United States Patent [19]

Durkos et al.

[11] **3,901,656**

[45] **Aug. 26, 1975**

[54] **APPARATUS AND METHOD FOR PREPARING AND PRESENTING SERUM CHEMISTRIES FOR ANALYZATION**

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[73] Assignee: **American Monitor Corporation,** Indianapolis, Ind.

[22] Filed: **Mar. 20, 1974**

[21] Appl. No.: **452,728**

Related U.S. Application Data

[63] Continuation of Ser. No. 283,415, Aug. 24, 1972, abandoned, which is a continuation-in-part of Ser. No. 179,013, Sept. 9, 1971, abandoned.

[52] **U.S. Cl.** ..... **23/230 B;** 23/253 R

[51] **Int. Cl.**[2] **G01N 31/00;** G01N 33/16

[58] **Field of Search** .. 23/253 R, 259, 230 B, 230 R; 195/127 (U.S. only), 103.5 R (U.S. only); 141/130, 186

[56] **References Cited**

UNITED STATES PATENTS

3,193,358	7/1965	Baruch	23/253 R
3,202,188	8/1965	Allington	23/253 R UX
3,489,521	1/1970	Buckle et al.	23/253 R
3,508,879	4/1970	Findl et al.	23/253 R
3,574,064	4/1971	Binnings	23/254 R X
3,589,867	6/1971	Heinz et al.	23/253 R X
3,660,638	5/1972	Oberli	23/253 R X
3,698,870	10/1972	DeJong	23/253 R
3,725,010	4/1973	Penhasi	23/253 R

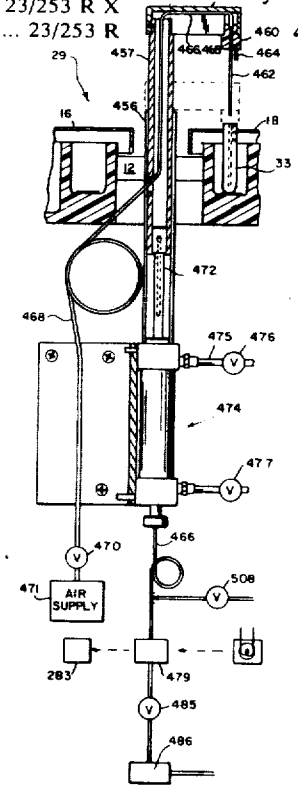
Primary Examiner—Joseph Scovronek
Attorney, Agent, or Firm—Jenkins, Hanley & Coffey

[57] **ABSTRACT**

Apparatus for handling and preparing for analyzation serum chemistries composed of serum specimens and chemical reagents. Serum specimens are loaded into a plurality of specimen cups in a specimen conveyor, and chosen ones of said cups are successively pressurized by a transfer apparatus to a predetermined pressure level. The transfer apparatus has a water-filled pickup tube having one end received in the specimen in a pressurized serum cup, and the other end couplable by a vent valve to atmospheric pressure for a closely controlled time period to allow the pressure within the serum cup to cause flow of a predetermined amount of the specimen into said pickup tube. The transfer apparatus transfers the picked-up specimen to above a chemistry cup in a chemistry conveyor where the other end of the pickup tube is selectively coupled by a pressure valve to a pressurized water supply for a predetermined time period to cause deposition of a predetermined amount of picked-up specimen into the underlying chemistry cup.

Each of the reagents is contained in a reagent bottle which is maintained by pressurizing means at a substantially constant pressure level. A delivery tube has one end received in the reagent and the other end couplable by a delivery valve to a position above one of the chemistry cups of the chemistry conveyor. The delivery valve is selectively operable for a predetermined time period to allow deposition of a predetermined amount of reagent into the underlying chemistry cup.

42 Claims, 26 Drawing Figures



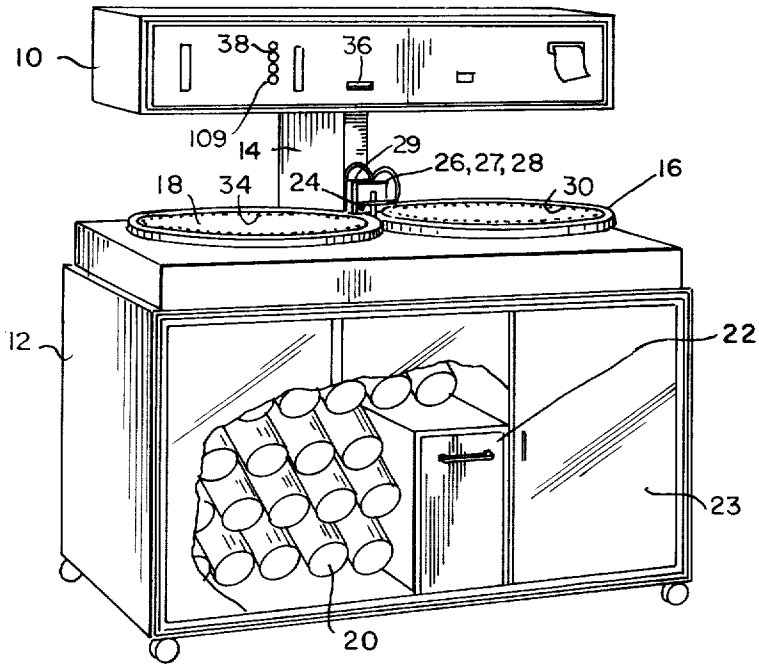

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Fig. 1

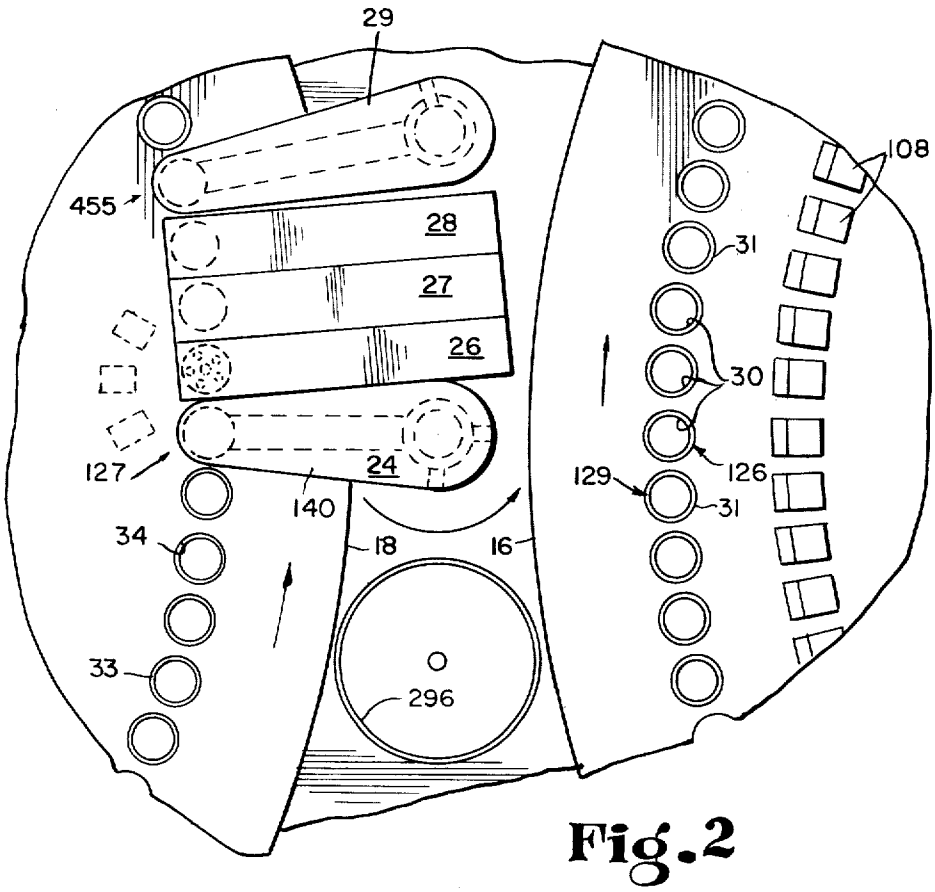
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Fig. 2

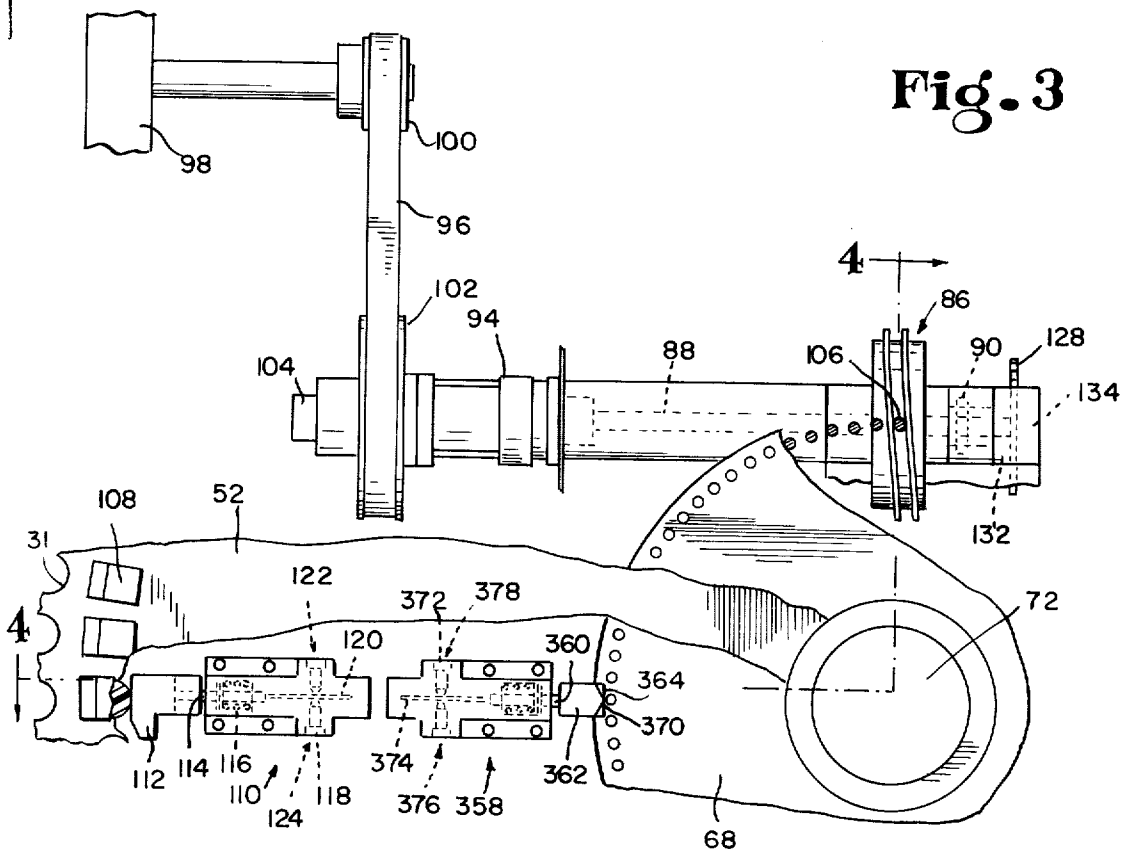
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Fig. 3

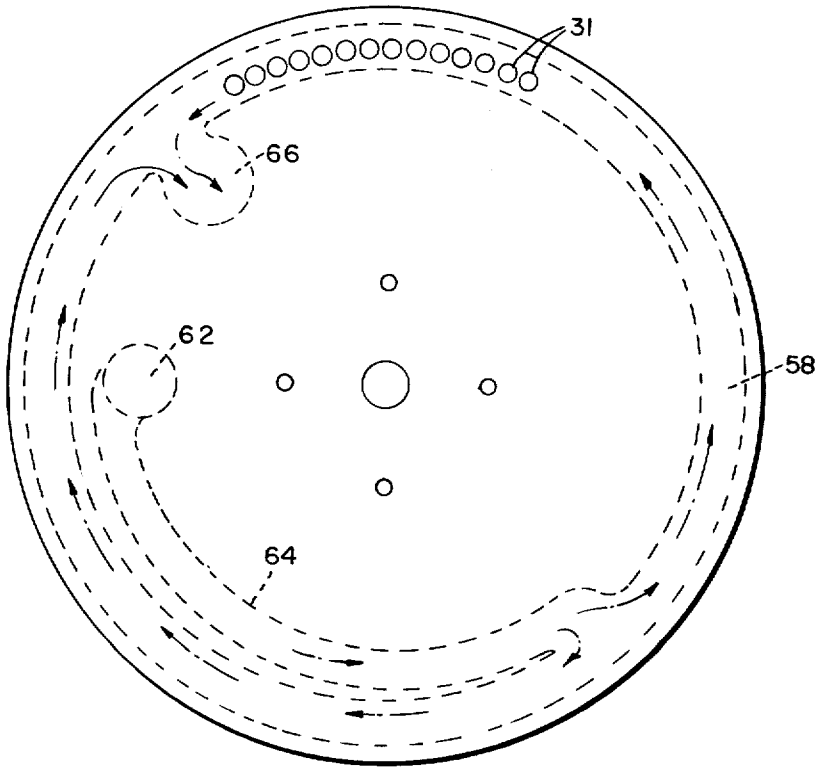
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Fig. 5

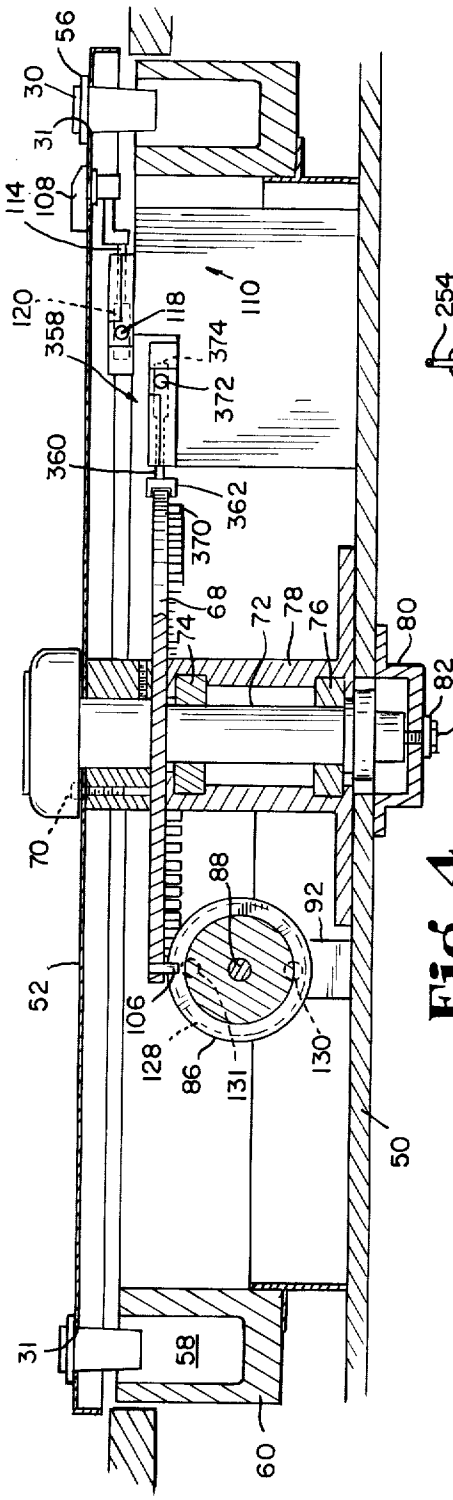

Fig. 4

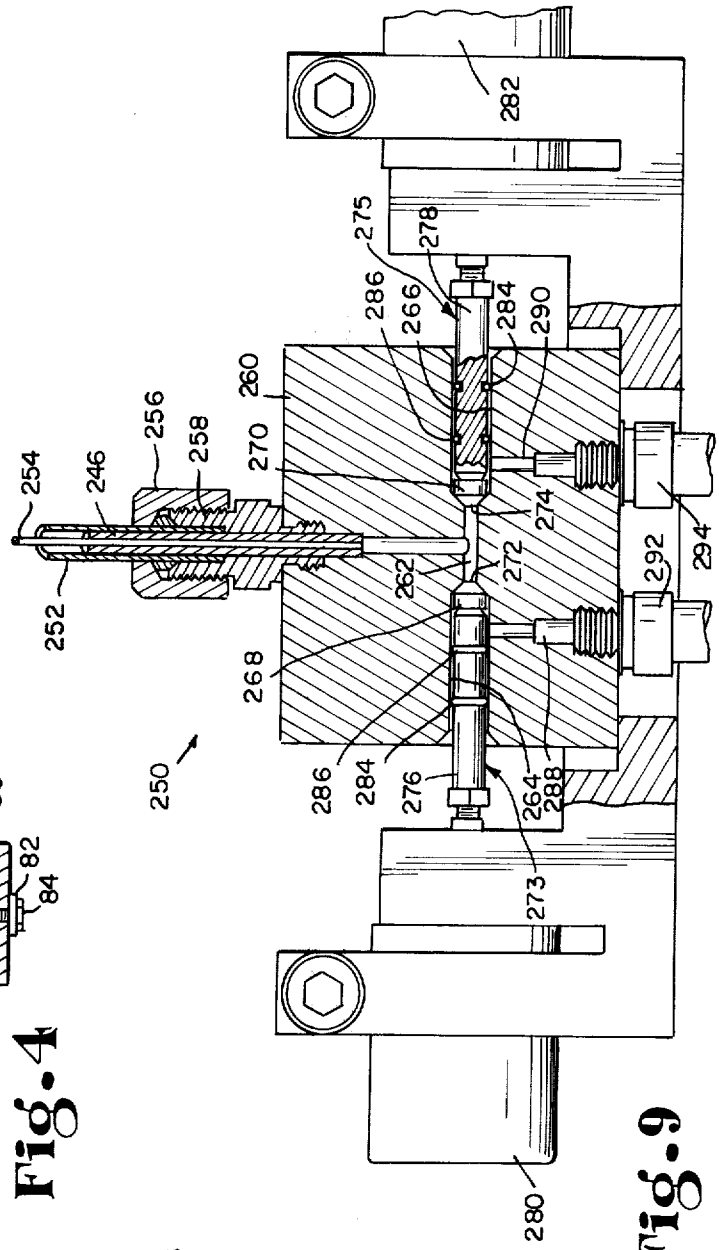

Fig. 9

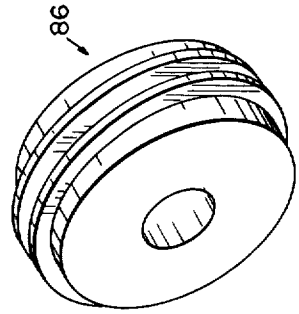

Fig. 6

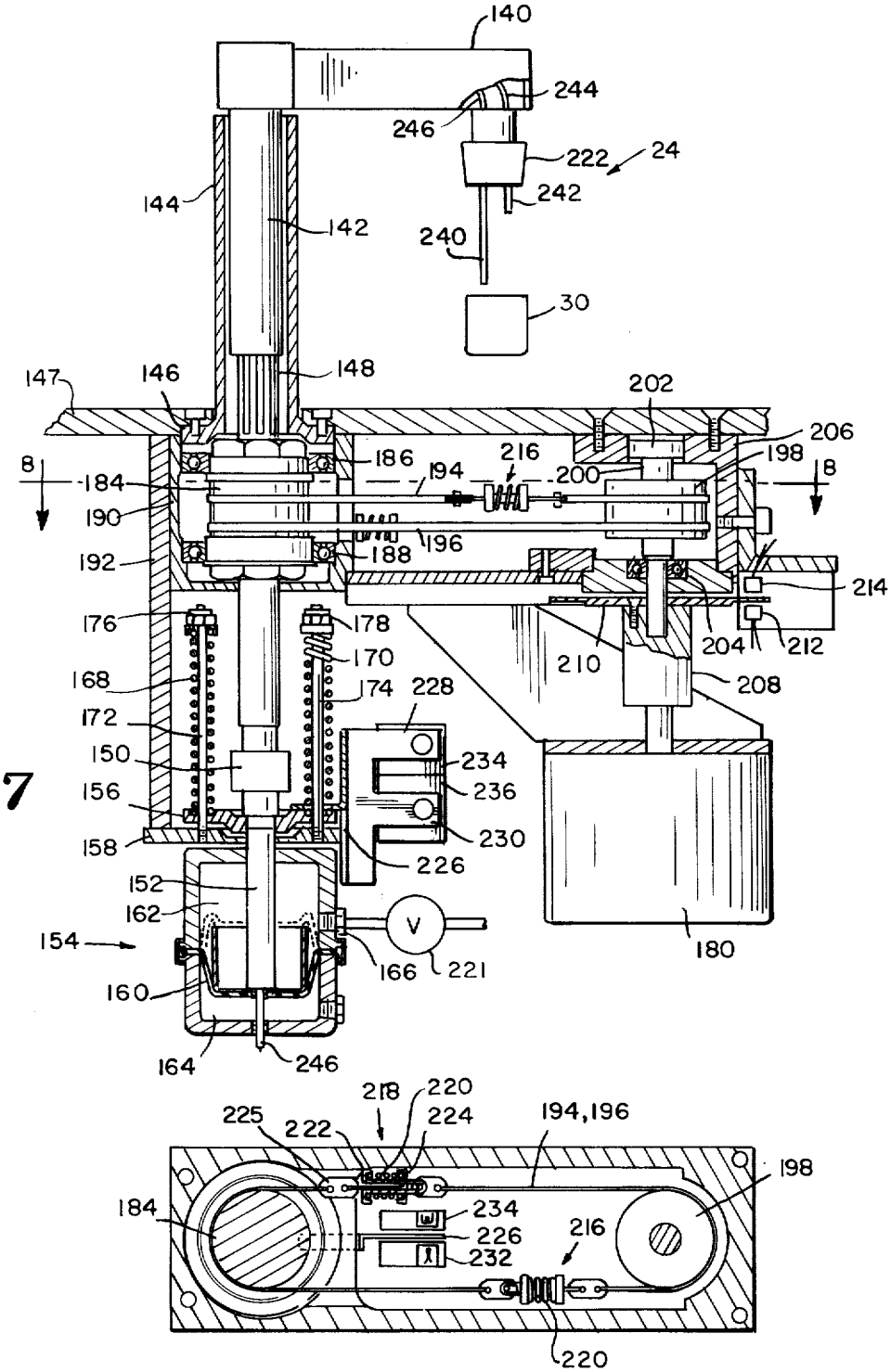
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Fig. 7

Fig. 8

Fig. 10

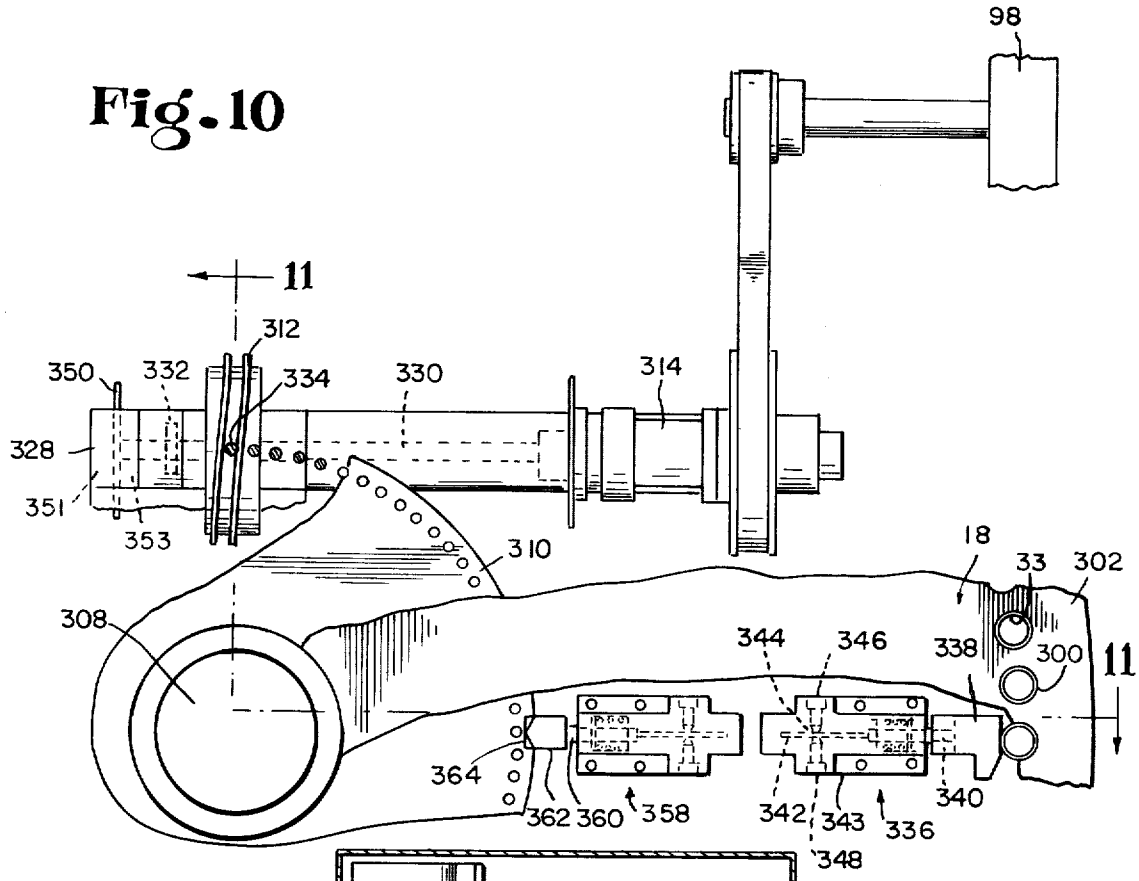
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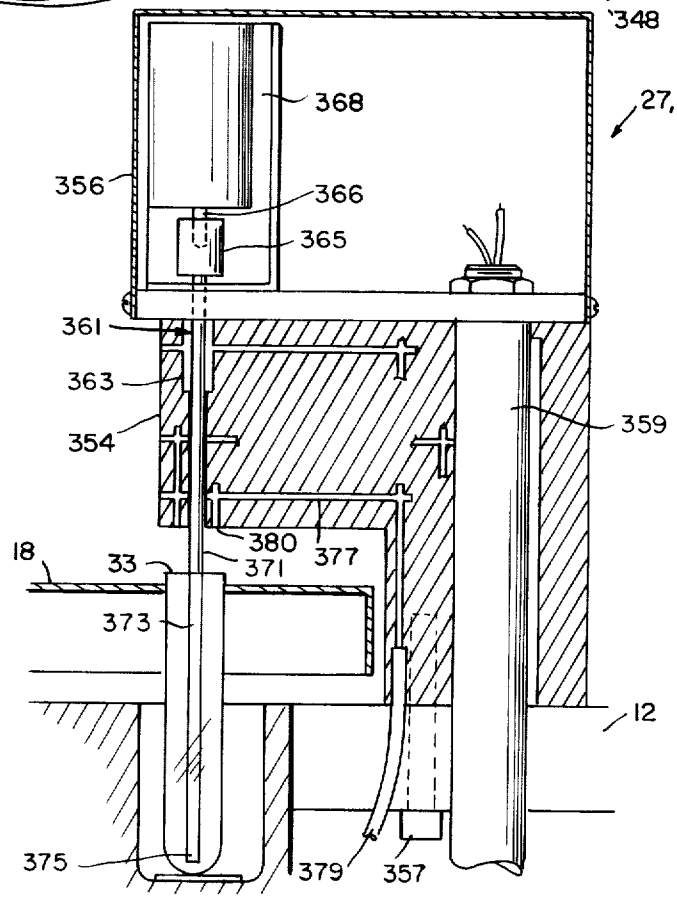
Fig. 12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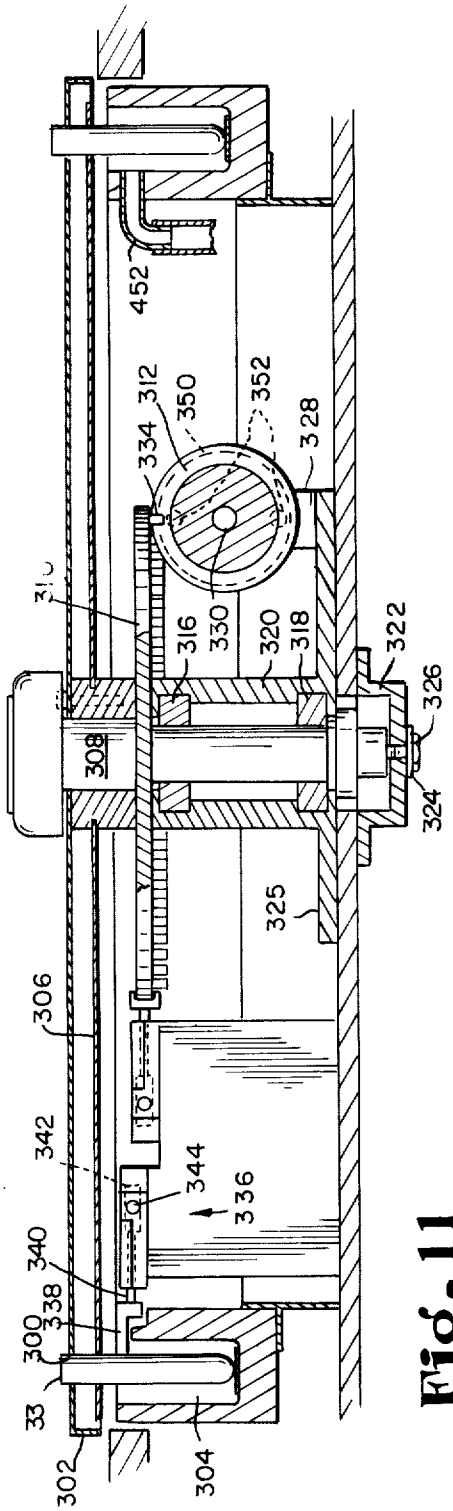
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Fig. 11

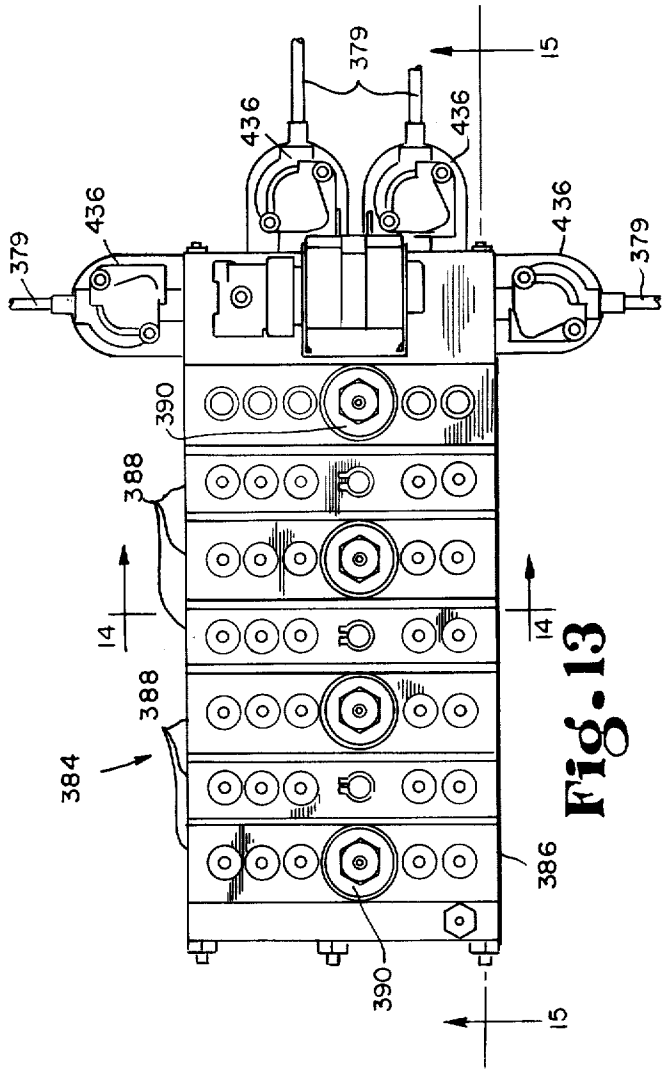
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Fig. 13

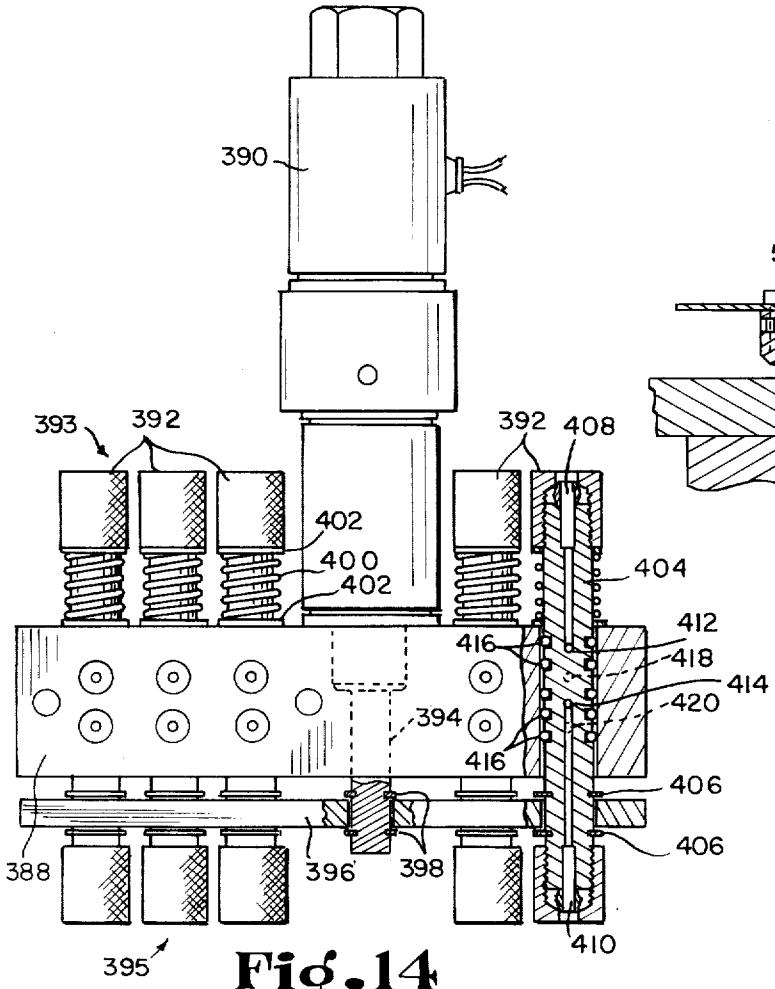


Fig. 14

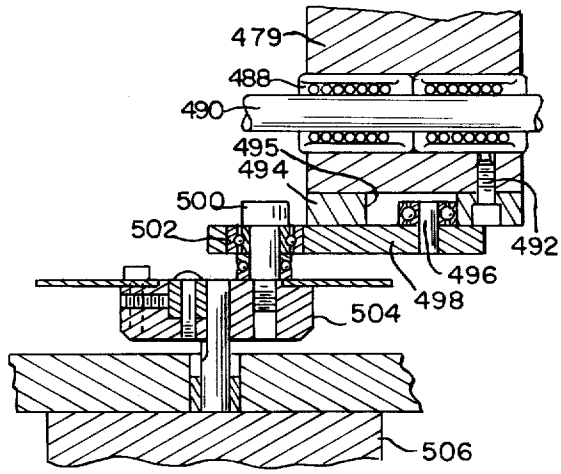


Fig. 18

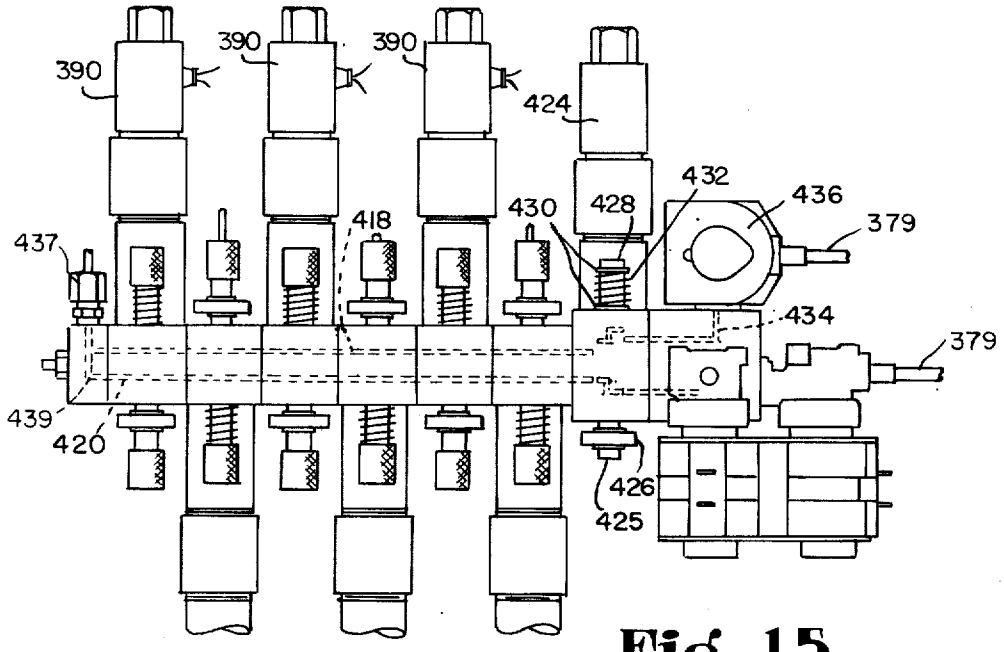
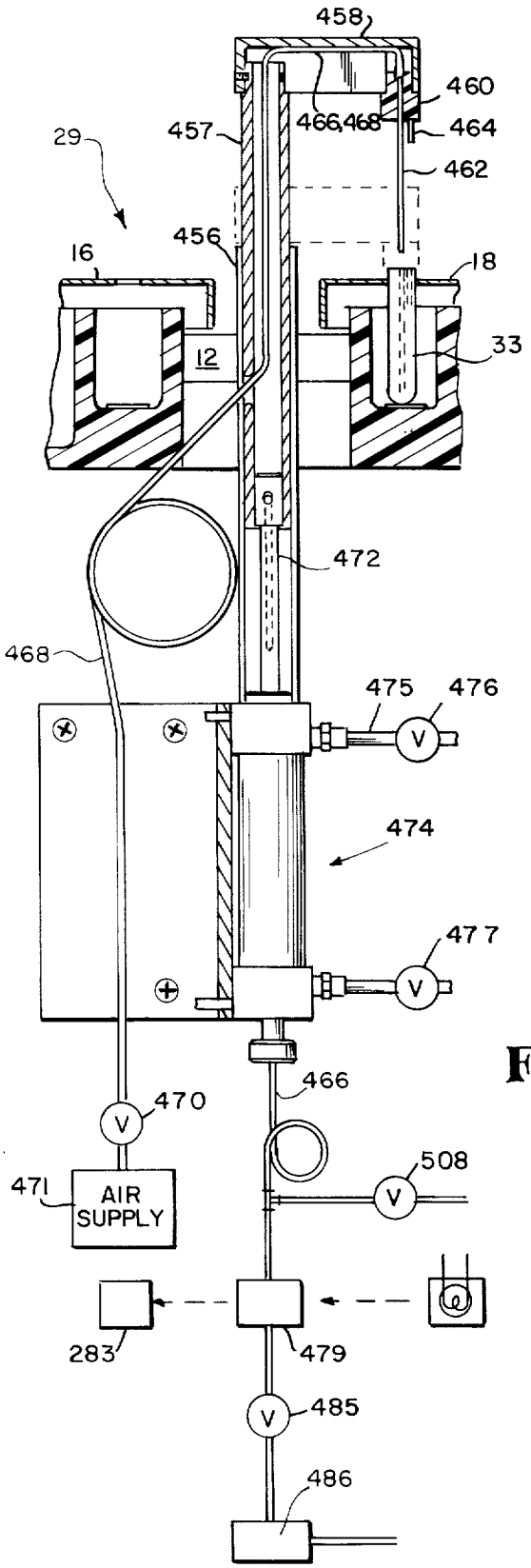


Fig. 15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AIR SUPPLY
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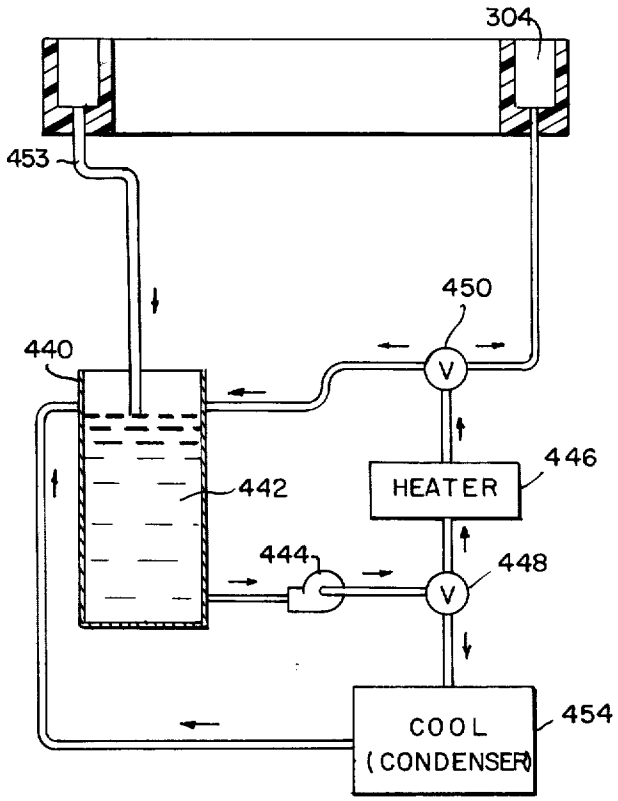
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Fig. 16

Fig. 17

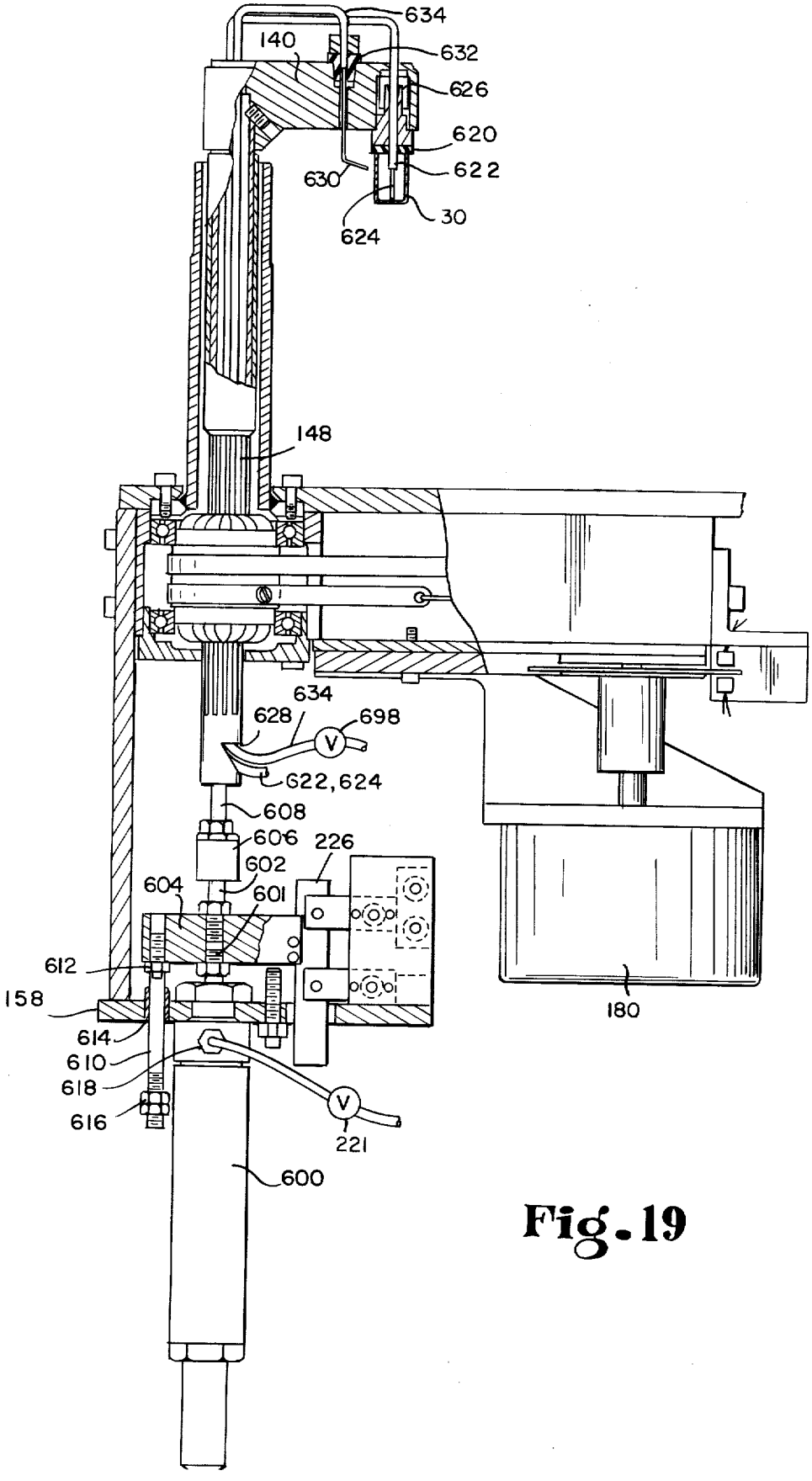
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Fig. 19

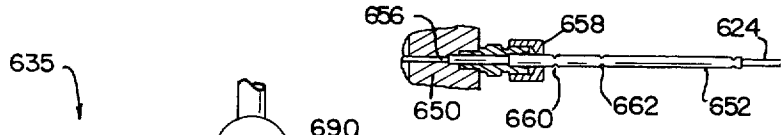
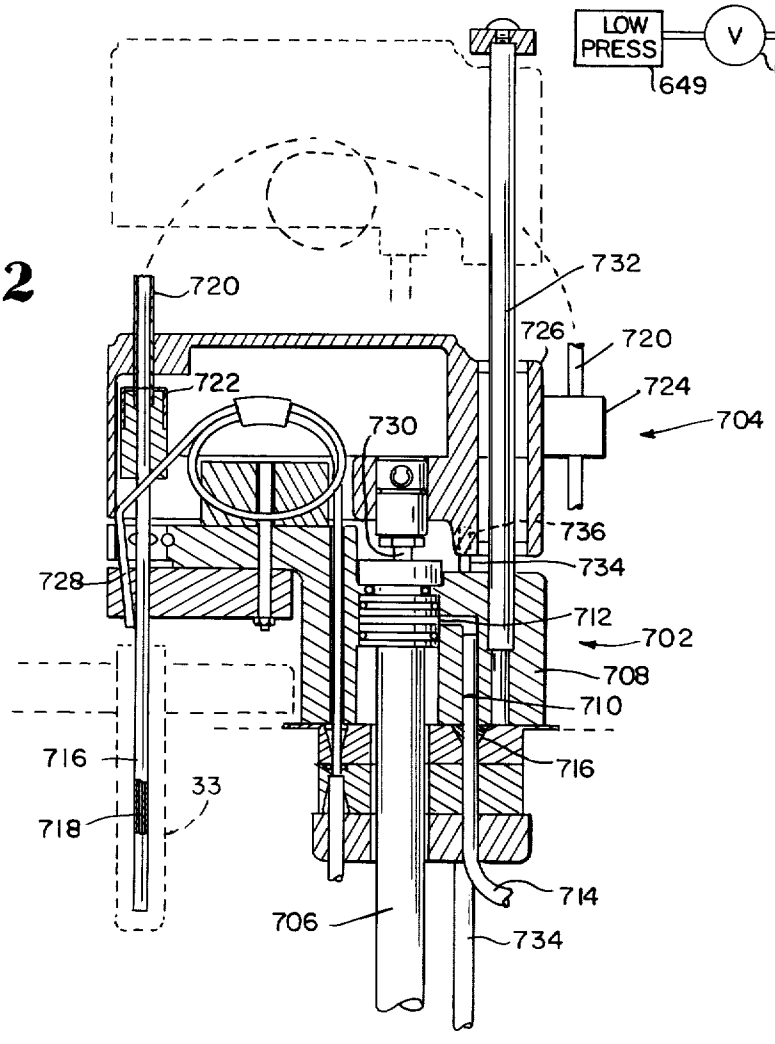


Fig.21

Fig.20

Fig.22



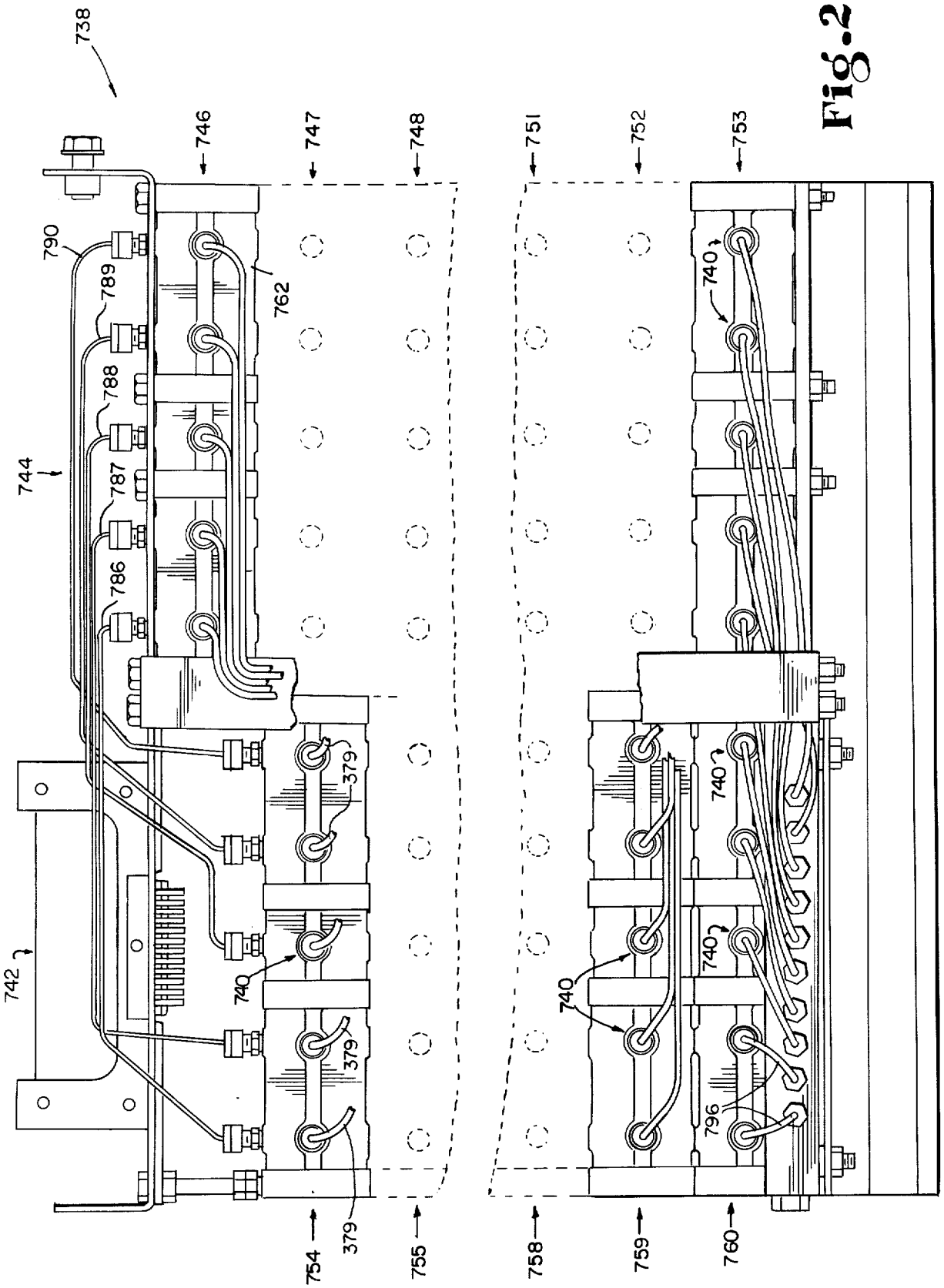

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Fig.23

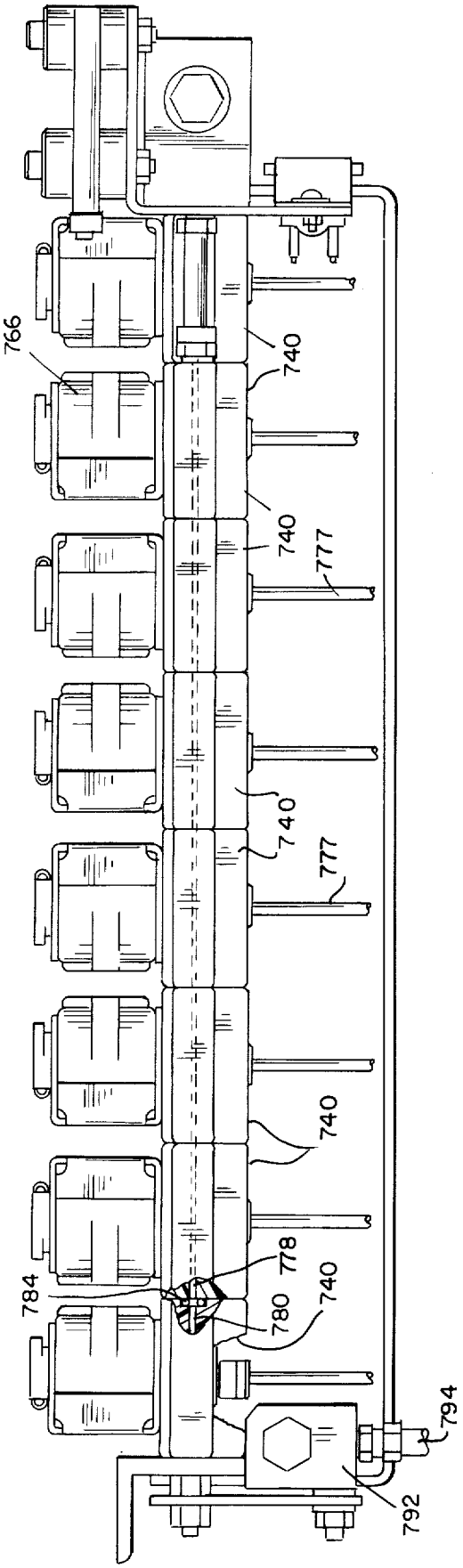
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Fig.24

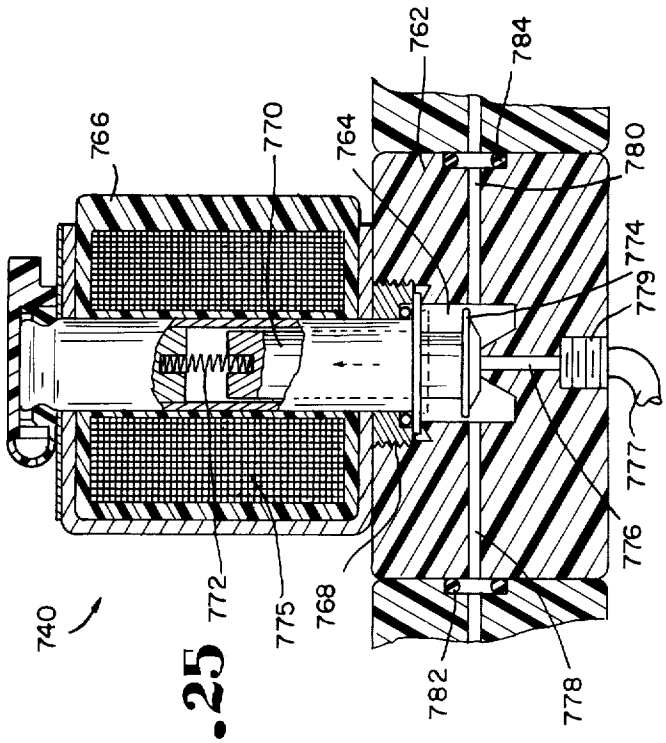
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Fig.25

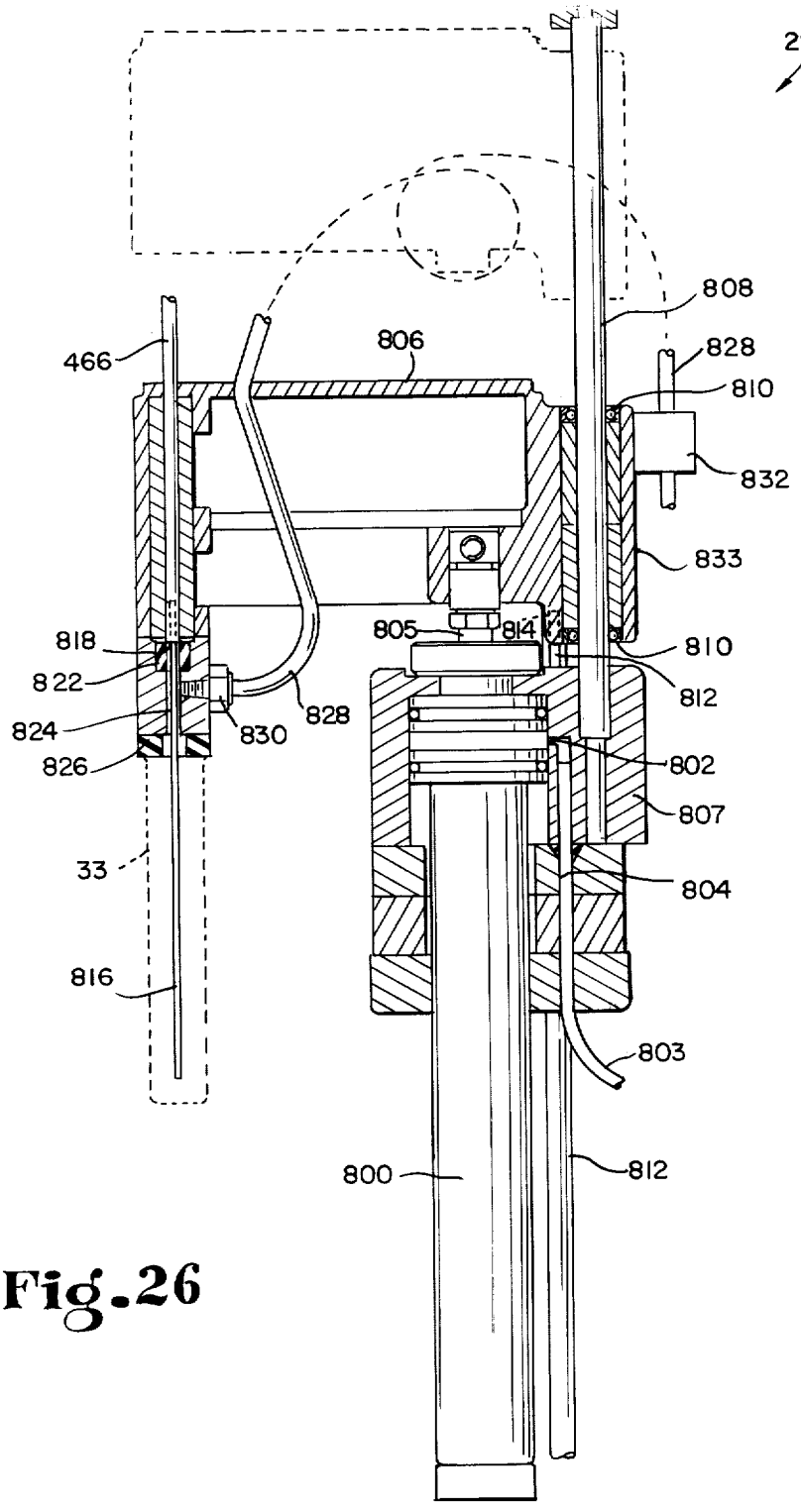
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Fig.26

APPARATUS AND METHOD FOR PREPARING AND PRESENTING SERUM CHEMISTRIES FOR ANALYZATION

This is a continuation application of co-pending application Ser. No. 283,415, filed Aug. 24, 1972, and now abandoned, which was in turn a continuation-in-part of co-pending application Ser. No. 179,013, filed Sept. 9, 1971, and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to apparatus and a method for preparing and chemically analyzing a serum sample from a specimen of serum, e.g., blood or other body fluid. More specifically, the apparatus comprises means to rapidly and successively present samples of identified serum specimens to individual test tubes; means to automatically and precisely dispense a number of programmed chemical test reagents into these test tubes at programmed intervals; means to incubate the resulting test chemistries for a predetermined period of time at a predetermined temperature; and means to remove, at the proper time, a preselected amount of each of the thereby formulated test chemistries for spectral analysis.

The chemical analysis of a serum, e.g., for the presence of sugar or albumin or in other vital assays to measure other medically-significant factors, is a vital step of medical diagnosis. Testing for various serum constituents is generally performed in a manual or automated process by adding specific amounts of various reactive chemicals or reagents to a sample of serum in a specific sequence and under specified conditions of temperature and time. The color or light transmittance of the resulting test chemistry is related to the amount of the particular constituent being measured in the serum.

In manual procedures, such assays are normally performed in a laboratory by a trained technician. The technician conventionally has used a graduated transfer pipette to place the serum sample to be tested in a test tube, after which he adds, at certain intervals of time, the proper reagents for the specific test. Some tests allow all the reagents, normally up to four or five in number, to be added simultaneously, while others require that predetermined incubation periods take place between the addition of the required reagents. The incubation periods, at times, must be carried out while elevating the temperature of the partially or fully complemented test chemistry so that a required chemical reaction may take place. A discrete amount of the test chemistry is removed by a pipette after all the reagents have been added and the incubation periods, if any, have elapsed. The light transmittance value of this test chemistry can then be ascertained using a conventional spectrophotometer. This value can then be used to calculate the optical density of the chemistry and from which the percentage concentration in the serum of the constituent of interest must be derived.

Disadvantages of such manual methods include undue labor cost and time, and the accuracy of this type of laboratory testing is at most, even under optimum conditions, only proportional to the skill of the technician. Error may be introduced into the test by any one of several ways, such as by adding incorrect amounts of reagent or by not incubating the test chemistry for the proper interval of time at the proper temperature. The inability of even the most skilled technician to prevent changes in thermally and oxidatively labile reagents constitutes an additional and often inevitable source of inaccuracy.

Several automatic systems have been proposed to eliminate the problems and disadvantages inherent in manual testing; and such automated procedures constitute at the present time a large portion of the assays currently conducted. The automated testing devices perform the assay functions automatically, and have attempted to eliminate one or more of the disadvantages of the manual methods. Automated analyzers of the prior art have primarily used two means of automatically dispensing specific amounts of reagents. Whitehead et al., in 1959, (U.S. Pat. No. 2,899,280) described a device in which the reagents are proportioned into the test chemistry and the chemistry transmitted or conveyed by a peristaltic pumping action. The reaction thereby occurs in a flowing stream. The amount or proportion of each reagent which is added is determined by the diameter of the tubes in the peristaltic pump. This has a particular disadvantage in that the tubes must be changed in order to change the proportions or amount of reagents added to a particular test.

Most other automated devices which have been developed use a hydraulic dispensing principle in which a device similar to a syringe displaces a volume of liquid into a reaction vessel. Such a dispensing mechanism was described by Feichtmeir in 1958 (U.S. Pat. No. 3,012,863). Even though such dispensers may be accurate in the amount they dispense, they must be mechanically adjusted to change from one volume of dispensing to another; and it is difficult to cleanse a previously used reagent from them. Both of these steps are required in changing from one test to another.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the invention, an automatic machine is provided which is generally comprised of a serum specimen holder and conveyor, a serum sample transfer station, a test chemistry holder and conveyor, multiple reagent dispensing stations, and an extraction station for transferring a completed test chemistry comprised of serum and reagents to an analyzing apparatus such as a spectrophotometer or a fluorometer for determining the light transmitted by or emitted from the solution.

The serum specimens to be assayed are obtained from patients in a conventional manner. These specimens are placed in individual test cups carried in holes in the top of the serum specimen conveyor. An advantageous feature of this equipment is that the amount of the serum placed in these cups is not critical, for the precise amount needed for a test sample will be extracted from these cups automatically. Degradation of the serum specimens is prevented by cooling means in a channel in the serum specimen conveyor into which the specimen cups project.

The serum specimen cup holes are successively numbered to provide patient identification. There is also an actuator button associated with each of the test cups. The buttons, when displaced to a control position or setting, signify to electronic controlling logic means the particular serum specimens which are to receive the particular serum chemistry test being performed at that time. The utilization of patient identification buttons

selectively permit a plurality of assays to be performed on specimens of the same serum specimen.

The particular test and its associated parameters, such as the volume and type of each reagent to be dispensed, the time and temperature of each incubation, if any, and the volume of serum sample required, are presented to the machine by means of a program card which has been specifically prepared for that type of test. The card, once inserted in the machine, serves as the program memory for the electronic control logic section of the machine. Any parameters may be easily changed by punching a new program card.

The testing procedure is completely automatic and requires no operator intervention after the proper patient identification buttons have been displaced and appropriate parameters set. In a preferred embodiment, the specimen conveyor indexes to position the first serum specimen cup located adjacent a displaced patient identification button into a transfer position for transferal of a sample or portion of the serum specimen to a test tube in the test chemistry conveyor. The pick-up portion of the serum transfer apparatus aligns with and descends onto the specimen cup. The specimen cup is pressurized and a precise amount of serum for the test sample thereof is extracted using a controlled orifice technique. The sample apparatus transfers the extracted serum sample to a waiting test tube which is carried in the test chemistry conveyor. If desired, an amount of diluent, such as water, can be added to the serum in the test tube at this time. The tip of the sample extractor is washed and dried as the sample apparatus swings back to pick up the next serum sample.

In position, the transfer apparatus again descends to pick up the sample amount of the next serum specimen which has been indexed to the transfer position. This procedure continues until samples have been extracted from all the cups in the specimen conveyor identified by a displaced patient identification button. The specimen wheel then returns to a home position which is preferably defined as when the specimen cup in the hole designated as position "one" on the specimen conveyor is one cup position removed from the sample transfer position.

Concurrent with the indexing of the specimen conveyor, the test chemistry conveyor indexes the first test tube under a first chemical reagent dispensing head as it indexes to present another empty test tube for deposition of a serum sample by the sample transfer apparatus. This begins the dispensing cycle of the test which may be varied in several ways, all of which are at the option of the programmer and under the control of the electronic logic. The dispensing operation makes use of a pressure-time flow regulation technique permitting the use of single valves as its only moving parts. All of the reagents required for the test in progress may be added simultaneously or each reagent may be added on a different pass of the test tubes beneath the dispensing head. Some reagents require an incubation period after being added to the serum sample so that a desired reaction might take place. If required, an incubation period may be utilized after the addition of each reagent. The programmer also has the ability to heat the test chemistries during an incubation period if the particular reaction requires an elevated temperature. The partially completed test chemistries can be mixed after the addition of each reagent to assure a homogeneous mixture and a completed reaction that will not give an erroneous result when the chemistries are analyzed.

The reagents can be kept in individual bottles under pressure desirably supplied by an inert gas, e.g., nitrogen. Any reagents requiring sub-ambient temperatures can be refrigerated. The valves which select the programmed reagents can be flushed with diluent after each set of test reagents has been used, thereby preventing cross-contamination of reagents, and can be purged with the particular set of test reagents at the beginning of a test to prevent any dilution of reagents used in the test by residual diluent.

At the completion of the formulation phase, the test chemistry conveyor indexes the first test tube containing a now-completed test chemistry beneath a test extractor head. After the required amount of test chemistry has been taken from each test tube, the test tube and its remnant chemistries are dropped into a waste container for removal. The displaced patient-identification buttons can then be reset.

This instrument is capable of performing both end point reaction tests and kinetic tests, as required in various types of assays. There are a great number of variables in the kinetic test which must be closely controlled, the two most important being time and temperature. The temperature of the chemistry may be specified by the programmer. Physically, the precise temperature may be achieved by immersing the test chemistries in a controlled temperature and recirculating fluid.

The subsequent analysis of the test chemistries can be carried out using a spectrophotometer or a fluorometer. The spectrophotometer or fluorometer output signals can then be electronically processed to obtain more usable data.

DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate the invention and, by way of example, show a preferred embodiment of the invention. In such drawings:

FIG. 1 is a perspective view of a machine embodying the invention;

FIG. 2 is a plan view showing a portion of the specimen and test conveyor and the apparatus located therebetween;

FIG. 3 is a horizontal section of the specimen conveyor;

FIG. 4 is a vertical section taken along the line 4—4 of FIG. 3;

FIG. 5 is a diagrammatic representation showing the specimen conveyor cooling channel;

FIG. 6 is a diagrammatic showing of a driving cam for the specimen and test chemistry conveyors;

FIG. 7 is a vertical view, in partial section, of a portion of the sample transfer apparatus;

FIG. 8 is a vertical section taken along the line 8—8 of FIG. 7;

FIG. 9 is a vertical section showing the serum pickup valve apparatus used in conjunction with the transfer apparatus of FIG. 7;

FIG. 10 is a horizontal section of the test conveyor;

FIG. 11 is a sectional view taken along line 11—11 of FIG. 10;

FIG. 12 is a vertical section of a combined dispensing and mixing head;

FIG. 13 is a plan view of a reagent selector apparatus and associated dispensing valves;

FIG. 14 is a vertical section along line 14—14 of FIG. 13;

FIG. 15 is a vertical section along line 15—15 of FIG. 13;

FIG. 16 is a diagrammatic representation of the temperature control apparatus for the test chemistry conveyor;

FIG. 17 is a vertical section, partially diagrammatic, of the test chemistry extraction apparatus and spectrophotometer flow cell;

FIG. 18 is a vertical section of the spectrophotometer flow cell reciprocating apparatus;

FIG. 19 is a vertical view, partially in section, of an alternate embodiment of the sample transfer apparatus;

FIG. 20 is a side view, partially in section, of an alternate embodiment of the serum pickup valve apparatus;

FIG. 21 is an enlarged section of the orificing tube assembly utilized in the valve apparatus of FIG. 20;

FIG. 22 is a vertical view, in section, of an alternate embodiment of the combined dispensing and mixing head;

FIG. 23 is a plan view, partially in section, of an alternate embodiment of the reagent selection apparatus and dispensing valves;

FIG. 24 is a side view, partially in section, of the apparatus valves shown in FIG. 23;

FIG. 25 is a section of one of the valving units shown in FIG. 23, with portions thereof broken away; and

FIG. 26 is a vertical section of an alternative embodiment of the test chemistry extraction apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The chemical analyzation machine shown in the drawings is for the serial analyzation of serum specimens which have been obtained from respective patients by conventional means. The term "serum" is used herein in the sense of representing any animal fluid. The electronic logic control which controls the operation of this machine is shown and described in a co-pending application, U.S. Ser. No. 179,133, now abandoned.

The machine shown in FIG. 1, and which is a preferred embodiment of the invention, comprises an upper housing 10 supported on a lower housing 12 by a post 14. A serum specimen conveying wheel 16 and a test chemistry conveying wheel 18 are supported in and by the top of the lower housing 12. The drive motor for these wheels is located within the lower housing 12. The bottom portion of the lower housing 12 encloses an array of pressurized bottles 20, some of which are enclosed in a refrigerated compartment 22. These bottles 20 contain the various chemical reagents used in the performance of a serum analysis by the machine. They are desirably pressurized with inert nitrogen gas to prevent degradation of the reagents. Dark transparent doors 23 on the front of the lower housing 12 permit the bottle compartment to be observed, while reducing reagent degradation due to light.

A serum transfer apparatus 24, a plurality of dispensing heads 26, 27 and 28, and a test chemistry extraction head 29 are, as shown in FIG. 3, located in close proximity to the serum specimen wheel 16 and the test chemistry wheel 18.

Serum specimens, from which samples are taken during the analysis procedure for test samples, are placed in a plurality of specimen cups 30 which are carried in equally-spaced cavities 31 in the top of the specimen conveying wheel 16. Each of the cavities is numbered and has a patient-identification selection switch 108 associated with it. In a similar manner, test tubes 33 are carried in equally-spaced peripheral holes 34 in the test chemistry conveying wheel 18.

In operation, a serum sample in a position 126 to be transferred, is appropriately taken from its specimen cup 30 in the specimen wheel 16 and transferred to a test tube 33 waiting in a transfer position 127 in the test wheel 18, by the serum sample transfer apparatus 24. The portion of the sample transfer apparatus 24 which transfers the sample can be washed by jets of air and water as it passes over a basin-like cavity 296 on its return trip to the sample wheel 16.

Properly selected reagents are added by means of the dispensing heads 26, 27 and 28 to each of the serum samples which have been transferred to test tubes 33 as the test wheel 18 is indexed through the dispensing stations. The test chemistries thereby formulated are then serially extracted for subsequent optical analyzation, as in a spectrophotometer or fluorometer, by the test chemistry extraction head 29. The spectrophotometer or fluorometer may be housed within the supporting post 14.

The electronic logic control circuitry for controlling each of the operations is contained in the upper housing 10. This circuitry may be programmed by a specially prepared card which is inserted in a slot 36 leading to a card reader (not shown), also supported in and by the upper housing 10. An array of actuation buttons 38 may be located adjacent the card reader slot 36 for manually controlling a part or all of the machine operations. Electronic circuitry, which may also be located in the upper housing 10, can be used to convert the output signals from the spectrophotometer or like device into more usable forms of data such as international enzyme units or milligram percentage concentrations by automatically comparing the spectrophotometer output from the test chemistry with the output from a standard solution whose concentration is known.

The serum specimen wheel 16 is shown in FIGS. 3 through 6 and is comprised of a stationary lower base plate 50 and a rotating top disk 52. The specimen vials, or cups 30, are placed in holes 31 located adjacent to the outer edge of the rotating top disk 52 of the specimen wheel 16. Each of the cups 30 is retained in its receiving cavity 31 by a lip 56 around its upper edge. The cups 30 extend through the top supporting disk 52 and into a channel 58 formed by a circular channel member 60 which is fastened to the base plate 50 of the specimen wheel 16.

The serum specimens in the cups 30 are advantageously cooled as they travel within the specimen wheel channel 58 by cool air which is forced into the channel 58 from the refrigeration compartment 22. As shown in FIG. 5, the cool air is forced through an inlet 62 into an entrance channel 64. This channel 64 opens into the cup channel 58, so that part of the air goes in a clockwise direction and part of the air goes in a counterclockwise direction. The air proceeds for 180° in both directions and leaves the channel 58 by an outlet port 66.

The cup-carrying top disk 52 is rotatably driven by a driving pin plate 68 connected to its lower surface as by pins 70. The plate 68 is also attached to a central shaft 72 which is mounted in bearing blocks 74 and 76

in a cylindrical supporting member **78** connected to and extending from the base plate **50**. The lower end of the shaft **72** is supported in a hub **80** by a thrust washer **82** and is held in place by a nut **84**.

The driving pin plate **68** is driven by a barrel cam **86**. This cam **86** is mounted on a shaft **88** which is supported in a bearing block **90** which is mounted in a supporting bracket **92** that is fastened to the base plate **50** of the specimen wheel **16**. The cam driving shaft **88** is driven through a conventional one-half turn clutch **94** from a drive pulley **96** which turns a pulley gear **102** mounted on the clutch **94**. The pulley **96** is driven from a motor **98** which drives a second pulley gear **100** on which the drive pulley **96** is mounted.

A solenoid (not shown) is energized to engage the clutch **94** and permit the cam drive shaft **88** to rotate. This solenoid may be de-energized once the clutch has begun to rotate to effect only a 180° rotation of the shaft **88** and cam **86**. The shaft **88** and cam **86** may be rotated indefinitely if the solenoid is held in a continuously energized state.

The configuration of the two sets of tracks in the cam **86** is shown in FIG. **6**. A 180° rotation of the cam corresponds to the advancement of one cup position by each of the serum cups **30**. Preferably, the cup-carrying disk **52** will have a capacity of one hundred serum cups, and thus the advancing of the equally-spaced cups **30** by one cup position means that the wheel **16** has been moved through an angle of 3.6°.

The driving pin plate **68** has a driving pin **106** for each of the test cup holes **54**. The double lead in the barrel cam **86** allows two such pins to be in communication with the barrel cam even though only one pin is driven at a time. The barrel cam is rotatably driving the pin-driving plate **68** during only a fraction of its total revolution due to the configuration of the barrel cam **86**. This places the control of the indexing step with the barrel cam **86**, rather than making it dependent upon the accuracy of the one-half turn clutch **94**. This independence of control avoids any problems with an accumulated positioning error which may be incurred by the clutch **94**.

In operation, a serum specimen from each patient to be tested is placed in one of the serum cups **30**. Normally, each of the serum specimens will not be meant to receive all of the tests which may be performed in a series of tests. For example, perhaps only the specimens in cups "**2**", "**5**", and "**10**" are to receive an albumin test, but possibly all the specimens in the specimen wheel **16** are to receive a subsequent test for cholesterol content. The selection of the particular serum specimens which are to receive a particular test is made by the respective patient-identification slide switches **108** which are associated with each of the serum cups **30**. In the above example, the switches **108** adjacent cups "**2**", "**5**", and "**10**" would be displaced, i.e., moved to a control position, prior to the albumin test to signify that the serum in those cups is to receive a test for albumin content. At the conclusion of the albumin test, the patient-identification switches **108** associated with all of the serum specimens would be displaced for the cholesterol content test.

A test start button **109** on the front of the machine (FIG. **1**) is pressed to initiate a testing cycle after the program card has been inserted and the proper patient-identification buttons **108** corresponding to the serum samples which are to receive that particular test have been displaced. At that time, the clutch solenoid is energized to begin the rotation of the driving cam **86**. The one-half turn clutch **94** continues to be engaged until a displaced patient-identification button **108** is detected by a sensing device **110** beneath the rotating disk **52**. The sensing device **110** comprises an L-shaped member **112** which is connected to a spring loaded deflection arm **114**. The arm **114** is moved to compress a spring **116** when the L-shaped member **112** is deflected by a patient-identification button **108** which has been pushed to a displaced, control position.

The movement of the arm **114** also positions an aperture **118** in an otherwise optically black plate **120** between a light source **122** and a photocell **124**. The resulting electrical signal from the photocell **124** is detected by the control logic which de-energizes the clutch solenoid (not shown) and thereby halts the rotation of the pin-driving cam **86**. The patient-identification detection device **110** is located so that a depressed button **108** is detected as the corresponding serum cup enters the transfer station **126**. This station or cup position **126** is defined as being one cup position removed from the home position **129** of the number one cup which is adjacent the sample or serum transfer apparatus **24**.

A flat strobe disk **128**, with two diametrically opposed holes **130** and **131** therein, is connected to, and rotates with, the cam shaft **88**. A light source **132** and a photocell **134** are positioned such that each time the disk **128** rotates 180° one of the holes **130** or **131** permits a pulse of light to fall on the photocell **134**. The electrical pulse generated by the photocell **134** is stored in the electronic logic section and permits the particular serum cup **30** in the transfer station **126** to be identified at any time. The signal from the photocell **124** in the patient-identification button detection device **110** is also stored in the electronic logic section as a means of identifying the particular serum specimens which were sampled.

The stopping of a specimen cup **30** in the transfer position **126** initiates the movement and operation of the serum pickup and transfer apparatus **24**. This apparatus **24**, one embodiment of which is shown in detail in FIGS. **7** through **9**, is supported in, and projects vertically from, the top of the lower machine housing **12**. The portion of the transfer mechanism **24** which is located above the level of the test wheel **18** is comprised, in general, of a horizontal swingable arm **140** which is supported on a shaft **142**. The shaft **142** is enclosed by a tubular support member **144** which is fastened to the underside of the top **147** of the lower housing **12** by a flange **146** on its lower end.

The enclosed shaft **142** is connected to a spline shaft **148** within the tubular support **144**. The spline shaft **148** is connected at its lower end to a coupling block **150** for coupling the piston shaft **152** of an air cylinder **154** to the spline shaft **148**. This cylinder **154** is supplied with a pressurized gas for purposes of pneumatic actuation. This is referred to herein as an "air cylinder" even though this embodiment conveniently uses compressed nitrogen which is available from the supply for the pressurization of the reagent bottles **20**. All the remaining air cylinders in the system also utilize this supply.

The piston shaft **152** extends through a spring extension plate **156** and through a bottom supporting bracket **158** before entering the air cylinder **154**. The

shaft **152** is attached at its lower end, within the cylinder **154**, to a rollable membrance or diaphragm **160**. The diaphragm **160** separates the air cylinder **154** into an inlet section **162** and an exhaust section **164** and seals the one from the other.

Air or other gas as referred to above, is applied, under pressure, to the inlet section **162** through an inlet port **166** to cause the diaphragm **160** to roll downwardly into the solid line position shown in FIG. **7**. Correspondingly, the piston shaft **152** is moved downward due to its fixed connection to the diaphragm **160**. The downward movement of the piston shaft **152** is transferred by the coupling block **150** to the spline shaft **148** and to the spring extension plate **156** which the coupling block **150** contacts as it moves downward.

Two springs **168** and **170** are each connected at their lower end to the spring extension plate **156**. The springs **168** and **170** are respectively supported on and encompass a shaft **172** and **174** which passes through the extension plate **156** and is mounted in the bottom supporting bracket **158**. The upper ends of the springs **168** and **170** are connected to end plates **176** and **178** which are mounted on the ends of the shafts **172** and **174**. The springs **168** and **170** are extended by the downward movement of the extension plate **156** and oppose this movement.

The spline shaft **148** may be rotatably driven, concurrently with its up and down movement, from a servo stepping motor **180** by wear resistant pulley bands **194** and **196** which are connected to a spline nut **184** on the shaft **148**. The spline nut **184** is mounted by means of bearings **186** and **188** in a nut housing **190** which is mounted on a side bracket **192**.

Positive rotary drive is supplied to the spline nut **184** by the pulley bands **194** and **196** from a motor-driven pulley **198** around which the bands **194** and **196** pass. The shaft **200** for this pulley **198** is mounted in a bearing block **202** at is upper end. Its lower end is reduced in diameter and is supported in, and extends through, another bearing block **204** and a bracket **206** which supports the pulley **198**. This bracket **206** is mounted on the lower side of the top **147** of the lower machine housing **12**. The pulley shaft **200** is terminated in a shock absorbing coupling **208**, and is connected thereby to the servo stepping motor **180**.

An optical position detection disk **210** is mounted on the shock coupling **208** concentrically with the pulley shaft **200**. This disk **210** has two holes through it at diametrically opposed locations. The holes are positioned such that one of them is between a light source **212** and a photocell **214** when the horizontal serum transfer arm **140** is above the test chemistry wheel **18** and the other when the arm **140** is above the specimen wheel **16**. The resulting electrical signal from the photocell **214** is used to synchronize the up and down motion of the transfer apparatus with the dispensing and pick up of a serum sample.

The band drive system for the spline nut **184** is shown in somewhat more detail in FIG. **8**. The pulley bands **194** are preferably comprised of a material with extreme longevity, e.g., a composition of beryllium and copper. One end of each of the bands **194** and **196** is attached to the spline nut **184** and passes around the motor pulley **198** before being attached to a spring-loaded tensioning device **216**. The spanning length of each of the bands, from the spline nut **184** to the motor pulley **198**, can be interrupted by a second tensioning device **218**. Where appropriate, the second tensioning device **218** can be omitted.

The tensioning devices **216** and **218** comprise a spring **220** which is compressed by retaining shoulders **222** and **224**. These shoulders **222** and **224** form part of connecting tabs **225** to which the ends of the bands **194** and **196** are connected. The single-ended tensioning device **216** has one end fixedly connected to the frame of the apparatus.

As shown in FIG. **2**, the position for the horizontal transfer arm **140** at the beginning of a serum testing procedure, is above the test chemistry wheel **18**. Movement of the arm **140** from this position is initiated by a signal from the patient-identification switch detection photocell **124** beneath the specimen wheel **16** signifying that a serum cup **30** containing a serum specimen to be tested, has arrived at the transfer position **126**. At this time, the electronic logic control begins pulsing the servo stepping motor **180**. The motor **180** turns the motor pulley **198** through the shock absorbing coupling **208**, which in turn begins rotating the spline nut **184** by means of the driving bands **194** and **196**. The tensioning devices **216** and **218** controlling the bands **194** and **196** absorb the pulsing characteristic of the stepping motor **180** so that the spline nut **194** is smoothly rotated.

One of the holes on the optical transfer arm position detection disk **210** is positioned, as hereinbefore explained, between a light source **212** and a photocell **214** as the horizontal transfer arm **140** finishes its 180° swing to position itself above the specimen cup **30** in the transfer position **126**. The resulting electrical pulse from the photocell **214** opens a pressurization valve **221** leading from the pressurized air supply to the inlet port **166** of the up and down air cylinder **154**. The resulting gas pressure in the inlet section **162** of the cylinder **154** causes the diaphragm **160** to move downward taking the piston shaft **152** with it. The rolling action of the diaphragm **160** eliminates the need for any breakaway force, so the motion of the shaft **152** is initially and continually smooth.

The coupling block **150** associated with the piston shaft **152** is thereby forced downward onto the spring extension plate **156** as it simultaneously moves the spline shaft **148** downward. The spline shaft **148** is able to move downward by means of ball bearings within the spline nut **184**. The movement of the spline shaft **148** causes the horizontal arm **140** to move downward also. This downward travel of the arm **140** continues until a resilient and compressible stopper **222**, which protrudes from the lower side of the arm **140**, firmly seals itself against the top of a waiting serum cup **30**.

A bracket **226** is connected to the spring extension plate **156** on the air cylinder piston shaft **152** and moves up and down with this shaft. Two vertical position optical detection arms **228** and **230** are connected to this bracket **226** and move up and down therewith. Each of these arms **228** and **230** has a hole through it which provides a light path from a light source to a photocell when the arm is in the appropriate position. The upper arm **228** has its hole in communication with a photocell **232** and a light source **234** when the horizontal transfer arm **140** is in its upper-most vertical position. The hole in the lower arm **230** is in communication with a light source **236** and a photocell (not shown) when the horizontal transfer arm **140** is in its

lower-most vertical position, i.e., when the resilient stopper **222** has sealed a sample cup **30.**

The extraction of the required amount of a serum sample is initiated, by apparatus shown in detail in FIGS. **7** and **9,** when the lower of the position photocells referred to above has an electrical output signifying that a serum cup **30** has been sealed by the transfer arm stopper **222.** Two small diameter stainless steel tubes **240** and **242** extend from within the horizontal arm **140** and protrude through the resilient end stopper **222.** These stainless steel tubes **240** and **242** are inserted at their upper end into the ends of flexible tubes **244** and **246** which extend through the hollow interior of the horizontal arm **140** and into and through the hollow of the supporting shaft **142,** the hollow of the spline shaft **148** and the hollow of the air cylinder piston shaft **152,** before exiting through the bottom of the air cylinder **154.** A loop (not shown) is formed in the two tubes within the housing **12** to provide the take-up and dispensing of the excess tubing as the sample transfer arm **140** is raised and lowered.

The lower end of the flexible tube **244** which is connected to the shorter stainless steel tube **242** in the stopper **222** is connected to the outlet of a pressurization valve (not shown). The inlet of this valve is connected to the pressurized air supply, preferably maintained at a pressure of approximately 10 psi. The lower end of the other flexible tube **246,** coupled to the longer stainless steel tube **240** in the stopper **222,** is connected to a valve assembly **250** by inserting the tube into a tubular supporting member **252** which contains a glass capillary tube **254** which projects up into the tube **246.** A tapered and threaded locking member **256** is then tightened about a similarly tapered member **258** causing the latter to tighten about the inserted flexible tube **246** and form an air-tight seal.

The glass capillary tube **254** extends down into the main valve block **260** and terminates in a perpendicular intersection with a second glass tube **262.** Each side of this intersecting glass tube **262** is enlarged in diameter a short distance from its intersection with the vertical tube **254.** Within each of these enlarged diameter tubes **264** and **266** is a piston-operated valve plunger **268** and **270.** Each of these plungers **268** and **270** is terminated at its forward end by a small resilient washer **272** and **274,** respectively, which firmly seats itself against the constricted passageway **262** at the respective end to seal that end from the passageway.

The movement of each of these valving members **268** and **270** is controlled, respectively, by a piston **273** and **275.** The pistons **273** and **275** and **274** are rapidly moved by respective solenoids **280** and **282.** Each of the piston arms **276** and **278** is supported within the valve block **260** by O-rings **284** and **286** which not only prevent leakage from the valve block but help guide the piston arms **276** and **278** and prevent them from being skewed within their passageways.

Vertical passages **288** and **290** intersect and open into each of the valved passages **264** and **266** just behind each of the valve plungers **268** and **270.** These vertical passages **288** and **290** communicate with the narrow cross passage **262** and thereby with the vertical orificed capillary tube **254** when the appropriate valving member **268** and **270** is in its retracted position. One of these vertical passages **288** is connected by a connector **292** in the valve block **260** to a waste receptacle (not shown). The other vertical passage **290** is connected by a similar connector **294** in the valve block **260** to a pressurized water supply which is preferably maintained at a pressure of approximately 10 pounds per square inch.

In operation, and at the beginning of the sample pass i.e., the pass of the specimen wheel **16** through the transfer position **126,** both of the solenoid piston arms **276** and **278** are in their extended position, thereby closing off the respective passages **288** and **290.** The transfer arm **140** has been rotated and has descended, seating the resilient stopper **222** on the waiting specimen cup **224.** The descent and final positioning of the transfer arm **140** positions the hole in the lower optical position arm **230** between the light source **236** and the corresponding photocell. The resulting electrical pulse from the photocell opens the pressurization valve leading from the pressurized gas or air supply to the short tube **242** in the resilient stopper **222.** The resulting flow of gas pressurizes the contents of the cup **30.**

Shortly after the electronic logic detects the presence of an output from the lower position photocell **236,** the logic energizes the sample pickup solenoid **280** which withdraws its connected valving member **268.** This withdrawal places the passage **288** leading to the waste receptacle in communication with the long stainless steel tube **240** which has its end submerged in the serum sample in the serum cup **30.** The pressure in the cup **30** induces and sustains a flow of serum into this tube **240** as long as the pick-up solenoid **280** is energized. This pickup solenoid **280** is de-energized and re-extends its valving member **268** when the programmed amount of serum has been extracted from the specimen cup **30.** The steel extraction tube **240** and the supply tube **246** to which it is connected is initially filled with water, as will hereinafter be described, so that this water is displaced into the waste receptacle when the amount of serum enters the tube **240** under the applied pressure. The serum never reaches the vertical orificed capillary tube **254,** thereby allowing all orificing to be done on water.

The signal from the control logic which de-energizes the pick-up solenoid **280** and terminates the extraction of the serum sample also de-energizes the pressurization air valve connected to the short tube **242** and allows the built-up pressure to vent into the atmosphere. The air valve **221** which has been supplying the air cylinder **154** to hold the transfer arm **140** down and the resilient stopper **222** on the sample cup **30** is subsequently de-energized. The two extension springs **168** and **170** acting on the extension plate **156** are then no longer maintained in their extended position by air pressure, so they cause the plate **156** to move upwards, thereby forcing the coupling block **150** and spline shaft **148** to move upward also. The upward movement is buffered to some extent by the air or gas in the inlet chamber **162** of the air cylinder **154** as it is then compressed by the upward moving diaphragm **160** to slowly escape through inlet **166.** It can be seen that this upward movement also moves the hole in the position detection arm **230** out of communication with its light source **236** and associated photocell so that the photocell no longer conducts.

The electronic logic notes the absence of this photocell output and once again begins pulsing the servo stepping motor **180** to rotate the transfer arm **140** through 180°, back to its position above the test chemistry wheel. The first rotary motion of the stepping

motor coupling **208** rotates the optical position detection disc **210** on the stepping motor shaft coupling **208** so that the specimen wheel position detection hole is no longer in communication with its light source **212** and photocell **214**. The elimination of this photocell **214** output may be used to close the pressurization valve connected to the short tube **242**, as the pressure in the specimen cup is no longer needed.

The horizontal transfer arm **140** is rotated back to the test chemistry wheel position **127** at a rate which slowly increases and then decreases before coming to a rest above that wheel **18**. This acceleration and deceleration is controlled from the control logic by the rate at which the control logic pulses the servo stepping motor **180**. The varying rate is used so that not even a minute part of the carried serum sample will be slung from the extraction tube **240** due to abrupt stopping or starting of the rotation.

The positioning of the transfer arm **140** into its position above the test wheel **18** brings the test wheel position hole on the optical position detection disk **210** into communication with the light source **212** and photocell **214**. The resulting photocell output signals the logic circuitry which ceases to pulse the servo stepping motor **180** and initiates the expulsion of the required amount of serum sample from the steel extraction tube **240**. This is done by energizing the transfer solenoid **282** which retracts its piston arm **278** and valving member **270** in the valve block **260**. The retraction permits pressurized water from the pressurized supply to enter the valve block **260** through the connector **294** and vertical passage **290** and communicate with the lower end of the tube **246** containing the test sample of serum. This in-flowing forces the serum out the pick-up tube **240** into a test tube **33**. The time for which the solenoid **282** is energized is closely controlled, thereby expelling the required amount of serum into the waiting test tube **33** using the pressurized water.

Preferably, an amount of serum was initially extracted from the sample cup **30** in the sample wheel **16** slightly in excess of that which was required for the test to be performed. This insures that the required amount of serum will be deposited in the test tube without any unwanted water which might dilute the serum and affect the test. Water may, however, be desired and is added accordingly.

The logic signal which terminates the expulsion of the required amount of serum sample into the test tube may also be used to initiate the solenoid for the one-half turn clutch **94** in the specimen wheel **16** drive so that the next serum specimen to be tested may be indexed into the transfer position **126** by the specimen wheel. The presence of such a specimen is again detected by the patient-identification detection device **110** which, by means of its photocell **124**, initiates a second swing of the transfer arm **140** to pickup another sample from a waiting cup **30**. As the horizontal transfer arm **140** makes the second, and all subsequent 180° traverses from the test chemistry wheel **18** to the specimen wheel **16**, the transfer solenoid **282** is turned on to purge the extraction tube **240** of any serum sample remaining from the previous sample pickup, to thoroughly wash the tube **240** to prevent any cross-contamination between the serum samples and to fill the tube **240** with water to be displaced during the first or next pick-up. This purging of the extraction tube **240** occurs over a receptacle **296** in the top of the lower housing **12** beneath the swinging arc of the transfer arm **140**.

An alternative embodiment of the serum pickup and transfer apparatus **24** is illustrated in FIGS. **19** through **21**. In this embodiment, the up and down movement of the spline shaft **148** is effected by an air cylinder **600**. The piston shaft **601** of the air cylinder **600** is coupled, by a short shaft **602** which is secured in a mating block **604**, to a flexible coupling **606**. The output shaft **608** from the coupling **606** is secured to the lower end of the spline shaft **148**. The flexible coupling **606** effects the transfer of the up and down motion of the air cylinder **600** to the spline shaft **148**, yet isolates the rotation of the spline shaft **148** from the lower mating block **604** and cylinder piston shaft **602**.

In this instance, the mating block **604** serves two functions. A vertical rod **610** is connected as by a nut **612** to the underside of the mating block **604** and extends downwardly into and through a hollow sleeve **614** in the lower bracket **158**. The rod **610** provides a vertical guide for the up and down movement of the mating block **604** and the lower end of the spline shaft **148**. Limiting nuts **616** are threaded on the lower end of the vertical guiding rod **610** to define the uppermost limit to which the horizontal arm **140** can rise.

The mating block **604** is also used as a supporting means for the vertical position detection arm bracket **226**, as explained with respect to FIG. **7**. Actuation of the air cylinder **600** is initiated by the pressurization valve **221** which is coupled to the inlet port **618** of the cylinder **600**. As before, opening this valve **221** allows activating air, under pressure, to communicate with the inlet port **618** of the cylinder **600** to effect the downward movement of the spline shaft **148**. Closing this valve **221** allows a return spring (not shown), within the cylinder **600**, to return the spline shaft and the piston shaft **602** to their uppermost position.

As before, the extraction of the required amount of a serum sample is initiated when the lower of the positioned photocells has an electrical output signifying that a serum cup **30** has been sealed by a stopper **620** in the transfer arm **140**. In the embodiment shown in FIG. **19**, a pressurization tube **622** has the pickup tube **624** disposed concentrically therein with sufficient space about the periphery of the pickup tube **624** to afford an adequate discharge annulus for the pressurizing air. These two concentric tubes **622** and **624** are vertically secured by means of a two part threaded fastener **626** which carries the stopper **620** at its lower end. The concentric tubes **622** and **624** extend out of the top of the horizontal arm **140** and re-enter the arm to pass through the hollow in the center of the spline shaft **148** before exiting at the lower end of the spline shaft through an outlet cavity **628** in the wall of the spline shaft **148**.

A second stainless steel tube **630** extends vertically through the horizontal arm **140** and has its lower end directed at the pickup tube **624**. The tube is held in place by a threaded fastener **632** which also serves to mate the tube with a more flexible tube **634** which, like the two concentric tubes **622** and **624**, passes through the interior hollow of the spline shaft **148** and exits through the exit cavity **628**. As will be seen, the directed tube **630** is used to clean residual serum sample from the external surface of the pickup tube **624** during the transfer process. This cleansing operation will be described in more detail with respect to the operation

of the alternate embodiment of the valve assembly shown in FIG. 9.

The alternate valve assembly **635**, shown in FIG. **20** and **21**, utilizes a single solenoid driver **636** for effecting the requisite valving action. The lower end of the concentric pickup and pressurization tubes **622** and **624** are coupled to a tee-section **638** within which the outer tube, i.e., the pressurization tube **622**, is intersected by an input tube section **640** which supplies the input air needed to this tube **622**. The pressurization tube **622**, within the tee-section **638**, is then blocked off immediately after the intersection of the input tube **640**. Accordingly, only the pickup tube **624** is coupled between the tee-section **638** input **642** and the output of the valve assembly **635**.

The input tube **640** to the pressurization tube **622** is coupled to the output of the three valves **644, 646** and **648**. The first of these valves **644** is, in effect, a venting valve which is opened to release the pressure on the specimen cup to the atmosphere after a sample has been picked up. The second of these valves **646** couples a high pressure air supply **647** to the pressurization tube **622** when it is open. This high pressure air is used, as will be hereinafter more adequately explained, to wipe the outside of the pickup tube **624** during a purging procedure.

The third valve **648** is opened to connect a pressurizing air supply **649**, preferably at 10 psi, to the pressurization tube **622** when a serum cup has been sealed by the downward movement of the horizontal arm **140**.

The valve body **650** for the serum-pickup valve assembly **635** is coupled to the input end **642** of the tee-section **638** by an orificing tube assembly shown in detail in FIG. **21**. The serum pickup tube **624**, between the tee-section **638** and the valve body **650** is secured in a short length of stainless steel tubing **652** which is secured in communication with the serum pickup port **656** of the valve body **650** as by a tapered and threaded sealing connector **658**. The length of stainless steel tubing **652** can be appropriately crimped as at **660** and **662** to provide the necessary size of orifice for precise serum pickup.

As previously mentioned, the valving action of the serum pickup valve **635** is effected by a single solenoid driver **636** mounted in one end of a valve body supporting block **663**. The output shaft **664** of the driver **636** is secured to a valve shaft **666** by a coupling **668**. The valve shaft **666** extends into the valve body **650**, through a waste passage **670**, a resilient sealing member **672** and into an internal valving chamber **674**. A valve plunger **676** is secured to the end of the valve rod **666** in this chamber **674**. The plunger **676** is formed with generally spherically shaped ends **678** and **680**.

The valve chamber **674** has three passages **682, 684** and **686** in communication therewith. The first of these passages **682** is connected by a coupling **688** to a valve **690** whose other side runs to a waste receptacle (not shown).

The second inlet passage **684** extends from the valve chamber **674** through a second resilient member **692**, through the valve body **650** and into the threaded coupling **658** linking the serum pickup tube **624** with the valve body **650**. The third passage **686**, like the first passage **682**, is connected by an inlet coupling **694** to a valve **696** which, when open, ports water under pressure from a pressurized supply (not shown) to the third passage **686**.

In operation, the horizontal transfer arm **140** is positioned above the serum cup **30** in the sample wheel **16** which is in the transfer position **126**. The air cylinder **600** causes the spline shaft **148** to move downward thereby sealing the sample cup **30** with the resilient stopper **620** carried in the horizontal arm **140**. At that time, the pressurization valve **648** is opened to admit pressurizing air to the pressurizing tube **622**. After a sufficient time delay to allow the pressurization of the serum cup **30**, the solenoid driver **636** in the serum pickup valve **635** is appropriately energized to retract the valve rod **666** and cause the valving member **676** to seal against the left resilient member **672**. This action places the serum pickup passage **684** in communication with the valve chamber **674**. Concurrently with this, the waste valve **690** is opened thereby also allowing the valve chamber **674** to also communicate with the waste receptacle. The serum in the cup **30**, being under pressure, enters the serum pickup tube **624** thereby displacing water which has remained in the tube **624** from the last purging cycle through the waste valve **690** and into the waste receptacle.

The amount of serum picked up is determined by the amount of time which the valve rod **666** is maintained in a retracted position. After the appropriate amount of time, the voltage to the solenoid driver **636** is reversed, thereby causing the valve rod **666** to extend and seal the serum pickup passage **684** with the valving member **676**. The electronic logic control thereafter closes the pressurization valve **648** and opens the venting valve **644** to allow the pressure in the serum cup **30** to be dissipated before the horizontal arm **140** rises.

The air cylinder **600** thereafter moves the spline shaft **148** and thereby the horizontal arm **140** to their uppermost position as determined by the position nuts **616** on the vertical guiding rod **610**. The stepping motor **180** then initiates the swing of the horizontal arm **140** toward the test chemistry wheel **18**. Intermediate this swing, the pickup and pressurization tube **624** and **622** pass over the waste receptacle **296** in the top of the lower housing **12**. At this time, the high pressure purge valve **646** is opened to present high pressure air to the pressurization tube **622**. This high pressure air wipes off the outside of the serum pickup tube **624** to insure that no extra serum has been retained on the exterior surface of this tube **624**. This air flow is maintained for approximately ½ second, after which the swing of the horizontal arm **140** continues toward the test chemistry wheel.

When the serum pickup tube **624** is in position over a test tube **33** in the test chemistry wheel **18**, the serum pickup solenoid **636** is again energized to retract the valving member **676**, and the water valve **696** is concurrently opened to present pressurized water to the valve chamber **674**. The water, being under pressure, forces the serum in the pickup tube **624** to flow out into the test tube **33**. Again, the appropriate amount of dispensed serum depends on the amount of time which the valve rod **666** is held in its retracted position. Appropriately, the voltage on the solenoid **636** is reversed to extend the valve member **676** against the right resilient member **692** to thereby close off the pickup tube **624** from the water valve **696**. This valve **696** is then also closed.

Having completed the dispensing of the serum sample, the horizontal arm **140** is then swung back toward the specimen wheel to pick up the next serum sample

from the cup which has been indexed into the transfer position **126** by the serum specimen wheel **16.** However, intermediate this return swing, a purging procedure is performed which removes all traces of the previous serum sample from the pickup tube **624** thereby preventing any danger of cross contamination between samples. The horizontal arm **140** pauses in its swing as the pickup tube **624** becomes vertically aligned with the receptacle **296** in the top of the lower housing **12.** At this time, the water valve **696** whose output port leads to the valve chamber **674** in the pickup valve **652,** is opened, to allow pressurized water to flow through the valve chamber **674** and into the pickup tube **624.** This water exits the pickup tube **624** and is deposited into the waste receptacle **296.** At the same time, the purging air valve **646** is open to permit high pressure air to flow through the pressurizing tube **622** to blow off the outside of the serum pickup tube **624.** Concurrently with the air flow, a water valve **698,** which is connected to the directed purging tube **634** in the horizontal arm **140,** is opened which shoots water against the outside of the pickup tube **624.** The downward flowing air and the inward shooting water generates an aerated water turbulence along the exterior surface of the pickup tube **624** which thoroughly cleanses it. The pickup water valve **696** is then closed to stop the flow of water through the pickup tube **624** and the purging water valve **698** is also closed to stop the water flowing in the purging tube and against the outside of the tube pickup **624.** The purging air valve **646** is thereafter held in an open position for a short time to effect a drying of the outside of the tube **624.** The arm **140** then continues toward the specimen wheel to repeat the operation of picking up a serum sample.

The valve chamber **674,** as well as the water and waste passages **686** and **682,** can also be purged as desired, preferably at the beginning of a test cycle. This initial purge is performed by opening the waste valve **690** and the water valve **696** while maintaining the valve rod **666** in its extended position to seal off the serum pickup passage **684.** This allows water to circulate in the valve chamber **674** and exit through the waste valve **690.** Due to the extended position of the valving member **676,** an amount of the water will leak around the valve rod **666** only to be directed to waste through the waste passage **670** through which the rod **676** passes.

The initiation of a test series, in addition to each sample pickup in that series, causes the test chemistry wheel **18** to index empty test tubes **33** into the transfer position **127** to receive a serum sample. The drive and controlling devices for the test chemistry wheel **18** are shown in FIGS. **10–11** and comprise essentially the same type of components as that of the specimen wheel **16.** The test tubes **33** are inserted and supported in holes **300** in the top **302** of the test chemistry wheel. They are permitted to rest and ride on the bottom of the tube-receiving channel **304** and are supported in a vertical position by a supporting plate **306.** The top **302** of the test wheel **18** and the supporting plate **306** are centrally mounted on a main drive shaft **308.** The shaft **308** is rotatably driven through a driving pin plate **310,** a barrel cam **312** and a one-half turn clutch **314** by the same motor **98** which drives the specimen cup wheel **16.**

The test chemistry wheel drive shaft **308** is rotatably mounted in bearing blocks **316** and **318** which are supported in a drive shaft housing **320.** The bottom of the shaft is mounted in thrust bearings **322** in a hub **324** before being terminated and secured by a lock nut **326** on the bottom side of the hub **324.** A flange **325** extending from the bottom of the drive shaft housing **320** supports the end brackets **328** in which the shaft **330** carrying the driving cam **312** is mounted in bearings **332.**

The electronic logic control energizes the one-half turn clutch **314** in the test wheel **18** as the horizontal sample transfer arm **140** begins its 180° swing to the specimen wheel **16** to extract a serum sample. The cam **312** is rotated thereby to drive the pin **334** in communication with its track which results in a rotary movement of the test chemistry wheel. The wheel **18** continues to index through test tube positions until the arrival of a test tube **33** into the serum sample transfer position **127** is detected by a detection device **336** mounted in the base of the test wheel **18** below the supporting plate **306.**

The detection device **336** comprises a deflection arm **338** which is connected to an activating arm **340** extending from a housing **343.** The activation arm **340** is connected to a slidable, optically black blade member **342** which contains a hole **344.** The deflection arm **338** is positioned so that a test tube entering the transfer position **127** in the test chemistry wheel will cause deflection of the arm **338** thereby pushing the activating arm **340** and sliding the hole **344** in the optically black blade **342** into communication with a light source **346** and a photocell **348.** The resulting electrical signal from the photocell **348** is detected by the logic control resulting in the de-energization of the one-half turn clutch **314** which stops the rotation of the test chemistry wheel.

The relative position of the test chemistry wheel **18** can be recorded in a memory portion of the control logic by the use of a position detection disk **350.** This disk **350** is mounted on the driving cam shaft **330** so that it makes one-half revolution each time the cam drives a pin **334** to index the test chemistry wheel one position. Holes **352** in this disk **350** communicate with a light source **351** and a photocell **353** each time the disk **350** and the cam make one-half of a revolution. The number of the resulting electrical pulses from the photocell **353** is recorded in memory by the control logic for later utilization.

The above-described transfer of serum samples to the test chemistry wheel **18** for receiving a specific chemistry analysis is continued until the specimen wheel **16** has made a complete revolution and the first sample cup position is again in the "home" position **129.** The control light is signalled that this event has occurred by an optic detection device **358,** as shown in FIG. **3.** This device **358** has a deflection arm **360** which is connected at its end to a deflection member **362** shaped to communicate with a notch **364** in the periphery of the driving pin plate **68.** The notch **364** is located adjacent the pin **370** which corresponds to the home position **129.** The deflection member **362** and arm **360** are held in a deflected position by the periphery of the driving pin plate **68** as the plate rotates.

Upon reaching the home position **129,** the notch **364** in the plate **68** permits the spring loaded deflection arm **360** to extend, which brings a hole **372** in a blade **374** into communication with a photocell **376** and light source **378.** The resulting electrical signal from the photocell **376** signals the control logic that all of the

cup positions in the specimen wheel have been tested for a displaced patient-identification selection switch **108.** Movement of the specimen wheel **16** is terminated for the remainder of the test in progress.

As shown in FIG. **2,** the test tubes in the test chemistry wheel **18** pass beneath dispensing heads **26, 27** and **28** after leaving the transfer position **127.** It may be that the first of these passes is caused by empty test tubes being indexed into the transfer position **127** to receive a serum sample. The first of the dispensing heads **26** is a "dispense only" apparatus, and is identical to the other two dispensers **27** and **28** except that it does not have means by which to mix the chemical reagents supplied therefrom with the serum sample. The two subsequent dispensers **27** and **28** having mixing apparatus included therewith so that the reagents that are added to the test tubes from these heads **27** and **28** may be mixed with the sample to insure uniform distribution of the reagents within the serum. The uniform distribution of reagents avoids "hot spots" of reagents within the serum sample which would yield erroneous test results, when the test chemistry is subsequently analyzed, which would result from the non-homogeneity of the mixture.

One of the combination dispensing and mixing heads **27** and **28** is shown in FIG. **12.** These heads are mounted in the top of the lower housing **12,** as by bolts **357,** and generally comprise a lower dispensing unit **354** and an upper mixing unit **356.** The dispensing unit **354** is stationary, while the mixing unit **356** is reciprocated up and down by a rod **359** which is fastened at its upper end to the mixing unit **356** and at its lower end to a piston in an air cylinder (not shown). The air cylinder provides the necessary up and down stroke to place a mixing rod **361** extending from the mixing unit **356** through a channel **363** in the stationary dispensing unit **354,** into the serum and reagent combination in the test tube **33** located therebelow. The upper end of the stirring rod **360** is connected by a coupling **365** to the shaft **366** of a stirring motor **368.** The stirring shaft **360** is comprised of a stainless steel rod **371** over which has been slipped a piece of inert and chemically resistant tubing **373** such as that sold by the DuPont Corporation under the trademark Teflon. The lower end **375** is sealed to prevent any of the test chemistry from entering the tubing **373.**

In operation, reagents which have been selected by apparatus hereinafter to be described, are supplied to three channels **377** in the dispensing head **354** by separate tubes **379.** The channels **377** lead to openings **380** above the waiting test tube **33** from which the reagents are dispensed. The mixing head **356** is then moved downward by its controlling air cylinder (not shown) and the stirring motor **368** is turned on by the logic control. The stirring rod **360** passes down into the test tube **33** and the combination of the serum sample and the chemical reagents which have been added by the dispensing head **354.** The spinning rod **360** rapidly combines the mixture and uniformly distributes the reagents throughout.

On signal from the logic control, the rod **359** again is extended by the air cylinder and the stirring rod **361** is retracted from the test tube **33,** and the stirring motor **368** turned off. The high speed at which the shaft rotates, preferably about 6000 rpm, coupled with the surface characteristics of the shaft **361,** throws all the chemistry off into the test tube as the shaft is extracted, thereby eliminating any possibility of later cross-contamination. The test chemistry wheel **18** is indexed to present an empty test tube to the transfer position **127** so that the test tube **33** containing the just-formed and mixed test chemistry is indexed to another dispensing station **28** or to the test chemistry transfer position **455,** as shown in FIG. **1.**

An alternate embodiment of the dispensing and mixing head utilizing a different mixing technique, is shown in FIG. **22.** The alternative apparatus generally comprises a lower dispensing unit **702** and an upper and movably mounted mixing unit **704.** The dispensing unit **702** is stationary, while the mixing unit **704** can be reciprocated up and down as by an air cylinder **706.** Activating air for the air cylinder **706** is supplied from a pressurized air supply to a manifold block **708** and by a passage **710** therein to an inlet port **712** in the air cylinder **706.** The air passage **710** in the manifold block **708** is preferably a tube which is inserted in the manifold block and which extends downwardly therefrom to communicate with the tube **714** leading from the valve for the pressurized air supply. The manifold tube **710** is sealed in the supply tube **714** as by a threaded rubber coupling **716.** This two part construction permits the manifold block **708** to be easily disconnected from the top of the lower housing **12.**

Air is provided to the cylinder input port **712** to lower the mixing unit **704** and extend a mixing tube **716** substantially all the way into the test tube which is in position under the apparatus. The mixing tube **716** is comprised of a stainless steel tube **718** over which a flexible, chemically inert tube **720,** such as Teflon, is slidably mounted. The two tubes **718** and **720** are fastened together within the mixing unit **704** by a threaded rubber cap **722.** The stainless steel tube **718** is terminated shortly above this cap **722,** with the flexible tube **720** continuing out the top of the mixing unit **704** and into a flow control valve **724** mounted on the rear **726** of the mixing unit **704.**

More specifically, air is ported to the air cylinder inlet port **712** after the specified reagents have been added through reagent dispensing tubes **728** into the test tube **33.** The air forces a piston and piston shaft **730** downwardly within the air cylinder **706.** The piston shaft **730** is connected at its upper end to the lower side of the mixing unit **704.** As a result, the mixing unit **704** is lowered along a vertical guiding rod **732** into the solid line position shown in FIG. **22.** As the unit **704** is lowered, the mixing rod **716** passes down, out of the lower dispensing unit **702** and into the test tube **33.** Inert air, preferably nitrogen, is, at the same time, supplied through the rate control valve **724** to the mixing tube **716.** The gas leaves the lower end of the mixing tube **716** in the form of bubbles which pass up through the contents in the tube **33** and escape through the upper surface of the solution. The bubbling action, the rate of which is controlled by the rate control valve **724,** thoroughly mixes the reagents and serum forming the solution in the test tube **33** at that moment to provide a homogeneous mixture.

At the conclusion of the predeterminable mixing time, as dictated by the logic control, the control valve (not shown) supplying the air to the cylinder **706** is closed, thereby allowing a spring (not shown) within the cylinder **706** to return the mixing unit **704** to its upper, dotted line position shown in FIG. **21.** The arrival of the unit **704** at its upper position is detected by the

logic control by means of a magnetic detector (not shown) which can be mounted at the lower end of a detector rod **734**. This rod **734** extends through the dispensing unit **702** and is secured in the mixing unit **704** as by threads **736**. The primary purpose in the use of this rod and vertical detecting mechanism is to prevent any indexing of the test chemistry wheel **18** while the mixing unit **704** is in its downward position.

The apparatus used in selecting the proper reagents and controlling the amount of each that is dispensed is shown in FIGS. **13** through **15**. A main selector valve **384** is shown which is capable of selecting reagents for a plurality of different tests or chemical analyses. The selector valve **384** comprises a main valve body **386** which can be made up of six individual valve bodies **388**. Each of the valve bodies **388** has a main selector valve solenoid **390** and five individual double ended reagent valves **392** associated therewith. The main selector solenoids **390** each have a control rod **394** which extends through the respective valve body **388** and is mounted on a selector valve plate **396** by means of snap rings **398**.

Each solenoid **390** controls the upper and lower end of five selector valve stems **404** in the reagent valves **392** by means of this plate **396**. Each respective selector valve **392** has a return spring **400** mounted between shoulders **402** on its upper end. The valve stems **404** extend through the valve body **388** and are connected on the other side by snap rings **406** to the valve selector plate **396**. Each end of the valve **392** has a central channel **408** and **410** which terminates in a T-slot **412** and **414**, respectively. A plurality of O-ring pairs **416** isolate these T-slots **412** and **414** from each other and from the reagent-carrying channels **418** and **420** in each of the individual valve bodies **388**.

The top ends **393** of the selector valves **392** are associated with a different test or tests than the bottom ends **395**. Each of the selector valve ends **393** and **395** have a different reagent, if desired, connected to its central channel **408** and **410**, as by Teflon tubing, from the reagent supply bottles **20** in the lower machine housing **12**. The reagents in these bottles are kept under constant pressure through the use of pressurized nitrogen which is inert and will not cause degradation of the reagents.

In operation, the main solenoid **390** associated with the selector valves **392** having the desired reagents connected to them is energized to extend its control rod **394** and move its connected valve selector plate **396** away from the valve body **386**. This action by the plate **396** causes the valve stems **404** of the five selector valves associated with that solenoid **390** to move under control of this actuation plate **396**. The valve stem **404** movement brings the two cross T-slots **412** and **414** in the valve into communication with the two main valve body channels **418** and **420** respectively. Only one such solenoid **390** and its associated selector valves **392** are energized for any given test. Each of the 10 reagents connected by tubing from their pressurized bottles to the ends **393** and **395** of the selector valves chosen are now available to the respective main reagent channels **418** and **420** in the valve body **386**. The reagents are able to flow in the main reagent channels **418** and **420** around the unselected selector valve stems and between defining "O" ring pairs **416**.

A differentiation must be made between the upper level selector valve ends **393** and the lower level selector valve ends **395**. Only the reagents supplied to one end, upper or lower, are required for any one test. To make this differentiation, a level selection solenoid **424** is used to move a selector valve actuation plate **426** in correspondence with the level of a particular set of selector valves **392** needed for a particular test. An upper/lower level selection valve **328** has spaced shoulders **430** on its upper end for receiving a return spring **432** and is connected at its lower end, on the opposite side of the valve body **386**, to the actuation plate **426**. A path or channel is provided, as may be seen from FIG. **15**, for the reagents in the lower level valve ends when the upper/lower selection solenoid **424** is deenergized. When energized, the solenoid **424** extends its actuation rod **425** and moves the actuation plate **426** carrying the lower ends of the valves **428** away from the valve body. This action interrupts the path for the lower level reagents and brings the upper level reagents into communication with their outlets **434**.

The chosen reagents pass through the appropriate upper or lower level channels provided for them and are made available to one side of extremely fast acting and accurate dispensing valves **436**. The outlet sides of these dispensing valves **436** are connected to the individual tubes **379** leading to the dispensing heads **27** and **28**. Two of these valves are connected to one head **27** while three are connected to the other dispensing head **28**.

The reagents needed for a test are presented to the inlet side of the dispensing valves **436**, as above described, as soon as a test cycle is initiated. The individual dispensing valves **436** are selectively energized by the control logic when a test tube carrying a serum sample is positioned beneath the respective dispensing head **27** and **28**. The first dispensing head **26**, which has no mixing unit, is used for the dispensing of highly contaminable reagents, e.g., as used in a test for cholesterol or glucose. The reagents pose extreme danger of cross-contamination which would render the test chemistries unusable. These reagents are not selected by the selection valve **384** but are supplied to the dispensing head **26** directly from their pressurized bottles by means of separately activated dispensing valves (not shown) which are identical to the other dispensing valves **436**.

The main reagents are added at the proper time by the last two dispensing heads **27** and **28**. The logic control initiates the appropriate dispensing valves **436** for the required amount of time to dispense a precise amount of each specified reagent into the waiting test tube. When the dispensing is completed, the mixing unit descends and mixes the serum and the newly added reagents. After mixing, the mixing head unit ascends and the test tube is indexed to the next dispensing head **28** or to the test chemistry transfer position **455**, depending on where the test tube **33** is at the time. At the completion of a test series, the channels **418** and **420** in the selector valve **386** are washed out with water supplied through a valve **437** to an inlet **439** in the valve body **386**.

The selector valve may also be purged before a test is begun with the reagents that will be used in that test. This may be done by using a purge test tube which does not receive a serum sample, but is indexed through the dispensing stations to receive the test reagents. The flow of specific reagents in the selector valve **386** and dispensing valves **436** removes any water or reagent left from a previous test.

An alternate reagent selection apparatus is illustrated in FIGS. 23, 24 and 25. The main valve assembly 738, shown in FIGS. 23 and 24, is comprised of a plurality of individual valving units 740 which are secured together to comprise the main valve assembly 738. In this instance, the main assembly 738 is grouped for operation into two general columns of valves 742 and 744, each having rows containing five of the valving units 740. The assembly 738 may have any number of rows, but, in the illustrated embodiment, the right hand column group 744 has eight rows 746 through 753 and the other group has seven rows 754 through 760. The first row 754 of valves in the left hand column group 742 is used as the output dispensing valves to the dispensing and mixing apparatus 27 and 28.

The operation of the valve assembly 738 is best described with respect to FIG. 25 wherein one of the individual valving units 740 is illustrated. Each of these units 740 comprises a valve block 762 with a cavity 764 therein. A solenoid driver 766 is mounted, as by screw threads 768, into the top, open side of the cavity 764 in the valve body 762. A valve driver 770 is movably supported within the solenoid 766 by a spring 772 at its upper end and a resilient diaphragm 774 at its lower end. Movement of the driver 770 is effected by energizing the solenoid coil 775 which compresses the spring 772 and moves the diaphragm 774 upwardly. The upward movement of the diaphragm 774 permits an inlet port 776 to communicate with the enclosed cavity 764 within the valve body 762. A tube 777 for conveying a reagent from a pressurized reagent bottle 20 to this port 776 is secured in the lower portion of the port 776 by a threaded connector 779. The valve body 762 has an inlet passage 778 and an outlet passage 780 which open into the central cavity 764. The inlet passage 778 is aligned and in communication with the outlet passage 780 of the respective unit 740 in the immediately preceding row. Likewise, the outlet passage 780 is in communication with the inlet passage 778 of the valve unit 740 immediately following. O-rings 782 and 784 provide the necessary seals between the valve units 740. This tandem coupling of the inlet and outlet passages 778 and 780 is best seen in FIG. 24.

The individual valve units 740 are, as previously mentioned, arranged within each general group 742 and 744 in rows of five units each. An entire row of five valve units 740 is selected for each different test to be performed on a serum sample. In operation, each of the five solenoids 766 in the particular row of valves 740 having the reagents for the particular programmed tests supplied thereto is energized along with the valves in the dispensing valve row 754. Only one row of five solenoids of the reagent selection rows 746–753 and 753–755 are energized at any one time. The reagents coupled to the respective inlet ports 776 of the energized row of selection valves enter their respective valve bodies, flow into the internal cavities 764 and exit therefrom by the outlet passages 780. The reagents flow on into the inlet passage 778 in the next valve body 762 in that column, circumvent the diaphragm sealed inlet port 776 in the next valve body, and leave that valve body by means of the outlet passage 780. This flow continues until, if the selected row of valves is in the left hand group 742, the reagents enter the dispensing valve row 754. In the case where the selected row is in the right hand column 744, the outlet passages 780 of the top row of valve units 746 in FIG. 23 are respectively coupled, as by tubes 786 through 790, to what has heretofore been called the outlet passages 780 of the dispensing row of valves 754 in the first group 742. The valves in the dispensing row 754 are identical to the other valves except that their inlet and outlet passages 778 and 780 are both used as inputs and the inlet port 776 is utilized as the output port to the reagent tubes 379 leading to the dispensing and mixing stations 27 and 28.

It should be seen, that only the reagents coupled to the selected rows 746–753 and 755–760 of valve units 740 will be able to flow into the respective valves in the dispensing valve row 754 and out the heretofore called inlet ports 776.

In the case where only three reagents, for example, are needed for a particular test, all of the reagents coupled to the five, selected valving units 740 in the selected valve row 746–753 and 755–760 are presented to the dispensing valve row 754. It is the valves 740 in the dispensing row 754 which then are selectively energized to dispense, or not to dispense, the particular reagents available to that valve. The output tubes 379 of the dispensing row 754 of valves are the input tubes 379 leading to the dispense and mixing stations 27 and 28.

Preferably the reagents needed for a test are presented to the inlet side of the dispensing row of valves 754 as soon as a test cycle is initiated and all of the valves in the dispensing row 754 and the particular reagent selection row 746–753 and 755–760 are energized to permit the reagents to be used during that test to flow into and through the dispense valves. Desirably, both the selected valve row 746–753 and 755–760 and the dispense valve row 754 remain energized until all of the dispense valves and the dispense tubes 379 have the respective selected reagents therein. The selected valve row 746–753 and 755–760 then remains energized while the dispense row 754 is turned off. This purging with reagents insures that any water or reagent left in the individual units or tubes is flushed out, and that a precise amount of the reagents will be dispensed by the dispensing valves when appropriately energized.

At the conclusion of a test analysis, the various inlet and outlet passages 778 and 780 in the valve assembly 738 can be purged or flushed out with water. This is accomplished using a row of purging valves 792 which have their inlet ports 776 coupled as by tubes 794 to a pressurized water supply (not shown). The passages 778 and 780 in the bodies of these valves are individually coupled by a tube 796 to this inlet passage 778 in respective ones of the valve units 740 in the bottom row of valves 760 and 753 in the two major valve columns 742 and 744. Using both the inlet and outlet passages 778 and 780 of each of the valves 740 allows five purging valves to be used to purge the 10 columns of selection valves.

The row of dispense valves 754 are energized at the same time the purging valve row 792 is energized during the water purging. Water is thereby permitted to flow through all of the tandemed inlet and outlet passages 778 and 780 in the valve assembly 738, through the dispense valves 754 and through the dispense tubes 379. The purging and dispensing valves 792 and 754 are then de-energized to stop the purging process and await the next test.

There are several options available to the programmer in effecting the desired test. These options are par-

tially controlled by the nature of the test to be performed. A normal chemical serum analysis may be performed by adding the reagents as hereinbefore described and then extracting an amount of the thereby-formulated test chemistries as the test tubes **33** pass beneath the test chemistry extraction head **29.** The extraction procedure, as well as the analysis procedure, will be described in more detail below.

However, there are certain serum chemistry test analyses which must provide incubation periods after the addition of one or more of the reagents and before the addition of subsequent reagents. In many instances, this incubation period must take place at a precise, elevated temperature. In accordance with these requirements, all of the reagents may not be dispensed to the test tubes on their first pass beneath the dispensing heads **26** through **28.** Furthermore, during certain tests, certain of the reagents must be added to the test tubes and the mixture raised to a specific temperature before the serum samples are added. The incubation periods are controlled by the control logic, but the increase in temperature must be provided for by means in the test wheel.

A system shown diagrammatically in FIG. **16** is provided to furnish the rapid elevation to the precise temperatures needed. Specifically, a reservoir **440** is filled with a fluid **442** which has been treated to resist bacteria growth. This fluid **442** is constantly recirculated by a pump **444** through a heater **446** and back to the reservoir **440.** When an incubation is programmed which requires that the reagents be at an elevated temperature, a valve **450** in this constant recirculation path directs the heated fluid **442** into the channel **304** in the test wheel **18** and into communication with the test tubes **33** carried therein. One or more sensors, such as thermistors, are positioned about the circumference of the test wheel in this channel **304** to control the heating of the fluid in the heater **446,** in accordance with the desired temperature.

The fluid is pumped into the channel **304** until an overflow condition is reached, as defined by the height of an overflow outlet **452** (FIG. **11**) which directs the fluid back to the reservoir **440.** The fluid continues to recirculate on this path into and out of the test wheel channel **304,** until the control logic signals the termination of the elevated temperature incubation period. At this time, the valve **450** leading from the heater **446** no longer directs the fluid to the test wheel channel **304** but recirculates it into the reservoir **440.** An exit port **453** in the bottom of the test wheel channel is also opened to drain the fluid already in the channel back into the reservoir.

The temperature at which the fluid has been raised may then be above that which is desired for recirculation purposes. In such event, a second valve **448** which is supplied directly from the pump **444** directs the fluid through cooling condenser coils **454** and then back to the reservoir **440.** The fluid continues to recirculate on this path until the desired temperature level is reached at which time it is permitted, by the second valve **448,** to recirculate through the heater and heater valve **450** back to the reservoir **440.**

The various tests which may be performed, as well as the sequencing of serum transfers, reagent dispensing, and proper incubating techniques are all under the control of the control logic and are described in detail in the above-mentioned co-pending application. The completed test chemistry is extracted by the test chemistry extraction apparatus **29** after the appropriate reagents have been added and all incubations completed.

The extraction head apparatus **29** is shown in more detail in FIG. **17.** It is supported in the top of the lower housing **12** by a tubular support member **456** which contains a vertically movable rod **457.** The rod **457** supports, at its upper end, a horizontal arm **458.** A resilient stopper **460** similar to that used in the serum sample transfer arm **140** is secured beneath and projects into the arm **458** at one end thereof. This stopper **460** contains two stainless steel tubes **462** and **464** which are connected within the stopper **460** to the ends of flexible tubes **466** and **468.** The shorter of the stainless steel tubes **464** is connected by its flexible tube **468** to the outlet of a pressurization valve **470** whose inlet is connected to the pressurized air supply **471.**

The lower end of the vertically moving rod **457** is connected to the piston rod **472** of an air cylinder **474.** Pressurized air is supplied to the top inlet port **475** of this air cylinder **474** to move the piston rod **472** in a downward direction. This causes the horizontal arm **458** to descend on a waiting test tube **33,** immerse the longer tube **462** of the two stainless steel tubes in its stopper **460** in the test chemistry contained in that test tube **33** and seal the top of the test tube **33** with the stopper **460.** The other end of the tubing **466** connected to the longer stainless steel rod **462** passes through the hollow air cylinder piston rod **472** and air cylinder **474** and is made available to a flow cell **479** as used in a spectrophotometer. The other side of the flow cell **479** is connected to the inlet of a valve **485.** The other side of this valve **485** is connected to a waste receptacle **486.**

In operation, when the control logic senses that all the reagents have been added and any incubation period completed, the test tubes **33** containing the completed test chemistries are successively indexed into the test chemistry extraction position **455.** A portion of each test chemistry is extracted and made available to the flow cell **479** for analysis, after which the next test chemistry is indexed into the extraction position **455** and the process repeated. More specifically, the indexing of a completed test chemistry into the extraction position initiates the closing of the air valve **476** to provide pressurized air to the top inlet port **475** of the air cylinder **474.** This causes the horizontal arm **458** to descend and seat its stopper **460** against the top of a waiting test tube **33.** The pressurization valve **470** is then opened permitting pressurized air to be applied to the contents of the test tube through the short stainless steel tube **464** in the stopper **460.** The flow cell valve **485** is opened to permit test chemistry to be forced out of the test tube **33** by the air pressure, into the extraction tube **462,** through the connected flexible tube **466** and into the flow cell **479.**

A large amount of the test chemistry is permitted to flow in this manner through the extraction tubes **462** and **466,** through the flow cell **479,** and to waste through the valve **485** before the flow cell valve **485** is turned off to trap test chemistry in the flow cell. The excess flow of test chemistry is used to wash the tubes, the flow cell and the cell valve of the previous test chemistry thereby avoiding any cross-contamination which might affect the subsequent spectroanalysis.

The spectroanalysis of the test chemistry is conducted in a conventional spectrophotometer which has

been modified to provide means by which the flow cell is moved in and out of the requisite light path, instead of disturbing that path with rotating mirrors as is often done.

The flow cell **479**, as shown in FIG. **18**, is supported by bearings **488** on a rail **490** which permits and guides linear movement of the flow cell **479**. The base of the flow cell is connected, as by a pin **492**, to a slotted member **494**. A finger member **496** is mounted on, and is eccentrically driven by, a wheel **498** and moves within the slot **495** in the slotted member **494**. A shaft **500** is eccentrically mounted by ball bearings **502** to this finger supporting wheel **498**. The shaft **500** is also connected to a second rotating wheel **504** at a location offset from the center of rotation of that wheel **504**. The latter wheel **504** is rotated at approximately 30 rounds per minute by an electric motor **506**.

As the motor **506** rotates this wheel **504**, the finger-supporting member **498** is eccentrically driven to reciprocate the flow cell **482** on its supporting rod **490**. As can be seen from FIG. **18**, this reciprocation serves to move the flow cell and the test chemistry contained therein into and out of the light path. The reciprocation of the flow cell and test chemistry provides a continuous source of calibrating signals for the spectrophotometer. Electronic logic may be associated with the spectrophotometer to process its output and transform it into various forms of usable data.

At the conclusion of the spectrophotometer analysis, the inlet air valve **475** (FIG. **17**) closes and air is instead supplied through a second valve **477** to the lower side of the extraction head air cylinder **474** (FIG. **17**). The resulting movement breaks the seal of the resilient stopper **460** on the top of the test tube **33** and the horizontal arm **458** is returned to its uppermost position. At the conclusion of each test the pressurization valve **470** supplying the pressurizing air is turned off.

An alternate embodiment of the extraction head apparatus **29** is shown in FIG. **26**. In this apparatus, the extraction head **806** is reciprocated up and down at the appropriate time, by an air cylinder **800** which is similar to the cylinder **706** used in the alternate embodiment of the mixing and dispensing apparatus **27, 28** shown in FIG. **22**. Air, under pressure, is supplied to an input tube **803** which is coupled to an inlet passage **804** in a manifold block **807**. The inlet passage in turn supplies an inlet port **802** in the air cylinder **800** to force the piston contained therein downwardly. A piston output shaft **805** is secured to the underside of the horizontal arm thereby transmitting the downward motion to the extraction head **806**. The extraction head **806** is guided in this downward movement by a vertical rod **808** on which the head **806** is movably supported as by bearings **810**. The lower position of the extraction head **806** is specified by the travel of the piston shaft **805** within the air cylinder **800**, and is detected by means of a sensing rod **812** which is secured, as by threads **814** in the lower portion of the extraction head **806**. At the lower position, this sensor rod **812** makes contact with a detection means, such as a switch or a magnetic sensor (not shown), which in turn generates a signal indicative of such lower position. This signal is used to inhibit the electronic control logic during the time which the extraction apparatus **806** remains at its lower position, to prevent any indexing of the test wheel **18**.

The extraction of the completed test chemistry from the test tube **33** in the extraction position **455** on the test wheel **18**, is performed by a stainless steel tube **816** which is inserted into the test tube **33** and test chemistry as the extraction head **806** moves downwardly. The extraction tube **816** extends up, into the extraction head **806** and is fitted into the lower end **818** of the flexible tube **466** which leads to the flow cell **479**. A tight seal is maintained between these two, interfitting tubes **816** and **466** by a threaded rubber cap **822**.

A slightly enlarged cavity **824** is provided immediately below the lower end **818** of the flexible tube **446**. The stainless steel extraction tube **816** is held in a generally centered position in this cavity **824** by its secured connection in the rubber stopper **822**, and extends downwardly through the cavity **824** and through a resilient stopper **826** before emerging from the lower side of the extraction head **806** to communicate with contents of the test tube **33**. A second, flexible tube **828** communicates with this cavity **824** and is secured in place with a threaded coupling **830**. The second tube **828** supplies the cavity **824** with pressurized air from a flow control **832** mounted on the rear side **833** of the extraction head **806**. The extraction head **806**, in its downward position, seals the top of the test tube **33** with the resilient stopper **826** which permits the pressurized air flowing into the cavity **824** to pressurize the contents of the test tube **33**. When the flow cell valve **485** is subsequently opened, this pressurized condition forces test chemistry from the test tube **33** up into the stainless steel extraction tube **816**, through the flexible tubing **466** and into the flow cell **479**.

When the predetermined amount of test chemistry has been extracted, the air supplied to the inlet port **802**, by means of the manifold **807** and supply tube **803**, is turned off, thereby allowing a spring (not shown) within the air cylinder **800** to return the extraction head **806** to its upper position and await the indexing of the next test chemistry into the extraction position.

The entire process is repeated when the next test chemistry carrying test tube **33** is indexed into the extraction position **455** and continues until all the test chemistries have been analyzed by the spectrophotometer. The used test tubes are discarded by opening a trap door in the bottom of the test tube channel **304** (FIG. **11**) which is arcuately disposed after the extraction position **455**. At the conclusion of all the tests of one type, a purging valve **508** leading from a pressurized water supply to the extraction tube **466** is opened, as is the flow cell valve **485**. Water is thereby permitted to purge the extraction tubes **462** and **466** and clean the chemistry passages within the flow cell **479** and flow cell valve **485**. The purging valve **508** is closed at the completion of the cleansing cycle.

We claim:

1. Apparatus for preparing a succession of serum chemistries for analysis, comprising serum conveyor means for conveying a plurality of specimen containers each containing a serum specimen along a first path; chemistry conveyor means for conveying a plurality of chemistry containers along a second path; a transfer arm; drive means for driving said transfer arm between successive communication with preselected ones of said specimen containers and communication with successive ones of said chemistry containers; sealing means carried in said transfer arm for sealing a speci-

men container when said arm is in communication therewith; first tube means carried in said transfer arm and having one end for communicating with the specimen container sealed by said sealing means, the other end of said first tube means being coupled through first valve means to a first fluid under pressure, said first valve means being selectively operable to admit said first fluid to the sealed specimen container to pressurize said container; second tube means carried in said transfer arm and having one end for reception in the serum specimen in the sealed specimen container, the other end of said second tube means being coupled through second valve means to venting means, said second valve means being selectively operable for a predetermined time period to allow the pressure in said sealed container to induce a predetermined amount of the serum specimen to flow into said second tube means; third valve means coupled between the other end of said second tube means and a second fluid under pressure, said third valve means being selectively operable for a predetermined time period when said transfer arm is in communication with one of said chemistry containers to cause a predetermined amount of the serum specimen in said second tube means to flow into said chemistry container; and dispensing means for selectively dispensing a predetermined and repetitive amount of a reagent into each of the chemistry containers to form serum chemistries.

2. Apparatus as set forth in claim **1** with the addition of extraction means for successively extracting a predetermined portion of the formulated serum chemistries for analysis.

3. Apparatus as set forth in claim **1** wherein said first valve means is selectively operable to admit said first fluid to said sealed specimen container to raise the pressure in said container to a predetermined level, and to maintain said level while said second tube means is vented.

4. Apparatus as set forth in claim **1** with the addition of fourth valve means coupled between the other end of said first tube means and second venting means, said fourth valve means being selectively operable to release the pressure in the specimen container after the predetermined amount of the specimen has been induced to flow into said second tube means.

5. Apparatus as set forth in claim **1** wherein said serum conveyor means includes rotary drive means for successively presenting said preselected specimen containers to a transfer station for communication with said transfer arm.

6. Apparatus as set forth in claim **1** wherein said chemistry conveyor means includes rotary drive means for successively presenting said chemistry containers to a receiving station for reception of a predetermined amount of one of said serum specimens.

7. Apparatus as set forth in claim **1** wherein said second tube means is supported in and protrudes from said sealing means, whereby said second tube means is inserted into the serum specimen in a specimen container when said sealing means is in sealing engagement with the specimen container.

8. Apparatus as set forth in claim **1** wherein said first tube means is supported in and protrudes from said sealing means, whereby said first tube means communicates with a specimen container when said sealing means is in sealing engagement with the specimen container.

9. Apparatus as set forth in claim **1** wherein said first tube means is supported in and protrudes from said sealing means, and said second tube means is disposed within the hollow of said first tube means, whereby said first and second tube means communicate with a specimen container when said sealing means is in sealing engagement with the specimen container.

10. Apparatus as set forth in claim **1** wherein said transfer arm includes purge means for removing any serum from the external surface of said second tube means after the transfer arm is out of communication with the specimen container.

11. Apparatus as set forth in claim **1** wherein said dispensing means includes selection apparatus for selecting and supplying a predetermined amount of a reagent from among a plurality of reagents.

12. Apparatus as set forth in claim **44** wherein said dispensing means comprises a plurality of reagents each contained in an individual reagent container pressurized to a substantially constant pressure level, each of said reagents having a delivery tube with one end received therein and the other end for communication with said plurality of chemistry containers, an individual reagent valve coupled to each delivery tube for selectively opening and closing said delivery tube, said reagent valves being selectively operable for predetermined time periods to allow the pressure in the respective reagent containers to cause a flow of predetermined and repeatable amounts of selected ones of said reagents into successive chemistry containers.

13. Apparatus as set forth in claim **1** with the addition of mixing apparatus for selectively mixing the contents of the chemistry containers.

14. Apparatus as set forth in claim **13** wherein said mixing apparatus comprises a motor, a mixing member operatively connected to said motor for rotation thereby, said mixing member having reciprocation means coupled thereto for positioning said mixing member into and out of the chemistry containers to selectively immerse said mixing member in the contents of the chemistry containers.

15. Apparatus as set forth in claim **13** wherein said mixing apparatus comprises a mixing member having a passage therein, a pressurized gas supply coupled to said passage, means for reciprocating said mixing member into and out of the chemistry containers to immerse said mixing member in the contents of the chemistry containers to bring said passage into communication with the container contents whereby the pressurized gas is induced to flow through and mix said contents.

16. Apparatus as set forth in claim **1** including identification means for identifying the preselected specimen containers which are to have a predetermined amount of the serum specimen therein transferred to a chemistry container.

17. Apparatus as set forth in claim **2** wherein said extraction means includes an extraction arm for successively communicating with each of said chemistry containers for extracting a predetermined amount of the formulated serum chemistries therein for analysis.

18. Apparatus as set forth in claim **17** wherein said extraction arm includes sealing means, drive means for successively positioning said sealing means into sealing engagement with each of the chemistry containers, a first passage in said sealing means for connecting the chemistry container sealed thereby to a source of fluid under pressure to pressurize the contents of said con-

tainer, an extraction member in said sealing means having a second passage disposed therein so that said second passage is in communication with the contents of the chemistry container when the container is sealed, and means for connecting said second passage to a test receptacle for a predetermined time period whereby a predetermined amount of the chemistry container contents is induced to flow into said test receptacle.

19. Apparatus as set forth in claim **18** wherein said test receptacle comprises the flow cell of a spectrophotometer.

20. Apparatus as set forth in claim **1** wherein said chemistry conveyor means includes incubation means for selectively controlling the temperature of the contents of the chemistry containers.

21. Apparatus as set forth in claim **1** with the addition of cleansing means for cleansing serum from said second tube means after the predetermined amount of serum specimen has been deposited in one of the chemistry containers, said cleansing means including receptacle means disposed between said chemistry conveyor means and said serum conveyor means for receiving the serum cleansed from said second tube means.

22. Apparatus as set forth in claim **1** wherein said first fluid under pressure comprises a compressed gas.

23. Apparatus as set forth in claim **1** wherein said second fluid under pressure comprises a control liquid.

24. Apparatus as set forth in claim **23** wherein said control liquid is water.

25. Apparatus as set forth in claim **1** wherein the other end of said second tube means is connected to a valve member having said second and third valve means therein, said second valve means being selectively operable to connect said member to venting means and said third valve means being selectively operable to connect said member to said second fluid under pressure.

26. Apparatus as set forth in claim **1** wherein the other end of said second tube means is connected to a valve member having said second and third valve means therein, said valve member and second tube means being filled with said second fluid, said second valve means being selectively operable to vent said valve member to permit a portion of the second fluid in said second tube means to flow through said valve member and escape therefrom to allow a predetermined amount of the serum specimen to flow into said second tube means, said third valve means being selectively operable to provide flow of a predetermined amount of said second fluid through said valve member into said second tube means to cause a predetermined amount of the serum specimen in said second tube means to flow out of said second tube means into a chemistry container, whereby said second fluid is the only fluid that flows through said valve member.

27. Apparatus as set forth in claim **26** wherein said second fluid comprises a preselected liquid diluent, and said second valve means is selectively operable to cause a predetermined amount of said diluent to flow into the chemistry container along with said serum specimens.

28. Transfer apparatus for transferring a predetermined amount of a liquid specimen from a first container disposed at a pickup station to a second container disposed at a receiving station, comprising a transfer arm disposed generally between said pickup and receiving stations; drive means for driving said transfer arm between a position in communication with said first container and a position for communication with said second container; sealing means carried in said transfer arm for sealing said first container when said arm is in communication therewith; first tube means carried in said transfer arm and having one end communicating with said first container when said container is sealed, the other end of said first tube means being coupled through first valve means to a first fluid under pressure, said first valve means being selectively operable to admit said first fluid to said sealed container to pressurize said container; second tube means carried in said transfer arm and having one end for reception in the liquid specimen in said first container when said container is sealed, the other end of said second tube means being coupled through second valve means to venting means, said second valve means being selectively operable for a predetermined time period to allow the pressure in said sealed container to induce a predetermined amount of the liquid specimen to flow into said second tube means; and third valve means coupled between the other end of said second tube means and a second fluid under pressure, said third valve means being selectively operable for a predetermined time period when said transfer arm is in a position to communicate with said second container to cause a predetermined amount of the liquid specimen in said second tube means to flow into said second container.

29. Apparatus as set forth in claim **28** wherein the other end of said second tube means is connected to a valve member having said second and third valve means therein, said valve member and second tube means being filled with said second fluid, said second valve means being selectively operable to vent said valve member to permit a portion of the second fluid in said second tube means to flow through said valve member and escape therefrom to allow a predetermined amount of the specimen to flow into said second tube means, said third valve means being selectively operable to provide flow of a predetermined amount of said second fluid through said valve member into said second tube means to cause a predetermined amount of the specimen in said second tube means to flow out of said second tube means into a chemistry container, whereby said second fluid is the only fluid that flows through said valve member.

30. Apparatus as set forth in claim **28** with the addition of fourth valve means coupled between the other end of said first tube means and second venting means, said fourth valve means being selectively operable to release the pressure in the sealed container after the predetermined amount of the specimen has been induced to flow into said second tube means.

31. A method of preparing a succession of serum chemistries for analyzation, comprising the steps of conveying a plurality of serum specimens each contained in a specimen container along a first path; selecting particular ones of said serum specimens to be analyzed; successively transferring a predetermined amount of each of said particular serum specimens to individual chemistry containers in a chemistry conveying means, said transferring step for each of said selected serum specimens including the steps of sealing the specimen container containing one of the selected serum specimens, inserting a pressure tube into the sealed container and connecting said pressure tube to a first fluid under pressure to pressurize said container

to a predetermined and substantially constant pressure level, inserting one end of a pickup tube into the serum specimen in said sealed container, venting the other end of said pickup tube through a venting valve for a predetermined time period to allow the pressure in the sealed container to cause a predetermined amount of the serum specimen to flow into said pickup tube, moving said pickup tube to a position for communication with one of said chemistry containers, and connecting the other end of said pickup tube through a first valve to a supply of a second fluid under pressure and selectively opening said first valve for a predetermined time period to allow said second fluid to flow into the other end of said pickup tube to cause a predetermined amount of the serum specimen in said pickup tube to flow into said chemistry container; and dispensing a predetermined and repetitive amount of a preselected reagent into each of said chemistry containers.

32. The method as set forth in claim **31** with the additional step of successively extracting a portion of the contents of the chemistry containers for analysis.

33. The method as set forth in claim **32** with the additional step of incubating the contents of the chemistry containers for a predetermined time period before said extracting step.

34. The method as set forth in claim **31** wherein said dispensing step includes the steps of maintaining a plurality of reagents under substantially constant pressure in individual reagent containers, each of said reagents having a delivery tube with one end received therein and the other end communicating through an individual valve member with successive ones of said chemistry containers, and selectively opening preselected ones of said valve members for predetermined time periods to allow selected and repetitive amounts of preselected ones of the reagents to successively flow into said chemistry containers.

35. The method as set forth in claim **31** wherein said transferring step is performed after said dispensing step.

36. The method as set forth in claim **33** wherein said transferring step is performed after said incubating step.

37. The method as set forth in claim **34** including the step of selectively opening said preselected ones of said valve members for a predetermined time period before reagent is delivered into the chemistry containers to allow the pressure in the reagent containers to cause flow of the preselected reagents into and through their respective delivery tubes and valve members to purge said tubes and valve members and to fill the same with reagent.

38. The method as set forth in claim **31** wherein said transferring step also includes the step of venting each particular sealed specimen container to release the pressure therein after the predetermined amount of the serum specimen therein has been induced to flow into said pickup tube.

39. The method as set forth in claim **32** wherein said extracting step includes the steps of successively sealing each of the chemistry containers, connecting said sealed chemistry container to a pressurized fluid to pressurize said container, inserting one end of an extraction tube into the contents of said pressurized chemistry container, connecting the other end of said extraction tube to venting means for a predetermined time period to induce a portion of the chemistry container contents to flow into and through said extraction tube into a test receptacle for analysis.

40. A method of transferring a predetermined amount of a liquid specimen from a first container at a pickup station to a second container at a receiving station, comprising the steps of sealing said first container, inserting a pressure tube into said sealed container and connecting said pressure tube to a first fluid under pressure to pressurize said sealed container to a predetermined and substantially constant pressure level, inserting one end of a pickup tube into the specimen in said sealed container, venting the other end of said pickup tube through a venting valve for a predetermined time period to allow the pressure in the sealed container to cause a predetermined amount of the specimen to flow into said pickup tube, moving said one end of said pickup tube to a position for communicating with said second container, and connecting the other end of said pickup tube through a first valve to a second fluid under pressure and selectively opening said first valve for a predetermined time period to allow said second fluid to flow into the other end of said pickup tube to cause a predetermined amount of the specimen in said pickup tube to flow into said second container.

41. The method as set forth in claim **40** with the additional step of venting said sealed first container to release the pressure therein after the predetermined amount of the specimen has been induced to flow into the pickup tube.

42. Apparatus for automatically preparing a succession of serum chemistries for analysis, comprising serum conveyor means for conveying a plurality of specimen containers each containing a serum specimen along a first path; chemistry conveyor means for conveying a plurality of chemistry containers along a second path; means for successively picking up a precise and predetermined amount of each of said serum specimens and depositing a preselected amount of each picked up specimen into one of said chemistry containers; a plurality of reagent dispensing heads each disposed adjacent said chemistry conveyor means; a plurality of liquid reagents each contained in an individual reagent container, each of said containers having a supply of a gas under pressure coupled thereto for pressurizing said containers to a predetermined and substantially constant pressure level; a plurality of reagent tubes each having one end received in one of said reagents and the other end disposed in one of said dispensing heads for communicating with successive ones of said chemistry containers as said chemistry containers are carried along said second path by said chemistry conveyor means; a plurality of reagent valves each coupled to one of said reagent tubes for selectively opening and closing said reagent tubes; and selection means for automatically opening selected ones of said reagent valves according to the particular analysis to be performed for a first predetermined time period to allow the pressure in the reagent containers associated with said selected reagent valves to cause flow of selected ones of said reagents out of their respective containers and into and through their respective reagent valves and tubes to flush said respective valves and tubes, and then for automatically opening said selected reagent valves for second and subsequent predetermined and repetitive time periods immediately after said first time period to allow the pressure in the reagent containers associated with said selected valves to cause flow of predetermined and repetitive amounts of said selected reagents out of their reagent containers and into successive ones of said chemistry containers to formulate serum chemistries.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,901,656 Dated August 26, 1975

Inventor(s) Larry G. Durkos, Charles D. Christie, Jerry W. Denney, Jon C. Trusty, Walter L. Reynolds, Robert W. Cole, Fred E. Brinson, and Allen K. Lovell.

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

Column 11, line 51, after "275", delete "and 274".

Column 12, line 30, change "This" to --The--.

Column 22, line 6, change "328" to --428--.

Column 28, line 12, change "446" to --466--.

Column 30, line 17, change "44" to --1--.

Signed and Sealed this

twenty-fifth Day of *November 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks