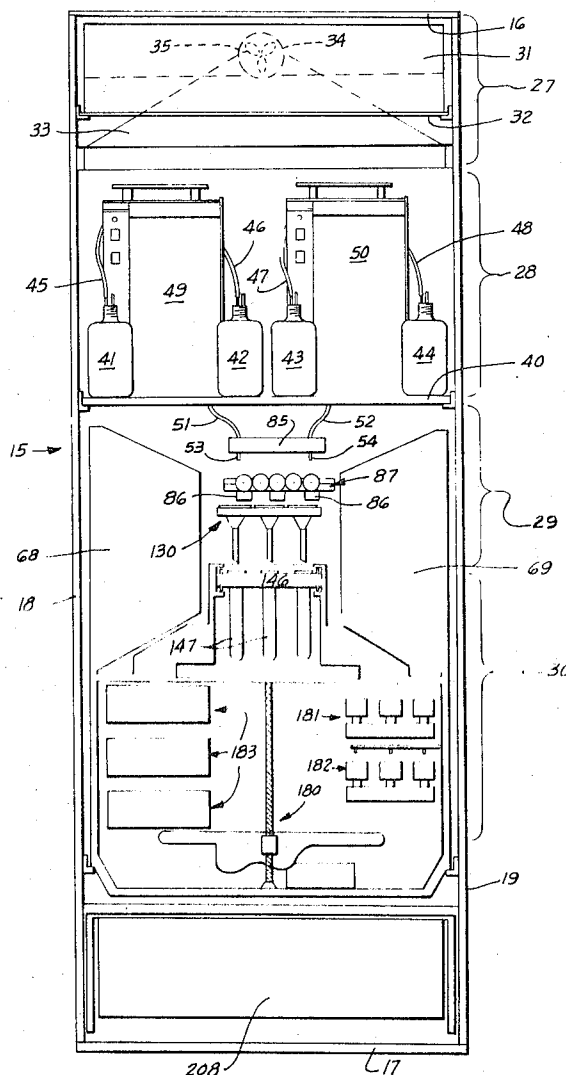
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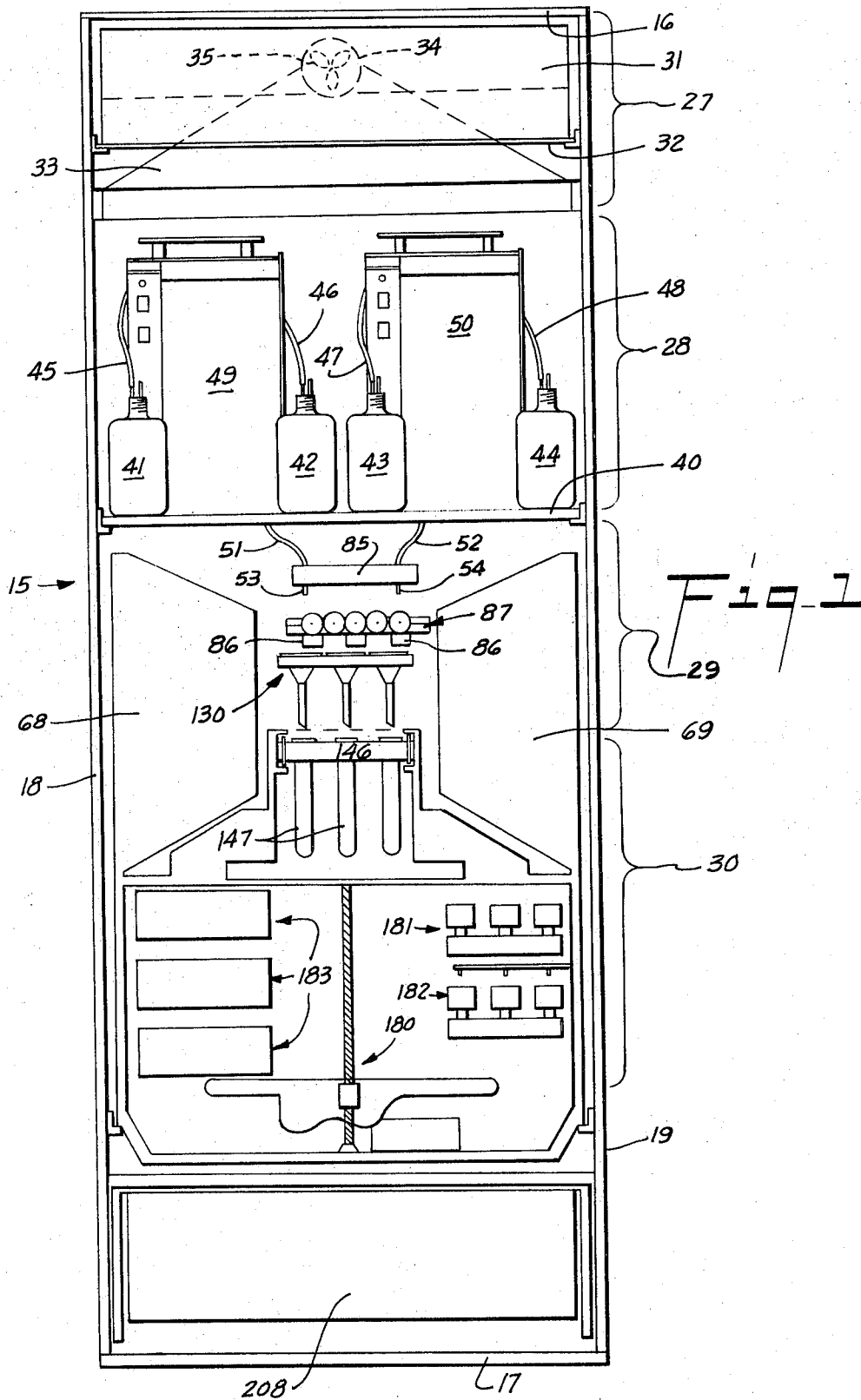
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[57] **ABSTRACT**

A method and apparatus for automatically handling and treating a plurality of samples wherein the samples remain stationary and individual treatment units are selectively moved into a desired relationship with the samples to perform simultaneously on all of the samples a desired operation. This abstract is not intended to define the invention, which is of course measured by the claims, or to be limiting in any way as to the scope of the invention.

9 Claims, 14 Drawing Figures





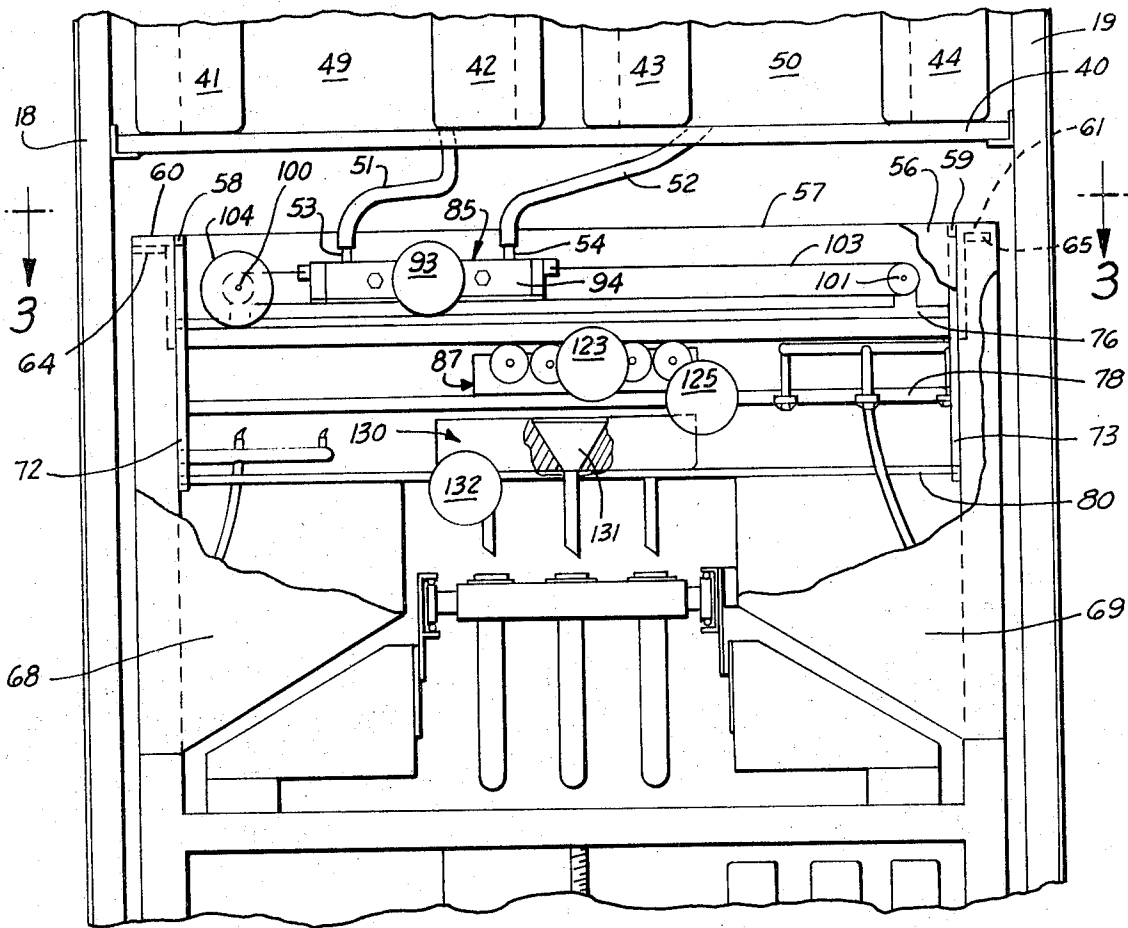


Fig. 2

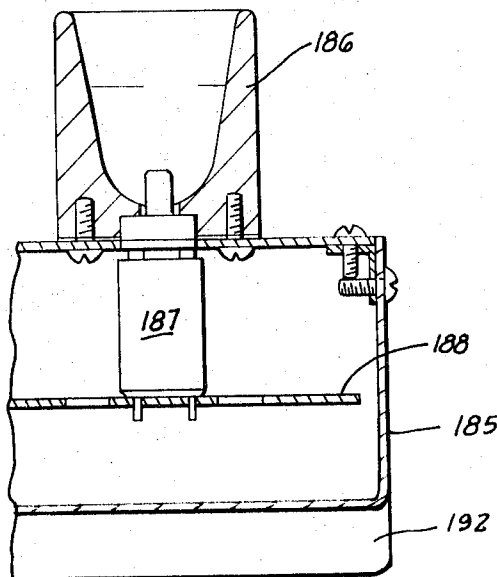


Fig. 3

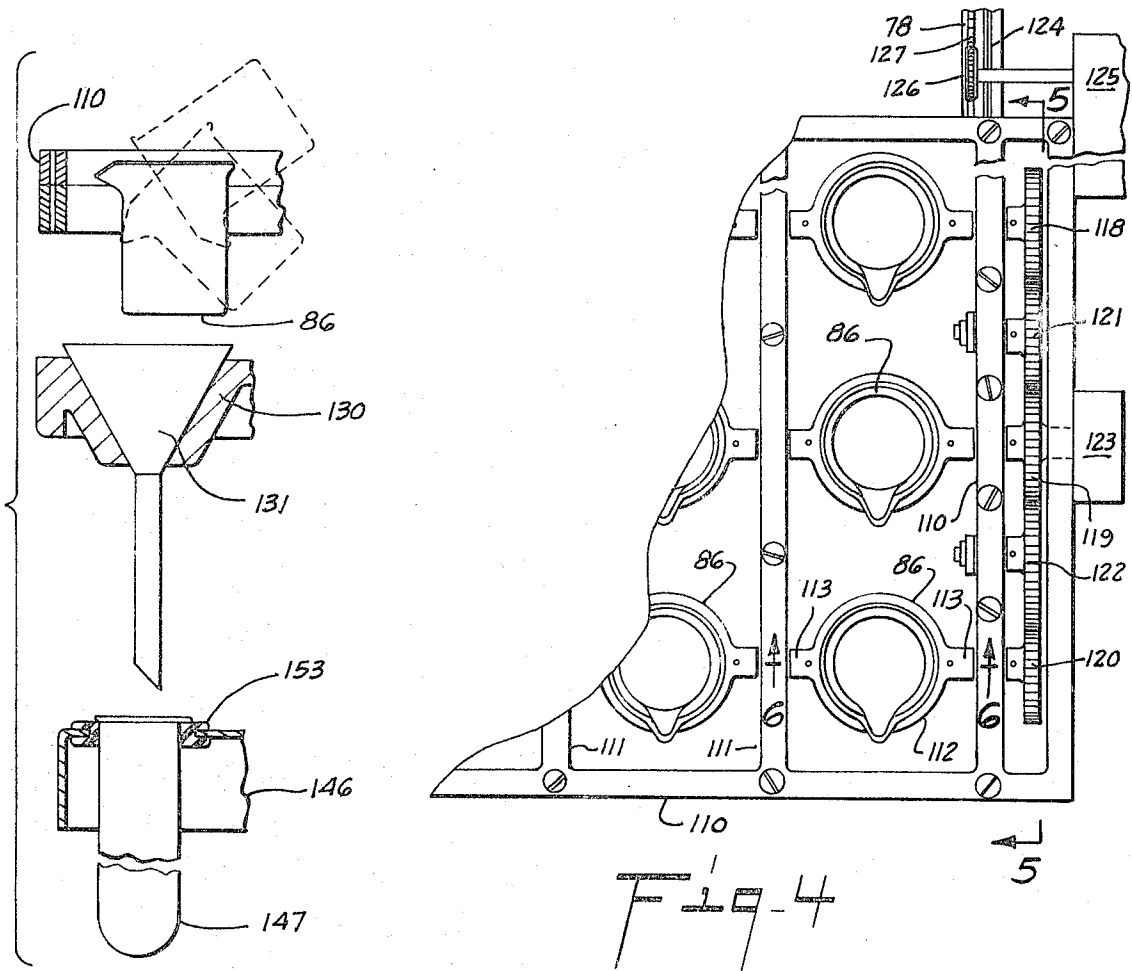
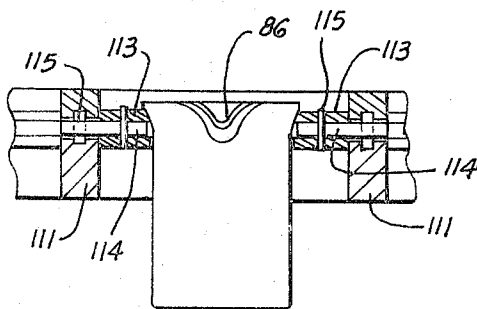
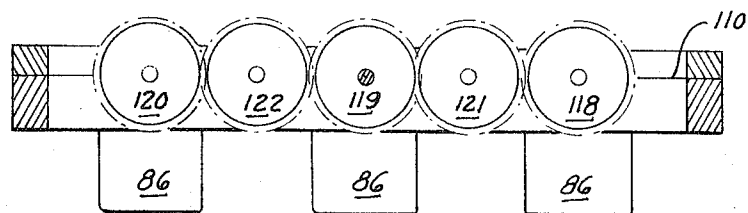


Fig. 7



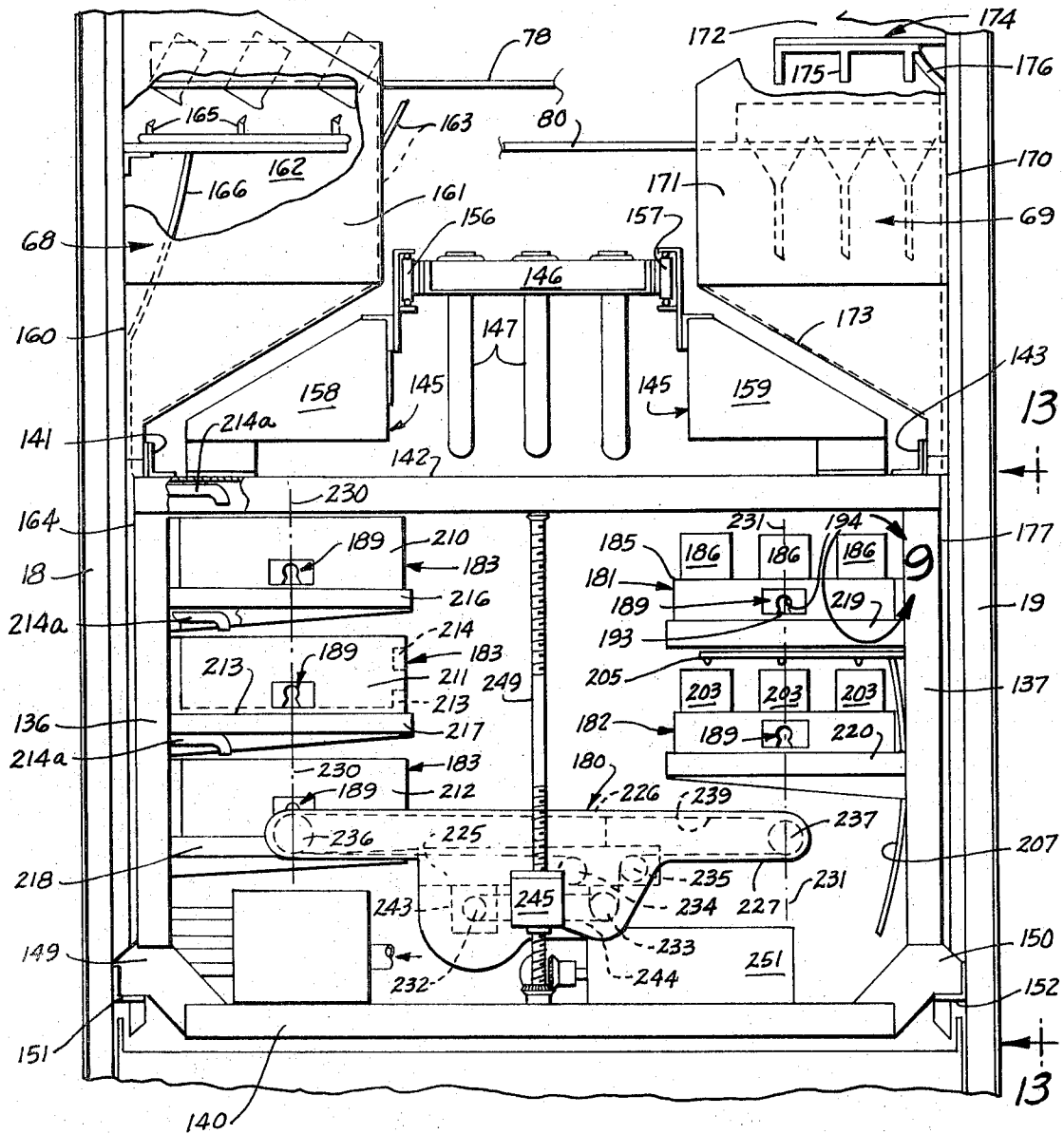


Fig. 8

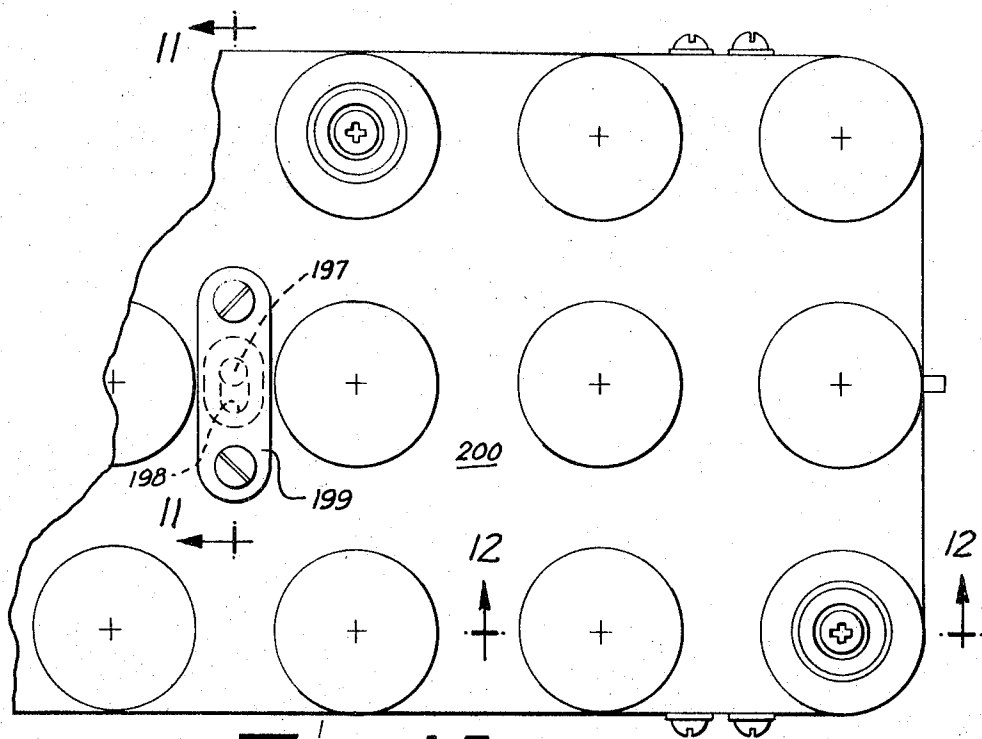


Fig-10

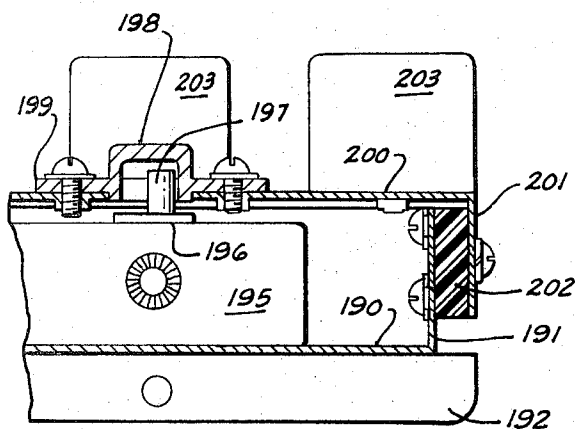


Fig-11

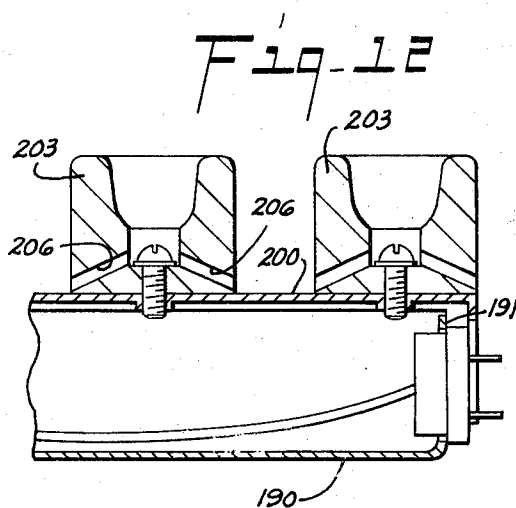
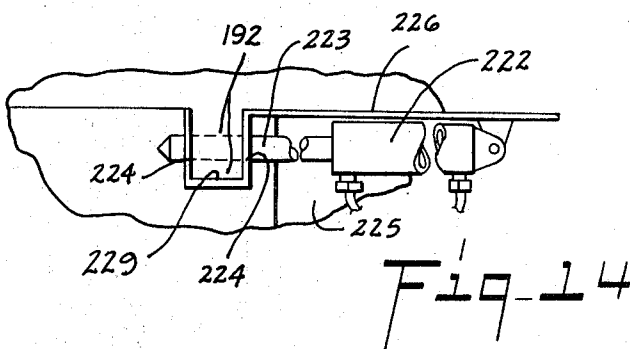
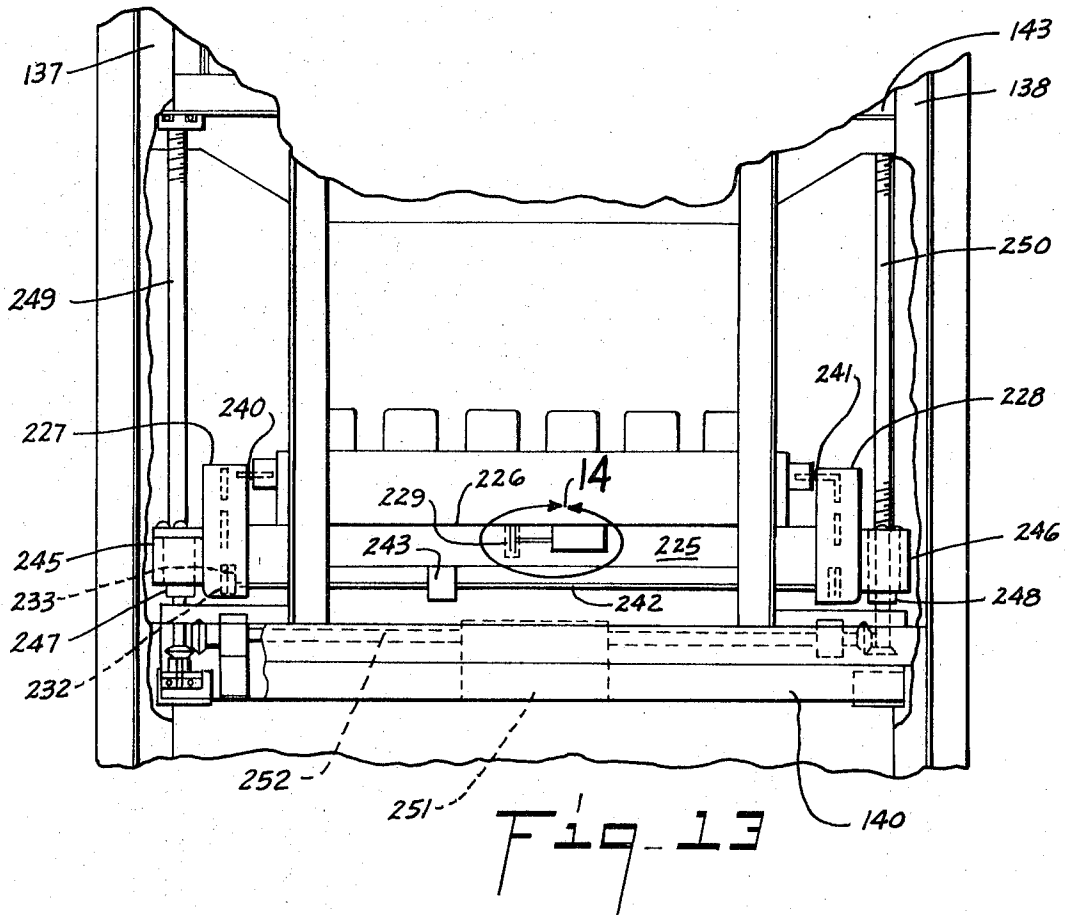


Fig-12



AUTOMATED HANDLING AND TREATING APPARATUS

OBJECTS OF THE INVENTION

This invention relates to an improved apparatus for handling and treating samples in accordance with standard analytical procedures.

It is an object of this invention to provide an improved apparatus for handling and treating samples wherein a plurality of samples of similar character are subjected to the same process.

It is an additional object of this invention to provide an improved apparatus for handling and treating samples wherein a plurality of samples are processed simultaneously.

A further object is to provide an improved apparatus for handling and treating a plurality of samples wherein the samples remain stationary and the devices accomplishing the various operations comprising the process are each selectively brought into a desired space relationship with such samples.

A still further object is to provide an improved apparatus for handling and treating samples wherein the timing of the individual operations comprising the process may be precisely controlled.

A further object is to provide an improved apparatus for handling and treating samples wherein the time delays caused by the variable time periods of the operations comprising the process are diminished.

Another object is to provide an improved apparatus for handling and treating stationary samples wherein the apparatus is adapted to carry out certain analytical procedures and is adapted to function as a component of a modularized automated system containing other components performing additional analytical procedures.

An additional object is to provide an improved apparatus for handling and treating samples wherein the apparatus may perform any one of a plurality of several different processes with a minimum of change-over or conversion time from one mode of performance to another.

A still further object is to provide an improved apparatus for handling and treating samples wherein the apparatus results in lower purchase, operation and maintenance cost.

Other objects and advantages of the invention will be apparent from the drawings, the specification, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein a preferred embodiment of the invention is shown and wherein like reference numerals indicate like parts:

FIG. 1 is a front elevational schematic view of the preferred apparatus according to this invention.

FIG. 2 is an enlarged view of the central portion of the apparatus of FIG. 1 including the nozzle subassembly and lower section of the reagent subassembly, certain parts thereof being shown in section.

FIG. 3 is a detail top view of a portion of the beaker tray and beakers according to this invention taken at line 3—3 in FIG. 2.

FIG. 4 is a detail top view of the components of the beaker tray shown in circle 4 in FIG. 3.

FIG. 5 is a schematic side view of the beaker tray taken at line 5—5 in FIG. 4.

FIG. 6 is a detail sectional view of a beaker in the beaker tray taken at line 6—6 in FIG. 4.

FIG. 7 is a schematic view of the relationship existing among the cuvettes, funnels and beakers in their operational positions.

FIG. 8 is an enlarged view of the lower portion including the cuvette subassembly, of the apparatus of FIG. 1.

FIG. 9 is a detail sectional view of the portions of the cuvette sensing means shown in circle 9 in FIG. 8.

FIG. 10 is a schematic top view of a portion of cuvette shaker.

FIG. 11 is a sectional view of cuvette shaker taken at line 11—11 in FIG. 10.

FIG. 12 is a sectional view of cuvette shaker taken at line 12—12 in FIG. 10.

FIG. 13 is a side view of certain portions of the apparatus according to this invention taken at line 13—13 in FIG. 8.

FIG. 14 is a detail view of the solenoid and plunger of the unit transporter shown in circle 14 in FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The automated handling and treating apparatus according to this invention receives a plurality of samples, holds such samples stationary in a desired arrangement, and selectively moves various treatment units into a desired relationship with the samples in order to perform simultaneously on all of the samples each of the desired individual operations comprising a desired analytical process. The disadvantages inherent in moving the samples progressively to a plurality of treatment units and there performing a particular operation progressively on each of the samples are obviated by our invention. For instance, troublesome variables of time delay and time differences in a given analytical process are eliminated. Purchase, operation and maintenance costs are decreased. And the factor of reproducibility of results from one test of a given nature to a subsequent test of the same nature is enhanced.

The apparatus for handling and treating samples according to this invention may be utilized to accomplish many varied analytical processes. For purposes of illustrating the preferred embodiment of this invention, however, the preferred apparatus will be described with respect to handling and treating samples, such as blood, serum, plasma and plasma components, wherein the desired analytical process requires the following selective, individual treatment operations: combining a measured quantity of various reagents to form a desired dosage and combining such dosage with each sample, shaking the combined dosage and sample for a desired duration of time, and maintaining the combined dosage and sample at a desired temperature for a desired duration of time.

The preferred apparatus is referred to in its entirety as the processing assembly 15, which, as schematically shown in FIG. 1, is in the nature of a modular rectangular structure housing a plurality of components and subassemblies. The outer framework of processing assembly 15 is preferably constructed of parallel top and bottom rectangular plates 16 and 17, respectively, spaced apart by at least four parallel vertical angle irons 18, 19, 20 and 21 to form an open rectangular structure. Front, back and side panels 22, 23, 24 and 25 (not shown in FIG. 1) are removably attached to

such outer framework and completely surround and enclose the components and subassemblies housed therein.

When the handling and treating apparatus according to this invention is used to accomplish the above stated analytical process, the components of the processing assembly 15 are preferred to be constructed in four subassemblies indicated by brackets, namely, control subassembly 27, reagent subassembly 28, nozzle subassembly 29, and cuvette subassembly 30.

Control subassembly 27 is preferably located at the top of processing assembly 15. It comprises a removable module 31 containing the electronic components necessary to control the operation of the other subassemblies housed in processing assembly 15 and an exhaust system. The electronic components in module 31 are well-known in the art, do not constitute a portion of this invention and are not described. Module 31 preferably rests on a shelf 32 secured to the angle irons of the outer framework. Access to module 31 is gained through a roll-up or hinged door (not shown) in the front panel of processing assembly 15. The exhaust system is preferably comprised of an exhaust hard 33, exhaust duct 34 and fan 35. Hood 33 is secured to the angle irons of the outer framework and supports duct 34, which extends through the back panel of processing assembly 15 and contains and supports fan 35.

Reagent subassembly 28 functions to provide relatively permanent storage within the processing assembly 15 for a plurality of reagents, diluents or other desired materials and transfer desired quantities thereof to the nozzle subassembly 29.

Nozzle subassembly 29 functions to receive the desired quantities of reagents, diluents or other materials from reagent subassembly 28, combine such reagents, diluents or other materials into desired dosages, and transfer simultaneously such dosages to all of the samples held in cuvette subassembly 30.

Cuvette subassembly 30 functions to receive and hold stationary the plurality of samples so that the samples may receive from nozzle subassembly 29 the dosages and the various treatment units may perform preselected operations thereon. In this connection, cuvette subassembly functions to rinse the beakers and funnels of nozzle subassembly 29, to receive the waste rinsed from such heaters and funnels, to store the various treatment units, and to position selectively such treatment units with respect to the samples.

Referring now to FIGS. 1, 2 and 3, the components comprising reagent subassembly 28 and nozzle subassembly 29 shall be more particularly described. A shelf 40 is secured to the angle irons 18, 19, 20 and 21 and functions to receive and support the various components of reagent subassembly 28. Access to these various components is through a roll-up or hinged door (not shown) in the front panel of processing assembly 15. To accomplish the above stated analytical process, the preferred embodiment uses four containers 41, 42, 43 and 44 to store the desired reagents. Hoses 45, 46, 47 and 48 are secured in the containers and function as conduits for the reagents between the containers and the means 49 and 50 to withdraw from said containers and dispense preselected quantities of the reagents. In the preferred embodiment, each dispensing means 49 and 50 is a standard apparatus, such as Manostat Corporation's Dualpet Automatic Dual Head Pipetting Machine, which functions to combine in desired pro-

portions the reagents available at its inputs and to emit through hose 51 or 52, respectively, a preselected quantity of the mixed reagents. Hoses 51 and 52 function to transmit the measured quantities of reagent to the nozzles 53 and 54 in nozzle subassembly 29 and are of sufficient length to allow such nozzles to move freely transversely and laterally in the interior of nozzle subassembly 29, as will be hereinafter explained.

Nozzle subassembly 29 is preferably constructed as a removable module comprising front and rear parallel plates 56 and 57, respectively, spaced apart by slender parallel plates 58 and 59 so as to form an open rectangular frame from which depend the various components of nozzle subassembly. A flange (only 60 and 61 are shown in FIG. 2) protrudes from each of the corners of such frame and removably rest on stub angles (only 64 and 65 are shown in FIG. 2) secured in the upper, inner corners of the waste receiving hoppers 68 and 69 of cuvette subassembly 30. Depending vertically from each of plates 58 and 59 are a pair of flanges 70 & 71 and 72 & 73, respectively (only 72 and 73 are shown in FIG. 2). Secured horizontally between these flanges and laterally across the interior of nozzle subassembly 29 are pairs of supporting bars. As shown in FIGS. 2 and 3, bars 75 and 76 are disposed vertically above the other supporting bars and function to support the nozzle transporter as will be hereinafter described. Supporting bars 77 and 78 are disposed below supporting bars 75 and 76 (as shown in cut-away section in FIG. 3) and support the beaker tray as will hereinafter be explained. Another pair of supporting bars (bar 80 only is shown and only in FIG. 2) are disposed below supporting bars 77 and 78 and support the funnel tray as will be hereinafter explained. Thus, the entire nozzle subassembly 29 may be removed from the processing assembly 15 by lifting it vertically from the supporting stub angles attached to the cuvette subassembly 30.

Nozzles 53 and 54 are spaced laterally a preselected distance from each other and vertically secured in such spaced relationship by a nozzle transporter means 85 for transporting them transversely and laterally over the tops of the beakers 86 held in beaker tray 87. As shown in FIGS. 2 and 3, nozzle transporter 85 is preferably comprised of an open rectangular frame 88 having two parallel traverse rods 89 and 90 connected therein. A cross member 91 is slidably mounted on and guided by traverse rods 89 and 90. Mounted transversely through the center of and rotatably attached to said frame 88 is a ball bearing screw 92. Screw 92 extends through an appropriately grooved hole in cross member 91 and functions to impart traverse movement to such cross member when rotated clockwise or counterclockwise by reversible electric motor 93. Electric motor 93 is secured to a flange 94 attached to the frame 88 so it may move laterally with nozzle transporter 85. One of the nozzles 53 and 54 is positioned, by spring clamp or other suitable means, to each end of cross member 91 so that the two nozzles are spaced apart by a distance equal to that between the two outer rows of the beakers 86 in beaker tray 87, which will be hereinafter described.

Nozzle transporter 85 is slidably mounted on "V" slides 98 and 99 of Teflon or Nylon, or the like, attached to the upper surfaces of supporting bars 75 and 76. Rotatably attached to and disposed between supporting bars 75 and 76 are two mandrels 100 and 101,

each of which has sprockets attached to each end thereof. Trained around the pairs of sprockets on the front and rear ends of such mandrels and attached to the frame 88 are chains 102 and 103, or the like. Rotary motion is imparted in either direction to mandrel 100 by reversible electric motor 104, which is secured to plate 56. This motion is transformed by the sprockets and chains into lateral motion and drives nozzle transporter 85 to a desired lateral location so that nozzles 53 and 54 carried therein are selectively positioned over a desired row of beakers in beaker tray 87.

Positioned on supporting bars 77 and 78 beneath nozzle transporter 85 is beaker tray 87. As shown in FIGS. 3-6, beaker tray 87 is comprised of an open, rectangularly shaped outer frame 110 with a plurality of cross members 111 connected thereto. Secured in such beaker tray 87 are a plurality of beakers 86, each of which functions to receive from nozzles 53 and 54 desired quantities of reagent, so that such reagents can combine to form a desired dosage, and to store temporarily such dosage. The quantity of beakers 86 and the physical arrangement thereof in the beaker tray 87 should correspond to the number and arrangement of individual locations or holes for cuvettes in the cuvette tray, as will be hereinafter explained. In the preferred embodiment, there are 18 beakers, arranged in three rows of six beakers each, in the beaker tray. Each beaker 86 is secured in a receiving ring 112 having two wings or flanges 113. Each wing or flange 113 is disposed around a mandrel 114 and secured thereto by a taper pin 115 (FIG. 6). Each mandrel is rotatably held by bearings in a cross member or, where applicable, in the outer frame. Mandrels positioned between any two beakers are continuous from one to the other so that the tilting of one beaker causes said other beaker to tilt and, accordingly, all six beakers in a row are pivotally disposed together. The mandrels 114 attached to the beakers on the end of each of the three rows protrude from the outer frame 110 and have secured thereto primary gears 118, 119 and 120 (FIG. 4). Disposed between said three primary gears 118, 119 and 120 are two intermediate gears 121 and 122, which are each pivotally attached to the outer framework 110 of the beaker tray through the similar use of mandrels, bearings and either taper pins or shaft retainer rings. Rotary motion is imparted by reversible electric motor 123 to primary gear 119 and the primary and intermediate gears act conjunctively to transmit this rotary motion simultaneously to all the rows of beakers. Reversible electric motor 123 is mounted on a flange secured to beaker tray 87 and thus moves laterally with the beaker tray.

Beaker tray 87 is slidably mounted on "V" slides attached to supporting bars 77 and 78 (only slide 124 on bar 78 is shown in FIG. 4). The lateral movement of beaker tray 87 along such slides is controlled by reversible electric motor 125 attached to the aforesaid flange secured to the tray. Electric motor 125 rotatably drives a pinion 126 positioned in a rack 127 on supporting bar 78 adjacent "V" slide 124. Beaker tray 87 is therefore movable laterally from its normal operational position to one side of nozzle subassembly for reasons that will be hereinafter explained.

Positioned on supporting bars 79 and 80 beneath beaker tray 87 is funnel tray 130. As shown in FIGS. 2, 3 and 7, funnel tray 130 is a rectangular structure having a plurality of funnels 131 secured vertically therein,

each of which functions to channel a dosage from a desired beaker to a desired sample held below funnel tray 130 as will be hereinafter explained.

Similarly to beaker tray 87, funnel tray 130 is slidably mounted on "V" slides secured to the upper surfaces of supporting bars 79 and 80, and is moved laterally thereon by reversible electric motor 132, attached to the tray, rotating a pinion in a rack. The "V" slide, pinion and rack are identical to those shown in FIG. 4.

The individual beakers 86 are arranged in beaker tray 87 and the beaker tray 87 is disposed on supporting bars 77 and 78 in its operational position in a desired space relationship with the individual funnels 131 in funnel tray 130 when it is in its operational position so that when reversible electric motor 123 tilts the beakers, the dosages therein will flow from the lips of the beakers into the appropriate funnels as shown in FIG. 7. The individual funnels in funnel tray 130 are arranged so that such dosage is transferred to a sample positioned therebelow. The quantity and arrangement of the beakers and funnels are governed by the number and arrangement of possible samples held in the cuvette subassembly.

Referring now to FIGS. 8-14, cuvette subassembly 30 will be particularly described. Cuvette subassembly 30 is preferably constructed as a removable module comprising four parallel vertical angle irons (only 136, 137 and 138 are shown) spaced apart at their lower ends by a horizontal perforated plate 140 and at their upper ends by horizontal angle irons (only 141, 142 and 143 are shown) so as to form an open rectangular structure with a perforated plate bottom. Disposed from such rectangular structure are various preselected treatment units and means to move them selectively into a desired space relationship with the samples to be tested. Secured to horizontal angle iron 141 and 143 are waste receiving hoppers 68 and 69 and a means 145 for receiving and holding stationary A tray 146 containing cuvettes 147 with samples therein. Secured between plate 140 and the lower ends of the vertical angle irons on each side of cuvette subassembly are two transverse angled flanges 149 and 150 which function to offset plate 140 and provide a pair of shoulders to seat upon angle irons 151 and 152 attached to the outer framework of processing assembly 15. Thus, the entire cuvette subassembly 30 may be slidably removed from processing assembly 15 through hinged doors or the like in the front panel (not shown). And, as previously described, once cuvette subassembly 30 is free of the outer framework, nozzle subassembly 29 may be lifted therefrom.

Each sample to be handled and tested is manually deposited in a container, such as a cuvette 147, which is placed in a particular location or hole in cuvette tray 146. In the preferred embodiment, cuvette tray 146 is a rectangular device with a plurality of vertical holes therethrough in preselected locations. The lip of each cuvette rests on a silicone rubber grommet 153 secured in such hole.

In the preferred embodiment, the quantity of 18 holes in the cuvette tray has been chosen as a convenient and economically optimum quantity (such number may of course vary) and the eighteen holes are arranged in three rows of six holes each. Accordingly, the quantity and arrangement of beakers in the beaker tray and funnels in the funnel tray shall be three rows of six each.

Generally three of the cuvettes placed in the tray contain a blank, a control and a standard, respectively (all referred to hereinafter as "samples,"). The remaining fifteen cuvettes contain samples to be processed. The loaded cuvette tray 146 is then manually, removably secured in cuvette tray holding means 145. In the preferred embodiment of this invention, cuvette tray holding means 145 consists of a pair of anodized aluminum, ball bearing slides having telescoping members to support a pair of T-shaped arms 156 and 157 protruding from the cuvette tray and permit the cuvette tray to be moved into and out of the cuvette subassembly. The slides are supported by flanges 158 and 159 secured to angle iron 142 and its counterpart as previously indicated.

Waste receiving hopper 68 functions to support the means for rinsing the beakers 86 in beaker tray 87 and to receive the waste rinsed therefrom. As shown in FIG. 8, hopper 68 is comprised of a side plate 160, front and rear plates 161 and 162, respectively, and an inner side plate 163, so as to form a hollow container. The lower portion of the hopper is sloped and functions to channel the waste fluid into a drainage pipe 164. The inner plate 163 does not completely enclose hopper 68, but rather encloses only that portion below the beaker tray's supporting bars 77 and 78 and beaker tray 87. Thus hopper 68 is open at its top to allow beaker tray 87 to be moved laterally as previously described from its normal operational position into hopper 68 as is illustrated in FIG. 8.

Secured to side plate 160 in hopper 68 are a plurality of jets 165 for rinsing and drying said beakers. Rinsing fluid and drying air is supplied to said plurality of rinse and dry jets 165 through a hose 166. Reversible electric motor 123 functions to tilt the beakers when they are properly positioned for rinsing. Each rinse and dry jet 165 is aimed such that the fluid or air dispensed therefrom will flow into the interior of a tilted beaker. Inner plate 163 is bent toward the center of the processing assembly 15 in order to act as a deflector. The rinsing fluid flowing from the jets and the waste material rinsed from the beakers is collected by hopper 68 and disposed of through drainage pipe 164.

Waste receiving hopper 69 is similarly constructed with a side plate 170, front plate 171, rear plate 172 and inner plate 173, except the upward extension of inner plate 173 stops below the funnel tray's supporting bars (only 80 is shown) sufficiently so that funnel tray 130 and its funnels 131 may move laterally into hopper 69 as is illustrated in FIG. 8. Depending from side plate 170 of hopper 69 is a means 174 for rinsing and drying the funnels contained in funnel tray 130. Funnel rinsing and drying means 174 comprises a plurality of rinse and dry jets 175 arranged such that when funnel tray 130 is laterally disposed in hopper 69, each rinse and dry jet is aimed downwardly into the mouth of a funnel. Fluid and drying air are provided to the rinse jets 175 through a hose 176 and the waste material cleansed from the funnels is collected by hopper 69 and disposed through second drainage pipe 177.

The rinse jets 165 in hopper 68 and the rinse jets 175 in hopper 69 are of the same quantity and arrangement as the beakers and funnels with which they associate. They occupy a space less than the beaker tray and funnel tray and, accordingly, fit easily in the space between the three front supporting bars and the three rear supporting bars for the nozzle transporter, beaker tray

and funnel tray. Accordingly, with the beaker tray and funnel tray in their respective normal operational positions, nozzle subassembly 29 may be lifted from cuvette subassembly 30 without any difficulty.

As shown schematically in FIG. 1, the lower portion of cuvette subassembly 30 stores additional various treatment units to be used to perform the preselected analytical process and the means 180 to move these units selectively into a desired space relationship with the cuvettes 147 in cuvette tray 146. In order to perform the previously stated desired analytical process, the preferred embodiment of this invention is described with the following treatment units contained in the lower portion of cuvette subassembly: means 181 to sense the presence or absence of cuvettes 147 in cuvette tray 146, means 182 to shake said cuvettes, and means 183 to maintain the samples in said cuvettes at preselected temperatures. Referring to FIGS. 8-13, the various treatment units and unit transporter 180 will be more particularly described.

Since the operator of the apparatus according to the invention may not wish to place a cuvette in every particular location or hole in the cuvette tray, there is preferably contained within cuvette subassembly 30 a means 181 for ascertaining or sensing if a cuvette 147 is physically located in each particular location or hole in the cuvette tray 146 and for transmitting such information to control subassembly 27. control subassembly 27 utilizes such information to cause the appropriate dispensing means 49 or 50 to dispense its reagents only when the appropriate nozzle 53 or 54 secured in nozzle transporter 85 is positioned over a beaker which will subsequently discharge its contents through a funnel into a cuvette. Cuvette sensing means 181 is preferably comprised of a hollow, rectangularly shaped supporting structure 185 which has mounted on its upper surface a plurality of guide cups 186. Depending from and running laterally along the center of the underside of structure 185 is a guidance flange 192 (FIG. 9) with a hole (not shown) through the center thereof to receive a locking pin as will hereinafter be explained. The arrangement of the plurality of guide cups 186 should be such that when the cuvette sensing means 181 is brought into its operational position, as will be hereinafter explained, each guide cup 186 is positioned to receive the lower end of a cuvette 147, if any, positioned in a particular location or hole in the cuvette tray 146.

As illustrated in FIG. 9, each guide cup 186 is preferably attached with screws to the top surface of supporting element 185. A pressure-sensitive push-button switch 187 protrudes through the top surface of supporting element 185 and extends upward into the interior of each guide cup 186. The lower portion of each switch 187 is secured to and supports a printed circuit board 188 disposed in the interior of supporting element 185. It is preferred that switch 187 be in a normally open position and close upon a desired amount of pressure being applied thereto. Thus, when the matrix of switches secured in cuvette sensing means 181 is brought into operational position under the cuvette tray 146, the absence of a cuvette 147 from such tray will cause a corresponding switch in the matrix to remain open, and the appropriate circuitry in control subassembly 27 will prevent the dispensing means 49 and 50 from depositing any reagents and forming any

dosage in the beaker corresponding to that particular location or hole.

Attached to and protruding from the center of the front and rear of structure 185 of cuvette sensing means 181 are receiving elements 189 which function to receive and secure means for imparting lateral movement to the cuvette sensing means, as will be hereinafter explained. As shown in FIG. 8, each receiving means preferably comprises an inverted "V" flange or plate with the apex thereof enlarged to form a locking recess. The planar surfaces 193 function as camming surface to guide a pin, as will hereinafter be described, into the locking recess 194.

Cuvette shaking means 182, as illustrated in FIGS. 8 and 10-12, is preferably comprised of a rectangularly shaped supporting plate 190 having upwardly extending walls 191 attached to each of its four sides. Depending from and running laterally along the center of the underside of plate 190 is a guidance flange 192 with a hole through the center thereof to receive a locking pin as will hereinafter be explained. Positioned inside the area formed by the walls and attached to the inner surface of plate 190 is an electric motor 195 which functions to provide rotary motion to motor shaft plate 196. Pin 197 is eccentrically attached to said plate 196 offset from the arbor of electric motor 195 and is movably positioned in a receiving slot 198 in receiving plate 199 secured to shaker plate 200. Receiving plate 199 preferably forms a protective cap over pin 197 and receiving slot 198 to protect the internal circuitry of cuvette shaker unit 182 from waste matter. Shaker plate 200 is rectangularly shaped and has downwardly extending walls 201 attached to each of its four sides. Shaker plate 200 and its attendant walls 201 envelop and are movably attached, such as with a resilient pad 202 which may be soft rubber, or mating and sliding Teflon blocks, to the upwardly extending walls 191 attached to supporting plate 190. Attached to the center of the front and rear of the cuvette shaker 182 are receiving elements 189 such as described with respect to cuvette sensing means 181.

Attached to the upper surface of shaker plate 200 are a plurality of shaker cups 203. The plurality of shaker cups 203 are arranged such that they form a matrix wherein each cup will be brought into communication with the lower end of a cuvette 147 in cuvette tray 146 when cuvette shaker means 182 is disposed in operable position. Each shaker cup 203 is preferably constructed of silicon rubber with a shaped recess therein to receive and firmly secure the lower end of a cuvette. Supplying power to electric motor 195 causes pin 197 to move in receiving slot 198 and thereby impart reciprocal lateral movement to shaker plate 200, which shaking motion is imparted to the lower ends of the cuvettes.

Should it be desirable to provide a means for emergency rinsing of the shaker cups in cuvette shaking means to eliminate damage from the rare instance of a cuvette breaking during the shaking operation, a series of small nozzles 205 (shown in FIG. 8) can be secured to the underneath of the shelf supporting cuvette sensing means 181 and each shaker cup 203 can have therein angular drain holes 206 as shown in FIG. 12. Rinsing fluid is provided through hose 207. Such rinsing fluid, breakage and other waste may run off of cuvette shaking means and be caught in a pull-out rinse pan 208 in the lower part of processing assembly 15.

In the preferred embodiment of processing assembly 15, the means 183 for maintaining the samples held in the stationary cuvettes at a preselected temperature comprises a plurality of fluid baths, each of which functions to maintain fluid at a desired temperature so that when one of such fluid baths is brought into its operable position, the lower ends of the cuvettes 147 in cuvette tray 146 are immersed therein and the sample is brought to and maintained at the temperature of the fluid. As illustrated in FIG. 8, each fluid bath 210, 211 and 212 is comprised of a rectangularly shaped bottom plate with upwardly extending walls attached thereto so as to form a water container having an open top. Depending from and running laterally along the center of the underside of each of the fluid baths 210, 211 and 212 is a guidance flange 192 similar to that previously described with respect to the cuvette sensing means 181 and the cuvette shaker 182. Attached to the front and rear of each fluid bath are receiving elements 189 such as described with respect to cuvette sensing means 181. A desired fluid, such as water, is stored therein and maintained at a desired temperature by an immersible heater 213, such as a Crom-a-lox strip. An immersible thermostatic control cartridge 214 controls the temperature of the fluid. Both the immersible heater and thermostat are preferably mounted in the fluid baths in such a position that electric wires may provide them power regardless of the position of the baths within the cuvette subassembly.

A float switch is provided to insure that the fluid in the container remains at a desired level. If additional fluid is heeded, it is provided through the tubes 214a positioned over each water bath in its storage position.

Cuvette sensing means 181, cuvette shaker 182, and fluid baths 210, 211 and 212 are each stored within cuvette subassembly 30 on shelves attached to the angle irons 136, 137, 138 and 139. The shelves 216, 217 and 218 for the three fluid baths 210, 211 and 212, respectively, are mounted one above the other along one side of cuvette subassembly 30; the uppermost fluid bath 210 is mounted below the lower end of the cuvettes contained in cuvette tray 146. The shelf 219 for cuvette sensing means 181 and the shelf 220 for cuvette shaking means 182 are mounted one above the other on the other side of cuvette subassembly 30; cuvette sensing means 181 is mounted below the cuvettes in cuvette tray 146. Accordingly, there exists a free space region within cuvette subassembly 30 below the cuvettes in cuvette tray 146 and between the fluid baths, on the one hand, and cuvette sensing means and cuvette shaking means on the other hand. Each such shelf is preferably comprised of a flat, rectangular supporting plate of some smooth material, having a groove laterally therethrough adapted to receive the guidance flange 192 of the treatment unit to be stored thereon. Each treatment unit, although securely maintained on its shelf, remains free to slide therefrom into the free space region in the interior of cuvette subassembly 30.

Provided in the lower portion of cuvette subassembly 30 is a means 180 for removing selectively each of the various treatment units from its respective storage shelf, elevating said unit to its proper operational position with respect to cuvette tray 146, and then returning such treatment unit to its proper shelf when its operation is complete. As shown in FIGS. 8 and 13, such

transport means 180 is preferably comprised of an elevator platform 225 of suitable material, such as a corrosive-resistant aluminum alloy, with Teflon strips set in its top surface 226 to facilitate sliding of the treatment units, and with both ends thereof having upwardly extending antifriction strips to guide and secure the ends of said treatment units. Said elevator platform 225 should have a width sufficient to support the physical treatment units but still be able to move freely vertically through the free space area in the interior of cuvette subassembly. Additionally, the depth from front to rear of elevator platform 225 should be sufficient to extend beyond the front and rear of shelves 216, 217, 218, 219 and 220 but still allow unfettered movement of said elevator platform vertically through the free space area. Formed laterally along the center of the upper portion of platform 225 is a slot or groove 229 adapted to receive the guidance flange 192 of the treatment unit to be stored thereon. As shown more particularly in FIG. 14, secured to the underside of the upper surface 226 of platform 225 is a spring-loaded solenoid 222 which functions when energized to drive a reciprocally slidable locking pin 223 through a hole 224 formed in slot 229. When solenoid 222 is deenergized, the locking pin 223 is withdrawn. The guidance flange 192 on each of the treatment units slides into and mates with lateral groove 229 of the platform. Hole 224 mates with the hole in the flange 192. Locking pin 223 extends and secures the treatment unit to the platform.

Attached to the front and to the rear ends of elevator platform 225 are casings 227 and 228 (FIGS. 8 and 13), which function to house and secure therebetween means to impart lateral movement to the treatment units. Each casing extends laterally in cuvette subassembly 30 to the vertical plane 230 and 231 (shown by dashed lines in FIG. 8) in which will be located the slotted receiving elements attached to the various treatment units when such units are stored on their respective shelves. Rotatably secured to the inside of casing 227 and 228 are a plurality of rotatable sprockets; FIG. 8 illustrates sprockets 232, 233, 234, 235, 236 and 237 in casing 227, and there are corresponding sprockets (not shown) in end casing 228. Secured around sprockets 233, 234, 235, 236 and 237 in casing 227, as well as around the counterpart sprockets in casing 228, are flexible drive means 239, such as endless chains. Firmly attached to each of said chains and extending inwardly therefrom is a pin 240 and 241; the two pins 240 and 241 correspond in lateral position to each other.

Secured between the center of sprocket 232 in casing 227 and the center of its corresponding sprocket in casing 228 is a mandrel 242. Such mandrel 242 passes through and is secured to a reversible electric gear motor 243 secured to the underside of elevator platform 225. Secured around sprockets 232 and 233 in casing 227, as well as around their counterparts in casing 228 (sprocket 233 and its counterpart being a double socket), are other flexible drive means 244, such as endless chains. Reversible electric motor 243 imparts rotary motion to mandrel 242, which in turn rotates sprocket 232 in end casing 227 and its corresponding sprocket (not shown) in end casing 228, thereby moving the chains wrapped therearound and driving sprocket 233 located in end casing 227 and its corresponding sprocket (not shown) located in end casing 228. Rotation of sprocket 233 and its corresponding sprocket moves chains 239 and pins 240 and 241,

thereby transducing the rotary motion to lateral motion. Thus, reversible electric motor 243 functions to position pins 240 and 241 laterally in the unit transporter 180.

Secured to the outer surfaces of casings 237 and 238 are flanges or wings 245 and 246, respectively, each of which has a traveling nut 247 and 248, respectively, fixedly housed vertically therein. Each traveling nut 247 and 248 has a vertical aperture therethrough which is appropriately grooved to receive a vertically extending screw 249 and 250, respectively, one of said screws having righthand threads and the other having lefthand threads. Screws 249 and 250 are rotatably secured to the framework of cuvette subassembly. Reversible electric motor 251, also secured to the framework of cuvette subassembly, produces rotary motion which is transmitted via mandrel 252 and ordinary miter gear arrangements to each of said screws. Revolution of screws 249 and 250 causes fixed nuts 247 and 248, and the wings in which they are attached, to move in a vertical direction. Thus, reversible electric motor 251 functions to position vertically said elevator platform 225 and its attendant casing 227 and 228.

The processing assembly preferably contains certain components not illustrated herewith, such as, pullout rinse pans and control, power, waste and fluid connections. The metallic components of the processing assembly should preferably be constructed of a light but strong material coated with an anti-corrosive material. all control, power, waste and fluid connections between the framework of the processing assembly and the various subassemblies therein are preferably releasable simply by removing the subassembly from within the framework of the processing assembly. The power and control connections between the appropriate subassembly and the various movable components housed therein should either be flexible enough to follow the movement of the component or be located such that the component will releasably connect therewith whenever it is in a position requiring power and control. Thus, each subassembly and component therein is "unitized" to facilitate easy maintenance. And change-over from one analytical process to another may easily be accomplished by changing one or more of the program of the control subassembly, the reagents in the containers or the selection of the various treatment units.

Although the embodiment of the invention described herein does not illustrate a spectrophotometer or other testing device positioned within the processing assembly, such could easily be maintained therein in accordance with this invention.

In operation, cuvette tray 146 is loaded with cuvettes containing samples and stationarily secured within cuvette subassembly 30. Module 31 in control subassembly 27 preferably contains electronic components sophisticated enough to accept programmed instructions controlling the manner, sequence and timing of the separate operations in the desired analytical process, and to generate the necessary electrical signals to cause the other components and subassemblies of the processing assembly to carry out properly such instructions. A small, general purpose digital computer, a perforated control card or magnetic tape system adequately accomplishes such a result. For purposes of describing this invention, it will be assumed that such a control system has been programmed to cause the vari-

ous other subassemblies and components thereof to accomplish the analytical process previously stated.

Initially, an electrical signal of proper polarity is applied to reversible electric motor 243 for a time duration necessary to move pins 240 and 241 secured to chains 239 into some preselected position, preferably near the center of the platform 225, so they will not hinder the vertical movement of the platform. An electrical signal of proper polarity is then applied to reversible electric motor 251 in the treatment unit transporter 180 for the time duration necessary to raise the platform 225 to a position in the free space area of cuvette subassembly 30 such that its top surface 226 is horizontal with the lower surface of cuvette sensing means 181 stored on shelf 219. Once elevator platform 225 and its attendant end casings are being brought into the proper vertical position, an electrical signal of proper polarity is applied to reversible electric motor 243 for a time duration necessary to move pins 240 and 241 into the desired position to grasp the slotted receiving elements 189 on the front and rear of cuvette sensing means 181. The pins 240 and 241 first move into engagement with the camming surfaces and then into the locking recesses of the slotted receiving elements. As the pins continue to move laterally toward the interior of cuvette subassembly, cuvette sensing means 181 is pulled onto the surface of elevator platform 225 and moved laterally toward the center thereof. The guidance flange protruding from the underneath of cuvette sensing means 181 will slide into the receiving slot in platform 225. An appropriately placed switch can be utilized to instruct the control system in control assembly as to when cuvette sensing means 181 is properly centered. Power to electric motor 234 is discontinued and power is supplied to solenoid 222 to drive pin 223 into the hole in the guidance flange 192. Once cuvette sensing means 181 is centered and secured on elevator platform 225, power is again supplied to electric motor 251 to cause cuvette sensing means 181 to be raised into its desired operational position wherein the lower portion of each cuvette 147 positioned in a particular location or hole in cuvette tray 146 is received by the appropriate guide cup 186 and actuates the pressure-sensitive element therein. Again, appropriately positioned pressure or limit switches may be utilized to instruct the control system of the position of cuvette sensing means 181.

At the beginning of the operation the dispensing means 49 and 50 had been set to form the desired dosages in the beakers. As the cuvette sensing means 181 is held in operating position under cuvettes 147 in cuvette tray 146, electrical signals are generated by cuvette sensing means 181 to inform the control system which holes in cuvette tray 146 contain cuvettes. Electrical signals of the proper polarity and time duration are transmitted to reversible electric motors 93 and 104 to position sequentially nozzle 53 and/or nozzle 54 over each of the beakers 86 which corresponds to a hole in cuvette tray 146 containing a cuvette. When the desired nozzle 53 or 54 is positioned over a beaker under which the cuvette sensor signals that there is a cuvette, an electrical signal is applied to the dispensing means 49 or 50 associated therewith to cause it to transfer the desired amounts of reagents from its inputs to such beaker.

Upon the desired dosages being formed in the proper beakers, an electrical signal of proper polarity is ap-

plied to electrical motor 123 attached to beaker tray 87. All of the beakers tilt, and the dosages are funneled simultaneously into the cuvettes where they combine with the samples.

Simultaneously with the funneling of the dosages into the cuvettes, the cuvette sensing means 181, having completed its desired operation, is returned to its shelf by unit transporter 180. Unit transporter 180 accomplishes this transfer by reversing the steps stated above.

The cuvette sensing means 181 being in storage on its shelf 219, electrical signals are transmitted to unit transporter 180 to remove cuvette shaker 182 from its shelf and bring it into its operational position wherein each of the cuvettes 147 in cuvette tray 146 is engaged in a shaker cup 203 and has been lifted a sufficient amount to disengage its lip from the silicone rubber grommet 153 in the hole in the cuvette tray. Electric motor 195 in cuvette shaker 182 is then driven for a desired time duration to shake the cuvettes.

Preferably contemporaneously with the shaking operation, electric motors 125 and 132 are driven so as to move beaker tray 87 and funnel tray 130, respectively, into waste receiving hoppers 68 and 69, respectively. Electric motor 123 is again energized to tilt the beakers. There, rinse jets 165 and 175 wash the residue of the dosages from the beakers and funnels. Once the beakers and funnels are clean, beaker tray 87 and funnel tray 130 can be returned to their operational positions in the center of nozzle subassembly 29.

Once the samples in the cuvettes have been sufficiently shaken, the unit transporter 180 is energized to return cuvette shaker to its shelf. the proper one of the fluid baths is then selected and moved to its operational position so that the cuvettes are maintained at a preselected temperature for a preselected duration of time.

Our invention, therefore, provides a novel method and apparatus for treating and handling a plurality of samples wherein the samples are stationarily held in a desired position and the individual treatment units are brought into a desired space relationship with the samples. Each treatment unit performs its operation simultaneously on all of the samples.

The invention has been described with respect to a particular embodiment. However, many variations and modifications will now be apparent to those having skill in the art. Therefore, the foregoing disclosure and description of the invention are only illustrative and explanatory, and various changes in the components, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. An apparatus for automatically handling and treating a plurality of discrete samples to perform preselected operations thereon, comprising:

a plurality of containers, each of which contains one of said samples;
means for holding stationary said containers, said container holding means having a particular location therein for each of said containers, said locations being positioned in a desired arrangement;
means for sensing which locations in said container holding means have containers held therein;
a plurality of first means for storing reagents used for relatively permanent storage of said reagents;

a plurality of second means for storing reagents used for temporary storage of said reagents, the number and arrangement of said plurality of second storage means corresponding to the number and arrangement of said locations in said container holding means;

means for transferring a preselected quantity of the reagents stored in at least one of said first storage means into at least one of said second storage means to form a desired dosage in at least one of said second storage means;

said reagent transferring means transferring reagents into and forming a dosage only in the one or ones of the second storage means associated with said locations in said container holding means having containers held therein;

means for transferring simultaneously from each of said second storage means said dosages temporarily stored therein to said containers held in said container holding means;

a plurality of means for performing desired operations on said plurality of samples, each of said performing means being movable with respect to said sample containers held in said container holding means;

means for selectively transporting each of said performing means into a desired operational relationship with said stationary sample containers and for maintaining said performing means in said relationship so that each of said performing means may perform its particular operation; and

means for controlling the operation of said first and second storage means, said reagent transfer means, said dosage transfer means, each of said performing means and said transporting means according to a preselected set of instructions.

2. An apparatus according to claim 1, wherein:

each of said second storage means has an opening therein above the normal storage level of the dosage temporarily stored therein;

said dosage transfer means comprises: means for tilting simultaneously each of said second storage means so that the dosages contained therein are simultaneously released through said opening, and means for funneling said dosages simultaneously into said sample containers;

said second storage means, said funneling means and said sample containers are arranged with respect to each other so that when said second storage means are tilted, said dosages flow by force of gravity from said second storage means through said funneling means to said containers;

said means for performing desired operations include: at least one means for containing and maintaining fluid at a desired temperature so that said sample containers may be at least partially immersed therein and brought to and maintained at a desired temperature, and means for supplying a desired shaking motion to said sample containers held in said container holding means;

said reagent transfer means comprises: means for holding at least one nozzle, said nozzle holding means being positioned in a desired spaced relationship with said particular locations in said container holding means and being movable so as to bring said nozzle selectively into a desired spaced relationship with each particular location in said

container holding means, at least one hose communicating between said nozzle and said first storage means, and means for selectively permitting and interrupting the flow of said reagent from said first storage means through said hose and out said nozzle,

means for cleansing said second storage means and said funneling means,

means for transporting said second storage means and said funneling means to a desired location in relation to said cleansing means so that said cleansing means may perform its particular operation, and

means for receipt and disposal of waste from said cleansing means, said receipt and disposal means being positioned in a desired location with relation to said cleansing means,

said control means also controlling the timing and operation of said cleansing means and said means for transporting said second storage means and said funnel means.

3. An apparatus according to claim 2, wherein: said apparatus is of modular construction and adapted to function as a component of a modularized automated system containing other components performing additional analytical procedures.

4. An apparatus for automatically handling and treating a plurality of discrete samples to perform preselected operations thereon, comprising:

means for holding the plurality of samples, the samples and the holding means remaining stationary during the performance of the desired operations on the samples;

the holding means comprising:

a plurality of containers, each of which contains one of the samples, and

means for holding stationary the containers, the container holding means having a particular location therein for each of the containers, the locations being positioned in a desired arrangement;

a plurality of means for performing the preselected operations on the plurality of samples, each of the performing means being movable with respect to the sample holding means and the samples; and

means for selectively transporting each of the performing means into a preselected operational relationship with the stationary sample holding means and the samples and for maintaining the performing means in the relationship so that the performing means may perform its particular operation;

one of the performing means performing the operation of adding a desired dosage to each of the plurality of samples and comprising:

a plurality of first means for storing reagents, the first storage means being used for relatively permanent storage of the reagents,

a plurality of second means for storing a dosage of reagents, the second storage means being used for temporary storage of the reagents, the number and general arrangement of the plurality of second storage means corresponding to the number and arrangement of locations in the container holding means, each of the second storage means having an opening therein above the normal storage level of the dosage temporarily stored therein,

means for transferring a desired quantity of the reagents stored in at least one of the first storage means into at least one of the second storage means to form the desired dosage of reagents in at least one of the second storage means, and 5

means for transferring simultaneously from the second storage means the dosages temporarily stored therein to the containers held in the container holding means, each of the second storage means being associated with a particular location in the container holding means and transferring the dosage temporarily stored therein to a particular one of the containers held in the particular location, the dosage transfer means including: 10

means for tilting simultaneously each of the plurality of second storage means so that the dosage contained therein is released through the opening, and 15

means for funneling the dosages into the containers, the second storage means, the funneling means, and the containers being arranged with respect to each other so that the dosages flow by force or gravity from the second storage means through the funneling means to the containers; 20

5. An apparatus according to claim 4, including: 25

means for cleansing the second storage means and the funneling means;

means for moving the second storage means and the funneling means to a preselected location in relation to the cleansing means so that the cleansing means may perform its particular operation; and 30

means associated with the cleansing means for receipt and disposal of waste from the cleansing means.

6. An apparatus in accordance with claim 4, wherein the reagent transfer means includes: 35

movable means for holding at least one nozzle in a desired spaced relationship with the locations in the container holding means;

means for moving the nozzle holding means so that the nozzle held therein may be positioned in a preselected spaced relationship with each location in the container holding means; 40

at least one hose communicating between the nozzle and the first storage means; and

means for selectively permitting and interrupting the flow of the reagent from the first storage means through the hose and out the nozzle.

7. An apparatus according to claim 4, wherein: 45

one of the performing means performs the operation of sensing whether a container is held in a particular location in the container holding means; and

the reagent transferring means transfers reagents into and forms a dosage only in the particular one or ones of the second storage means associated with a particular location in the container holding means having a container held therein.

8. An apparatus according to claim 4, wherein the plurality of performing means also include: 50

at least one means for containing and maintaining fluid at a desired temperature so that the samples in said containers may be immersed therein and brought to and maintained at the desired temperature;

means for supplying a desired shaking motion to the containers held in said container holding means; and

means for sensing whether a particular location in the container holding means contains a container.

9. An apparatus according to claim 8, including: 55

shelves storing each of the fluid containing means, the container shaker means, and the container sensing means; and the means for selectively transporting each of the fluid containing means, the container shaker means, and the container sensing means comprises: 60

a platform,

means for vertically raising and lowering the platform and maintaining the platform in any desired position along its vertical path, and

means associated with the platform for grasping each of the container shaker means, container sensing means, or fluid containing means and moving each of such means from the shelf provided therefor onto the platform and from the platform back onto the shelf. 65

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