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[54] **AUTOMATIC SAMPLER APPARATUS OF MODULAR CONSTRUCTION**

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[73] Assignee: **Varian Associates**, Palo Alto, Calif.

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[52] **U.S. Cl.**..... **73/423 A**, 73/431, 312/198, 312/223

[51] **Int. Cl.**... **G01d 11/24**, G01d 11/30, G01n 1/12

[58] **Field of Search**..... 73/422 GC, 423 A, 431; 23/259, 253; 220/23.2, 23.83, 23.86, 3.94; 137/343; 251/143; 312/198, 223; 317/120

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Primary Examiner—S. Clement Swisher

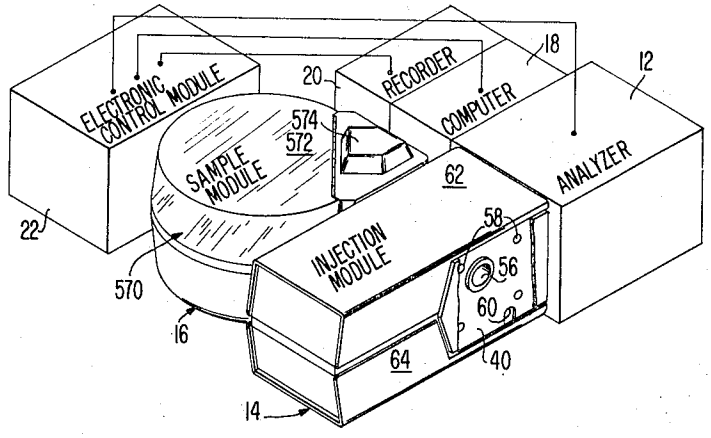
Attorney, Agent, or Firm—Stanley Z. Cole; Gerald M. Fisher

[57] **ABSTRACT**

A system for injecting sample fluids into an analyzer and processing the analysis data is disclosed. The system comprises a fluid sample analyzer, a sample storage module for a number of fluid samples, an injection module by which samples are injected into the analyzer, a data recording or processing device, and a control module for governing and sequencing the operation of the system.

The injection module and the storage module are configured to permit alternate orientations to facilitate horizontal or vertical injection without disconnecting of interconnecting conduits.

2 Claims, 7 Drawing Figures



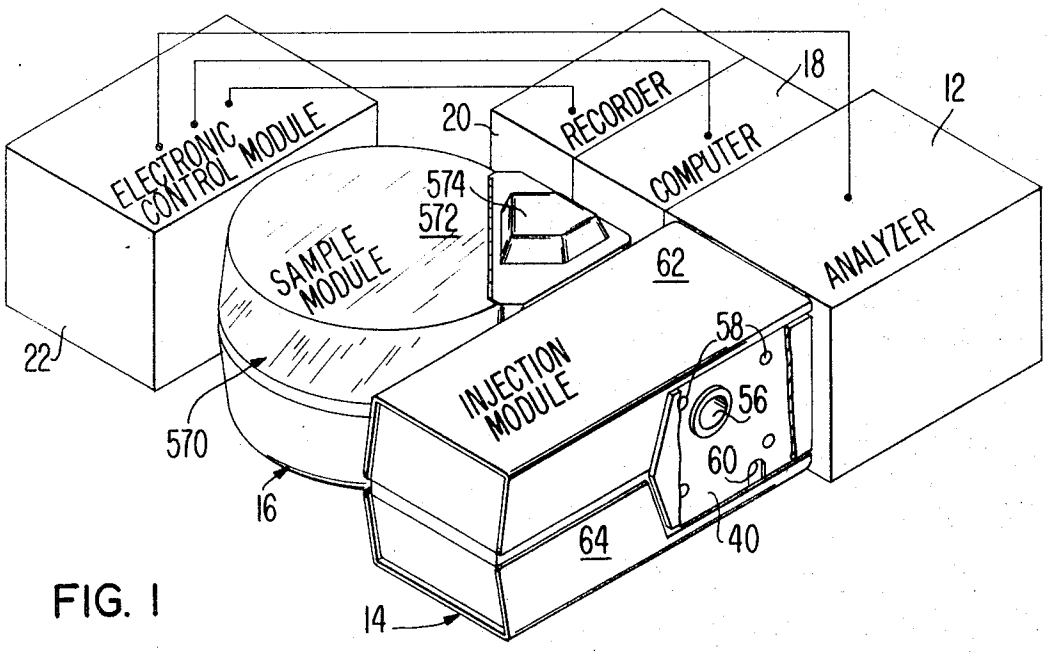

ELECTRONIC CONTROL MODULE
20
RECORDER
18
12
COMPUTER
574
572
SAMPLE MODULE
62
ANALYZER
58
22
INJECTION MODULE
56
570
60
16
64
40
14

FIG. 1

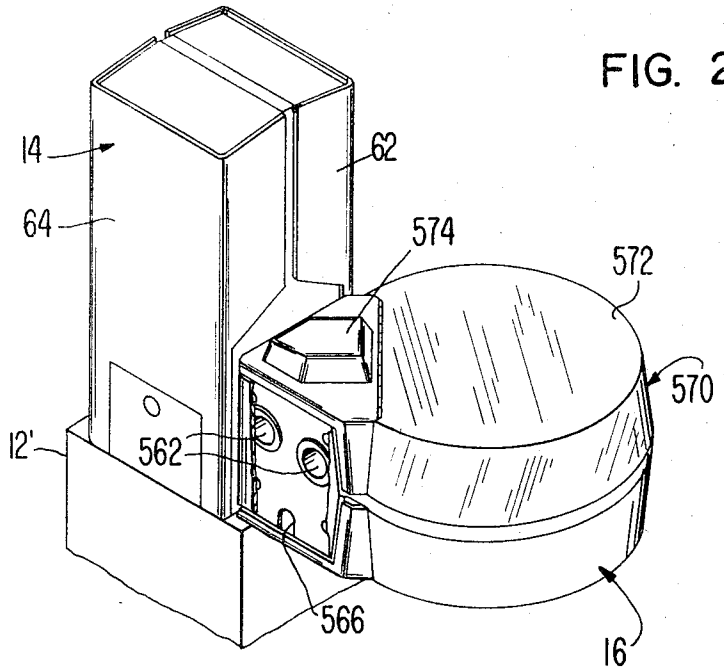

14
62
64
574
572
570
12'
562
566
16

FIG. 2

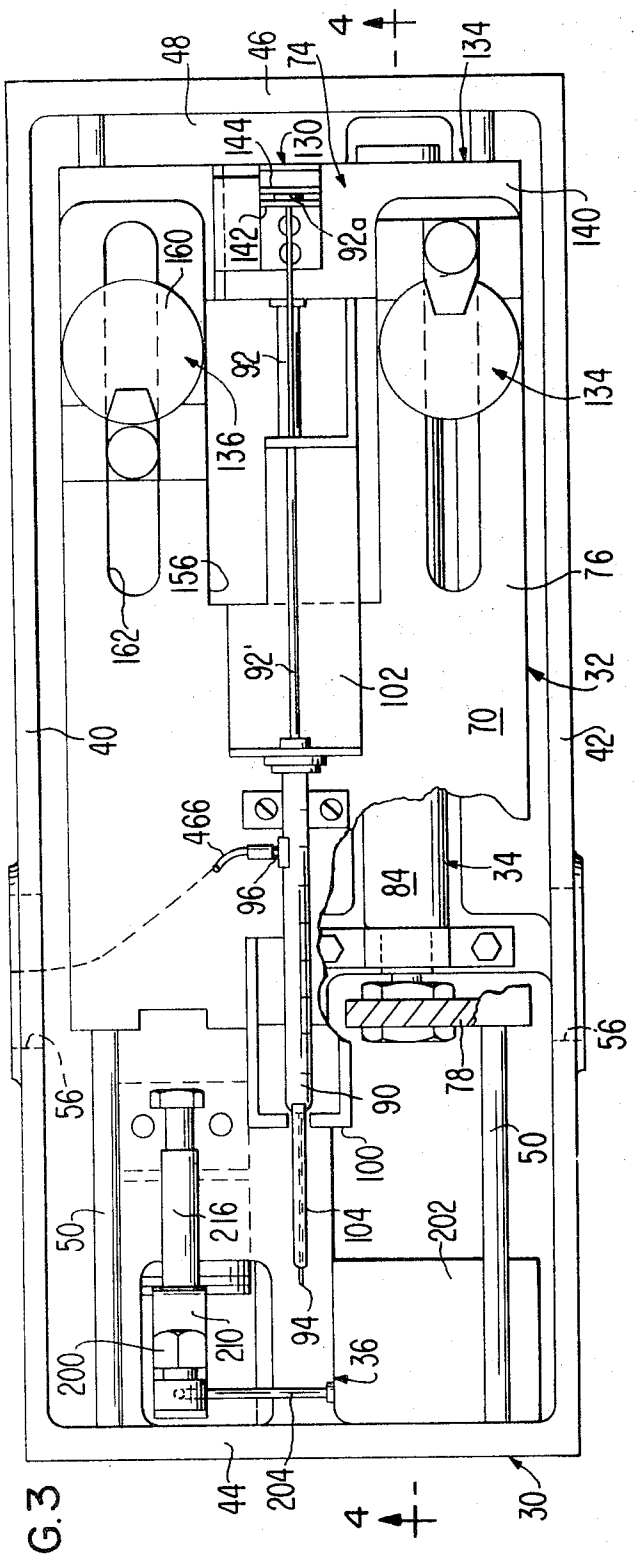

48
46
74
4
134
144
130
142
92a
140
160
92
136
134
156
76
162
92'
102
32
70
40
42
466
96
84
34
56
78
90
50
100
216
104
202
50
210
94
36
200
44
204
30
4

FIG. 3

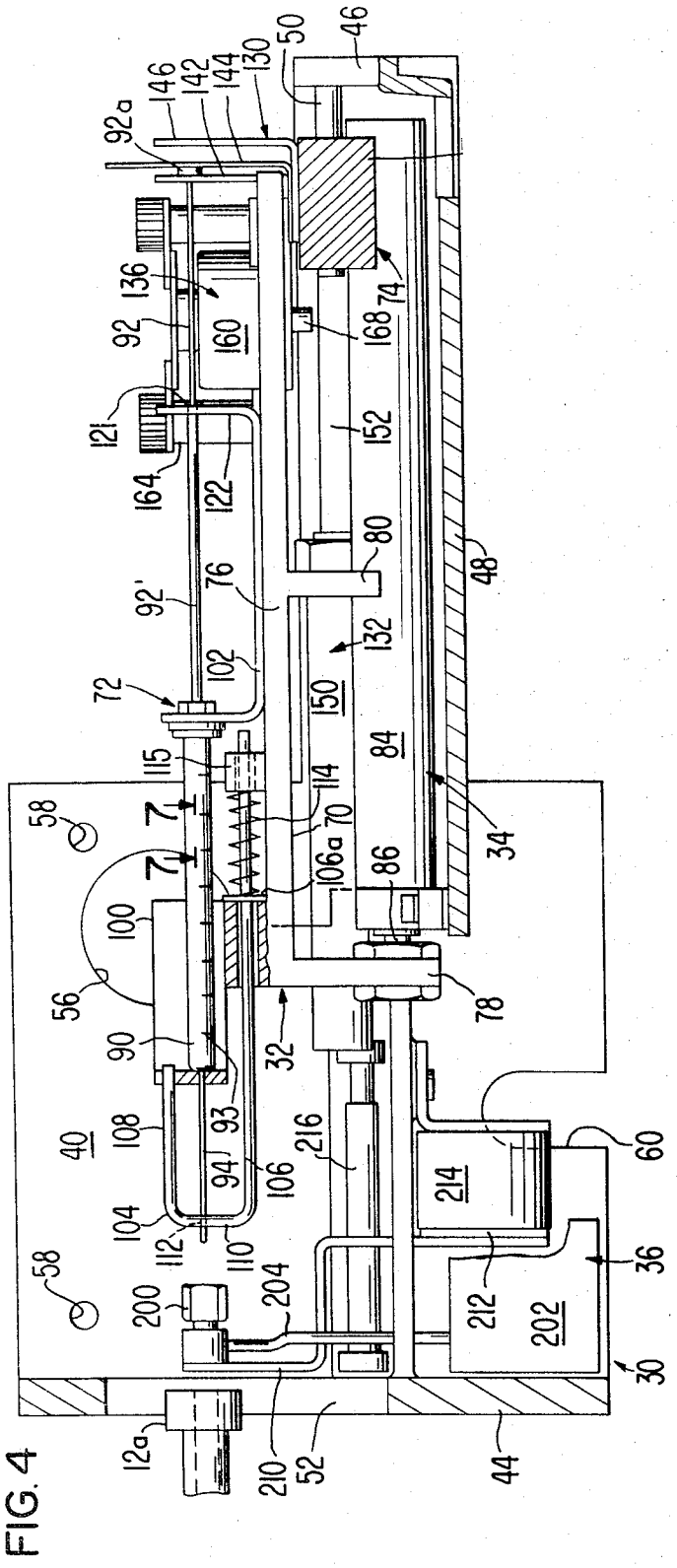

46
50
130
144
142
146
92a
136
92
160
121
164
122
92'
76
102
72
115
114
70
106a
58
7
7
100
56
90
93
94
106
108
40
104
112
110
58
200
204
216
214
212
202
36
30
60
34
86
84
150
132
152
168
74
80
48
78
32
12a
210
52
44

FIG. 4

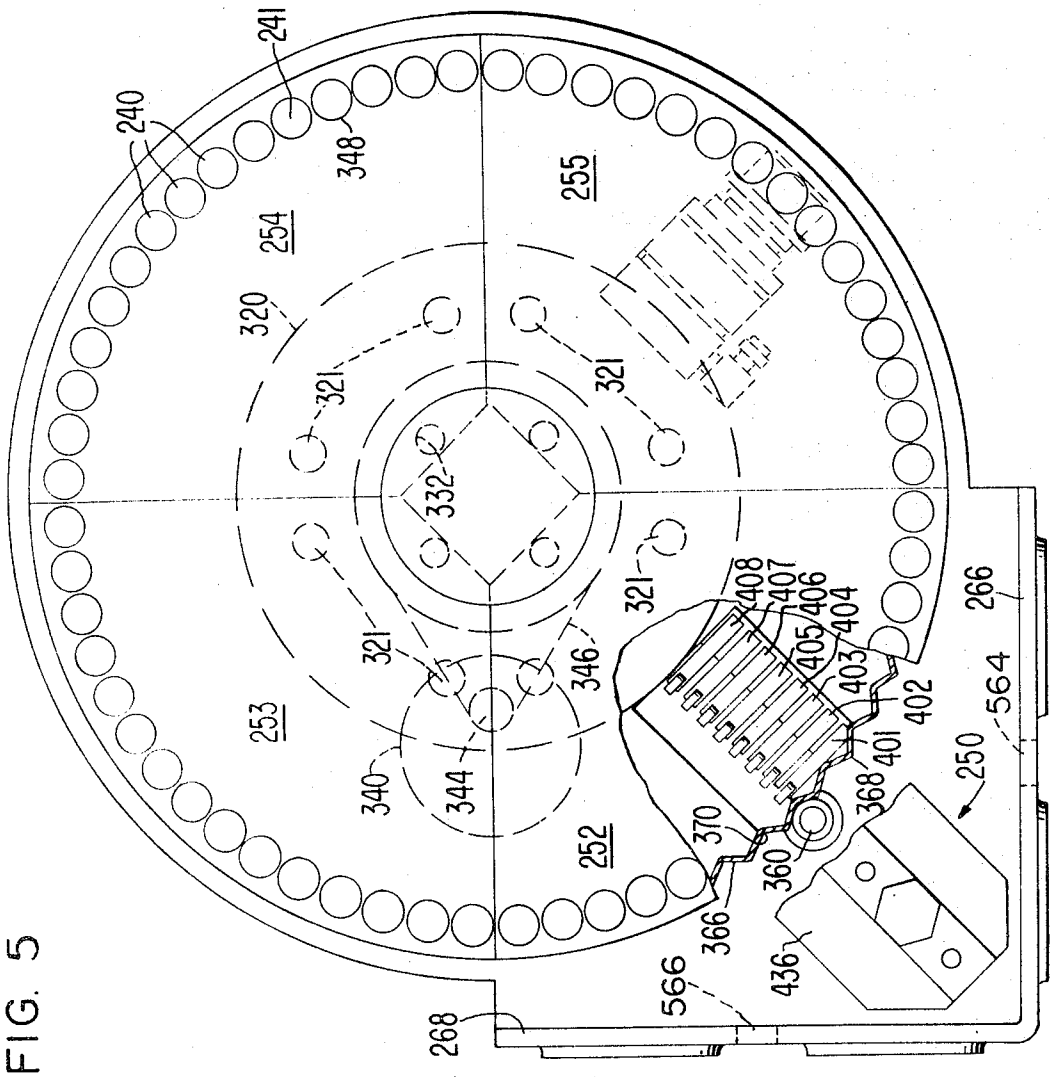

241
240
348
254
255
320
321
332
253
340
344
346
252
408
407
406
404
405
403
402
401
266
564
250
368
370
360
366
436
566
268

FIG. 5

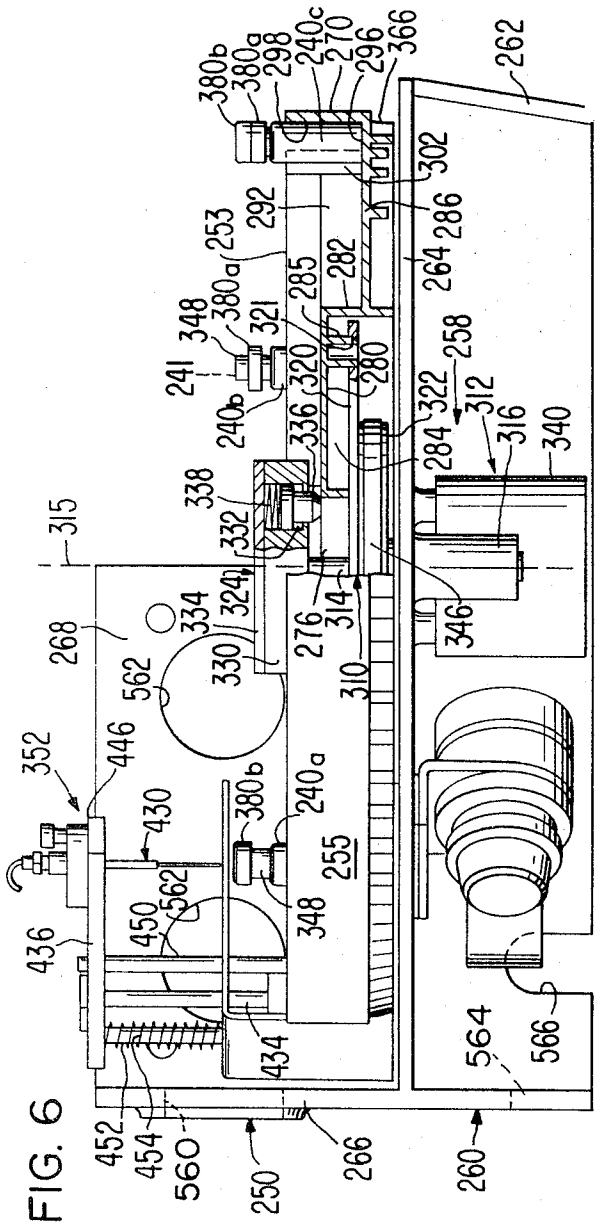
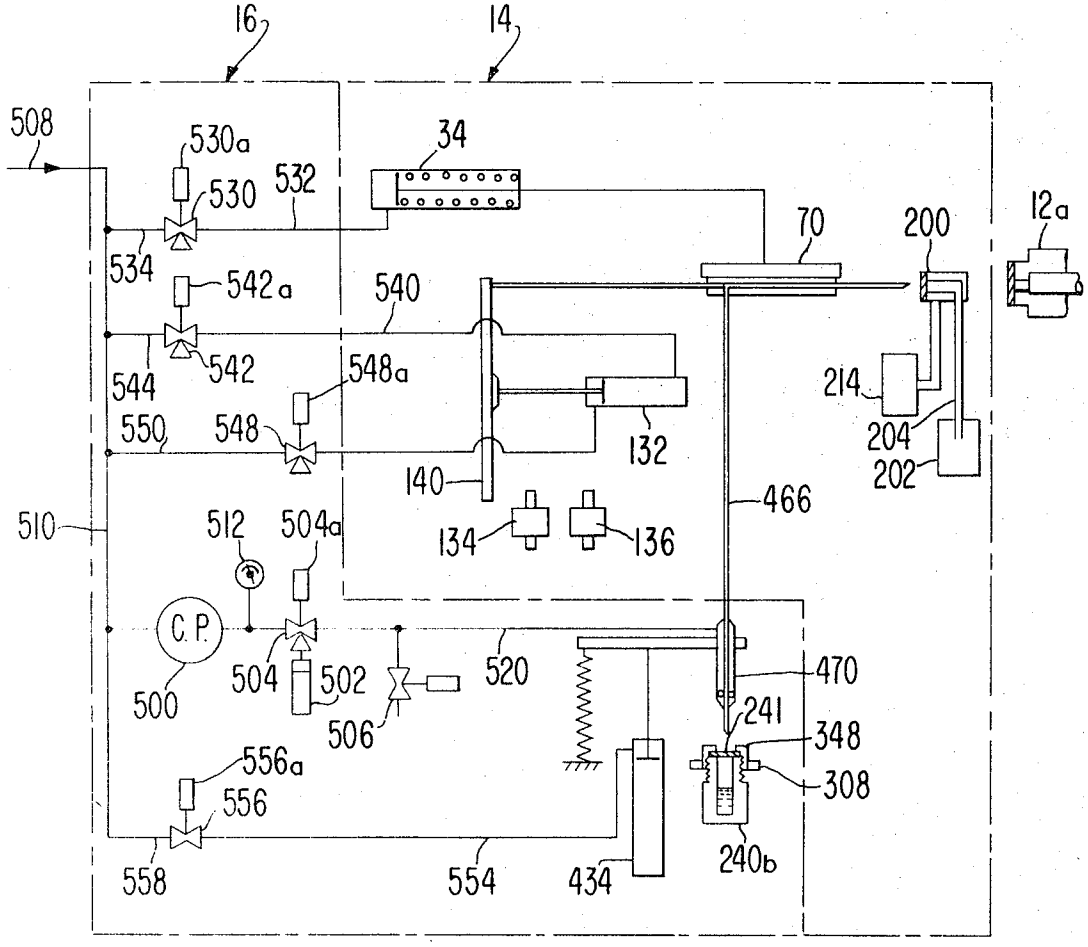

380b
380a
298
240c
270
296
366
262
302
292
286
253
264
282
285
380a
348
321
320
280
258
241
240b
336
322
312
316
340
284
338
332
315
324
334
314
276
346
268
330
310
562
352
446
240a
380b
430
255
562
450
348
436
434
564
566
452
454
560
250
266
260

FIG. 6

FIG. 7


16
14
508
530a
530
532
34
534
542a
540
544
542
548a
550
548
132
140
214
204
202
70
200
12a
466
510
512
504a
134
136
C.P.
500
504
502
506
520
470
241
348
308
556a
556
558
554
434
240b

AUTOMATIC SAMPLER APPARATUS OF MODULAR CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the analysis of sample fluids and more particularly relates to systems for controlling the introduction of sample fluids into an analyzer.

2. Prior Art

Systems for supplying fluid samples for analysis by equipment, such as chromatographic analyzers, have been proposed by the prior art. Some prior art systems have employed a syringe for introducing a predetermined quantity of sample fluid into the analyzer equipment. Sample fluids to be analyzed were disposed in separate closed sample containers and successive individual fluid samples were removed from their containers, supplied to the syringe, and injected into the equipment.

It is imperative in most sample analyses that the sample fluid being analyzed be as free as possible from any type of foreign substance. Accordingly, the injection syringe was required to be thoroughly purged of one sample fluid and/or any residual cleansing solvent before a succeeding sample was placed in the syringe. The syringes employed for sample fluid injection were quite delicate because of the extremely small quantities of sample fluid they handled, e.g., quantities of from 5 – 50 microliters, this made manual operation and purging of the syringes both tedious and time consuming. Furthermore, when large numbers of samples were being successively analyzed, a skilled operator was required to attend the equipment and perform the tedious and repetitive task of purging and filling the syringe.

In order to increase the speed and efficiency of the analysis of multiple fluid samples, mechanized syringe handling systems were proposed. The purpose of such systems was to reduce the amount of operator time required in connection with the analysis procedures and to reduce equipment failures, e.g. the syringe breakage and damage which inevitably resulted from frequent handling.

The mechanized systems generally consisted of a supporting tray for sample containers and an injection syringe manipulating mechanism which functioned to enable removal of sample fluid from individual containers, injection of the fluid into the analyzer and purging of the syringe. The sample container trays were usually actuatable to index successive sample containers to a location from which fluid was transferred to the syringe.

While the prior art mechanized systems were effective in reducing the amount of operator time required to analyze fluid samples, several problems arose relating to convenient coordination between the mechanized systems and the analyzers into which the sample fluid was to be injected.

Prior art apparatuses for sample storage and injection were frequently designed to accommodate one particular type of analyzer. For example, some analyzers were constructed with horizontal sample inlets while others had vertical sample inlets and the orientation of the sample storage apparatus with respect to the injection apparatus was necessarily difficult from analyzer to analyzer depending on the analyzer constructions. Hence,

in a facility having several differently constructed analyzers, the sample injection and storage apparatus could not always be interchanged between the analyzers.

SUMMARY OF THE INVENTION

The present invention provides a new and improved modular structure wherein fluid samples to be analyzed need not be loaded by the operator of the analysis system and confusion as to the identity of fluid sample analysis results is minimized; sample fluid injection equipment and associated sample flow conduits are purged by a controlled volume of purging fluid so that samples of fluid injected in the apparatus are nearly uniformly pure regardless of differences in sample fluid viscosity and/or volatility; the volume of sample fluid injected into the analyzer is accurately governed by adjustable dosage controls; damage to syringe-like elements of the system resulting from misalignment of sample containers or other fluid receivers and the syringe-like elements is avoided; and numerous different sample fluids can be analyzed automatically without requiring full time attendance of a skilled operator.

In a preferred and illustrated embodiment of the invention a sample analysis system is provided which comprises a sample analyzer, preferably a gas chromotograph, a sample injection module by which a sample of fluid to be analyzed is injected into the analyzer, a sample storage module which houses a number of discrete samples of fluid to be analyzed and which supplies sample fluid to the injection module, a sample analysis computer which may be programmed to partially govern operation of the system and to receive raw data from the analyzer concerning the analysis of the given sample of fluid, a recorder which is connected to the analyzer for producing graphic information concerning the analysis of given samples by the analyzer, and an electronic control module which governs operation of the components of the system.

The sample storage module is detachably connected to the injection module and sample fluid which is withdrawn from an individual container in the storage module is conducted into the injection module via a sample conduit. The injection module includes a syringe connected to the conduit which injects a predetermined dose of the fluid into the analyzer. Prior to the injection of a sample, the sample conduit and the injection syringe in the module are purged to remove residual fluid from a previous cycle of the system.

An important feature of the invention is the provision of a sample storage module and an injection module which are detachably fastened together and can be fastened together in various orientations with respect to each other without disconnecting electrical and fluid conduits extending between them. In one preferred embodiment, the storage and injection modules are interconnected by electrical and fluid flow conduits. The injection module and storage module are provided with alignable access openings through which the conduits extend when the modules are fastened together. Each module includes an alternate access opening for the conduits when the modules are fastened together in another orientation. The access openings are provided with slots which enable the conduits to be guided from one access opening through its associated slot into another access opening through its associated slot. The modules are then fastened together in the new orienta-

tion with the conduits extending through one or both of the now aligned alternate access openings.

This capability of the injection and storage modules enables the use of injection and storage modules constructed according to the present invention with many different analyzers and without requiring the various conduits between the modules to be disconnected when the modules are being oriented with respect to each other.

Other features and advantages of the invention will be apparent from the following detailed description of a preferred embodiment made with reference to the accompanying drawings which form a part of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a sample analysis system embodying the present invention with parts illustrated schematically;

FIG. 2 is a perspective view of a portion of the system of FIG. 1 with components shown in a different orientation;

FIG. 3 is a top plan view of an injection module forming part of the system of FIG. 1 with parts removed;

FIG. 4 is a cross sectional view seen approximately from the plane indicated by the line 5—5 of FIG. 3;

FIG. 5 is a plan view of a sample storage container module forming part of the system of FIG. 1 with parts removed and portions broken away;

FIG. 6 is a cross sectional view seen approximately from the line 9—9 in FIG. 5; and

FIG. 7 is a schematic diagram of a fluid pressure system contained within the injection and storage modules.

DESCRIPTION OF A PREFERRED EMBODIMENT

An automatic sample analysis system **10** embodying the present invention is illustrated in FIG. 1 as comprising a sample analyzer **12**, which may be, for example, an apparatus for analyzing a fluid sample by liquid or gas chromotography; a sample injection module **14** by which a sample of fluid to be analyzed is injected into the analyzer **12**; a sample storage module **16** which houses a number of discrete samples of fluid to be analyzed and which supplies sample fluid to the injection module; a sample analysis computer **18** which is programmed to partially govern operation of the system and to receive raw data from the analyzer concerning the analysis of a given sample of fluid and to process that data into a desired useable form; a recorder **20** which is connected to the analyzer for producing graphic information concerning the analysis of given samples by the analyzer; and an electronic control module **22** which generally governs the operation of the remaining components of the system **10**.

In brief, the system **10** operates in the following manner: The injection module and sample storage module are connected to each other in a desired orientation, for example, in the orientation shown in FIGS. 1 or 2 and are detachably connected to the analyzer **12**, which may be of any suitable or conventional type or construction, and a number of containers of sample fluid are disposed in the storage module. Automatic operation of the system is then initiated by the operator which results in a predetermined quantity of sample fluid from one container in the storage module **16** being extracted and delivered to the injection module **14** from which a predetermined quantity of the sample is injected into the analyzer **12**. The analyzer **12** processes the sample fluid and data resulting from the analyzer process is fed to the computer **18** and/or the recorder **20**. At the same time, information concerning the identity of the sample injected into the analyzer is supplied to the control module from the storage module and thence to the recorder and computer so that the data being obtained from the analyzer is identified with the particular container from which the sample was removed. After the first fluid sample has been analyzed, sample fluid from a second container is directed from the storage module to the sample injection module and the analysis process is repeated. When all of the samples have been analyzed, the operation of the system **10** is automatically terminatable.

Prior to the injection of each fluid sample into the analyzer, the flow passageways through which the sample passes from the storage module into the analyzer are purged to remove substantially all traces of the preceding sample fluid from the passages prior to the introduction of the next succeeding sample to the analyzer. Purging is conducted using the next succeeding sample fluid itself or using a suitable solvent and then the next succeeding sample fluid so that the possibility of contaminating any given fluid sample by the preceding sample or the solvent is minimized. The purging solvent is contained by the storage module like the samples and is introduced into the passages to be purged. The sequence of operation of the system **10** is governed by the control module in cooperation with the computer.

It should be appreciated that the brief description of the operation of the system **10** has been simplified and generalized in order to provide an overall understanding of the functions and interrelationships of the various modules and components of the system **10**. The various modules and components of the system **10** are described separately below.

THE INJECTION MODULE 14

The injection module **14** comprises a support frame **30** which supports a syringe carriage assembly **32**, a carriage actuator **34** and a waste receiving system **36**. The syringe carriage assembly **32** includes a sample injecting syringe, described in detail presently, which is movable by operation of the carriage actuator **34** to inject a predetermined quantity of sample fluid into the analyzer **12** as well as to inject purging fluid into the waste receiving system **36**. The injection module **14** is illustrated in FIG. 3 of the drawings.

Referring particularly to FIG. 3, the frame **30** is illustrated as including side panels **40, 42**, opposite end walls **44, 46** extending between the side panels, and a base section **48** extending from the end wall **46** between the side panels **40, 42**. A pair of cylindrical guide rods, or ways, **50** extend between the end walls **44, 46** parallel to the side panels. The end wall **44** mounts along the face of the analyzer **12** by interconnection of the end wall **44** to the analyzer by suitable connectors (not shown). The end wall **44** defines an opening **52** which is aligned with an analyzer sample inlet which is shown in part in FIG. 4 at **12***a*. The sample inlet **12***a* is provided with an inlet port through which the needle or canulla, of the injection syringe extends when a sample is being injected into the analyzer. The inlet sample port is covered by a septum as is conventional, so that

in order to inject a sample of fluid into the analyzer the syringe needle must pierce the septum covering the analyzer inlet port.

The side panels **40, 42** extend away from the analyzer **12** and each defines an access port **56** and connector openings **58.** Normally fluid and/or electric conduits extend through one or the other of the ports **56** from the storage module **16** depending upon which of the side panels **40** or **42** is engaged with the storage module. The connector openings **58** function to enable detachable connection of the storage module to the injection module by screws or other suitable fasteners which extend between the modules.

Alternatively, slot **60** enables repositioning of the storage module from one side panel of the frame **30** to the other side panel without requiring disconnection of the conduits extending between the modules during the repositioning if the conduits are guided from one access opening in the storage module through the associated slot **60,** or to the other access opening or slot in the storage module through its associated slot **60** without disconnecting the conduits from the injection module. Repositioning of the storage module with respect to the injection module might be occasioned where the storage and injection modules are utilized in connection with various analyzers having different physical configurations. One such repositioning of the modules is illustrated by FIGS. **1** and **2.** In the configuration shown by FIG. **1,** the modules are attached to an analyzer **12** having a horizontal sample inlet while in FIG. **2** the same modules are repositioned and connected to an analyzer **12'** having a vertical sample inlet.

Removable cover panels **62, 64** are connected to the frame **30** to shield the internal components of the injection module **14** when in use, and are removed to enable access to these components for servicing and maintenance. One or both cover panels **62, 64** are also removed when the injection module is repositioned with respect to the storage module to enable manipulation of the interconnecting conduits from one access opening to the other as described above. The cover panels **62, 64** are illustrated in FIGS. **1** and **2.**

THE STORAGE MODULE

The storage module **14** supports a plurality of separate containers **240** for fluid samples and purging solvents and defines an extraction station **250** at which a fluid sample or purging solvent is extracted from a respective container and is directed to the injection module **14.** The individual containers **240** are supported by a plurality of the sample supporting tray members, or racks, indicated by the reference characters **252–255** (see FIG. **5**). The trays, or racks, are individually removable from the storage module **16** with their associated sample containers. An actuator assembly **258,** forming a part of the module **16,** moves the container supporting trays in carrousel fashion so that individual containers are successively moved to the extraction station **250** from which the contents of the container at the extraction station can be removed and directed to the injection module.

Referring now to FIG. **6,** the storage module **16** comprises a support frame **260** which is defined by a peripherally extending skirt **262** and a circular base plate **264** connected to the skirt. Side panels **266, 268** extend perpendicularly with respect to each other and generally tangentially with respect to the support base portion **264** and skirt **262** to define a projecting corner of the storage module. The extraction station **250** is located at the projecting corner of the module and the trays **252–255** are circularly arranged over the support base **264.**

The sample supporting tray members **252–255** are, in most respects the same, and only the tray **253** is described in detail to the extent that the trays are identical. The tray **253** is shaped to approximate a frustum of a 90° circular segment having a circularly curved outer wall **270,** radially extending side edges **272, 274** and a radially inner edge **276** which extends between the side edges. A segmental radially inner tray body **280** extends between the edges **272, 274, 276** and terminates in a circular wall portion **282.** The edges of the tray member are defined by lips which project from face of the body **280** and these lips, along with radially extending webs **284,** rigidify the tray body portion **280.** A pair of cylindrical bosses **285** extends from the body **280** beyond the webs **284.** The bosses provide a detachable driving connection with the tray actuator assembly **258** as is described in greater detail presently.

A radially outer tray body portion **286** extends from the wall **282** and is recessed from the body **280.** The outer tray body portion **286** terminates in the circumferential wall **270** and is rigidified by integral webs **292** which extend radially outwardly from the wall **282** flush with the inner tray body portion **280.**

A circumferential series of sample container pockets **296** (preferably **15** pockets for accommodating **15** separate containers) is disposed circumferentially about the periphery of the outer tray body **286.** The pockets **296** are defined by semi-circular recesses **298** formed in the tray wall **270** and semi-circular faces **300** formed on projecting lugs **302** at the radially outer ends of the webs **292.** The recesses **298** and faces **300** are positioned with respect to each other so that the container in each individual pocket is maintained accurately positioned in the pocket and constrained against tipping, even if the tray should be vertically oriented.

The container support actuator **258** comprises a turntable assembly **310** to which the individual trays **252–255** are detachably connected and a turntable drive mechanism **312** by which the assembly **310,** and the attached trays, can be rotated with respect to the frame base **264.** The assembly **310** comprises a support shaft **314** which extends through the frame base **264** and is supported for rotation about an axis **315** by a bearing unit **316** connected to the frame base. The projecting end of the support shaft **314** carries a circular tray support member **320** which is fixed to the shaft **314** for rotation about the axis **315** and which defines four pairs of circumferentially spaced locating holes **321.** A drum-like member **322** is disposed between the tray support **320** and the frame base **264** and is fixed to the shaft **314** for rotation with it.

A tray locking assembly **324** is disposed beyond the tray support **320** from the drum **322** and functions to permit the individual sample supporting trays to be connected to and locked in place on the tray support member.

The locking assembly comprises a cylindrical body **330** which is fixed to the end of the shaft **314** for rotation about the axis **315.** Four shouldered holes **332** are formed in the body **330** at locations spaced 90° apart about the axis **315,** with the holes extending generally parallel to the axis. A circular retainer plate **334** is con-

nected to the body **330** to close the holes **332.** Each of the holes **332** supports a shouldered detent pin **336** and a helical compression spring **338** which reacts between the detent pin **36** and the retainer plate **334** so that the projecting end of the detent pin is urged from the body **330** towards the tray support **320.**

Trays are inserted and locked in placed in the assembly **310** by cocking the tray slightly with respect to the support member **320** and inserting the inner edge **276** of the tray between the support member **320** and the body **330** of the locking assembly. The end of the detent pin **336** is rounded so that the detent pin is forced into its shouldered hole **332** against the force of the spring **338** as the tray is slid radially inwardly along the support member **320.** When the locating bosses **285** are aligned with one pair of the locating holes **321** the tray is cocked downwardly so that the bosses **285** extend through the associated locating holes **321.** At this juncture the webs **284** of the tray are engaged along the face of the support member **320** and the detent pin **336** is firmly engaged with the tray body portion **280** to maintain the tray member in contact with the support member **320.** The bosses **285** cooperate with their respective locating holes to enable the transmission of drive from the rotatable support member **320** to the tray.

The drive mechanism **312** includes a reversible electric motor **340** having a gear reduction (not shown) connected to its rotor shaft. An output shaft of the gear reduction (not shown) extends through the frame base **264** and an output pulley **344** is connected to the projecting end of the gear reduction output shaft. A drive belt **346** is reeved about the pulley **344** and the drum **322** so that drive from the motor **340** is transmitted to the turntable assembly **310** and thence to the individual trays supported by the turntable assembly.

The containers **240** may be of any suitable construction but in the illustrated embodiment are glass vials which fit snuggly into the pockets **296.** The containers **240** have a capacity of several milliliters of fluid and each container is closed by a septum **241** which is carried by a removable cap **348.**

An important feature of the invention resides in the ability of the storage module **16** to receive from one to four trays of a large number of support trays which may be loaded with sample containers at locations remote from the actual location of the system **10.** As an example, the system **10** can be a central analyzer system at which a primary analyzer system serves a number of separate laboratories. Sample trays can be loaded with sample and/or solvent containers in the laboratories and forwarded to the analyzer system, thus relieving the analyzer operator from the task of loading the sample trays and recording the identity of each sample and its position in the tray. Each of the trays is provided with indicia indicating the identity of the tray, by a decimal number as well as indicating, by decimal numbers, the identities of the individual pockets in the tray. When the trays are loaded at their individual laboratories, the personnel loading the trays need only record the tray or rack number and the substance in each container along with the associated pocket number. The operator of the analyzer need not be involved in this process. In the preferred embodiment, the module **16** can handle up to four of **16** separate sample trays at any given time.

The turntable assembly **310** moves the trays to position successive container locations at the extraction station **250.** Fluid in a container at the extraction station is removed by a syringe-like dipper tube assembly **352** (which is described in detail below) and is directed to the injection module **14.** The storage module **16** provides a container locating assembly which functions to precisely align the containers at the extraction station with the dipper tube assembly so that the dipper tube assembly is not damaged from being advanced into engagement with a misaligned container.

As is best seen in FIG. **6,** the dipper tube assembly **352** comprises an extraction syringe needle assembly **430,** an associated pneumatic fluid purging system **432** (see FIG. **7**) and an extraction syringe actuator assembly **434.** The actuator assembly **434** comprises a syringe needle support plate **436** which is connected to a single acting pneumatic ram including a cylinder **440** connected to the frame by a supporting bracket **442** and a piston rod **444** extending between the cylinder **440** and the support plate **436.** A radially inwardly projecting plate end **446** carries the needle assembly **430** for reciprocating motion towards and away from a container **240** at the extraction station. The plate **436** is connected to guide rods **450, 452** which extend through bores in the bracket **442** to guide the motion of the plate and the needle assembly as the plate is reciprocated by the ram **438.** The guide rod **450** is surrounded by a helical compression spring **454** which reacts against the syringe support plate **436** to urge the piston rod **44** towards its fully extended position. When the piston rod retracted the plate and needle assembly **430** move towards the container and the needle assembly is thrust into the container through its system.

In the preferred and illustrated system, the injection syringe has an internal volume of about 10 microliters and the sample conduit **466** has an internal volume of about 10 microliters. It has been found that purging such a system with a flow of fluid equal to about 10 times the combined syringe and conduit volumes reduces the quantity of residual material in the purged volume to consistently low levels, e.g., to less than 0.01 percent by volume. Accordingly, in the preferred system, the **100** microliter accumulator, charged to 25 psig, is effective to produce a purging volume of solvent and/or sample fluid of about 200 microliters.

Some sample fluids have high vapor pressures at room temperature and if the accumulator were discharged into a container of such a fluid, the partial pressure of the vapor combined with the PV energy of the purging gas could cause an excessive quantity of the fluid to be forced from the container. Accordingly, in the preferred embodiment of the invention, after the needle assembly has been inserted into a container, the vent valve **506** is opened to communicate the container to atmospheric pressure via the needle **470,** the conduit **520** and the valve **506.** The valve **506** is operated by a solenoid **506*a*** which is energized and deenergized from the control module **22.**

After the vent valve **506** is opened to vent the container, it is reclosed and the container volume is substantially at atmospheric pressure. The control valve **504** is then actuated to discharge the accumulator into the container so that a predetermined controlled pressure differential is applied across the sample fluid, the fluid conduit **466** and the injection syringe assembly **72.** In the preferred embodiment of the invention the

control module functions to allot a one minute period during which purging is accomplished. Purging is normally completed within the alloted time.

Where a sample fluid has a relatively high viscosity, (e.g., greater than 1 cp) its flow resistance is relatively great and a single discharge of the accumulator may not provide sufficient energy for a complete purge during the alloted one minute purging period. In such circumstances the operator can condition the control module to operate the control valve **504** to discharge the accumulator a second time during the purging period, e.g., after 30 seconds have elapsed. The additional PV energy thus supplied to the container compensates for the high fluid viscosity. After purging is completed the dipper tube assembly is withdrawn from the container. Just as the dipper tube begins to withdraw, the control valve **504** is again operated to discharge the accumulator. The accumulator discharges partly into the container and partly to atmosphere as the dipper tube needle assembly is moved from the container septum. The portion of the discharge into the container is effective to provide an air pocket at least in the dipper tube needle **460.** This reduces the chance that a drop of fluid from a preceding sample container can drip into a succeeding sample container during the dipper tube insertion.

Referring further to FIG. 7 the injection and storage modules **14, 16** are shown schematically by broken lines along with the various elements of the pneumatic system for operating the actuators in the modules.

As illustrated by FIG. 7 the injection syringe carriage actuator **34** is communicated to a solenoid control valve **530** in the storage module by a conduit **532.** The control valve **530** is in turn connected to the pressure manifold **510** by a conduit **534.** The valve solenoid **530***a* is energized and deenergized from the control module **22** to control operation of the valve. When the actuator **34** is operated to advance the syringe carriage towards the analyzer inlet **12***a* or the waste receptacle, the valve **530** is operated to direct high pressure air to the actuator **34.** The carriage is retracted by operating the valve **530** to vent the actuator **34** so that the actuator return spring retracts the carriage.

The double acting plunger actuator **132** is communicated to the manifold **510** at one end via a conduit **540,** a control valve **542** and a conduit **544.** The opposite end of the actuator **132** is communicated to the manifold via a conduit **546,** a control valve **548** and a conduit **550.** The valves **542** and **548** each are operated by solenoids **542***a*, **548***a* slot which are wired to the control module. The valves **542, 548** are constructed like the valve **530** to either supply high pressure air to their respective ends of the actuator **132** or to vent the actuator, depending on energization of the solenoids. When both valves direct pressurized air to the actuator **132** the plunger is positively positioned by the actuator, as noted previously. This operation of the valves only occurs when the cross bar **140** engages one or the other of the dosage stops **134, 136,** which are schematically illustrated in FIG. 7, to enable retraction of the dosage stop element.

The single acting dipper tube actuator **434** is communicable to the manifold **510** via a conduit **554,** a control valve **556** and a conduit **558.** The control valve **556** includes a solenoid **556***a* wired to the control module **22.** The valve **556** is constructed and functions the same as the valve **530.**

As is apparent from FIG. 7 the pressure conduits **532, 540** and **546,** as well as the sample fluid conduit **466** all extend between the storage and injection modules. Additionally, as noted above, the electric conductors for the dosage stops **134, 136** and the waste system solenoid **214** also extend from the storage module to the injection module.

As illustrated in FIGS. 2 and 6 the storage module frame side panels **266, 268** each include an access opening **560, 562,** respectively, through which the various conduits and wires extend to the injection module. When the storage and injection modules are fastened together one or the other of the access openings **560, 562** is aligned with an injection module access opening **56,** with the conduits and wires extending through the aligned opening.

In some circumstances it is desirable to be able to reorient the storage module with respect to the injection module in such a way that the conduits and wires all extend through the same injection module access opening **56** but through a different access opening in the storage module. In order to accommodate this type of reorientation each storage module access opening has an associated guide slot **564, 566,** (FIG. 6) respectively, which opens into the access opening and extends to a side edge of the associated frame side panel **266** or **268.** When the storage module is reoriented with respect to the injection module the conduits and wires can be guided from one access opening through the slots **564, 566** and to the other access opening without requiring disconnection of any of the conduits or wires from either module.

The storage module is preferably provided with a removable cover **570** (see FIGS. 1 and 2) having a transparent cover portion **572** extending over the turntable and container trays and a second cover portion **574** extending over the extraction station **250.** The cover portion **572** is hinged to the portion **574** so that it may be lifted to enable quick removal and replacement of the trays. The entire cover **570** can be lifted from the storage module to permit access to the extraction station for servicing as well as to permit guiding of the conduits and wires from one access opening to the other.

The sequence control circuitry **600** functions to cause the system components to perform the following steps:

1. The syringe carriage **70** is advanced to thrust the needle **94** into the waste receiver **200;**
2. The actuator **132** for the plunger **92,** which is initially in its fully depressed position, is subjected to fluid pressure to urge the plunger toward the depressed position;
3. The dipper tube assembly **430** is thrust into the sample container at the extraction station;
4. The container vent valve **506** is opened to vent vapor pressure from the container;
5. The vent valve **506** is reclosed;
6. The accumulator control valve **504** is operated to discharge the accumulator into the container;
7. The syringe plunger actuator **132** is operated to withdraw the plunger **92** to the side arm port;
8. A dwell period is provided during which purging is of the sample conduit **466** and the syringe assembly **72** is completed;
9. The dipper tube assembly is raised from the container;

10. The accumulator is discharged via the control valve **504** to place an air pocket in the dipper tube needle **460**;

11. A dosage stop solenoid is energized to provide a preset dosage stop;

12. The plunger **92** is depressed to the dosage stop thus closing the syringe side arm port;

13. The syringe carriage is retracted to withdraw the needle **94** from the waste receiver;

14. The waste receiver is actuated to its retracted position;

15. The carriage **70** is advanced to thrust the needle **94** into the analyzer inlet **12***a*;

16. The pressure across the piston of the plunger actuator **132** is equalized;

17. The dosage stop solenoid is deenergized to retract the stop element;

18. The plunger **92** is driven into the syringe barrel to its limit of travel;

19. The syringe carriage **70** is retracted to withdraw the needle **92** from the analyzer inlet;

20. The waste receiver **200** is repositioned between the needle **92** and the analyzer inlet;

21. The plunger actuator is deenergized.

The enumerated steps each occur immediately after the preceding step except for steps **6** and **10** which preferably require a four second delay prior to the succeeding step. This is due to the time required to completely discharge the accumulator and each time the control valve **504** is actuated to discharge the accumulator the four second delay period follows. So far as step **10** is concerned it should be noted that since the dipper tube assembly is withdrawn from the container as the accumulator discharges, the accumulator discharges directly to atmosphere during part of the four second period. The energy supplied to the container is not sufficient to remove all of the sample fluid from the conduit **466.**

The time delay periods are determined by a clock circuit **620** which provides timed pulses to the sequence control circuit **600.**

When a viscous sample fluid is to be injected the operator can enable a high viscosity circuit **622** which conditions the sequence control circuit **600** to discharge the accumulator into the container a second time during the dwell period of step **8.**

When the sample is actually injected into the analyzer the sequence control circuit **600** sends an appropriate confirmatory signal.

When the fluid is injected the sequence control circuit provides a signal to the logic circuitry **584,** the injection counter **604,** an analysis time clock circuit **630,** an auxiliary time clock circuit **632,** the recorder **20,** and to an integrator associated with the recorder.

The logic circuitry **582** initiates operation of the computer via the enabling circuitry **584** so that data from the analyzer is processed by the computer. The injection counter receives and stores the injection signal for comparison with the required number of injections per container selected by the circuitry **602.** The signal to the recorder results in an injection mark being placed on the graph produced by the recorder.

Some analyzers have two analyzer inlet ports and with such an analyzer it is possible to provide an injection module **14,** a storage module **16** and a control module **22** for each inlet port. The operation of these separate units can be interrelated by interconnecting the logic circuits of each control module. This interconnection allows one unit to be readied for an injection while a sample from the other unit is being analyzed and vice versa.

While a single embodiment of the present invention has been illustrated and described in considerable detail, the invention is not to be considered limited to the precise construction shown. Numerous adaptations, modifications and uses of the invention may occur to those skilled in the art to which the invention relates and it is the intention to cover all such adaptations, modifications and uses which fall within the scope or spirit of the appended claims.

We claim:

1. In a system for injecting fluid samples into a fluid receiver;

a. a fluid sample storage module comprising:
   i. a sample fluid support for a plurality of separate fluid samples,
   ii. sample fluid extraction means defining a station along said sample fluid support at which fluid is extracted from said sample fluid support; and
   iii. laterally spaced side walls having a corner intersection, each said side wall defining first and second spaced access means located in the vicinity of said extraction station, said first access means being a hole in said side wall and said second access means being a slot extending to the edge of said side wall;

b. an injection module for receiving sample fluid from said storage module and comprising;
   i. sample fluid injection means for directing a quantity of fluid into an analyzer;
   ii. actuating means for controlling operation of said injection means; and
   iii. at least a wall defining an access opening;

c. structure defining a fluid sample conduit extending between said modules for directing sample fluid from said storage module to said injection module through said second access means in a said side wall of said sample storage module and through said injection module access means; and

d. connecting means for detachably connecting said modules together with said third access opening aligned with one of said first or second access openings, said conduit structure extending between said modules through said aligned access openings.

2. In a system as claimed in claim **1** wherein said injection module includes a second wall defining further injection module access means, said injection module access means in each said first and second wall being a hole and a slot, each said slot extending to said injection module wall edge.

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