United States Patent [19]

Liston

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[45] **June 18, 1974**

[54] **CHEMICAL DISPENSER**

[75] Inventor: **Max D. Liston,** Irvine, Calif.

[73] Assignee: **Abbot Laboratories,** North Chicago, Ill.

[22] Filed: **May 3, 1973**

[21] Appl. No.: **357,065**

Related U.S. Application Data

[62] Division of Ser. No. 133,081, April 12, 1971, abandoned.

[52] **U.S. Cl.** ..... **222/1,** 23/259, 73/423 A, 222/145, 222/309

[51] **Int. Cl.** **G01f 11/16**

[58] **Field of Search** ..... 222/145, 309, 386, 1; 73/425.6, 425.4 P, 423 A; 23/259

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Primary Examiner—Stanley H. Tollberg
Assistant Examiner—Thomas E. Kocovsky
Attorney, Agent, or Firm—Molinare, Allegretti, Newitt & Witcoff

[57] **ABSTRACT**

The disclosure describes a specimen dispenser in which first and second syringes are used to dispense a sample liquid and a reagent liquid. The inlet orifice of the second syringe is connected to a second end opening of the first syringe through a three-way valve so that the first syringe is purged by reagent liquid each time a dispensing operation is completed.

10 Claims, 16 Drawing Figures

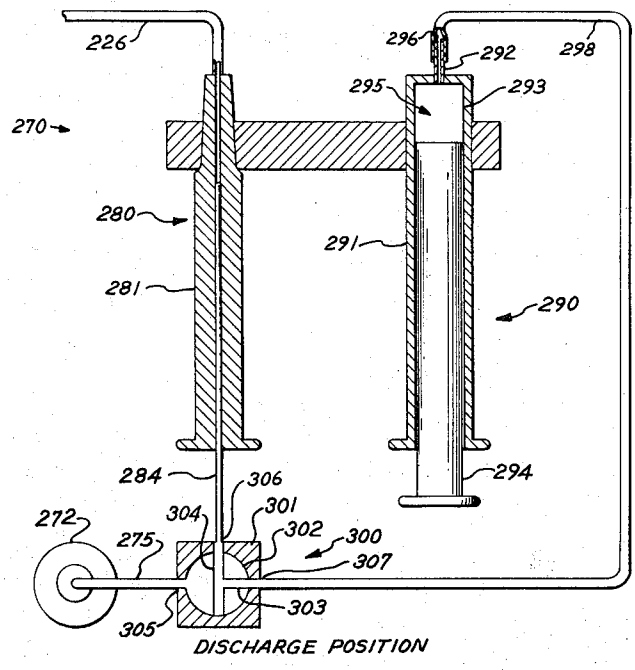
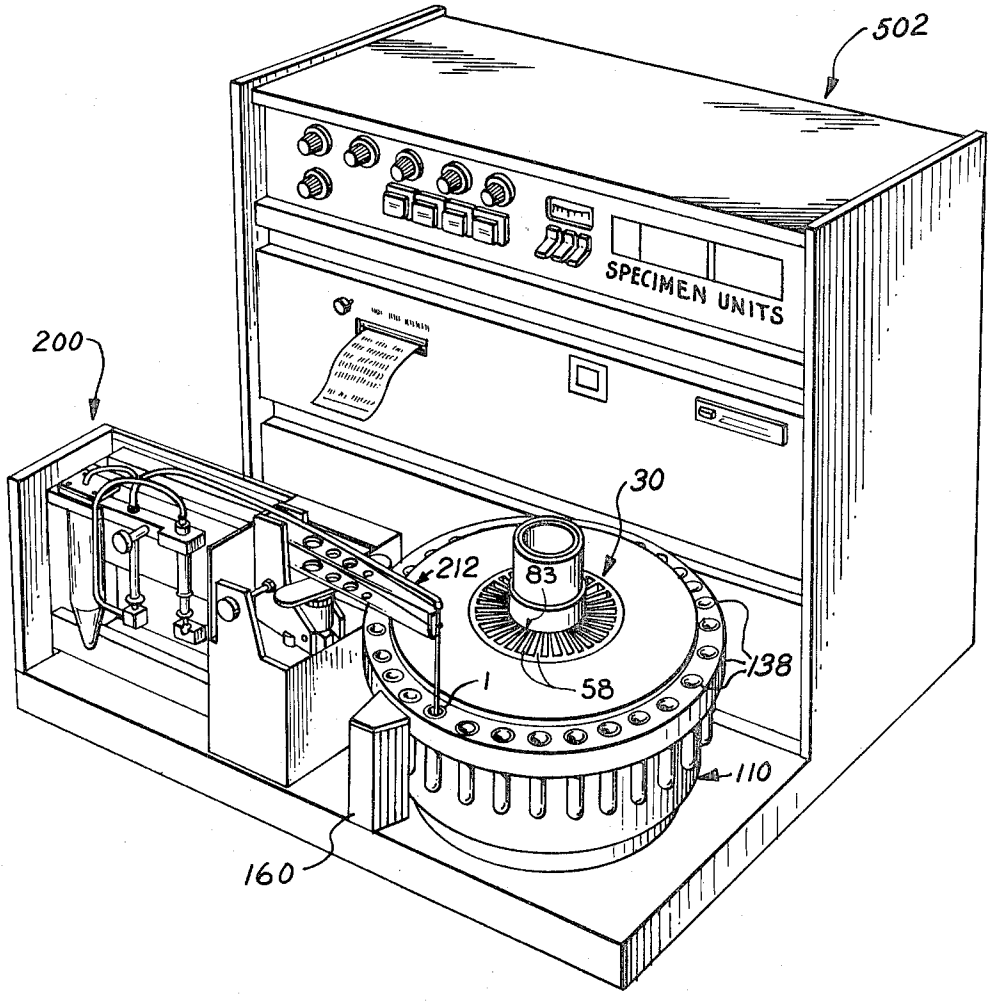


Fig. 1



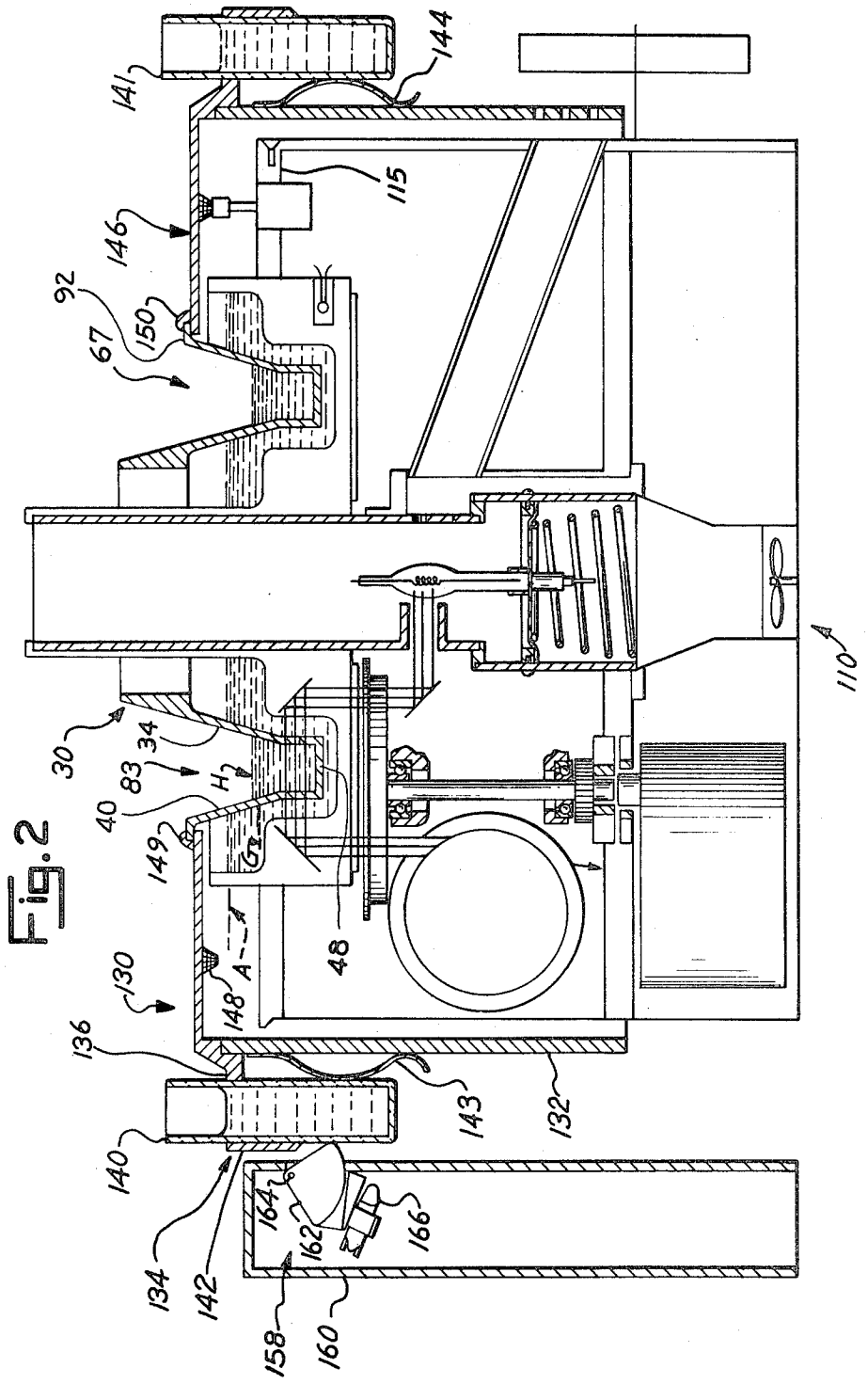
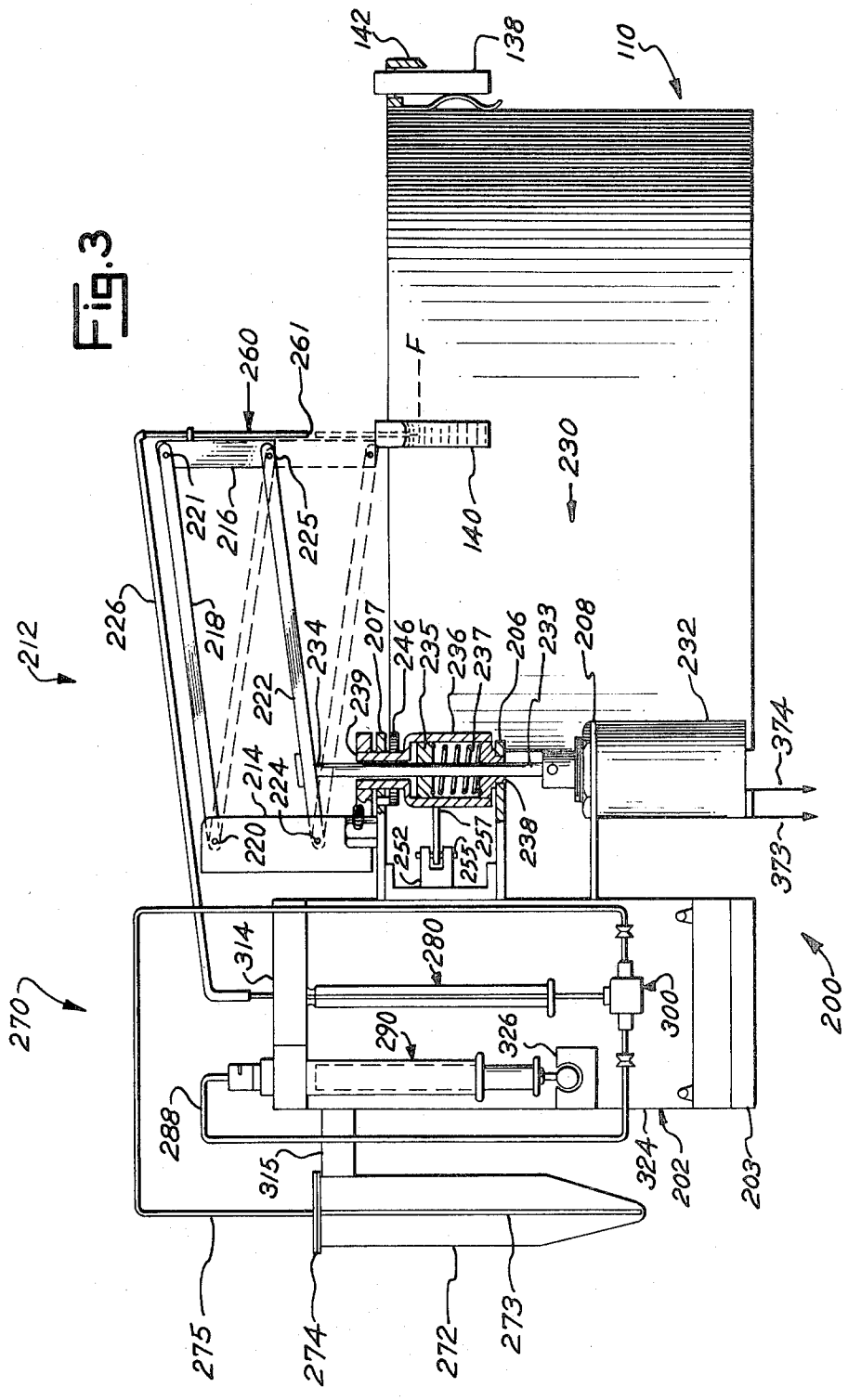

141
144
115
146
92
67
150
110
30
34
83
H_2
40
149
G_1
48
A
A
130
148
136
143
132
140
134
142
164
162
166
158
160

Fig. 2

Fig. 3


142
138
110
260
261
F
230
140
221
216
225
226
218
234
207
246
235
236
237
206
233
208
232
212
222
239
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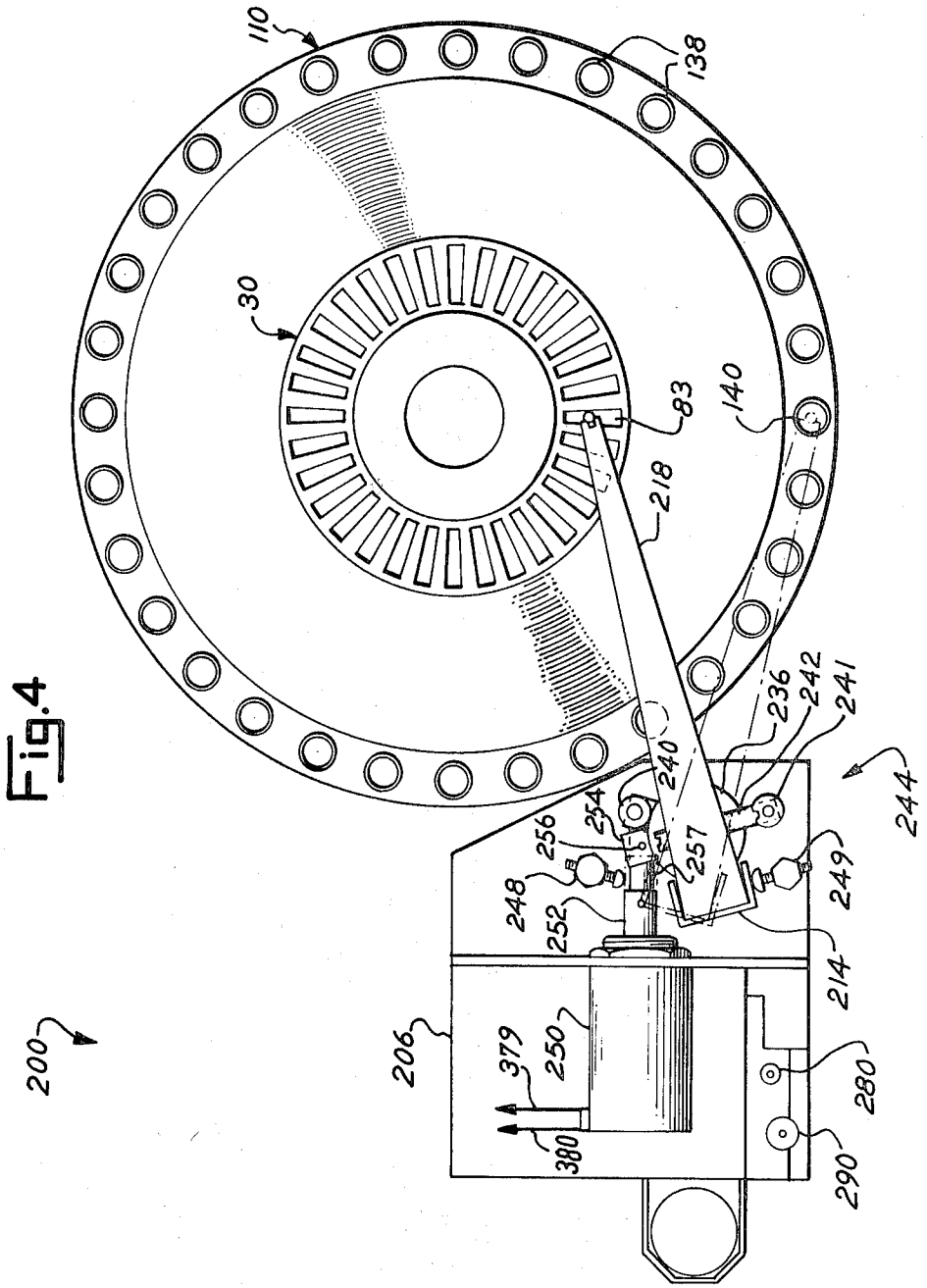

110
138
30
83
140
218
236
242
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244
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214
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380
290
200

Fig.4

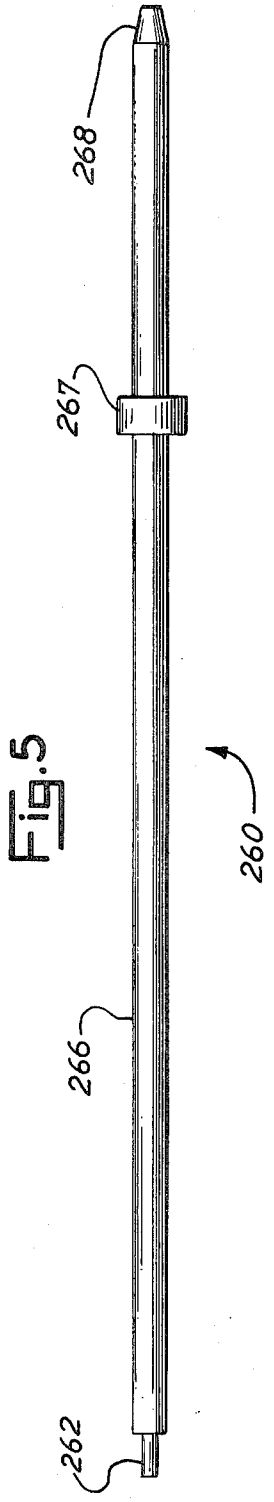


Fig. 5

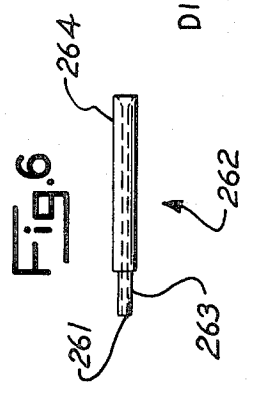


Fig. 6

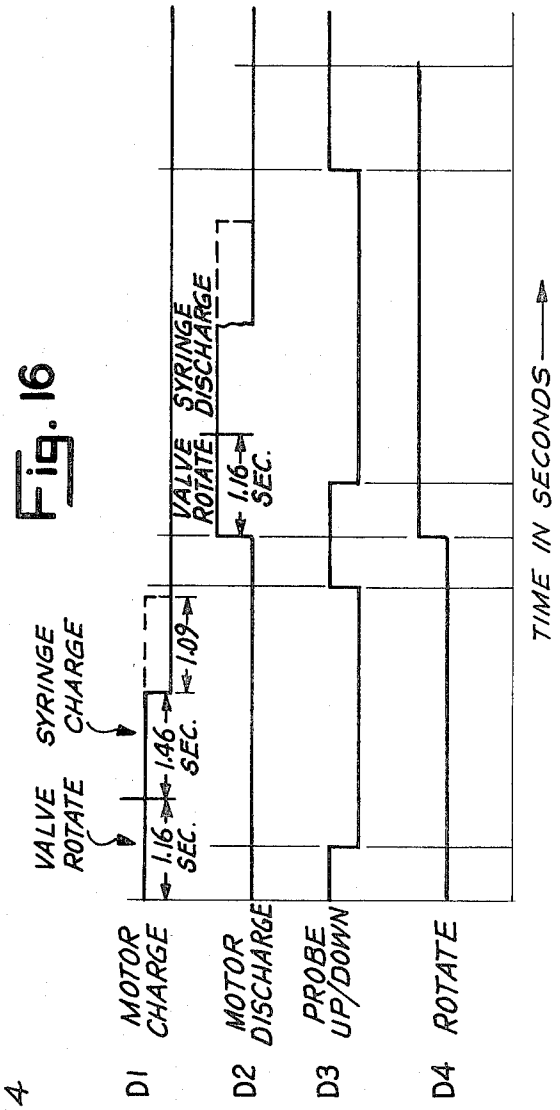


Fig. 16

Fig. 7

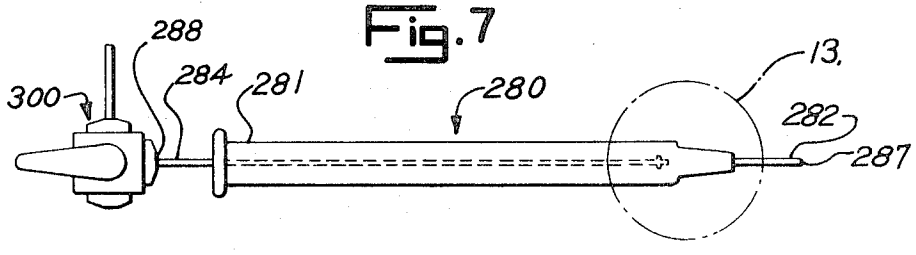
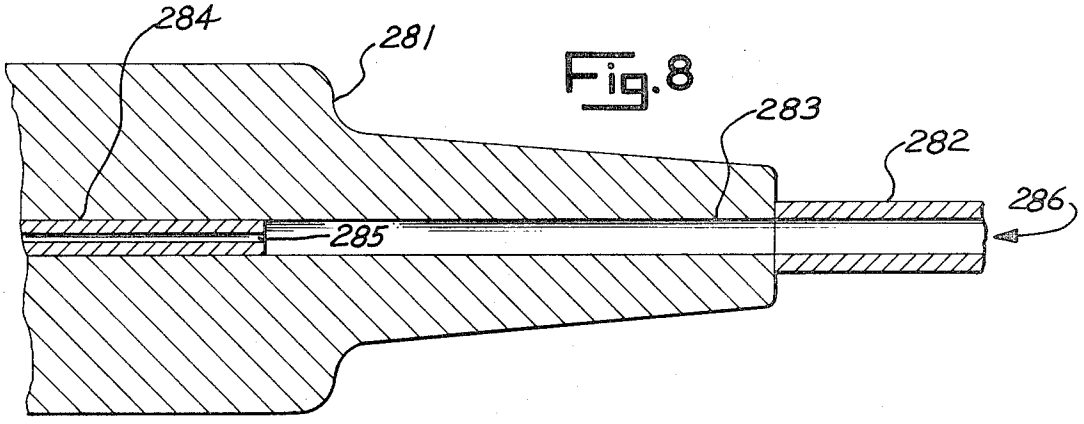
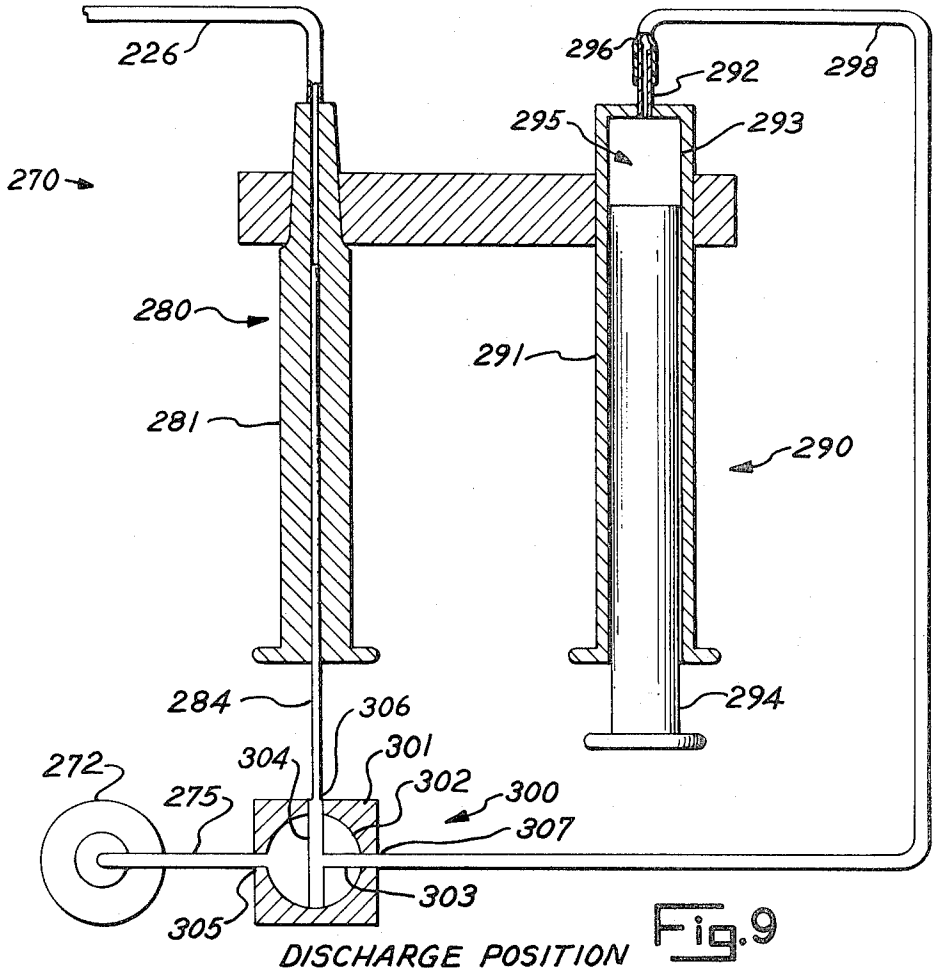
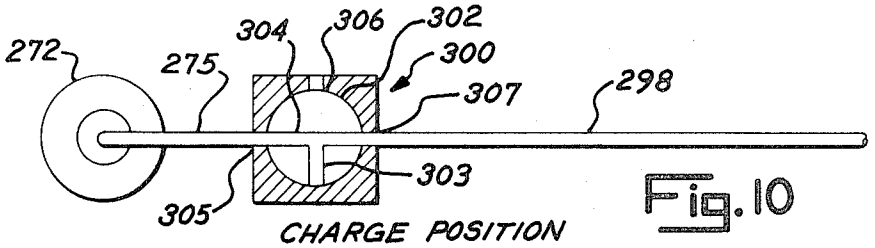


Fig. 8





DISCHARGE POSITION Fig. 9



CHARGE POSITION Fig. 10

Fig. 11

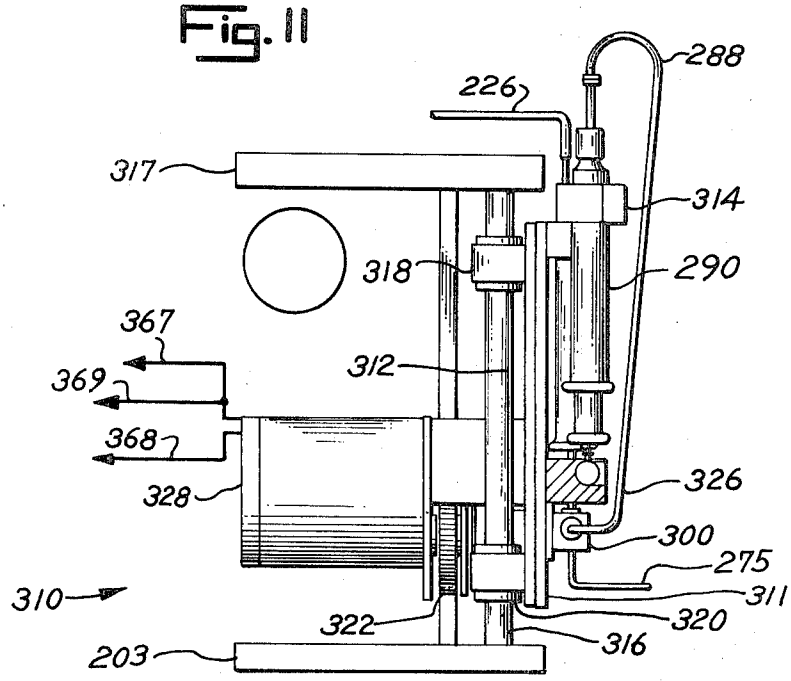
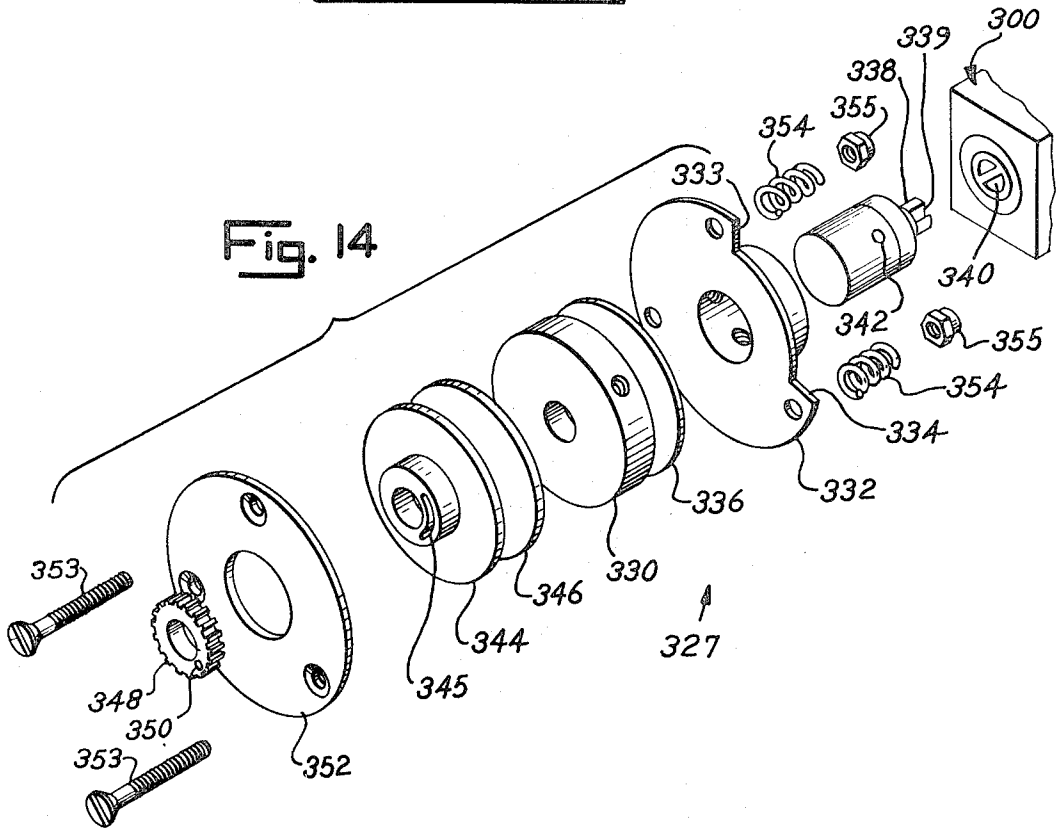

288
226
317
314
318
290
367
312
369
368
328
326
300
275
311
310
322
320
316
203

Fig. 14


300
339
338
355
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348
350
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352

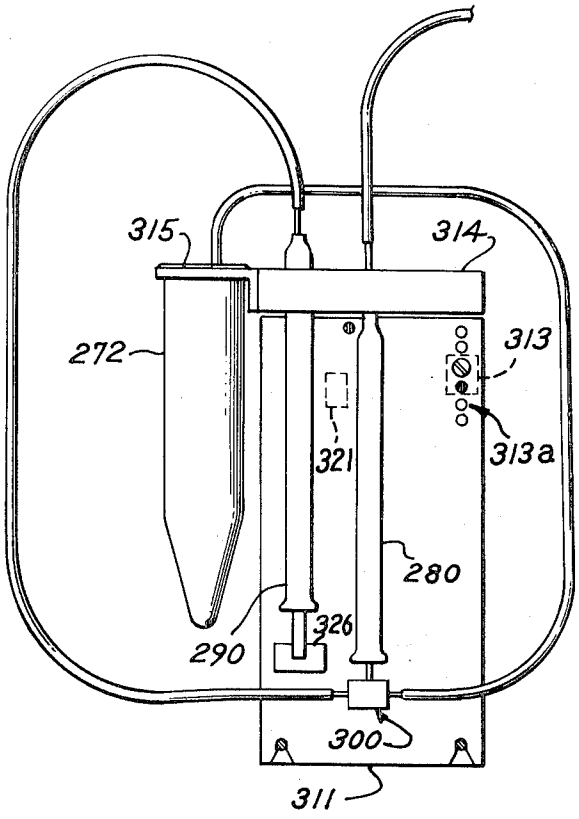

315
314
272
313
321
313a
280
326
290
300
311

Fig. 12

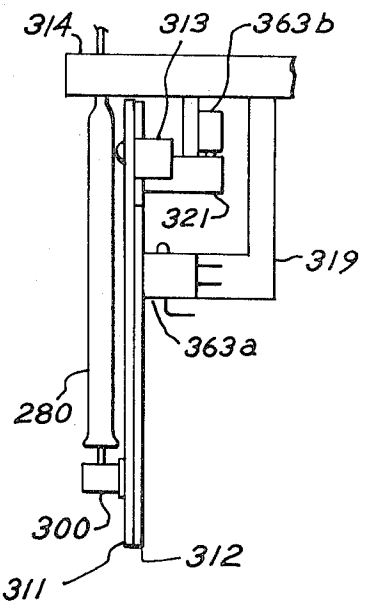
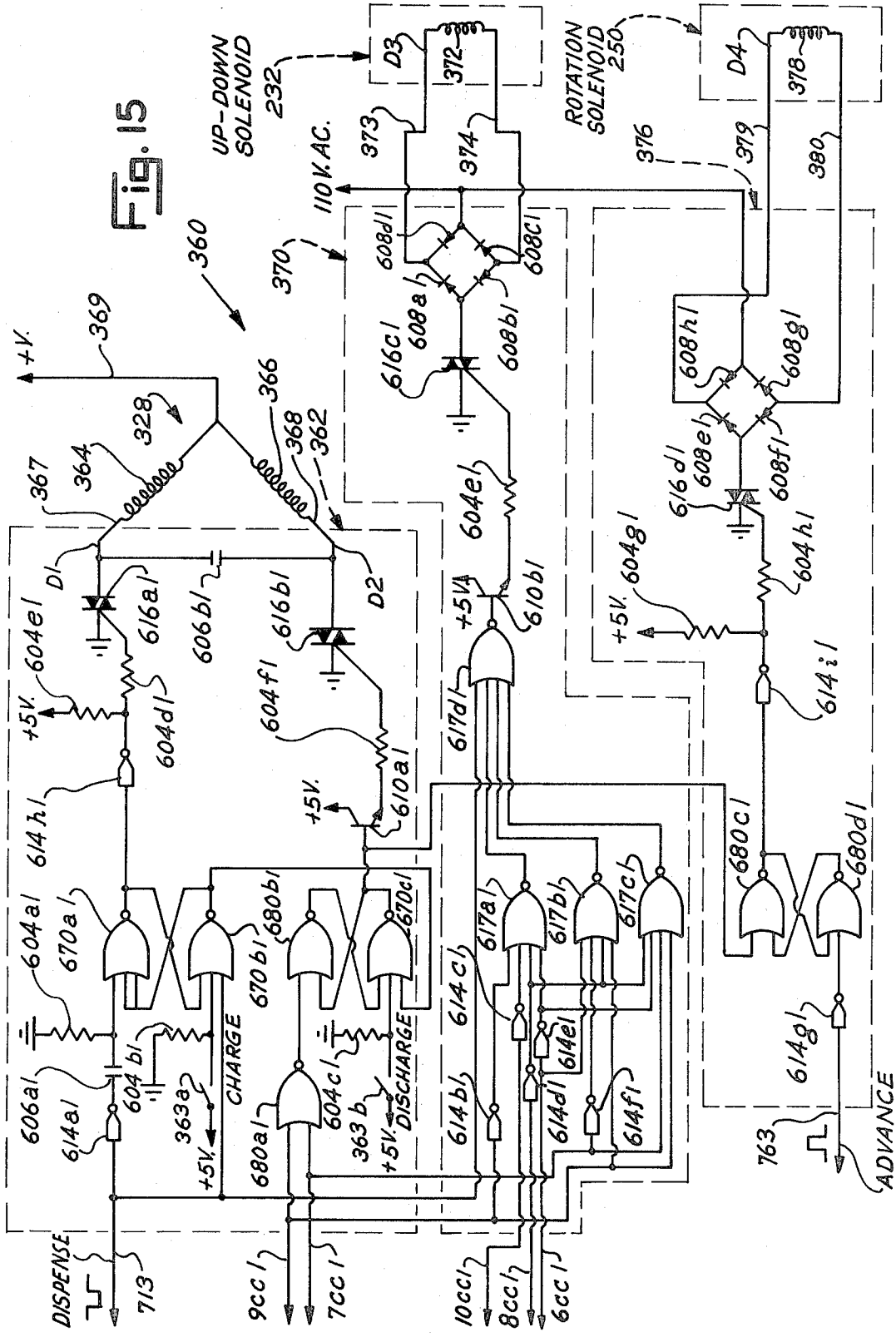

314
313
363b
321
319
363a
280
300
312
311

Fig. 13

Fig. 15


UP-DOWN SOLENOID
232
ROTATION SOLENOID
250
110 V. AC.
360
370
369
+V.
328
366
368
362
364
367
D1
D2
D3
D4
372
373
374
376
378
379
380
608d1
608c1
608a1
608b1
608h1
608g1
608e1
608f1
616c1
616d1
616a1
616b1
604e1
604d1
604f1
604g1
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604c1
606a1
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610a1
610b1
614h1
614i1
614a1
614b1
614c1
614d1
614e1
614f1
614g1
617a1
617b1
617c1
617d1
670a1
670b1
680a1
680b1
680c1
680d1
+5V.
+5V.A
363a
363b
CHARGE
DISCHARGE
DISPENSE
713
9cc1
7cc1
10cc1
8cc1
6cc1
763
ADVANCE

CHEMICAL DISPENSER

RELATED APPLICATION

This application is a division of my application Ser. No. 133,081, filed Apr. 12, 1971, entitled "Digital Chemical Analysis Apparatus," now abandoned.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to chemical dispensing apparatus and more particularly relates to apparatus adapted to dispense and mix minute quantities of fluid.

In order to rapidly analyze the concentration of a particular substance present in a chemical specimen, such as blood, chemists are placing increasing reliance on various types of machines. Such machines devised in the past may be divided into at least the following types:

1. Blood gas analyzers;
2. Prothrombin time determining systems;
3. Flow systems;
4. Electromechanical methods not related to colorimetry; and
5. Monochromatic servomechanism systems.

Although such machines have somewhat reduced the labor involved in performing chemical analysis, they have exhibited many deficiencies that have limited their overall usefulness.

For example, prior art specimen dispensers used with the machines are difficult to load and clean.

According to a principal feature of the invention, applicant's dispenser comprises two cavities, such as syringe barrels, each fitted with means for changing the volume of the cavities, such as plungers. By interconnecting the barrels and plungers in the manner described herein, the applicant has found that the dispenser will mix sample and reagent fluid with a degree of accuracy heretofore unattainable. In addition, the dispenser has a selfpurging feature which significantly reduces contamination and also reduces the volume of sample and reagent fluid required for each analysis.

DESCRIPTION OF THE DRAWINGS

These and other advantages and features of the present invention will herein after appear for purposes of illustration, but not of limitation, in connection with the accompanying drawings, in which like numbers refer to like parts throughout, and in which:

FIG. **1** is a perspective view of a preferred form of apparatus made in accordance with the present invention;

FIG. **2** is a cross-sectional, fragmentary, partially schematic view showing the cuvette assembly, carrousel assembly, cycling apparatus, positioning apparatus, and a portion of the analyzing apparatus of the preferred embodiment;

FIG. **3** is a front elevational view of a preferred form of a dispenser assembly made in accordance with the present invention, with the hood and cabinet thereof removed, the probe holding assembly of the dispenser assembly being positioned over a test tube of the carrousel assembly;

FIG. **4** is a top plan view of the apparatus shown in FIG. **3** in which the probe holding assembly is positioned over the cuvette assembly;

FIG. **5** is a side elevational view of a preferred form of a probe assembly used in connection with the dispenser assembly;

FIG. **6** is an enlarged, side elevational view of a preferred form of a probe nozzle used in connection with the probe assembly;

FIG. **7** is an enlarged, top plan view of a valve and a microsyringe shown in FIG. **3**;

FIG. **8** is an enlarged, fragmentary, cross-sectional view of the like-numbered encircled portion of FIG. **7**;

FIG. **9** is an enlarged schematic diagram of the syringes and valve shown in FIG. **8** during a discharge mode of operation;

FIG. **10** is an enlarged, fragmentary, schematic diagram of the valve shown in FIG. **14** during a charge mode of operation;

FIG. **11** is a fragmentary, side elevational view of a portion of the dispenser assembly shown in FIG. **3**;

FIG. **12** is a front elevational view of the removable plate of the dispenser assembly, together with the apparatus connected thereto;

FIG. **13** is a fragmentary, side elevational view similar to FIG. **16** and showing additional apparatus used to operate the dispenser assembly;

FIG. **14** is an enlarged exploded view of a portion of the apparatus shown in FIG. **13**;

FIG. **15** is a schematic diagram of a preferred circuit used to control the dispenser assembly; and

FIG. **16** illustrates certain signal waveforms produced by the circuit shown in FIG. **15**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a preferred system for analyzing chemical specimens made in accordance with the present invention basically comprises a cuvette assembly **30**; a carrousel assembly **110**; test tubes **138**; a dispenser assembly **200**; and a console **502** that includes analyzing apparatus, a processing circuit and a memory.

Referring to FIG. **2**, cuvette **30** comprises a plurality of compartments, such as compartments **67** and **83**. Compartment **83** comprises sidewalls **34, 40** and a bottom-wall **48**. Spacers **58** (FIG. **1**) are fitted between sidewalls **34** and **40** to enclose the compartment. Compartment **67** is constructed in a similar fashion.

Referring to FIGS. **1** and **2**, assembly **110** is provided with a movable positioning platform **130** comprising a cylindrical skirt **132** and a ring-shaped test tube retainer **134**. The retainer comprises a horizontal ring member **136** that is provided with holes for receiving **32** test tubes commonly designated by the number **138**, and including exemplary test tubes **140, 141**. Each of the test tubes lies along a radius common to a corresponding cuvette compartment. The retainer also comprises a vertical ring-shaped retainer **142**. According to the preferred embodiment of the invention, the test tubes are used to hold chemical samples prior to the time they are mixed with a suitable reagent to form a specimen for analysis. The tubes are biased against retainer **142** by resilient spring clips, such as exemplary clips **143, 144**. The clips are mounted on skirt **132**.

Positioning platform **130** also comprises a raised, ring-shaped portion **146** that carries on its underside a circular positioning member **148** bearing detents. Member **148** is provided with one detent opposite each

test tube and corresponding cuvette compartment, so that each specimen may be accurately located in a predetermined analyzing position during the analysis procedure. The entire positioning platform is rotatably mounted on platform **115** by means not shown. The inner edges of platform **130** are fitted with guides, such as guides **149, 150,** that comate with the notches of a lip **92** of cuvette assembly **30.** By using the guides, the cuvette assembly is precisely located on the platform and is rotatable therewith.

As shown in FIG. **2,** a test tube detection assembly **158** is held in a cabinet **160** that is located one position ahead of the analyzing position. The assembly comprises a pendulum **162** pivoted around a rod **164.** The pendulum normally swings into the path of test tubes **138,** and in that position, causes a mercury switch **166** to be closed. When a test tube is positioned opposite assembly **158,** pendulum **162** is moved to the position shown in FIG. **2,** thereby causing switch **166** to open. Assembly **158** operates in a manner described hereafter so that the normal operation of the system is interrupted if no test tube is present at a particular position in ring member **136.**

Referring to FIGS. **3** and **4,** dispenser assembly **200** comprises a frame **202** that includes a base member **203** and mounting plates **206, 207** and **208.**

The dispenser assembly also comprises a probe holding assembly **212** that includes vertical support members **214** and **216.** The vertical support members are positioned by an upper arm **218** that is rotatably mounted by pins **220, 221.** Likewise, the vertical support members are positioned by a lower arm **222** that is rotatably mounted by pins **224, 225.** A tube **226** is used to convey fluid to a probe assembly **260** that is mounted on support member **216.**

Dispenser assembly **200** also comprises a vertical positioning assembly **230** that includes an up-down solenoid **232** which operates a push rod **233** having an upper end **234** along its longitudinal axis. Push rod **233** is rigidly connected to a piston **235** that operates in a cylinder **236.** The piston is normally biased in an upward direction by a helical bias spring **237** that is held within the cylinder below the piston. As a result, the probe holding assembly is normally positioned in the position shown in solid lines in FIG. **3.** (i.e., in the UP position). Cylinder **236** is rotatably mounted on plate **206** through a lower bearing **238** and is rotatably mounted on plate **207** through an upper bearing **239.** Adjustable stop members **240** and **241** cooperate with a bar **242** mounted on the probe holding assembly in order to determine the lowermost position of the probe assembly when it is positioned over the test tubes and cuvette, respectively.

Dispenser assembly **200** also comprises a horizontal positioning assembly **244** that inclues a spiral spring **246** having one end connected to plate **207** and the other end connected to cylinder **236.** This spring normally biases the probe holding assembly in the position shown in phantom in FIG. **4** (i.e., in the "test tube" position).

Adjustable stops **248** and **249** are used to control the position of the probe holding assembly when it is positioned over the test tubes and the cuvette assembly, respectively. Assembly **244** further comprises a rotation solenoid **250** that operates a push rod **252** along its longitudinal axis. Push rod **252** is connected through pins **255, 256** and arm **257** to a fixture **254** that, in turn, is rigidly affixed to one side of cylinder **236.**

Referring to FIGS. **5** and **6,** the dispenser assembly also comprises a probe assembly **260.** The probe assembly comprises a stainless steel nozzle **262** that includes a front barrel **263,** a rear barrel **264,** and an end point **261.** The front barrel has an inside diameter of 0.015 inches and an outside diameter of 0.020 inches. The rear barrel has an inside diameter of 0.015 inches and an outside diameter of 0.032 inches. The total length of the nozzle is 0.39 inches. As shown in FIG. **10,** the nozzle is fitted into a tube **266** so that the rear barrel is completely enclosed by the tube. A solder rod **267** is placed over tube **266** in the location shown in order to precisely locate tube **266** in corresponding notch in support arm **216.** Tube **266** is terminated in a beveled portion **268** that comates with tube **226** in the manner shown in FIG. **3.**

Applicant has discovered that the dimensions of the nozzle are critical for the efficient and accurate dispensing of organic liquids, such as blood serum. More specifically, applicant has discovered that the inside diameter of the nozzle should be between 0.010 inch and 0.020 inch. If the nozzle diameter is substantially less than 0.010 inch, the nozzle tends to clog with any foreign matter that is located in the system. If the inside diameter of the nozzle is substantially greater than 0.020 inch, two problems occur:

1. The velocity of the discharge is not sufficient to cause adequate stirring or mixing of the reagent fluid and blood serum.

2. The meniscus of the fluid at the end point of the nozzle becomes difficult to control. For example, the lower portion of the meniscus might break off, thereby decreasing the accuracy of the amount of fluid transferred.

The outside diameter of the nozzle should be made as small as possible consistent with an appropriate degree of structural strength, thereby reducing the area of the nozzle wetted by the blood serum and holding carry over to a minimum.

The dispenser assembly also comprises a mixing assembly **270.** Referring to FIGS. **3** and **7–10,** the mixing assembly comprises a reagent or mixing liquid reservoir **272** that holds a reagent fluid or mixing liquid which is mixed with samples held in test tubes **138** in order to prepare specimens for the various cuvette compartments. The reagent reservoir comprises a dip tube **273,** a cover **274,** and a transfer tube **275** that is connected with the dip tube.

Referring to FIGS. **7–9,** the mixing assembly also comprises a microsyringe **280** having a capacity of 50 microliters. The microsyringe has a glass barrel **281** and a stainless steel tip **282** that define an outer cylinder **283.** A hollow plunger **284** defining an inner cylinder **285** is arranged to slide within the outer cylinder **283.** Cylinders **283** and **285** together define a cavity or chamber **286** having an inlet orifice or end opening **287** located at the end of tip **282** and an outlet orifice or end opening **288** located at the end of plunger **284.** Tip **282** is connected to tube **226,** which, together with probe assembly **260** defines a passageway to the probe nozzle tip **261.**

Referring to FIG. **9,** the mixing assembly also comprises a macrosyringe **290** having a capacity of 2,500 microliters. The macrosyringe comprises a stainless steel tip **292** that is fitted into a glass barrel **291** which

defines a cylinder **293.** A solid glass plunger **294** is adapted to slide within cylinder **293.** Cylinder **293** defines a cavity or chamber **295** having an inlet orifice **296** at the end of tip **292** that is connected to a tube **298.**

Referring to FIGS. **9** and **10,** the microsyringe and the macrosyringe are connected to a three-way valve **300** that comprises a case **301** and a valve element **302.** The valve element defines channels **303, 304** that may be interconnected to various inlets **305, 306** and **307.** Plunger **284** has its outlet orifice **288** rigidly connected to inlet **306** of valve **300.** As shown in FIG. **9,** when the valve is in its "discharge" position, it forms a passageway, together with tube **298,** that extends from outlet orifice **288** of microsyringe **280** to the inlet orifice **296** of macrosyringe **290.** As shown in FIG. **10,** when the valve is in its "charge" position, tube **275,** together with the valve and tube **298,** form a passageway that extends from the reagent reservoir **272** to inlet orifice **296.**

Referring to FIGS. **3** and **11–14,** the dispenser assembly also comprises an operating assembly **310.** The operating assembly comprises a horizontal support bar **314** that rigidly connects barrels **281** and **291** of syringes **280** and **290,** respectively to the frame. Another horizontal support bar **315** connects reservoir **272** to the frame. Assembly **310** also includes a removable plate **311** that is connected to valve **300** and to plunger **294** of macrosyringe **290** through a fixture **326.** Plate **311** is connected to a carriage **312** by means of screws (not shown). By merely removing these screws, the entire plate assembly shown in FIG. **12** may be removed. This is an important feature since it facilitates the changing of the microsyringe, macrosyringe, and reservoir in order to run different determinations. By removing one plate assembly and substituting another, the apparatus may be changed to accommodate a different determination in a matter of seconds. Plate **311** carries a stop member **313** that may be adjusted by mounting it opposite various multiple holes **313***a* in plate **311.** Member **313** controls the lower position of plate **311** by engaging a microswitch **363***a* that is attached to the frame through a bracket **319.** Plate **311** also carries another stop member **321** that engages another microswitch **363***b* which controls the upper position of plate **311.** Carriage **312** is adapted to move along a vertical shaft **316** that is connected between base plate **203** and horizontal plate **317.** The carriage is coupled to shaft **316** through linear bearings **318, 320** that are adapted to slide in a vertical direction along the shaft. The carriage is driven by a rack **322** that cooperates with a pinion gear described hereafter.

Referring to FIGS. **11** and **14,** the operating assembly further comprises a clutch assembly **327,** that includes an electric motor **328** which has its rotor connected to a clutch plate **330** through a shaft (not shown). The clutch plate operates a valve drive plate **332** having stop facings **333, 334** through a low coefficient clutch facing **336.** Drive plate **332** is pinned by means of a hole **342** to a shaft **338** having a slot **339.** Stop facings **333, 334** cooperate with stop members connected to the frame which prevent shaft **338** from turning through more than 90° of arc. Slot **339** cooperates with a rib **340** of valve element **302** in order to move the valve element between the discharge and charge positions shown in FIGS. **9** and **10.** The clutch plate also operates a pinion drive plate **344** having a slot **345** through a high coefficient clutch facing **346.** A pinion gear **348** is connected to the drive plate through a pin (not shown) that fits through a hole **350** into slot **345.** This arrangement allows the clutch plate to move through 90° of arc before the pinion gear is moved. The entire clutch assembly is held together by a retaining plate **352,** screws **353,** springs **354,** and nuts **355.**

Referring to FIG. **15,** the operating assembly also comprises a dispenser control circuit **360.** The control circuit basically comprises a motor control circuit **362** having microswitches **363***a* and **363***b* that are mounted on the frame adjacent the carriage. Stop members **313** and **321** on the carriage engage the microswitches during the operation of the dispenser. The motor control circuit is used to control windings **364** and **366** that form a part of motor **328.** The motor control circuit controls the windings by transmitting signals over conductors **367, 368** and **369.**

The dispenser control circuit also comprises an up-down solenoid control circuit **370** that is used to control a winding **372** of up-down solenoid **232** by means of conductors **373, 374.** The dispenser control circuit further comprises a rotation solenoid circuit **376** that is used to control a winding **378** of rotation solenoid **250** by means of conductors **379, 380.**

The reference numbers in FIG. **15** identify components of the type described in the following Table A:

TABLE A

Reference Number	Type of Component
604	resistor
606	capacitor
608	diode
609	solenoid winding
610	junction transistor
611	thyristor
612	field-effect transistor
616	triac
624	switch contact
626	switch wiper

In FIG. **15,** other reference numbers are used to identify components described as follows in Table B:

TABLE B

Reference Number	Type of Component	Manufacturer	Part or Model No.
614	Hex-inverter	Texas Instruments, Inc.	7404
670	NOR gate	Signetics Corp.	370
680	NOR gate	Signetics Corp.	380

In addition, in the FIG. **15,** conductors are indicated by numbers from **700–799.** Like-numbered conductors are connected together.

The NOR gates shown in the drawings are conventional logic gates that produce one of two voltage levels at their output terminals in response to voltages transmitted to their input terminals. When switched to their one state, the gates produce a relatively high voltage at their output terminals, and when switched to their zero state, the gates produce a relatively low voltage at their output terminals.

A preferred circuit for controlling the operation of the circuit shown in FIG. **15** is described in my related application identified above which is incorporated by reference. Reference is made particularly to FIGS. **31**

and 33 of that application which show the interconnection of conductors 6CC1 – 10CC1, 713 and 763 shown in FIG. 15.

DISPENSER ASSEMBLY OPERATION

The operation of the dispenser assembly will now be described assuming that a test tube 140 and its corresponding cuvette compartment 83 are moved into the position shown in FIGS. 3 and 4. It is further assumed that test tube 140 holds an aqueous solution such as blood or the like, and that air has been removed from the mixing assembly.

As previously mentioned, springs 237 and 246 normally bias the probe holding assembly in its up position over the test tubes (i.e., the position shown in solid lines in FIG. 3 and in phantom in FIG. 4). Referring to FIGS. 15 and 16, operation of the dispenser assembly is commenced by the transmission of a negative pulse over the dispense line 713 to the motor control circuit 362. In response to this signal, the motor control circuit produces signal D1 across winding 364 of motor 328 in the manner shown in FIG. 16. In response to signal D1, motor 328 rotates clutch 330, valve drive plate 332, shaft 338, and rib 340 of valve element 302 through 90° of arc so that the valve element is moved to the position shown in FIG. 10. As shown in FIG. 16, the rotation of valve element 302 requires approximately 1.16 seconds.

While valve element 302 is being rotated, up-down solenoid circuit 370 transmits signal D3 (FIG. 16) to winding 372 of up-down solenoid 232. Referring to FIG. 3, in response to the D3 signal, solenoid 232 rapidly lowers push rod 233, thereby lowering end point 261 of probe assembly 260 below the surface of the liquid held in test tube 140 to level F. In other words, the probe holding assembly 212 is lowered to the position shown in phantom in FIG. 3 (i.e., the "charge" position). By properly adjusting stop member 240, end point 261 is located not more than 2 millimeters below the surface of the liquid. Applicant has found that this is an important feature, since it reduces the amount of surface area of the probe nozzle which is in contact with the liquid.

After the probe assembly is in its charge position and after valve element 302 has rotated to the position shown in FIG. 10, the pin inserted in hole 350 of pinion gear 348 (FIG. 14) engages an end of slot 345, thereby causing the pinion gear to rotate. When the pinion gear rotates, it drives rack 322 and carriage 312 in a downward direction (FIG. 11). Since carriage 312 is attached to plunger 294 and valve 300, the plungers of the syringes are pulled away from the syringe barrels, thereby enlarging the cavities defined by the syringes. In this mode of operation, a small amount of fluid is drawn from test tube 140 through end point 261 of the probe assembly into nozzle 262. Normally, the amount of fluid is approximately 10 microliters. At the same time, reagent fluid is drawn from reservoir 272 through tube 275, valve element 302, and tube 298 into the cylinder of syringe 290. In order to achieve the foregoing results, carriage 312 is moved downward approximately one-half inch in approximately 1.46 seconds. When carriage 312 moves downward far enough to engage microswitch 363a (FIG. 15) signal D1 is terminated and the carriage stops. If larger quantities of fluid are to be drawn into the probe assembly, carriage 312 may be moved downward an additional amount, by repositioning stop member 313. After carriage 312 has stopped in its lower position so that plungers 284, 294 have stopped moving, the operating assembly causes nozzle 262 to be retained in the fluid for at least 0.1 second. After the 0.1 second interval has passed, D3 is removed from winding 372 of the up-down solenoid 232 as shown in FIG. 16. At this time, spring 237 rapidly accelerates the probe nozzle away from the liquid in test tube 140 in an upward direction. This is an important feature, since the rapid upward acceleration causes the probe nozzle to break away from the liquid in test tube 140 without retaining a drop of liquid on the nozzle itself. The probe assembly continues to accelerate upward until it attains the position shown in solid lines in FIG. 3.

After the charged probe assembly is in its up position, rotation solenoid circuit 376 causes signal D4 (FIG. 16) to appear across winding 378 of rotation solenoid 250 (FIG. 15.) In response to the signal, solenoid 250 drives push rod 252 toward itself (as shown in FIG. 4) thereby causing the probe holding assembly to move from the position shown in phantom in FIG. 4 to the position shown in solid lines.

At the same time the probe holding assembly is rotating toward the cuvette, motor control circuit 362 causes signal D2 (FIG. 16) to be transmitted through winding 366 of motor 328 (FIG. 15). In response to the signal, the direction of clutch plate 330 is reversed so that valve element 302 is returned to its original position shown in FIG. 13. This operation takes approximately 1.16 seconds.

While the valve element 302 is rotating to the position shown in FIG. 9, up-down solenoid control circuit 370 again impresses signal D3 across winding 372 of the up-down solenoid 232 (FIG. 15). In response to this signal, the end point 261 of the probe assembly is lowered into compartment 83 of the cuvette to level G (FIG. 2). Level G is calculated to be not more than 2 millimeters below the terminal level of liquid which will be in compartment 83 after the probe assembly is discharged. This terminal level is shown as level H in FIG. 2. As previously explained, nozzle end point 261 may be lowered to exactly level G by adjusting stop member 241. This is an important feature, since experience has shown that a liquid bubble will be retained on the probe nozzle if the nozzle end point 261 is not extended slightly below the terminal liquid level. If the nozzle end point remains above this level, a bubble of fluid will be retained on the nozzle, thereby tending to contaminate the next specimen prepared. Likewise, if the nozzle end point extends too far below the terminal level, an excessively large area of the nozzle is wetted, so that an excessive amount of the specimen fluid is carried over to the next compartment.

After valve element 302 has rotated to the position shown in FIG. 9, the pin in hole 350 of the pinion gear 348 engages the opposite end of slot 345, thereby driving rack 322 and carriage 312 in an upward direction as shown in FIG. 11. As a result, plungers 284 and 294 are moved into barrels 281 and 291 of syringes 280 and 290, respectively. This movement reduces the size of the cavities defined by syringes 280 and 290 so that the sample fluid located in probe assembly 260 is expelled into cuvette compartment 83, and the reagent fluid held in cylinder 295 is expelled through tube 298, valve 300, plunger 284, cylinder 283 of microsyringe 280, tube 226, and probe assembly 260 into cuvette com-

partment **83.** The carriage continues to move upward until microswitch **363***b* is operated by stop member **321,** thereby terminating signal D2 and stopping the carriage. The foregoing method of discharge is an important feature, since the reagent fluid is passed through the microsyringe **280,** tube **226,** and the probe assembly after the fluid sample from the test tube has been expelled into the cuvette compartment. This operation purges these components of the sample fluid, thereby preparing the system to mix another sample with an additional quantity of the reagent fluid. In order to provide adequate purging, the amount of reagent fluid discharged through the probe assembly should be at least 10 times as great as the amount of sample fluid discharged. The proper ratio of reagent to sample fluid is provided by adjusting the relative sizes of the microsyringe and macrosyringe.

The curved bottom and angled sidewalls of cuvette **30** cause the fluid discharged by the probe assembly to be mixed in each cuvette compartment by a swirling action. After the sample and reagent fluid are completely discharged, the resulting specimen in compartment **83** has risen to the level H (FIG. 2) which is 1 to 2 millimeters above the level of end point **261** of the probe nozzle. After carriage **312** has stopped in its upper position, the operating assembly causes nozzle end point **261** to be retained below level H for at least 0.1 second. After this time interval has passed, the up-down solenoid control circuit **370** removes signal D3 from winding **372** of the up-down solenoid **232.** In response to the removal of the signal, spring **237** rapidly accelerates the probe assembly upward and away from the specimen fluid in compartment **83.** Thereafter, signal D4 is removed from winding **378** of the rotation solenoid **250.** In response to the removal of the signal, spring **246** moves the probe holding assembly away from the cuvette to the position shown in phantom in FIG. **4** over the test tubes. At this point, the dispenser assembly is ready for another cycle of operation as soon as another test tube and cuvette compartment are moved into the dispensing position by the cycling assembly.

Those skilled in the art will appreciate that the specific embodiments described herein may be altered and changed by those skilled in the art without departing from the true spirit and scope of the invention which is defined in the appended claims.

What I claim is:

1. A dispenser for mixing and dispensing a sample liquid from a sample reservoir and a mixing liquid from a mixing liquid reservoir comprising:

first means for defining a first chamber having a first end opening and a second end opening opposite the first end opening,

second means for defining a second chamber having an inlet orifice;

third means for defining a first passageway between the second end opening and the inlet orifice;

fourth means for defining a second passageway between the inlet orifice and the mixing liquid reservoir;

fifth means for defining a third passageway between the first end opening and the sample reservoir;

valve means for closing the first passageway and opening the second passageway in a first position and for opening the first passageway and closing the second passageway in a second position; and

operating means for positioning the valve means in its first position and for enlarging the size of the first and second chambers simultaneously whereby a portion of the sample liquid is drawn into the third passageway and a portion of the mixing liquid simultaneously is drawn into the second passageway, said operating means also being for positioning the valve means in its second position and for decreasing the size of the first and second chambers simultaneously whereby the portion of the sample liquid is expelled through the third passageway and the portion of the mixing liquid is expelled through the first chamber and the third passageway so that the first chamber and third passageway are purged by the mixing liquid.

2. A dispenser, as claimed in claim **1,** wherein the valve means comprises:

valve means for defining a first inlet orifice, a second inlet orifice and a third inlet orifice that lead to a central chamber; and

valve element means rotatable within the valve case means for defining one or more channels, whereby the inlet orifices may be interconnected through one or more of the channels by rotating the valve element means with respect to the valve case means.

3. A dispenser, as claimed in claim **1,** wherein the first means comprises the barrel of a first syringe and the second means comprises the barrel of a second syringe.

4. A dispenser, as claimed in claim **3,** wherein the operating means comprises:

a removable plate; and

means for connecting the first and second syringes, the valve means, and the second reservoir to the removable plate, whereby the exchange of the syringes is facilitated.

5. A dispenser, as claimed in claim **3,** wherein the third means comprises a hollow first plunger adapted to move in the barrel of the first syringe, and wherein the second means comprises a second plunger adapted to move in the barrel of the second syringe.

6. A dispenser, as claimed in claim **5,** wherein the diameter of the barrel of the first syringe is smaller than the diameter of the barrel of the second syringe.

7. A dispenser for mixing and dispensing a first liquid from a first reservoir and a second liquid from a second reservoir comprising:

a first syringe barrel having a first end opening and a second end opening;

a hollow first plunger adapted to move in the first syringe barrel;

a second syringe barrel having an inlet orifice;

a second plunger adapted to move in the second syringe barrel;

first means for defining a first passageway between the second end opening and the inlet orifice;

second means for defining a second passageway between the inlet orifice and the second reservoir;

third means for defining a third passageway between the first end opening and the first reservoir;

valve means for closing the first passageway and opening the second passageway in a first position and for opening the first passageway and closing the second passageway in a second position;

first support means for connecting the first syringe barrel to the second syringe barrel;

second support means for connecting the first plunger to the second plunger;

a motor;

clutch means driven by the motor;

first plate means located on one side of the clutch means for operating the valve means; and

second plate means located on the opposite side of the clutch means for moving the first support means with respect to the second support means only after the first plate means has turned through a predetermined arc, whereby the valve means is located in its first position as the first and second plungers are withdrawn from the first and second syringe barrels whereby a portion of the first liquid is drawn into the third passageway and a portion of the second liquid is drawn into the second passageway, and the valve means is located in its second position as the first and second plungers are moved into the first and second syringe barrels, whereby the portion of the first liquid is expelled through the third passageway and the portion of the second liquid is expelled through the first syringe barrel, first plunger and the third passageway so that the first syringe barrel, first plunger and third passageway are purged by the second liquid.

8. A method of mixing and dispensing a sample liquid held in a sample reservoir and a mixing liquid held in a mixing liquid reservoir by means of a first chamber having a first end opening and a second end opening and a second chamber capable of holding liquid, said method comprising the steps of:

removing all gas from the first and second chambers by filling the first and second chambers with the mixing liquid;

connecting the first end opening of the first chamber to the sample reservoir;

connecting the second chamber to the mixing liquid reservoir;

enlarging the first chamber so that a sample portion of the sample liquid is drawn into the first chamber;

enlarging the second chamber so that a mixing portion of the mixing liquid is drawn into the second chamber;

disconnecting the first chamber from the sample reservoir;

disconnecting the second chamber from the mixing liquid reservoir;

connecting the second chamber to the second end opening of the first chamber; and

expelling the mixing portion of the mixing liquid from the second chamber through the first chamber so that the sample portion of the sample liquid is expelled from the first end opening of the first chamber and the mixing portion of the mixing liquid passes through and purges the first chamber.

9. A method as claimed in claim **8,** wherein the steps of enlarging the first chamber and enlarging the second chamber are performed simultaneously.

10. A method, as claimed in claim **8,** wherein the step of expelling comprises the steps of:

decreasing the volume of the second chamber; and

decreasing the volume of the first chamber.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,817,425 Dated June 18, 1974

Inventor(s) MAX D. LISTON

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 7, kindly omit "now abandoned", and substitute therefor --now U. S. Patent No. 3,748,044, issued July 24, 1973.

Signed and sealed this 15th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
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