United States Patent [19]

Rohrbaugh et al.

[11] **3,787,185**

[45] **Jan. 22, 1974**

[54] **DISRUPTOR MODULE**

[75] Inventors: **Donald Gene Rohrbaugh**, Santa Ana; **Everett James Petersen, Jr.**, Glendora; **Charles Peter Chase**, Brea, all of Calif.

[73] Assignee: **Beckman Industries, Inc.**, Fullerton, Calif.

[22] Filed: **Mar. 2, 1972**

[21] Appl. No.: **231,268**

[52] **U.S. Cl.** ..... **23/253 R**, 23/259, 259/24, 259/67

[51] **Int. Cl.** **B01f 1/00**, G01n 1/10

[58] **Field of Search** .. 23/253, 259, 230; 259/23, 24, 259/67, 108; 222/144

[56] **References Cited**

UNITED STATES PATENTS

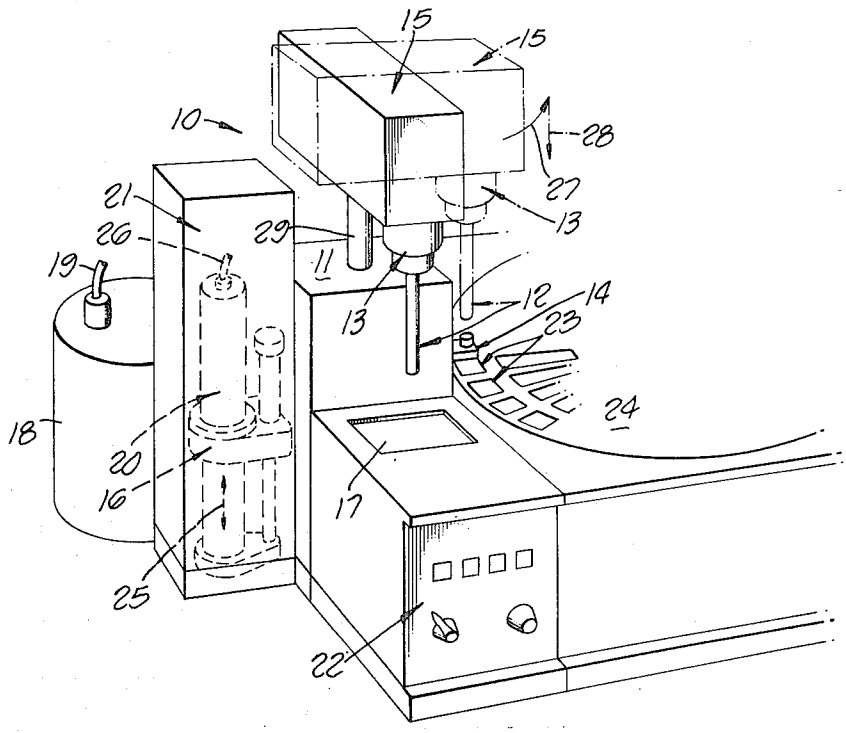
3,178,266	4/1965	Anthon	23/259 X
3,223,485	12/1965	Ferrari et al.	23/253
3,223,486	12/1965	Holl, Jr. et al.	23/259 X

Primary Examiner—Morris O. Wolk
Assistant Examiner—R. E. Serwin
Attorney, Agent, or Firm—Thomas L. Peterson et al.

[57] **ABSTRACT**

An automated device on signal serially dispenses a precise solvent volume into an individual chemical sample reactor module containing a single sample solid composition, provides agitation for disrupting and dissolving the sample, and supplies an aliquot filtered solution sample. The tablet disruptor device functioning in the reactor module is automatically programmed to disrupt the sample and to stir and dissolve it in the turbulent solvent. The disruptor device is then solvent washed, prior to being utilized again in the serialization disruption and solution of successive samples in successive solvent volumes in individual chemical reactor sample modules.

15 Claims, 11 Drawing Figures



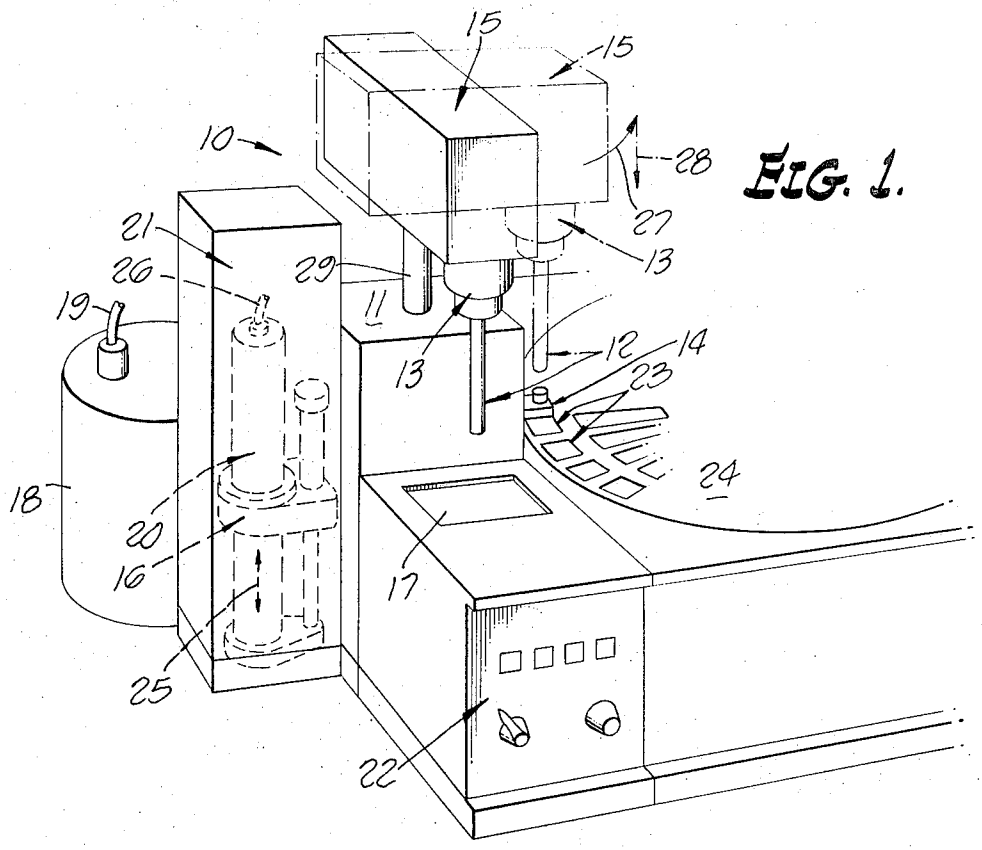

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FIG. 1.

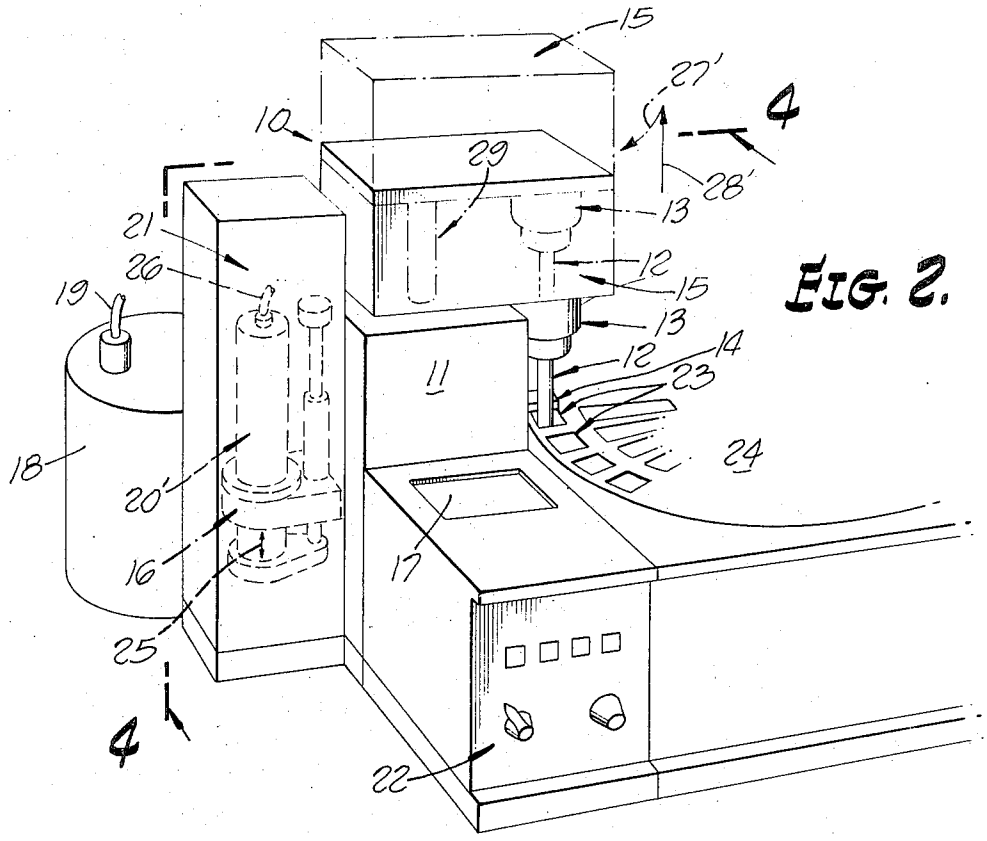
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FIG. 2.

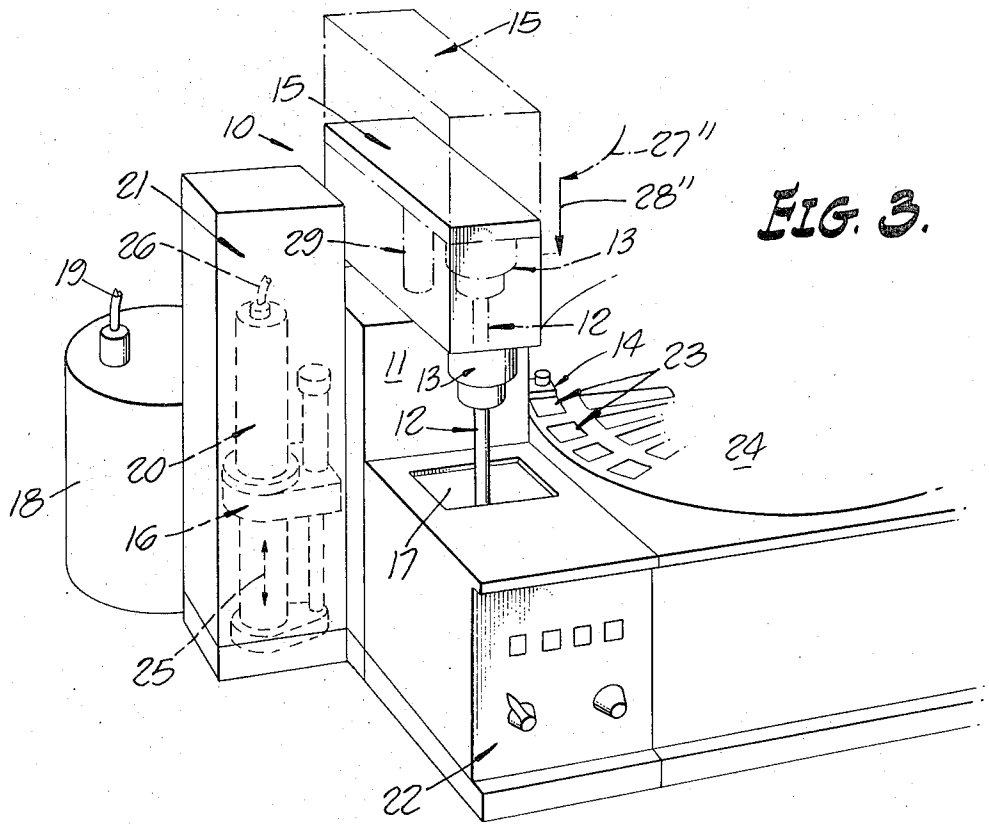
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FIG. 3.

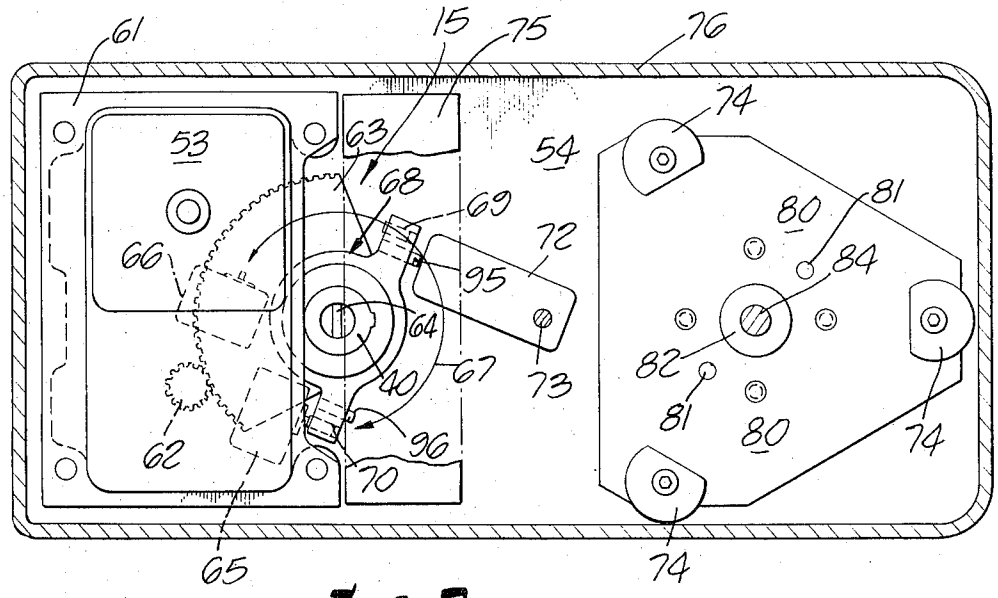
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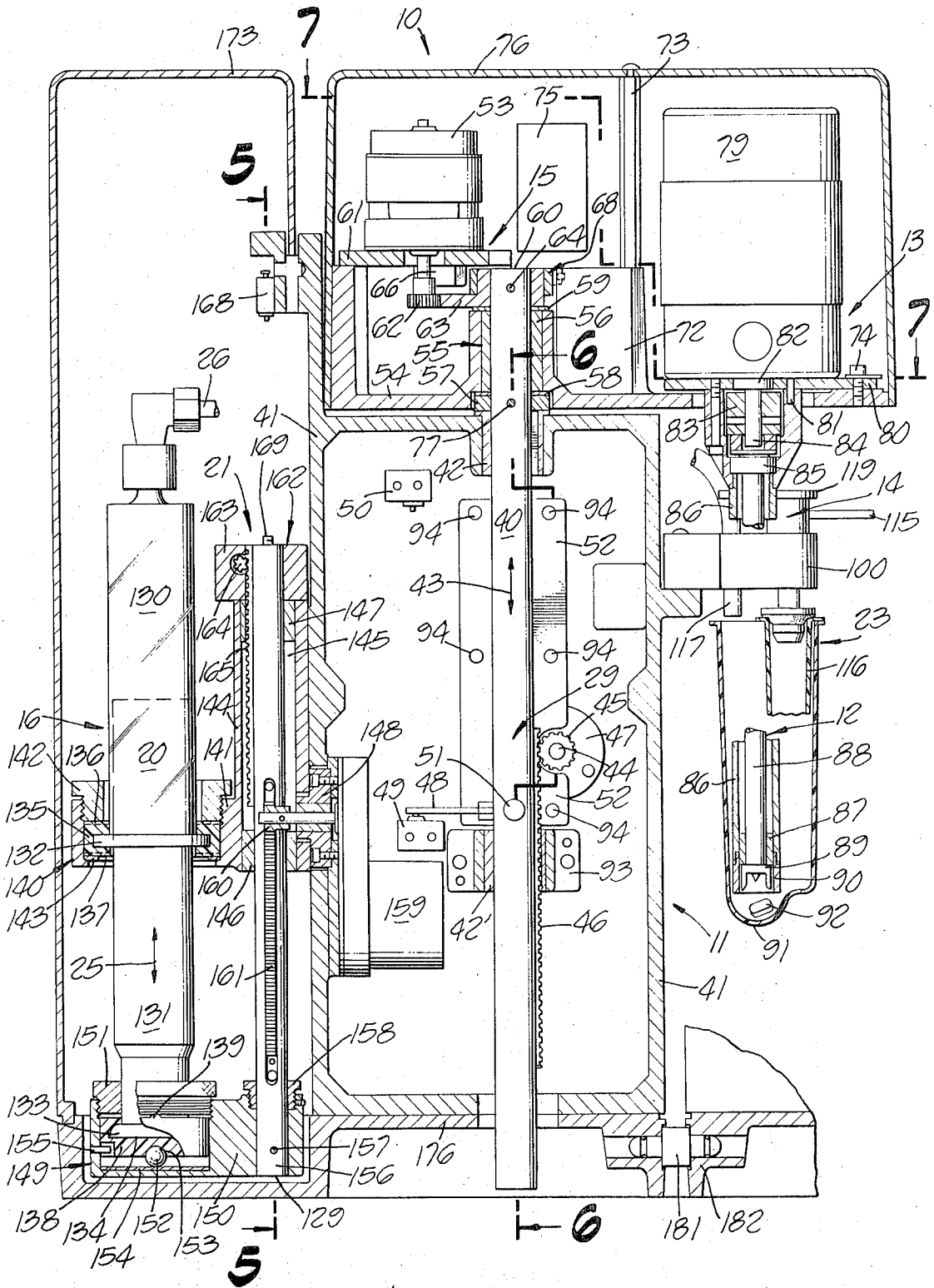
FIG. 7.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147
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117
23
164
145
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165
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144
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142
136
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FIG. 4.

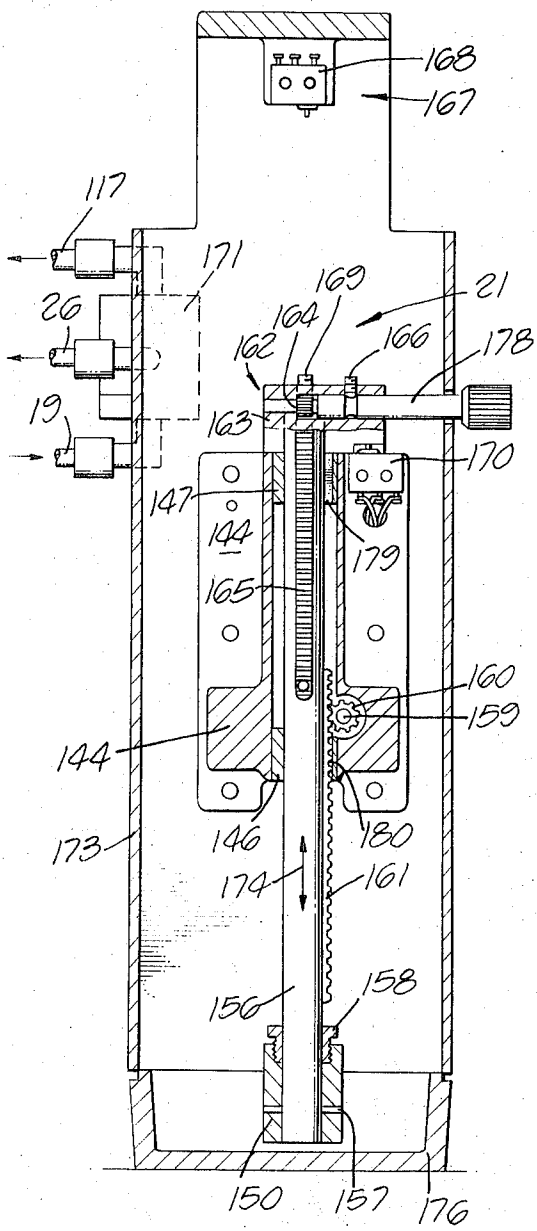
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FIG. 5.

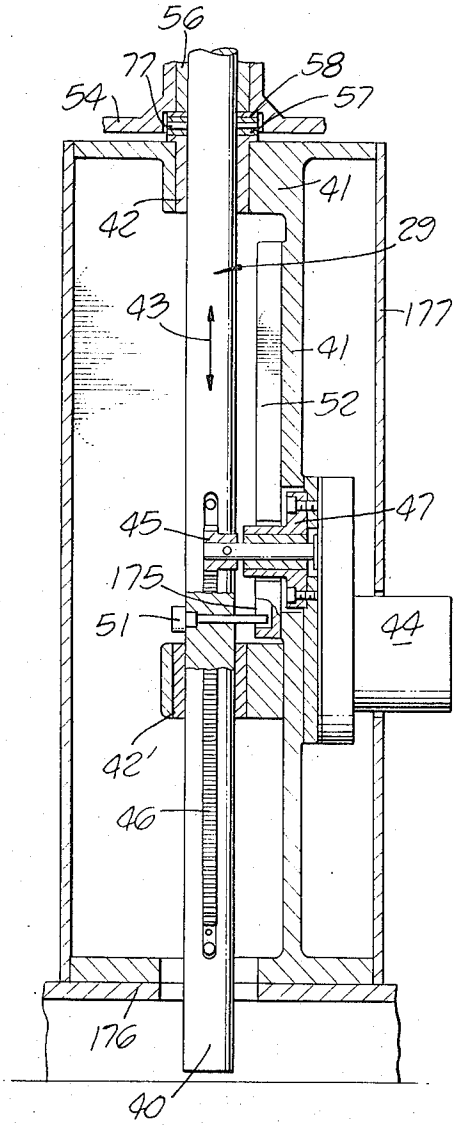
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FIG. 6.

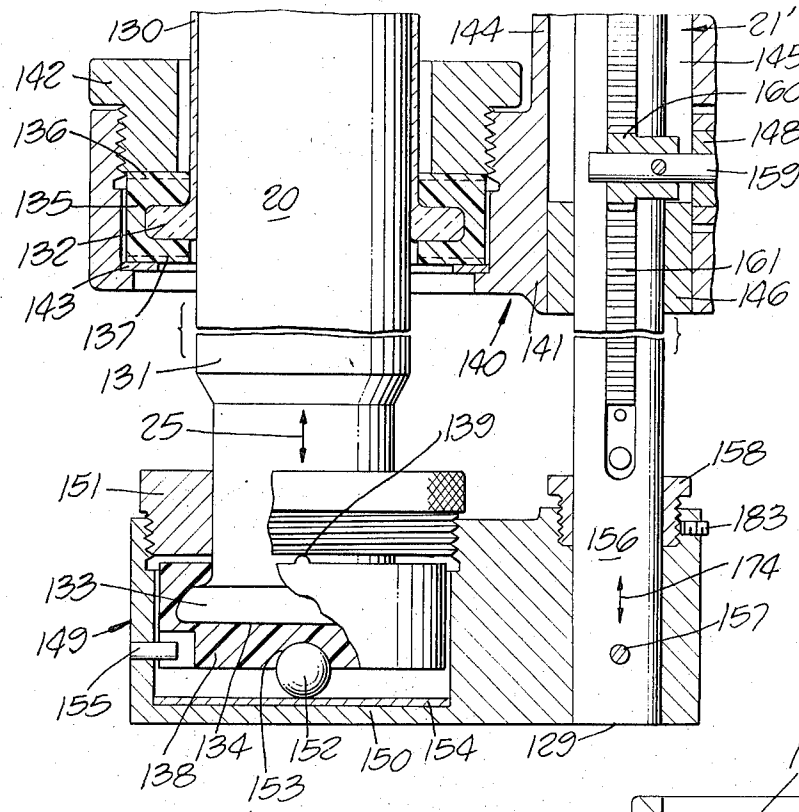

FIG. 8.

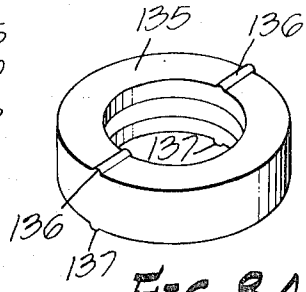

FIG. 8A.

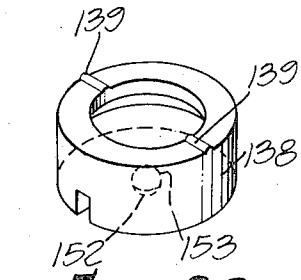

FIG. 8B.

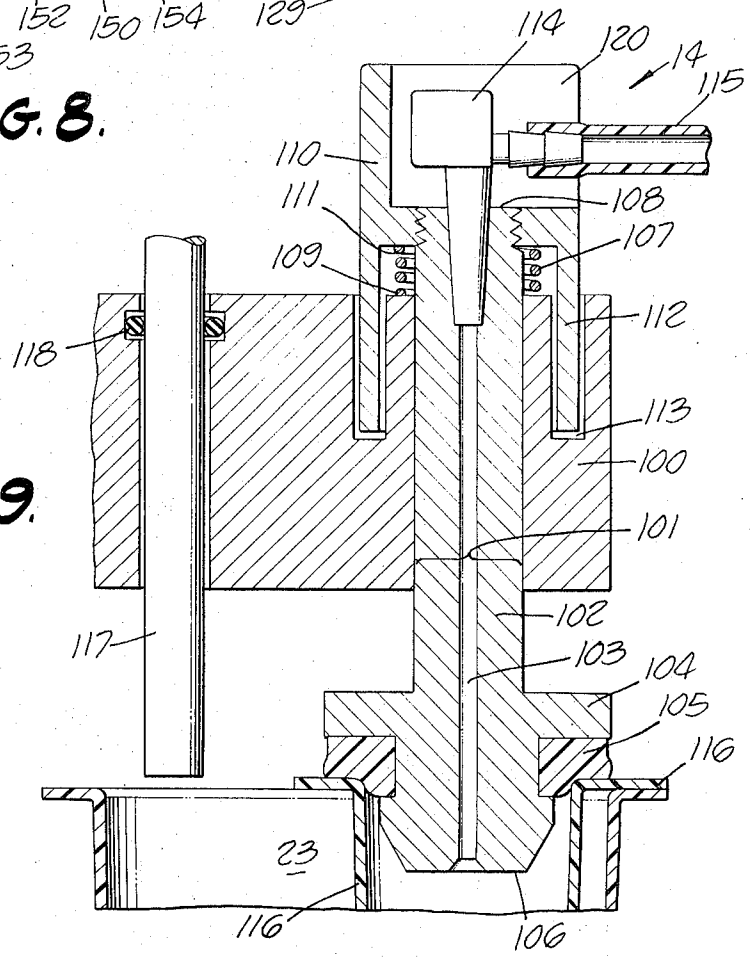

FIG. 9.

DISRUPTOR MODULE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is related to the following applications, all assigned to the same assignee as the present application:

Ser. No. 177,555 for TABLET DISRUPTOR DEVICE, by Donald G. Rohrbaugh and Everett J. Petersen, Jr., filed Sept. 18, 1971; and the following applications filed herewith:

Ser. No. 231,350 for CHEMICAL ANALYSIS TUBE MODULE by Donald G. Rohrbaugh;

Ser. No. 231,348 for CHEMICAL SAMPLE REACTOR MODULE, by Donald G. Rohrbaugh;

Ser. No. 231,353 for CHEMICAL ANALYSIS ROTARY MODULE by Donald G. Rohrbaugh and William R. Pearson; and

Ser. No. 231,351 for AUTOMATED CHEMICAL ANALYSER SYSTEM by Donald G. Rohrbaugh, William R. Pearson, Everett Petersen, Jr., and C. P. Chase.

BACKGROUND OF THE INVENTION

The chemical analysis sample dissolver module of this invention is specifically useful in automatically preparing solutions of solid samples. In an automated chemical analysis procedure it is necessary to dissolve a wide variety of chemical substances, in such forms as capsules, tablets, powders and the like, in a solvent such as water. In repetitive, serialized analysis of multiple samples from a mass production system, it is desirable to analyze these samples with the minimum of cross contamination between samples. The chemical analysis sample dissolver module repetitively disintegrates and dissolves individual solid samples in individual chemical reactor modules containing the required solvent, with a minimum of cross contamination and on an automated precisely determined schedule.

Ferrari and Kline disclosed in U.S. Pat. No. 3,223,485 an apparatus for preparation of solids for analysis, which embodies a multiplicity of cup containers, each cup receiving a single solid sample for analysis. Each solid sample in the automated line of reusable containers is separately, successively emptied into a single mixing and dissolving mechanism, which separately dissolves each solid sample and provides a take-off means for removing a sample solution. A single mixing and solution container mechanism is provided, thus requiring the mechanism to be returned to a clean condition prior to analyzing another incoming solid sample. The single container and mixing mechanism thus requires considerable care to prevent cross contamination of single chemical samples which are successively introduced into the mechanism. The problem of quickly and completely cleaning the mechanism between each single sample contributes to the problems of analysis speed, reproducability and precision in the sample analysis.

U.S. Pat. No. 3,223,486 to Holl and Walton also discloses an apparatus for dissolving solids for chemical analysis. This invention also provides a single sample solution and mixing mechanism which is subject to the slow rate of solution of samples and the contamination resulting from small portions of succeeding solid samples remaining in the same mixing mechanism.

SUMMARY OF THE INVENTION

An automated device on signal serially dispenses a precise solvent volume into an individual chemical sample reactor module containing a single sample solid composition, provides agitation for disrupting and dissolving the sample, and provides a source for an aliquoit filtered solution sample. A tablet disruptor device functioning in the chemical analysis sample dissolver module is automatically programmed to disrupt the sample and dissolve it in the stirred solvent. The disruptor device is then solvent washed in a separate wash container, prior to being utilized again in serially disrupting and dissolving successive chemical samples in successive individual reactor sample modules.

A transport means precisely, serially conveys a single table disruptor device to each one of a plurality of spaced positions on an adjustable precise time schedule. The individual sample composition is disposed in an individual chemical sample reactor module and the reactor module is disposed in a precise operative position.

A pressure filter head means applies a precise positive gas pressure to the second tube terminus of a filter tube of the chemical sample reactor module. The pressure filter head means is cooperatively disposed spaced parallel and adjacent to the tablet disruptor device on the transport means. Concurrent parallel operative positions are provided for the filter head means and the tablet disruptor device, the gas pressure being applied before the introduction of solvent into the chemical reactor module and also before initiating rotation of the tablet disruptor device. After the scheduled timed disintegration of the chemical sample and its solution in the solvent by the rotating disruptor device, the device is stopped, elevated vertically out of the chemical sample reactor module, rotated horizontally to a position above a solvent wash container and disposed in the solvent wash for a precisely predetermined rotation period, in order to clean the disruptor device in solvent. The transport means then precisely elevates the disruptor device to an initial position, preparatory to beginning another serially scheduled operative procedure for the automated chemical analysis sample dissolver module.

Other aspects and advantages of this invention are taught in the following description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The description of this invention is to be read in conjunction with the following drawings:

FIG. 1 is a perspective elevation view of the sample dissolver module of this invention including a dotted modification showing a new position of the dissolver module after rotation of the transport means.

FIG. 2 is another perspective elevation view of the sample dissolver module of this invention showing the module in position to disintegrate and dissolve a chemical sample in a solvent contained in a sample reactor module, together with another dotted modification indicating elevation of the module prior to further return rotation of the transport means.

FIG. 3 is still another perspective elevation view of the sample dissolver module, showing the tablet disruptor device disposed in a wash position in a solvent wash container prior to elevation of the module to the start-

ing position for a new serially scheduled operation of the dissolver module with a new chemical sample.

FIG. 4 is a perspective elevational, partial sectional view of the chemical sample dissolver module of this invention, showing the module in operative position suitable for sample preparation, and prior to the pumping of solvent into the sample reactor module.

FIG. 5 is an elevational view through 5—5 of FIG. 4 further illustrating the operation of the syringe pump.

FIG. 6 is still another sectional view through 6—6 of FIG. 4 illustrating further details of the elevator means.

FIG. 7 is a plan view through 7—7 of FIG. 4, illustrating the rotary displacement means of the transport means of the sample dissolver module.

FIG. 8 is a further enlarged elevational partical cross sectional detailed view of FIG. 4, illustrating the improvements in the syringe pump providing small pivoted displacements for the syringe piston and cylinder on actuating the syringe pump.

FIGS. 8A and 8B illustrate in further detail the contact ridges of the molded plastic flanges which provide the small pivoted displacements for the syringe pump.

FIG. 9 illustrates in sectional detail the pressure filter head means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1, 2 and 3 together in detail the sample dissolver module 10 is shown operatively disposed in several configurations. The transport means 11 comprises an elevator means 29 and a rotor displacement means 15. The tablet disruptor device 12, the motor drive means 13 for rotating the tablet disruptor device 12, are shown disposed on the rotary displacement means 15. The pressure filter head means 14 is attached to the elevator means 11. The solvent pump means 16 is shown partially enclosed, providing a solvent for the sample dissolver module 10. The wash container 17 is shown disposed in a fixed position. The frangible syringe pump 20 is operatively connected to a pumping mechanism 21. The electronic logic control system 22 contains means for adjusting the operating time and rotational speed of the tablet disruptor device 12. The individual chemical sample reactor modules 23 are disposed in multiple apertures in table disc 24. The vertical displacement of the syringe pump 20 is indicated by the arrow 25. The solvent conductive tubing 26 leads from the tip of the syringe pump 20.

In FIG. 1 the arrow 27 indicates the rotary displacement of the rotary displacement means 15, the phantom view of 15 indicating a 90° rotation from left to right. The arrow 28 indicates the potential elevation displacement downward of 15 by the elevator means 29.

FIG. 2 further indicates the positioning of the rotary displacement means 15 down in the sample reactor module 23. Its potential upward elevational displacement is indicated by the arrow 28' upward, placing the rotor displacement means 15 in the phantom elevated position 15 by operating the elevator means 29. The arrow 27' indicates the potential rotation of the rotor displacement means 15 to the left by 90°. Almost concurrent with the positioning of the disruptor device 12 in the module 23 is the subsequent operation of the syringe pump 20, displacing the solvent from the pump now 20' into the reactor module 23.

FIG. 3 illustrates the subsequent movement of the rotor displacement means 15 shown by the indicating arrow 27'' to the elevated phantom view of 15, and then a subsequent downward displacement of 15 into the wash container 17, as shown by the displacement arrow 28''.

Utilizing the electronic logic 22, the sample dissolver module 10 is automatically programmed through the series of operational steps outlined in sequence in FIGS. 1, 2 and 3. The tablet disruptor device 12 is programmed to rotate for scheduled periods of time in the rotationally opposed positions in the sample module 23 and the wash container 17. The syringe pump 20 is programmed to inject a precisely scheduled volume of solvent into the module 23 after the disruptor device 12 is disposed in the module 23, prior to the beginning of rotation of 12. The syringe pump 20 is provided with a volumetric means now shown in FIGS. 1, 2 and 3 whereby the pump 20 can be precisely adjusted to deliver the required solvent volume for a particular analysis procedure. Upon command from the ehemical analysis rotary module cited in the above cross references, the sample dissolver module 10 automatically sequence through the following series of steps:

1. Initially positions the tablet disruptor device 12 above the wash container 17 as in FIG. 1, providing a solvent pump means 16 filled with solvent.

2. The rotary displacement means 15 is rotated 90° disposing it above the sample reactor module 23.

3. The tablet disruptor device 12 on the rotary displacement means 15 is lowered into the sample reactor module 23, where the chemical sample has previously been manually placed.

4. The pressure filter head means 14 is lowered to seal to the filter tube 116 of the sample reactor module 23.

5. Through the pressure filter head means 14 is applied a positive gas pressure with controlled flow of gas into and through the filter tube 116 of sample reactor module 23.

6. The syringe pump 20 is discharged, dispensing solvent through tubing 26 into the sample reactor module 23.

7. The tablet disruptor device 12 is energized to disintegrate and dissolve the chemical sample in the solvent. The device 12 runs for the adjustable time and speed determined by the setting of the electronic logic 22.

8. The syringe pump 20 is refilled, drawing solvent from the storage container 18.

9. The tablet disruptor device 12 is stopped and elevated out of the sample reactor module 23.

10. The pressure filter head means 14 is concurrently released, removing the positive gas pressure from the filter tube 116 of module 23, allowing solution to seep into the filter tube 116.

11. The rotary displacement means 15 is also concurrently elevated by the elevator means 29 and rotated back 90°.

12. The tablet disruptor device 12 is lowered by the elevator means 29 into the wash container 17. The disruptor device 12 is energized in the solvent which is manually disposed in the container 17, washing the device 12 surfaces with the solvent, then stopped.

13. The rotor displacement means 15 is elevated by the elevator means 29 placing the rotor displacement means 15 in a stationary position.

The sample dissolver module 10 is then ready to begin another set of the above sequence for another serialized disruption and solution of another successive chemical sample in another successive solvent volume in another individual chemical reactor sample module.

Referring to FIG. 4 in detail, the perspective elevational view of the chemical sample dissolver module 10 illustrates the solvent pump means 16 disposed on the left side, the rotor displacement means 15 and the elevator means 29 disposed in the central portion of FIG. 4. The tablet disruptor device 12, and motor drive means 13 are shown with the rotor displacement means 15 on the right side of FIG. 4.

Referring to FIGS. 4 and 6 in further detail, the first elevator shaft 40 of the elevator means 29 is shown disposed in the first structural housing 41, the shaft 40 being slidably secured in the pair of spaced keyed bushings 42 and 42', secured on the structural housing 41. The vertical reversible displacement 43 of the first elevator shaft 40 is actuated by the first reversible AC gear motor drive 44 having a motor spur gear 45. The first gear rack 46 is coaxially secured on the shaft 40 parallel to the shaft axis of symmetry. The motor drive 44 is secured by the motor mount 47 to the first structural housing 41. A first sensor pin 48 is normally secured on the first elevator shaft 40, positioned to alternatively activate each one of a first pair of motor limit switches 49 and 50 which are fixed to the first structural housing 41. The motor limit switches 49 and 50 are spaced vertically opposed on the housing 41, providing a power detent for the motor drive 44 on activating one of the pair of switches 49 and 50. A second guide pin 51 is secured in the guide block 52 disposed on the housing 41, by fasteners 94. The second guide pin 51 rides in the guide block track 175, preventing the shaft 40 from rotating during the shaft elevation displacement 43.

The rotary displacement means 15 is illustrated in detail in FIGS. 4 and 7. A horizontal second housing arm 54 is rotatively secured by bushing means 55 shown near the top of FIG. 4. Bushing means 55 comprises the non-metalic bushing 56, the thrust collar 57 secured by the pin 77, the non-metallic thrust washer 58, and the non-metalic spacer 59, forming rotative support means for the arm 54. Adjacent the first elevator shaft top terminus 60 is secured the second reversible AC gear motor drive 53 mounted on the motor adapter plate 61. The spur gear 62 on the motor 53 engages a gear segment 63, pinned to the shaft 40 by pin 64.

As shown in FIG. 7, a second pair of limit switches 65 and 66 are arcuately disposed on and parallel to the plane of rotation of the arm 54. Each one of the pair of switches 65 and 66 are disposed at one terminus of an arc 67. A screw arc sensor means 68 has adjsutable screws 69 and 70 disposed in the means 68, providing micro arc angle adjustments of a power detent for the motor 53 on activating one of the pair of limit switches 65 and 66. The screw arc sensor means 68 is keyed to the shaft 40. The mechanical stop block 72 provides further protection for the screw arc sensor means 68, providing mechanical stop when the screws 95 and 96 alternatively contact the block 72. The vertical support post 73 extends upward supporting the housing 76 for the means 15. The electronic logic 75 is disposed in the adjacent blocks secured in the rotor displacement means 15.

The motor drive means 13 for rotating the tablet disruptor device 12 is shown disposed in FIGS. 4 and 7 together. Pressure filter head means 14 is attached to structural housing 41. The actuator arm 119 is attached to the stator tube 86 of drive means 13.

Referring to the motor drive means 13 in detail the variable speed third motor drive 79 is normally mounted on the adapter plate 80, which is secured by the adjustable fasteners 74 to the arm 54. The motor speed and operating time control 22 schedules the motor drive 79. An opposed pair of shear pins 81 and a first bearing 82 comprise an aligning means coaxially aligning the motor shaft 84 vertically downward with the rotatable shaft 88 of the disruptor device 12. A coupling means 83 secures the motor shaft 84 and the rotatable shaft 88 of the disruptor device. The shaft 88 is secured in a drive shaft aligning means comprising the ball bearing 85 attached to the stator tube 86, into which the bearing seal 87 is secured, at the operating end of the stator tube 86. The disruptor device rotor 89 and stator 90 are aligned at that end of the stator tube 86. The bearing seal 87 and the ball bearing 85 secured in the stator tube 86 align the drive shaft 88, allowing high speed rotation for the disruption of a chemical sample 92 or the like disposed in a recessed bottom cavity 91 of a sample reactor module 23. The adapter plate 80 provides adjustable secured positioning of the plate 80 on the housing arm 54, allowing the plate 80 to be coplanarly adjustable, thus allowing the tablet disruptor device 12 to be positioned directly above the recessed bottom 91 of the sample reactor module 23, for quick disruption of a sample 92 or the like.

Referring to FIGS. 4 and 9 in detail, a third support arm 100 extends horizontally from the structural housing 41 and is secured thereto. The structural arm 100 has a tubular aperture 101 disposed normally through the arm 100. A pressure filter head tubular plunger 102 slidably extends through the first uniform tubular aperture 101. The tubular plunger 102 has a second tubular aperture 103 coaxially disposed therein, and coaxial with the first tubular aperture 101. A plunger cap 104 is coaxially disposed adjacent a first terminus 106 of the plunger 102. A gasket sealing means 105 is coaxially disposed on the first terminus 106 of the plunger 102. An expansion spring 107 is coaxially disposed adjacently around a second terminus 108 of the plunger 102, one spring terminus 109 engaging the support arm 100. A guide cap 110 is coaxially secured on the second terminus 108 of the plunger 102, engaging a second terminus 111 of the expansion spring 107. The guide cap 110 has an integral annular skirt extension 112 slidably engaging an annular guide slot 113, which is disposed in the arm 100 normal to the horizontal position of the arm. A gas fitting 114 is disposed in the plunger 102, coaxially venting to the second tubular aperture 103. The gas fitting 114 is protectively disposed in a guide cap aperture 120 and the gas conductive tubing 115 is connected to the coupling 114. As shown in detail in FIG. 9, the pressure filter head means 14 is operatively disposed on filter tube 116, the gasket sealing means 105 securing a gas-tight seal. On an operative signal, gas can be conducted through the tubing 115, slightly pressurizing the reactor module filter tube 116 by the flow of gas into the module 23. The pressure filter head means 14 is operationally activated by the

plate 119 shown in FIG. 4. The plate 119 descends onto the guide cap 110 when the signal is given the elevator means 29 to lower the shaft 40. The plate 119 is permanently secured normal to the stator tube 86 at the precise position on the tube 86 required to compressively depress the guide cap 110 and the related components secured thereto, to provide a vacuum tight seal by the gasket means 105 secured on the sample filter tube 116. When the shaft 40 is elevated, the gas pressure is relieved and solution can flow into the filter tube 116.

FIGS. 4, 5 and 8 together in detail illustrate the inventive advance in the solvent pump means 16. A conventional frangible syringe 20, made of glass or the like, has a conventional cylinder 130 and piston 131. The syringe cylinder 130 has a cylinder support lip 132 and the piston 131 has a piston support lip 133 disposed adjacent the conventional piston force base 134. A cylinder lip securing flange 135 is coaxially molded around the cylinder lip 132, and a piston lip securing flange 138 of plastic is coaxially molded around the piston lip 133. As shown generally in FIG. 4, the cylinder molded lip flange 135 has two pair of contact ridges 136 and pair 137 molded on both sides of the cylinder flange 135. The two pair of contact ridges 136 and 137 on the flange 135 are shown in greater detail in FIG. 8 and FIG. 8A, the pair of contact ridges on each face are opposed 180°. The piston lip flange 138 has a pair of contact ridges 139 shown generally in FIG. 4, and in more detail in FIG. 8 and FIG. 8B. These two contact ridges are disposed 180° apart on the top flange face as shown in FIG. 4. A steel ball 152 is shown disposed in a hemispherical aperture 153 on the bottom side of the flange 138 in FIG. 4 and in more detail in FIG. 8. The contact ridges of the flanges 135 and 138 provide small pivotal displacements of the syringe cylinder and piston on vertical displacement of the piston into the syringe, decreasing syringe misalignment forces which can break the typical glass syringe. By disposing the contact ridges of the flange 135 and the flange 138 rotatively angularly disposed 90° apart in the plane normal to the syringe axis of displacement, the small pivotal displacement movements of the cylinder and the piston are assured.

A first support union mount 140 coaxially secures the cylinder lip flange 135 and has a first female mount 141 adapted to coaxially support the cylinder flange 135. A first male plug 142 is coaxially adapted to mate with the female mount 141 providing containment force on a back-up ring 143 coaxially disposed below the cylinder lip flange 135, which is secured in the mount 141. A tubular shaft guide mount 144 is secured to the first support union 140. The tubular guide mount 144 may be integrally cast with the female mount 141, or it may be secured to the same by conventional fastening means. The tubular aperture 145 of the guide mount 144 is disposed parallel to the cylinder 130 axis of symmetry, the guide mount 144 having a pair of shaft bushings 146 and 147 oppositely disposed in the tubular aperture 145 at the aperture terminus. Bushing 146 has a keyway 180 and bushing 147 has a keyway 179. The guide mount 144 is secured by conventional fastening means to the first structural housing 41 providing a vertical tubular aperture axis of symmetry. A second union support mount 149 is coaxially secured to the piston lip flange 138, having a female support mount 150 adapted to coaxially support the piston flange 138. A coaxial male plug 151 is adapted to mate with the female mount 150, providing containment force on the steel ball 152 rotatively disposed in a hemispherical aperture 153 molded in the second face of the piston lip flange 138. The ball thrust is on a hardened thrust washer 154 disposed on the base of the female mount 150, the second support mount 149 providing small pivotal and transverse displacements of the piston. Each one of a pair of locating pins 155 are secured normally in the wall of one of the female mounts 141 and 150, each one of the pins projecting through the mount wall, securing one of the lip flanges 135 and 138 and preventing lip flange rotation to insure normality of contact ridges 136 and 137 with ridges 139.

A second elevator shaft 156 has a first shaft terminus 129 secured by a pin 157 normally in the second union mount 149. The second shaft 156 is disposed parallel to the piston 131 axis of symmetry. A shaft bushing 158 is secured by screw 183 adjacent to the second union mount 149, providing a stop limiting the elevation of the piston 131. The shaft bushing 158 mechanically functions to prevent the piston 131 from hitting the bottom of the syringe 130 and breaking the syringe.

A reversible AC fourth gear motor drive 159 is mounted on the first structural housing 41 in the bearing plate assembly 148. A motor shaft third gear 160 actuates a second gear rack 161, whose length is coaxially secured on the second elevator shaft 156 parallel to the shaft axis symmetry. The motor drive 159 provides vertical displacement of the second elevator shaft 156 on power signal. A syringe volume adjustment means 162 has a locking collar 163 slidably mounted on the second elevator shaft 156. The collar 163 has a pinion gear 164 disposed on a rotating shaft 178 mounted in the collar. The pinion gear 164 engages a third gear rack 165 whose length is also coaxially secured on the second elevator shaft 156 parallel to the shaft axis of symmetry. The pinion gear 164 and gear rack 165 cooperatively provide precise vertical displacement of the locking collar 163 on the shaft 156, prior to locking the collar 163 with the screw 166 and fixing the syringe volume displacement.

A second pair of limit switch means 167 have two oppositely vertically disposed limit switches. The uppermost limit switch 168 is secured on the structural housing 41 and the bottom limit switch 170 is secured on the tubular shaft guide mount 144. The uppermost limit switch 168 is actuated by the adjustment screw 169, and the switch provides an electrical power detent, preventing the piston and cylinder of syringe pump 20 from colliding. Typically the adjustment screw 169 is adjusted to provide a space of 0.005 inches between the syringe cylinder 130 and the syringe piston 131 on closure. The bottom limit switch 170 is operatively contacted by the locking collar 163 when the piston 131 is partially displaced out of the cylinder 130. Thus by moving the locking collar 163 to a specific position on the shaft 156 and then locking the collar 163 with the screw 166, it is possible to precisely set the solvent volume which the syringe pump 20 can dispense.

A three-way diverter solenoid valve 171 is conductively secured by conventional flexible tubing, to the solvent exit orfice tubing 26 of the cylinder syringe 130. On electrical signal to valve 171 the solvent conductive tubing 19 from the solvent reservoir 18 vents to the syringe pump 20 as the piston 131 is displaced from the cylinder 130. The three-way diverter valve

171 can also alternatively vent through the solvent tubing conduit 117 to the sample reactor module 23 on signal. Conduit 117 is secured in arm 100 by O-ring 118. Thus by vertical displacement 174 of the elevator shaft 156 on power signal to the motor drive 159, the syringe pump 16 can automatically intake the required amount of solvent and on further signal dispense the solvent to the reactor module 23, or for that matter, to any other device as required. The solvent pump means 16 of this invention can be operatively disposed not only cooperatively in this invention, but can be operatively disposed with other devices supplying predetermined volumes of solvent.

A base 176 supports the sample dissolver module 10. A housing 177 covers and protects the components of the elevator means 29. The fastener 181 aligns the base 176 to the base 182 which supports other components in the chemical analysis system.

The sample dissolver module 10 disclosed in this application provides a means of preparing chemical samples in the form of tablets, capsules, powder and the like for content and uniformity analysis. It provides an automated quantitative means of adding a solvent volume to the chemical sample disposed in the sample reactor module, disintegrating the chemical sample and dissolving the sample in the selected solvent, agitating the solvent, and aids in the preparation of a portion of that solution for further chemical process. The sample dissolver module of this invention utilizes the sample disrupter device, the sample reactor module and the analysis tube module disclosed in the above referenced patent applications. Further, the sample dissolver module of this invention is proposed to be used in conjunction with the chemical analysis rotor module and the automated chemical analyzer system also cited in the referenced applications.

In view of the public need for repetitively analyzing large numbers of a great variety of complex chemical compositions, pharmaceutical and food products, it becomes necessary to devise automated means for analyzing these products. This invention provides a distinct inventive advance in the art of preparing a solid for further automated chemical analysis.

Obviously many modifications and variations in the improvement of the sample dissolver module can be made in the light of the above illustrations, embodiment and teaching. It is therefore understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. An automated chemical analysis sample dissolver module for serially preparing individual filtered solutions of serialized solid chemical samples in successive individual chemical sample reactor modules, comprising in combination:

a transport means for serially conveying a tablet disruptor device to each one of a plurality of spaced positions on a time schedule;

a drive means for rotating said tablet disruptor device on power signal, for scheduled time periods;

a pressure filter head means for supplying a positive gas pressure to the second tube terminus of a filter tube of one said chemical sample reactor module, said reactor module cooperatively disposed in a predetermined position, said filter head means cooperatively disposed spaced parallel and adjacent said tablet disruptor device secured on said transport means, providing concurrent parallel operative positions for said filter head means and said tablet disruptor device, said gas pressure being applied on signal and released on power signal;

a solvent pump means for securing a solvent volume from a solvent reservoir and dispensing said volume into said reactor module on power signal;

and,

a wash container for said tablet disruptor device, cooperatively disposed for immersion of said device and a subsequent predetermined period of rotation of said device on power signal.

2. A sample dissolver module as set forth in claim 1 wherein said transport means comprises in combination:

an elevator means for vertically displacing on power signal said tablet disruptor device to a plurality of precisely scheduled positions;

and,

a rotor displacement means rotatively displacing on power signal said tablet disruptor device to a plurality of precisely scheduled positions.

3. In a sample dissolver module as set forth in claim 2, the improvement wherein said elevator means comprises in combination:

a first elevator shaft supported in a first structural housing by spaced keyed bushings disposed to provide vertical displacement of said shaft on actuating power signal to a first reversible gear motor drive, the motor shaft gear actuating a first gear rack coaxially secured on said shaft parallel to the shaft axis of symmetry, said motor drive secured on said first housing;

a first sensor pin secured on said shaft, positioned to alternatively activate each one of a first pair of motor limit switches fixedly spaced vertically opposed on said first housing, providing a power detent for said first motor drive on activating one said switch;

and,

a second guide pin, secured in a guide block disposed on said first housing, said second pin riding in a guide block track preventing shaft rotation during shaft elevation displacement.

4. In a sample dissolver module as set forth in claim 2, the improvement wherein said rotor displacement means comprises in combination:

a horizontal second housing arm rotatively secured by bushing means on said elevator shaft adjacent the shaft top terminus, a second reversible gear motor drive rotating the second arm on actuating power signal, the rotating motor gear providing rotative thrust on an engaged gear segment fixed to the elevator shaft;

a second pair of motor limit switches arcuately disposed in a plane parallel to the plane of rotation of said second arm, each one of said second pair of switches disposed at one terminus of an arc, limiting the rotation of said second arm on power signal;

and,

a second final adjustment screw arc sensor means providing micro adjustment of said arc terminus, said arc sensor means having adjustable screws disposed in a secured arc stop block, providing micro-

arc angle adjustment of a power detent for said second motor drive on activating one said switch.

5. A sample dissolver module set forth in claim 1 wherein said motor drive means rotating said tablet disruptor comprises in combination:

a variable speed third motor drive for rotating said tablet disruptor device on power signal, said third drive normally mounted on an adaptor plate;

a motor speed and operating time control for said third motor drive;

a coupling means securing said third motor drive and said disruptor device;

a drive shaft aligning means coaxially aligning said disruptor device and said motor third drive;

and,

an adaptor plate securing means providing adjustable secure positioning of said adaptor plate, said plate coplanarly secured on said second housing arm, positioning the motor drive shaft vertically downward.

6. A sample dissolver module as set forth in claim 5 wherein said motor drive means for rotating said tablet disruptor comprises in combination:

a variable speed third motor drive normally mounted on an adaptor plate, said third drive secured to said plate by an aligning means coaxially aligning the motor shaft vertically downward with the rotatable shaft of said disruptor device;

a motor speed and operating time control for said third drive;

a coupling means securing said motor shaft and said rotatable shaft of said disruptor device;

a drive shaft aligning means having a second bearing coaxially disposed around said rotatable shaft adjacent said coupling means, said second bearing coaxially secured to the hollow stator shaft of said disruptor device, and having a bearing seal coaxially disposed around said rotatable shaft and secured in said hollow stator shaft adjacent the shaft rotor;

and,

an adaptor plate securing means providing adjustable secure positioning of said adaptor plate on said second housing arm, said plate coplanarly adjustable on said second arm, adapting said shaft rotor to positioning above the recessed bottom cavity of said sample reactor module.

7. A sample dissolver module as set forth in claim 1 wherein said pressure filter head means comprises in combination:

a third support arm extending horizontally from said first structural housing and secured thereto, said third arm having a first uniform tubular aperture disposed normally through said third arm;

a pressure filter head tubular plunger means slidably extending through said first uniform tubular aperture, said plunger means having a second coaxial tubular aperture disposed therein, said plunger means having a sealing means disposed on the lower terminus of said plunger means, said sealing means providing a gas-tight seal for a filter tube of a chemical sample reactor module, and said plunger means having a guide cap means coaxially secured to the upper terminus of said plunger means providing a slidable guide means in said third arm;

an expansion spring coaxially disposed around said plunger means between said guide cap and said third arm;

a coupling means providing gas pressure conductively to said plunger means adjacent to said guide cap means;

and,

a collar compressive means cooperatively secured around the stationary hollow shaft of the tablet disruptor device normal to the shaft axis of symmetry, said collar means positioned on the hollow shaft length to compressively displace the top terminus of said guide cap means downward a precise distance on lowering said disruptor device.

8. A sample dissolver module as set forth in claim 7 wherein said pressure filter head means comprises in combination:

a third support arm extending horizontally from said first structural housing and secured thereto, said third arm having a first uniform tubular aperture disposed normally through said third arm;

a pressure filter head tubular plunger slidably extending through said first uniform tubular aperture, said plunger having a seocnd tubular aperture coaxially disposed therein;

a plunger cap coaxially disposed on a first terminus of said plunger;

a first sealing means coaxially secured on said plunger cap;

an expansion spring coaxially disposed around a second terminus of said plunger, one spring terminus engaging said third arm;

a guide cap coaxially secured to said second terminus of said plunger, said cap engaging a second terminus of said expansion spring, said cap having an annular skirt extension slidably engaging an annular guide slot in said third arm disposed normal to said horizontal position;

a gas couple fitting disposed in said plunger coaxially venting to said second tubular aperture, said fitting protectively disposed in a guide cap aperture;

and,

a collar cooperatively secured around the stationary hollow shaft of the tablet disruptor device, said collar coaxially disposed normal to the shaft axis of symmetry and positioned on the shaft length to compressively displace the top terminus of said guide cap downward a precise distance on lowering said disruptor device.

9. A sample dissolver module as set forth in claim 1 wherein said solvent pump means comprises in combination:

a frangible syringe having a cylinder and a piston, each said cylinder and said piston having a force support lip disposed around the adjacent conventional force application terminus;

a pair of lip securing plastic molded flanges, each flange of said pair coaxially disposed around and separately forming a cylinder flange and a piston flange;

a contact pivot means disposed on each face of each flange, providing separate small pivotal displacements for each one of said molded flanges;

a first support union mount means coaxially securing the molded flange disposed around the cylinder support lip, providing containment force on said

flange, and providing small pivotal displacement for said cylinder engaged on said piston;

a tubular shaft guide mount means secured to said first support union mount means, having a slidable tubular mount aperture means, said shaft mount means secured to said first structural housing, providing a vertical aperture axis of symmetry;

a second support union mount means coaxially securing the molded flange disposed around the piston support lip, providing containment force on said flange and providing small pivotal displacement for said piston engaged in said cylinder;

a second elevator shaft having a first shaft terminus secured normally in said second union mount means, said second shaft disposed parallel to the piston axis of symmetry and having an elevation limiting shaft stop;

a reversible fourth gear motor drive means providing vertical displacement of said second shaft from a secured drive means mount on said first structural housing on power signal;

a syringe volume adjustment means having a locking collar slidably mounted on said second elevator shaft, said collar having a pinion gear disposed on a rotating shaft mounted in said collar, said pinion gear engaging a third gear rack whose length is coaxially secured on said second elevator shaft parallel to the elevator shaft axis of symmetry, said pinion gear and gear rack cooperatively providing vertical displacement of said collar prior to locking said collar and fixing the syringe volume displacement;

a second pair of limit switch means having two oppositely vertically disposed limit switches, a first switch secured on said first structural housing uppermost above second elevator shaft top terminus providing a power detent for said fourth drive means and having an adjustable limit actuating screw disposed in the top terminus of said second elevator shaft, and a second switch secured on said tubular shaft guide mount providing a power detent for said fourth drive means on actuating by said locking collar;

a three-way diverter solenoid valve conductively secured in common to the solvent exit orfice of said syringe cylinder, said valve on signal conductively alternatively venting to a solvent reservoir conduit and to a chemical sample reactor module conduit whose solvent outlet terminus is disposed parallel and cooperatively adjacent said pressure filter head means;

whereby said contact ridges of said cylinder lip and said piston lip provide small pivotal displacements to said syringe cylinder and piston on vertical displacement of said piston by said second elevator shaft in said tubular guide mount by said fourth gear motor drive means.

10. A sample dissolver module as set forth in claim 9 wherein said solvent pump means comprises in combination:

a frangible syringe having a cylinder and a piston, said sylinder having a first support lip coaxially disposed around the cylinder insertion aperture, said piston having a second support lip coaxially disposed around the piston force base;

a cylinder lip securing molded flange coaxially disposed around said cylinder lip, said flange having a pair of oppositely disposed contact ridges on each flange face, the pair of ridges on each face opposed 180°;

a piston lip securing flange coaxially disposed around said piston lip having the pair of contact ridges oppositely opposed on a first face of said piston flange;

said contact ridges of said cylinder lip securing flange and said contact ridges of said piston lip securing flange rotatively disposed 90° apart in the plane normal to the syringe axis of displacement;

a first support union mount coaxially securing said cylinder lip flange, having a first female mount adapted to coaxially supporting said cylinder flange, and a first male plug coaxially adapted to mate with said female mount, providing containment force on a back up ring coaxially disposed below said cylinder lip flange secured in said female mount, said first union mount providing small pivotal displacement movement of said cylinder;

a tubular shaft guide mount secured to said first support union, the tubular aperture of said shaft guide mount disposed parallel to a cylinder axis of symmetry, said guide mount having a pair of shaft bushings oppositely disposed in said tubular apetture at the aperture terminus, said shaft guide mount secured by fastening means to said first structural housing providing a vertical tubular aperture axis of symmetry;

a second support union mount coaxially securing said piston lip flange, having a female mount adapted to coaxially support said piston lip flange, and a male plug adapted to mate with said female mount, said second union mount providing containment force on a steel ball rotatively disposed in a mating hemispherical aperture centrally disposed in the second face of said piston lip flange, said ball thrusting on a hardened thrust washer disposed on the female mount base, said second mount providing small pivotal displacement of said piston;

a pair of locating pins, each one of said pins normally secured in a wall of each one of said female mounts, each one of said pins securing one said lip flange, preventing lip flange rotation;

a second elevator shaft, having a first shaft terminus secured normally in said second union mount, said second elevator shaft disposed parallel to the piston axis of symmetry and disposed in said tubular shaft guide mount, a shaft bushing secured adjacent said second union mount providing a shaft stop, limiting elevation of said piston;

a reversible fourth gear motor drive mounted on said first structural housing having a motor shaft gear actuating a second gear rack whose length is coaxially secured on said second elevator shaft parallel to the shaft axis of symmetry, said fourth drive providing vertical displacement of said second shaft on power signal;

a syringe volume adjustment means having a locking collar slidably mounted on said second elevator shaft, said collar having a pinion gear disposed on a rotating shaft mounted in said collar, said pinion gear engaging a third gear rack whose length is coaxially secured on said second elevator shaft parallel to the elevator shaft axis of symmetry, said pinion gear and gear rack cooperatively providing vertical displacement of said collar prior to locking

said collar and fixing the syringe volume displacement;

a second pair of limit switch means having two oppositely vertically disposed limit switches, a first switch secured on said first structural housing uppermost above second elevator shaft top terminus, providing a power detent for said fourth drive and having an adjustable limit actuating screw disposed in the top terminus of said second elevator shaft, and a second switch secured on said tubular shaft guide mount providing a power detent for said fourth drive on actuating by said locking collar;

a three-way diverter solenoid valve conductively secured in common to the solvent exit orfice of said syringe cylinder, said valve on signal conductively alternatively venting to a solvent reservoir conduit and to a chemical sample reactor module conduit whose solvent outlet terminus is disposed parallel and cooperatively adjacent said pressure filter head means;

whereby said contact ridges of said cylinder lip and said piston lip provide small pivotal displacements to said syringe cylinder and piston on vertical displacement of said piston by said second elevator shaft in said tubular guide mount by said fourth gear motor drive.

11. A solvent pump comprising in combination:

a frangible syringe having a cylinder and a piston, each said cylinder and said piston having a force support lip disposed around the adjacent conventional force application terminus;

a pair of lip securing plastic molded flanges, each flange of said pair coaxially disposed around and separately forming a cylinder flange and a piston flange;

a contact pivot means disposed on each face of each flange, providing separate small pivotal displacement means for each one of said molded flanges;

a first support union mount means coaxially securing the molded flange disposed around the cylinder support lip, providing containment force on said flange and providing small pivotal displacement for said cylinder engaged on said piston;

a tubular shaft guide mount means secured to said first support union mount means, having a slidable tubular mount aperture means, said shaft mount means secured to a structural housing, said tubular shaft guide means providing a vertical aperture axis of symmetry;

a second support union mount means coaxially securing the molded flange disposed around the piston support lip, providing containment force on said flange and providing small pivotal displacement for said piston engaged in said cylinder;

a pair of locating means, each one disposed in a wall of each one of said female mounts, each one of said means securing one said lip flange, preventing lip flange rotation;

an elevator shaft, having a first shaft terminus secured normally in said second union mount, said elevator shaft disposed parallel to the piston axis of symmetry and disposed in said tubular shaft guide mount, a shaft bushing secured adjacent said second union mount providing a shaft stop, limiting elevation of said piston;

a reversible gear motor drive mounted on said structural housing having a motor shaft gear actuating a gear rack whose length is coaxially secured on said elevator shaft parallel to the shaft axis of symmetry, said drive providing vertical displacement of said second shaft on power signal;

a syringe volume adjustment means having a locking collar slidably mounted on said elevator shaft, said collar having a pinion gear disposed on a rotating shaft mounted in said collar, said pinion gear engaging another gear rack whose length is coaxially secured on said elevator shaft parallel to the elevator shaft axis of symmetry, said pinion gear and gear rack cooperatively providing vertical displacement of said collar prior to locking said collar and fixing the syringe volume displacement;

a pair of limit switch means having two oppositely vertically disposed limit switches, a first switch secured on said structural housing uppermost above the elevator shaft top terminus, providing a power detent for said drive and having an adjustable limit actuating screw disposed in the top terminus of said elevator shaft and a second switch secured on said tubular shaft guide mount providing a power detent for said drive on actuating by said locking collar;

a three-way diverter solenoid valve conductively secured in common to the solvent exit orifice of said syringe cylinder, said valve on signal conductively alternatively venting to a solvent reservoir conduit and to a chemical sample reactor module conduit whose solvent outlet terminus is disposed parallel and cooperatively adjacent said pressure filter head means;

whereby said contact ridges of said cylinder lip and said piston lip provide small pivotal displacements to said syringe cylinder and piston on vertical displacement of said piston by said second elevator shaft in said tubular guide mount by said gear motor drive.

12. A solvent pump comprising in combination:

a frangible syringe having a cylinder and a piston, said cylinder having a first support lip coaxially disposed around the cylinder insertion aperture, said piston having a second support lip coaxially disposed around the piston force base;

a cylinder lip securing molded flange coaxially disposed around said cylinder lip, said flange having a pair of oppositely disposed contact ridges on each flange face, the pair of ridges on each face opposed 180°;

a piston lip securing flange coaxially disposed around said piston lip having a pair of contact ridges oppositely opposed on a first face of said piston flange;

said contact ridges of said cylinder lip securing flange and said contact ridges of said piston lip securing flange rotatively disposed 90° apart in the plane normal to the syringe axis of displacement;

a first support union mount coaxially securing said cylinder lip flange, having a first female mount adapted to coaxially supporting said cylinder flange, and a first male plug coaxially adapted to mate with said female mount, providing containment force on a back up ring coaxially disposed below said cylinder lip flange secured in said female mount, said first union mount providing small pivotal displacement movement of said cylinder;

a tubular shaft guide mount secured to said first support union, the tubular aperture of said shaft guide

mount disposed parallel to the cylinder axis of symmetry, said guide mount having a pair of shaft bushings oppositely disposed in said tubular aperture at the aperture terminus, said shaft guide mount secured to a structural housing providing a vertical tubular aperture axis of symmetry;

a second support union mount coaxially securing said piston lip flange, having a female mount adapted to coaxially support said piston lip flange, and a male plug adapted to mate with said female mount, said second union mount providing containmnet force on a steel ball rotatively disposed in a mating hemispherical aperture centrally disposed in the second face of said piston lip flange, said ball thrusting on a hardened thrust washer disposed on the female mount base, said second mount providing small pivotal displacement of said piston; a pair of locating pins, each one of said pins secured in a wall of each one of said female mount, each one of said pins securing one said lip flange, preventing lip flange rotation;

an elevator shaft, having a first shaft terminus secured normally in said second union mount, said elevator shaft disposed parallel to the piston axis of symmetry and disposed in said tubular shaft guide mount, a shaft bushing secured adjacent said second union mount providing a shaft stop limiting elevation of said piston;

a reversible gear motor drive mounted on said structural housing having a motor shaft gear actuating a gear rack whose length is coaxially secured on said elevator shaft parallel to the shaft axis of symmetry, said drive providing vertical displacement of said second shaft on power signal;

a syringe volume adjustment means having a locking collar slidably mounted on said elevator shaft, said collar having a pinion gear disposed on a rotating shaft mounted in said collar, said pinion gear engaging another gear rack whose length is coaxially secured on said elevator shaft parallel to the elevator shaft axis of symmetry, said pinion gear and gear rack cooperatively providing vertical displacement of said collar prior to lcoking said collar and fixing the syringe volume displacement;

a pair of limit switch means having two oppositely vertically disposed limit switches, a first switch secured on said structural housing uppermost above the elevator shaft top terminus, providing a power detent for said drive and having an adjustable limit actuating screw disposed in the top terminus of said elevator shaft, and a second switch secured on said tubular shaft guide mount providing a power detent for said drive on actuating by said locking collar;

a three-way diverter solenoid valve conductively secured in common to the solvent exit orifice of said syringe cylinder, said valve on signal conductively alternatively venting to a solvent reservoir conduit and to a chemical sample reactor module conduit whose solvent outlet terminus is disposed parallel and cooperatively adjacent said pressure filter head means;

whereby said contact ridges of said cylinder lip and said piston lip provide small pivotal displacements to said syringe cylinder and piston on vertical displacement of said piston by said second elevator shaft in said tubular guide mount by said gear motor drive.

13. In a sample dissolver module having a transport means, a motor drive means for rotating a tablet disruptor device, a pressure filter head means, a solvent pump means, and a wash container, the transport means combination comprising:

an elevator shaft supported in a first structural housing by spaced keyed bushings disposed to provide vertical displacement of said shaft on actuating power signal to a first reversible gear motor drive, the motor shaft gear actuating a first gear rack coaxially secured on said shaft parallel to the shaft axis of symmetry, said motor drive secured on said first housing;

a first sensor pin secured on said shaft, positioned to alternatively activate each one of a first pair of motor limit switches fixedly spaced vertically opposed on said first housing, providing a power detent for said first motor drive on activating one said switch;

a second guide pin, secured in a guide block disposed on said first housing, said second pin riding in a guide block track preventing shaft rotation during shaft elevation displacement;

a horizontal second housing arm rotatively secured by bushing means on said elevator shaft adjacent the shaft top terminus, a second reversible gear motor drive rotating said second arm on actuating power signal, the rotating motor gear providing rotative thrust on an engaged gear segment fixed to the elevator shaft;

a second pair of motor limit switches arcuately disposed in a plane parallel to the plane of rotation of said second arm, each one of said second pair of switches disposed at one terminus of an arc, limiting the rotation of said second arm on power signal;

and,

a second final adjustment screw arc sensor means providing micro adjustment of said arc terminus, said arc sensor means having adjustable screws disposed in a secured arc stop block, providing micro-arc angle adjustment of a power detent for said second motor drive on activating one said switch.

14. In a sample dissolver module having a transport means, a motor drive means for rotating a tablet disruptor device, a pressure filter head means, a solvent pump means, and a wash container, the motor drive means for rotating a tablet disruptor comprising in combination:

a variable speed motor device for rotating said tablet disruptor device on power signal, including a motor drive normally mounted downward on an adaptor plate;

a motor speed and operating time control for said third motor drive;

a coupling means securing said motor drive and said disruptor device;

a drive shaft aligning means coaxially aligning said disruptor device and said motor drive;

and,

an adaptor plate securing means providing adjustable secure positioning of said adaptor plate, said plate coplanarly secured on said second housing arm, positioning the motor drive shaft vertically downward.

15. In a sample dissolver module having a transport means, a motor drive means for rotating a tablet disrup-

tor device, a pressure filter head means, a solvent pump means and a wash container, the pressure filter head means comprises in combination:

a support arm extending horizontally from a first structural housing and secured thereto, said arm having a first uniform tubular aperture disposed normally through said arm;

a pressure filter head tubular plunger means slidably extending through said first uniform tubular aperture, said plunger means having a second coaxial tubular aperture disposed therein, said plunger means having a sealing means disposed on the lower terminus of said plunger means, said sealing means providing a gas-tight seal for a filter tube of a chemical sample reactor module, and said plunger means having a guide cap means coaxially secured to the upper terminus of said plunger means providing a slidable guide means in said arm;

an expansion spring coaxially disposed around said plunger means between said guide cap and said arm;

a coupling means providing gas pressure conductively to said plunger means adjacent to said guide cap means;

a collar compressive means cooperatively disposed to compressively displace the top terminus of said guide cap means downward a precise distance on lowering said collar means.

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