

[54] COMPRESSED AND THERMOSTATED AIR
REGULATED GAS LIQUID
CHROMATOGRAPHY OVEN WITH
SIMULTANEOUSLY OPERATED MULTIPLE
CHROMATOGRAPHY COLUMNS

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55/67, 386

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[57] ABSTRACT

The apparatus of the present invention comprises a

multiple column gas liquid chromatographic, GLC, oven assembly for chromatographing a plurality of samples simultaneously. Each of a plurality of GLC columns is contained in a separate small oven whose temperature is independently regulated using a controlled flow of compressed and thermostated dry air. Segments of the effluent gas from each of a plurality of GLC columns is passed individually and sequentially to a single detector using a single valve with multiple symmetrically spaced inlets but only two outlets. The effluent gas from all of the GLC columns but one is passed to waste while the effluent gas from one GLC column is passed to a common detector. The valve is repositioned to sequentially pass the effluent gas from each of a plurality of GLC columns to a single detector. The use of a single small valve is made possible by the use of a plurality of micro ovens for individual temperature control of each of a plurality of GLC columns. The use of micro ovens is made possible by the use of compressed and thermostated air as a source of heat for each GLC column oven. This simultaneous operation of a plurality of GLC columns results in a significant increase in the rate of GLC analysis for a plurality of samples.

11 Claims, 4 Drawing Figures

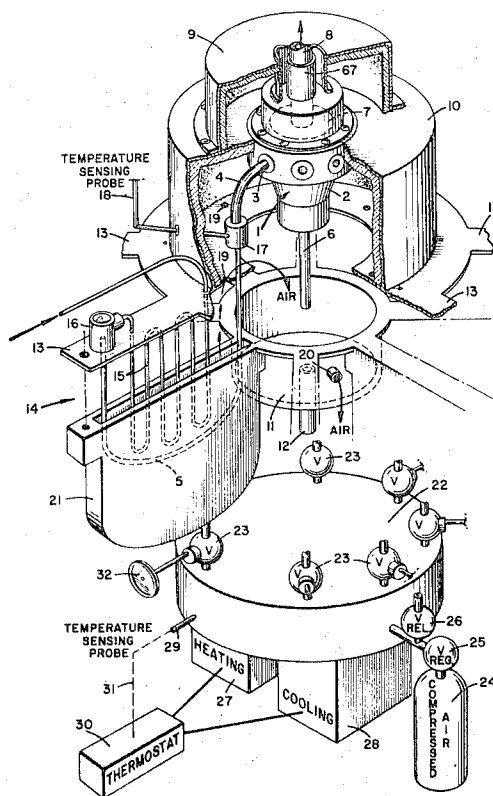


FIG. 1

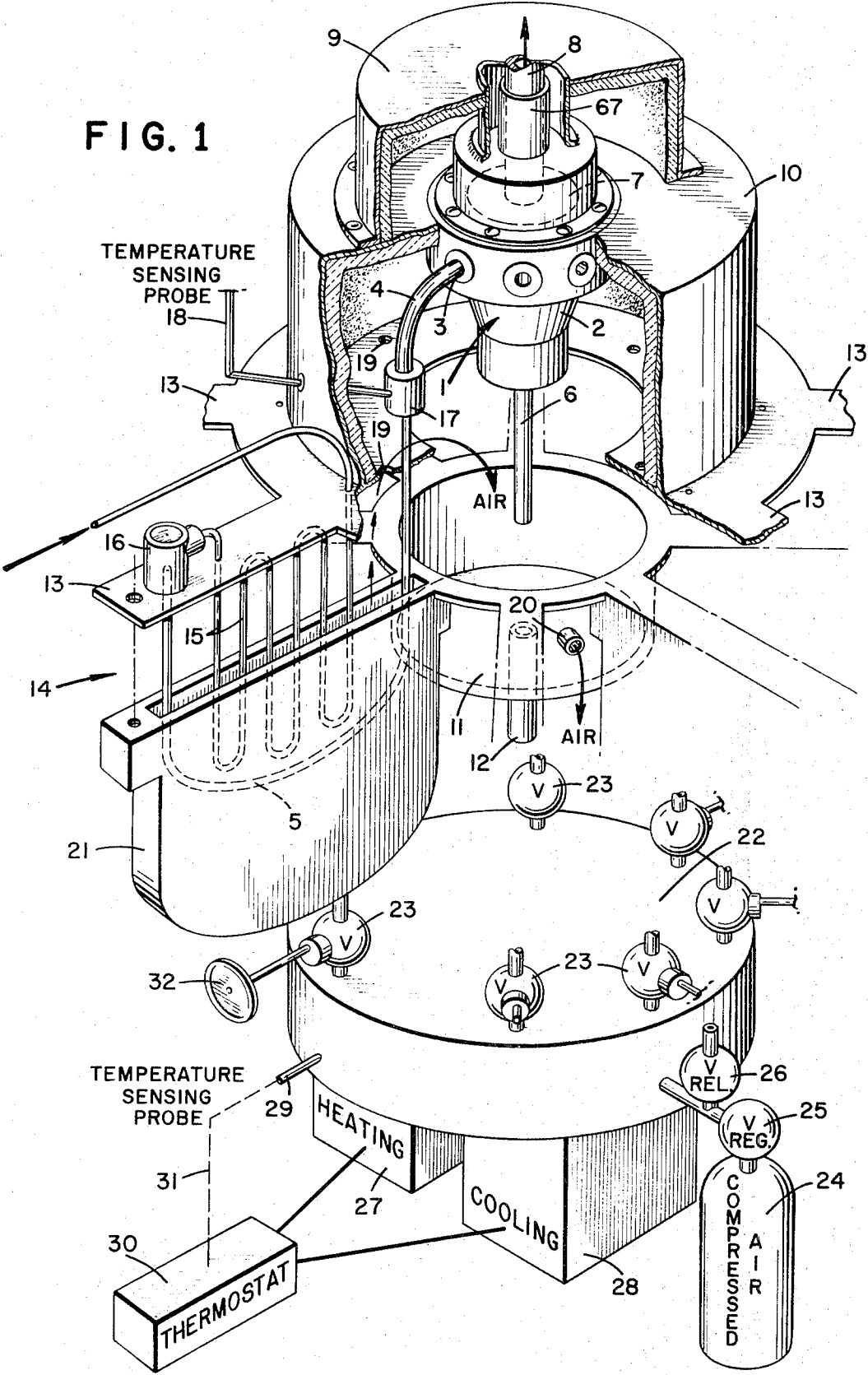


FIG. 2

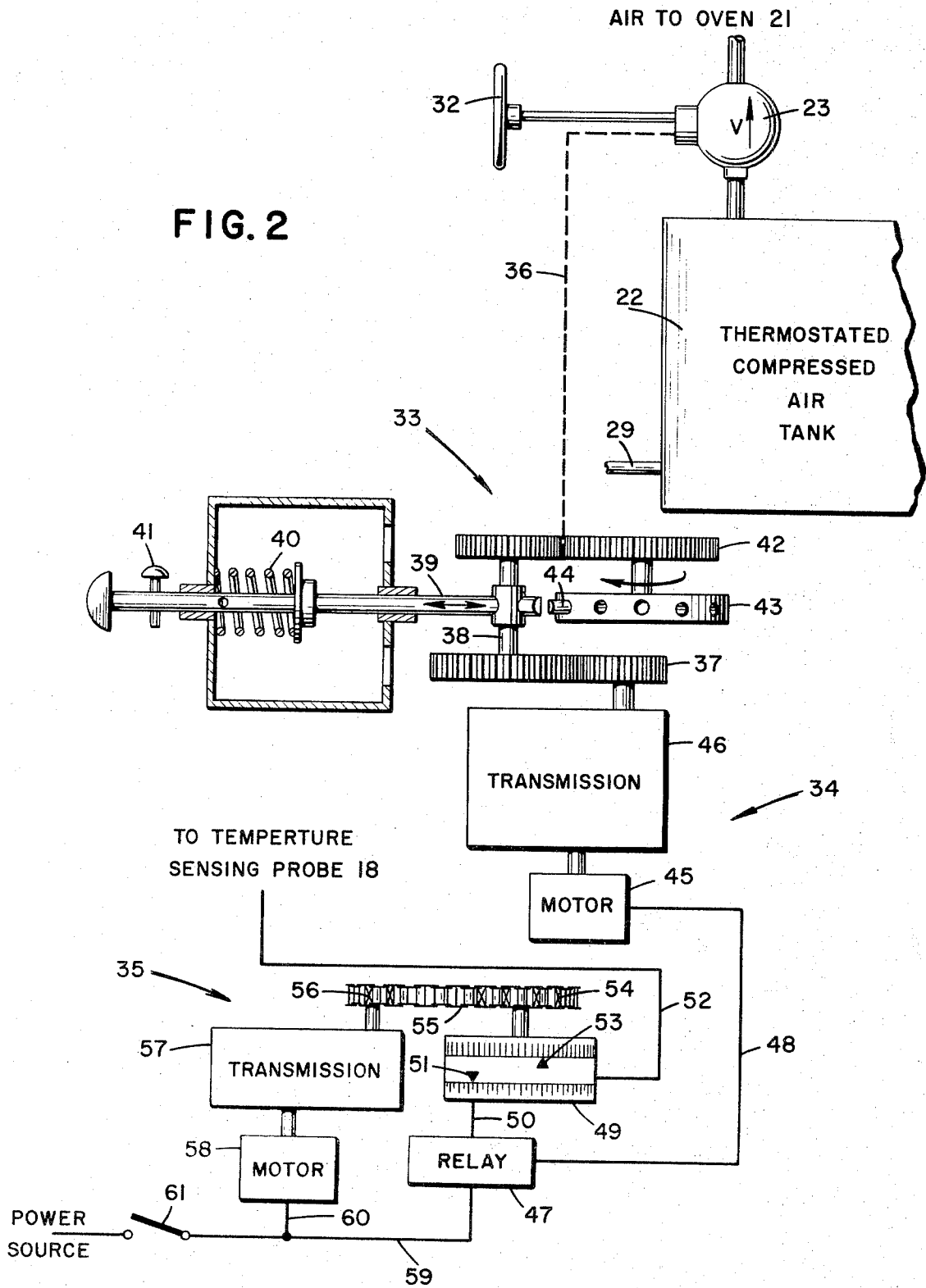


FIG. 3

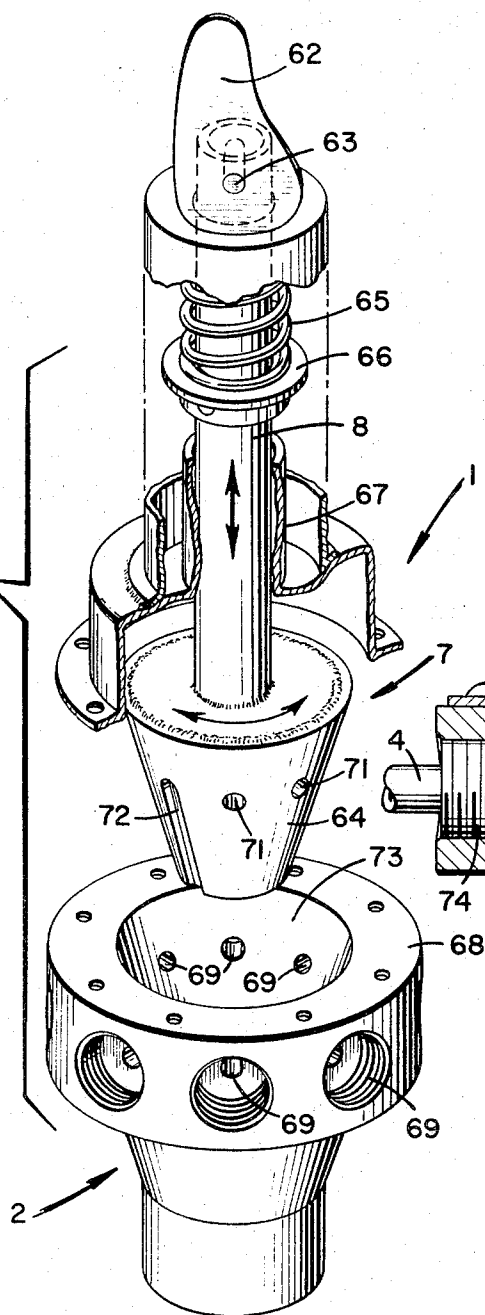
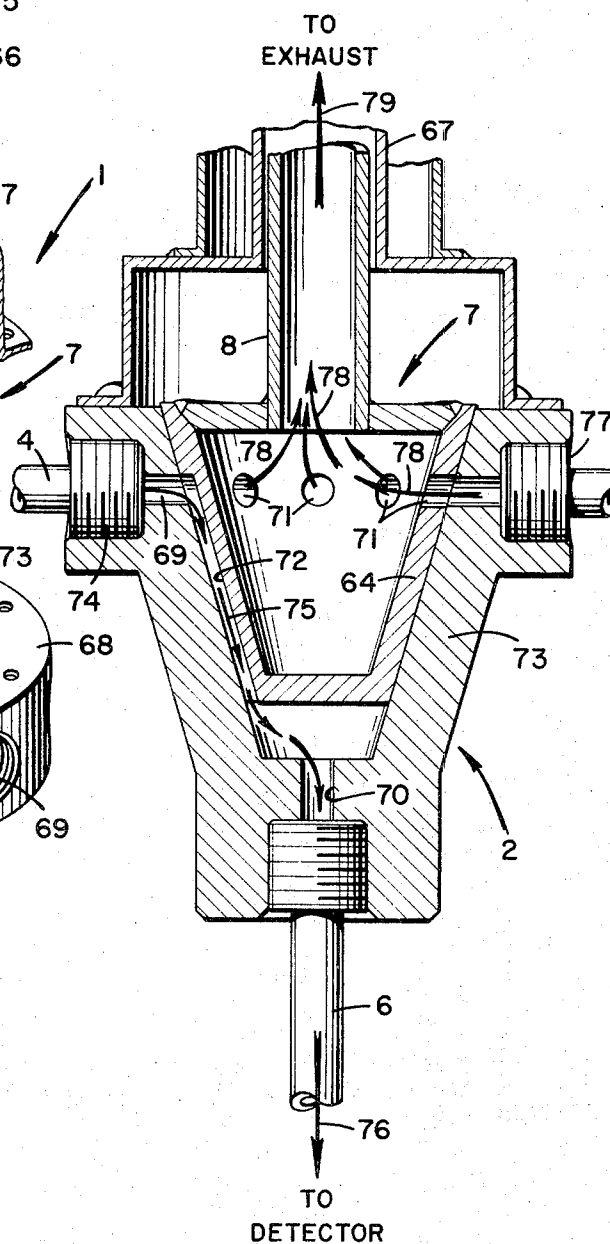


FIG. 4



COMPRESSED AND THERMOSTATED AIR REGULATED GAS LIQUID CHROMATOGRAPHY OVEN WITH SIMULTANEOUSLY OPERATED MULTIPLE CHROMATOGRAPHY COLUMNS

BACKGROUND OF THE INVENTION

In any forced air oven system the critical parameters important for temperature regulation of the same type. They are: (1) the amount of heat absorbed by the oven itself and the material being heated inside the oven, (2) the heat lost from the oven due to imperfect oven insulation, (3) the temperature of the air circulated in the oven, and (4) the rate of flow of thermostated air in or through the oven. Most oven systems rely on changes in parameter (3), air temperature, for regulation of oven temperature. In this type of oven system parameters (1), (2), and (4) are held essentially constant. The system for oven temperature regulation contained in the present invention uses an entirely different principle. It maintains parameters (1), (2), and (3) essentially constant and varies parameter (4), the rate of flow of thermostated dry air through the oven. This air flow regulation is attained using a separately maintained source of compressed and thermostated dry air with a partially manually and partially automatically operated variable gas flow valve for each of a plurality of GLC column ovens. By using compressed and thermostated air and an air flow regulator valve it is possible to reduce the size of each of a plurality of GLC column ovens considerably, which greatly reduces heat loss due to parameter (1). With these micro ovens a plurality of them can be maintained individually in a very small space allowing the use of a single valve for regulating the flow of each column effluent gas to a common detector. In fact, the multiple column effluent gas micro regulating valve, contained in the present invention, cannot be used effectively without the micro GLC column ovens, which in turn requires the use of compressed air for temperature regulation.

Gas liquid chromatography has been established as a superior means for doing an almost limitless number of difficult organic analyses. The oven systems which are presently available, however, do not allow analytic results to be obtained at a practical rate; in some cases it might take up to two hours for a single analysis. This usual slow rate of operation has greatly restricted the use of GLC in the routine analytical laboratory and has tended to exclude it almost entirely from the clinical chemistry analytical lab where their volume of work is relatively large and most of the results are needed quickly. The oven system described in the present invention allows a plurality of GLC analyses to be run simultaneously and therefore increases the rate of analysis by an order of magnitude over other types of oven systems. This striking increase in rate of analysis which is attained with the present invention represents a significant innovation in GLC column oven design. In the case of most routine GLC analyses, only one or a small number of components in a mixture is important in the analysis. The majority of the components in a sample are not important and therefore most of the effluent gas from a GLC column need not be passed to a detector for quantitation. For a given sample analysis, there are usually components coming off the GLC column before and after the component or components of interest which could be excluded from the detector and, therefore, from quantitation. All of the present oven systems

for GLC analysis must quantitate all components in a given sample and the time spent quantitating components which are not important in the analysis represents a significant increase in the overall time of analysis for each sample and therefore a striking decrease in the rate of sample analysis for a given GLC instrument. The apparatus of the present invention is designed to eliminate this unnecessary increase in analytical time. In the case of the present invention only those components of a sample which are important for the analysis are passed to the detector for quantitation while most of the other components are passed to waste. Because the number of components quantitated is small compared to the total number of components in the sample being analyzed, there is a tremendous savings in analytical time and therefore an increase in the rate of analysis by almost an order of magnitude for most samples analyzed.

SUMMARY OF THE INVENTION

An object of the present invention is to increase the rate of gas liquid chromatography, GLC, analysis by the simultaneous operation of a plurality of GLC columns.

Another object of the present invention is to run a plurality of GLC analyses simultaneously using only a single detector system by means of a single micro valve which passes a segment of the effluent gas from each of a plurality of GLC columns individually and sequentially to the detector.

Another object of the present invention is to use a plurality of micro GLC column ovens, each individually thermostated for constant temperature operation and/or variable temperature operation, in a small space to enable a single micro valve with multiple symmetrically spaced inlets and outlets to either the detector or to waste to be used to sequentially pass a segment of the effluent gas from each of a plurality of GLC columns to a single detector.

Another object of the present invention is to use compressed and thermostated dry air for regulating the oven temperature for each of a plurality of micro GLC column ovens with limited free space for air entrance and circulation.

Another object of the present invention is to provide a plurality of micro GLC column ovens with a common source of compressed and thermostated dry air using a compressed air source with its outlet side attached to a metal tank with interposed moisture trap and appropriate pressure valves to maintain a constant, but adjustable, tank pressure, a metal tank built to withstand the necessary operating temperature and pressure of the dry air and containing a heating means, a cooling means, a temperature sensing probe, inlet for dry air from the compressed air source and outlets for each of the micro GLC column ovens.

Another object of the present invention is to provide a temperature regulator means for the compressed air tank which will function to open or close the electric circuit to either the heating or cooling means depending on the preset temperature and the temperature inside the compressed air tank as indicated by a temperature sensing probe.

Another object of the present invention is to provide each micro GLC oven with a partially manually operated and partially automatically operated gas flow regulator valve to control the flow of compressed and ther-

mostated dry air into each of a plurality of GLC column micro ovens.

Another object of the present invention is to provide each micro GLC column oven gas flow regulator valve with a reversible motor and gear drive means to regulate the rate at which the valve is opened or closed which determines the rate of flow of thermostated dry air into each GLC column oven which, in turn, determines the temperature inside each oven.

Another object of the present invention is to provide each micro GLC column oven with a temperature regulator means which comprises a set temperature indicator associated with a motor-gear drive means to enable the set temperature to be altered at variable rates, degrees per minute, a temperature sensing probe inside each GLC column oven, a GLC column oven temperature indicator, and a means to reverse the current to the air flow regulator reversible drive motor depending on whether the GLC column oven temperature is less or greater than the set temperature.

Another object of the present invention is to place the GLC column micro oven temperature sensing probe for each oven in contact with the GLC column effluent gas.

Another object of the present invention is to provide each GLC column micro oven gas flow valve motor-gear means with a mechanical stop to prevent the valve from being opened past a preset point and thus prevent the oven from being heated beyond a given final temperature.

Another object of the present invention is to provide a means for preheating the carrier gas for each GLC column inside the GLC column micro oven before the carrier gas enters the GLC column.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

The general, overall operation of the apparatus of the present invention can be defined as follows. The gas flow regulator valves to the GLC column micro ovens are closed manually. The appropriate compressed air tank pressure is set on the tank pressure gauge and the pressure release gauge is set slightly higher than the tank pressure. The conduit means between the compressed air source and the tank is opened. The compressed air tank temperature regulator is set to heat or cool as required. The proper compressed air tank operating temperature is set on the thermostat and the switch connecting the compressed air tank temperature regulator to line voltage is turned on. As soon as the compressed air tank has reached the proper operating temperature and pressure, the automated drive means for each air flow regulator valve is disengaged and each GLC column oven gas flow regulator valve is manually opened a slight amount. The column effluent gas valve is set to pass the effluent gas from column one to the detector and the carrier gas valve for each GLC column is opened and its proper flow rate is set. Each air flow regulator valve is opened manually until the proper final oven temperature is maintained by each

oven as indicated by the temperature indicator means for each GLC column micro oven. The mechanical stop pins for each flow regulator valve automated opening drive means are now set. The mechanical stop pin is placed into the proper hole of the mechanical stop drive wheel to force the air flow regulator valve drive gear means to disengage when this amount of rotation of the mechanical stop drive wheel has occurred. Now each flow valve is manually closed until the temperature for each GLC column oven holds at the proper initial operating temperature. A second pin is placed in the mechanical stop wheel of each air flow regulator valve drive means to mark this position for subsequent resetting. The set temperature indicator on each GLC column oven temperature programming thermostat is disengaged and moved to indicate the initial operating temperature and a mechanical stop is positioned at a position equivalent to the final operating temperature. The set temperature indicator on the temperature programming thermostat will then stop when it reaches the final operating temperature setting. The means for manually disengaging the automated drive assembly for each air flow regulator valve is released. The variable speed gear box for both the air flow regulator valve drive means and the temperature programming drive means for each GLC column oven are set for the proper rate of temperature rise. Now each GLC column oven variable temperature programming means and sample injection will be started in a delayed sequence. The line voltage switch for the GLC column oven temperature programming means for column one will be turned on and a sample injected into column one, then after a given time interval the switch for column two will be turned on and a sample injected into column two and the procedure continued until all columns have been started. As soon as that portion of the component peaks separated by column one which are to be quantitated start reaching the detector the time interval for injection of samples is repeated for timing the turning of the GLC column effluent gas valve from column one to column two and so forth until a segment of the effluent gas from each GLC column has been quantitated.

To convert from variable temperature operation to constant temperature operation just set each temperature programming variable speed gear box to zero rate of change and repeat the remaining steps listed above.

The partially manual and partially electronic means of regulating the rate of opening of each air flow regulator valve described in the present invention is just one of many possible means, some being totally automated, for regulating the rate of opening of an air flow regulator valve to achieve a programmed variable temperature operation of a GLC column oven. Substitution of any one of the other possible means would not change the basic principle of GLC column oven temperature regulation which depends on the control of the flow of compressed and thermostated gas, air in this case, into an oven, a micro oven in this case, described in the present invention.

There are a number of different means of obtaining and/or maintaining compressed and thermostated gas for regulating the temperature of a GLC column oven, but none of these alternate means would constitute a change in the basic principle of using compressed and

thermostated gas to heat a GLC column oven as described in the present invention.

There are a number of different valve designs similar to the GLC column effluent gas valve described as part of the present invention but none of these would alter the basic principle of a plurality of GLC column effluent gas inlets and outlets to either waste or the detector and with the capability of sequentially passing a small segment of the total gas effluent from each of a plurality of columns to a single detector as described in the present invention.

The drawings and descriptions presented hereinafter and above which specify a given GLC column micro oven system with a set number of GLC column micro ovens is presented simply to illustrate the basic characteristics of the present invention. Certainly any number of micro ovens could be used in actual practice and would only constitute additional embodiments of the apparatus described in the present invention.

There are a variety of analytic modes of operation for the GLC oven assembly described in the present invention but in all cases the basic principle is the same. Only that portion of the effluent gas from each of a plurality of GLC columns which is important in the analysis of a sample is passed to the detector for final quantitation. By operating a plurality of columns essentially simultaneously one is able to reduce the time of analysis for any GLC column system, regardless of total run time for a given sample on the column, to just that segment of time necessary to quantitate the component or components of interest. With this GLC oven system, except for the first and last GLC columns, one no longer needs to wait for components running before or after that component to be quantitated to clear the detector. One simply passes the effluent gas from each of a plurality of columns to the detector only when a component or components of interest is coming off the columns. This column effluent valving system has no direct affect on the separation of components of a sample on the GLC column and also has no affect on the detector operation. The valving system eliminates time spent quantitating those components which are of little or no interest in the analysis of a sample. With this valving system, the effective time of GLC analysis for each sample is reduced by an order of magnitude in most cases. The column effluent valving assembly described in the present invention is a means for increasing the rate of analysis but has no significant qualitative affect on the gas liquid chromatographic analysis of a sample.

DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only and thus are not limitative of the present invention and wherein,

FIG. 1 shows a schematic representation of the invention with the oven assembly in exploded perspective;

FIG. 2 shows a schematic diagram of the oven temperature programming means;

FIG. 3 shows an exploded perspective view of the GLC column effluent gas valve assembly; and

FIG. 4 shows a longitudinal section view of the GLC column effluent gas valve assembly of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The gas liquid chromatography, GLC, column oven apparatus of the present invention according to FIG. 1 comprises a GLC column effluent gas valve assembly 1 which includes a female valve seat 2 containing a plurality of inlet holes 3 symmetrically spaced around the valve seat. Each of the inlet holes 3 are connected by appropriate conduit means 4 to the outlet side of one of a plurality of GLC columns 5. The effluent gas from each GLC column passes through a conduit means 4 and into the valve at one of the inlet holes 3. The effluent gas from one of a plurality of columns is passed to the bottom of the valve assembly and out the detector outlet hole 6. The effluent gas from the remainder of the GLC columns passes through the inlet holes in the wall of the female valve seat and through matching holes in the wall of the male valve seat 7 to the hollow center of the male valve seat and up through the hollow rod 8 to waste. The male valve seat 7 can be rotated around rod 8 as its axis to sequentially pass a segment of the effluent gas from each of a plurality of GLC columns through the detector outlet 6 to a single detector means not shown in the drawings. The GLC column effluent gas valve assembly 1 is contained within an insulated chamber comprising a top piece 9, a middle piece 10, and a bottom piece 11. The bottom piece 11 of the valve chamber has an outlet 12 in the bottom for the conduit means connecting the valve detector outlet 6 with the detector. The middle piece 10 of the valve chamber has a plurality of flanges 13 symmetrically spaced around the chamber for attachment of an equal number of GLC column assemblies 14. Each GLC column assembly 14 comprises a length of carrier gas conduit tubing 15 which is connected at one end to a source of compressed carrier gas, not shown in the drawings, and at the other end to a standard combined carrier gas-sample inlet means 16. The carrier gas conduit tubing 15 is folded to fill the space between the inlet and outlet sides of the GLC column 5 to preheat the carrier gas before it enters the GLC column. Each GLC column 5 is connected to the valve chamber middle piece flange 13 at the carrier gas inlet side by means of the standard combined carrier gas-sample inlet means 16 and at the effluent gas outlet side by standard tube fitting means 17. The GLC column micro oven temperature sensing probe 18 is attached inside tube fitting means 17 to monitor the temperature of the GLC column effluent gas. The hot oven air in the vicinity of the folded carrier gas conduit tubing 15 and GLC column 5 passes from the GLC column micro oven through the small orifice 19 and into the valve chamber. There is an exhaust outlet 20 for the hot air in the bottom of the valve chamber bottom piece 11. The path of the hot air is indicated by the arrows. The circulation of hot air from each of the GLC column micro ovens through the valve chamber serves to maintain the valve assembly 1 at approximately the average temperature of the plurality of GLC column micro ovens. Each of the GLC columns 5 and its carrier gas conduit tubing 15 fits inside a GLC column micro oven 21. Each oven 21 is attached by suitable conduit means to a common tank 22 of compressed and thermostated air through an air flow regulator valve 23. The air pressure inside tank 22 is maintained by a source of compressed air 24 and a pressure regulator valve 25 and a pressure

release valve 26. The temperature of the air in tank 22 is maintained by a temperature regulating means comprising a heating means 27, a cooling means 28, a temperature sensing probe 29, and a thermostat 30. The temperature sensing probe 29 and thermostat 30 are connected by suitable electrical means 31. Each air flow regulator valve 23 can be controlled manually using knob 32 or automatically by means shown in FIG. 2. The temperature inside each of a plurality of micro ovens 21 is controlled by the amount of thermostated air flowing into each oven through one of a plurality of air flow regulator valves 23.

FIG. 2 shows a schematic illustration of one of a plurality of automatic means for controlling each of the air flow regulator valves 23 associated with each of a plurality of GLC column micro ovens 21. It comprises a clutch assembly 33, a variable speed motor-gear drive means 34, and a temperature programming means 35. The clutch assembly 33 is associated with the air flow regulator valve 23 by suitable gear means 36 and to the motor-gear drive means 34 by drive gear 37. Clutch assembly 33 comprises a primary drive gear means 38 which is held in contact with gear means 36 by rod 39 and spring 40. Gear means 38 can be disengaged manually from gear means 36 by pulling out rod 39 and moving pin 41 to the forward hole shown in rod 39. In this position the air flow regulator valve 23 can be operated manually using knob 32. Gear means 38 drives gear means 36 which drives the air flow regulator valve 23 open or closed and also turns gear 42. Gear 42 is attached to wheel 43 which turns as gear 42 turns. Wheel 43 has a plurality of pin holes evenly spaced around its circumference. Pins 44 can be placed in wheel 43 and these pins will contact rod 39 whenever wheel 43 has rotated into the proper position as shown in FIG. 2. Whenever pin 44 contacts rod 39 it pushes both rod 39 and the attached gear means 38 back against spring 40 which causes gear means 38 and 36 to disengage and thus stops the automatic opening of the air flow regulator valve 23. By placing pin 44 in the proper hole in wheel 43 the automatic opening of the air flow regulator valve 23 can be stopped at any point between fully closed and fully open. The variable speed motor-gear drive means 34 comprises a reversible motor 45 which drives gear 37 through a variable speed gear box 46. The rate of rotation of drive gear 37 can be varied by changing gears in gear box 46. Different rates of rotation of gear 37 represent different rates of opening of the air flow regulator valve 23 corresponding, approximately, to different rates of rise of temperature in the corresponding GLC column micro oven 21. The direction motor 45 turns and therefore whether the air flow regulator valve 23 is being opened or closed is controlled by the temperature programming means 35 which comprises a relay 47 connected to motor 45 by means 48 and to thermostat 49 by means 50. Thermostat 49 has a temperature indicator 51 associated with the GLC column micro oven temperature sensing probe 18 by means 52 and a set temperature indicator 53 which can be set manually or driven automatically by gear 54, belt drive 55, gear 56, variable speed gear box 57, and motor 58. Relay 47 and motor 58 are connected to a power source by electrical means 59 and 60 through switch 61. The position of the set temperature indicator 53 can be varied automatically from some manually set initial temperature to a predetermined final temperature setting by rotation of the gear means

55, 56, and 57. The rate of change of the set temperature indicator setting in degrees per minute is determined by the arrangement of gears in the variable speed gear box 57 which determines the rate of rotation of gear 56. When the temperature indicator 51 is at a lower temperature than the set temperature indicator 53 the current from relay 47 to reversible motor 45 is such that the air flow regulator valve 23 is driven open. When indicator 51 is at a higher temperature than indicator 53 the current from relay 47 is reversed and motor 45 drives the air flow regulator valve 23 closed.

FIGS. 3 and 4 show an exploded perspective view and a longitudinal section view of the GLC column effluent gas valve assembly. FIG. 3 comprises a lever 62 which can be rotated in a vertical plane to seat and unseat the valve or in a horizontal plane to reposition the male valve seat to sequentially pass a segment of the effluent gas from each of a plurality of GLC columns to a single detector. Lever 62 is attached by pin 63 to hollow rod 8 which serves both as a means for repositioning the male valve seat 7 which includes wall 64 and as a waste gas conduit means from the valve assembly. The effluent gas from all but one of the GLC columns is passed to waste through hollow rod 8. The male and female halves of the valve seat are forced together by spring 65 pressing against spring support 66 which is attached to rod 8. Rod 8 is held in proper vertical position by guide 67 which is attached to the top flange 68 of the female portion of the valve seat 2. The top flange 68 of the female valve seat 2 has a plurality of GLC column effluent gas inlet holes 69 symmetrically spaced around the valve seat and an outlet 70, shown in FIG. 4, to the detector at the bottom. The wall 64 of the male valve seat 7 also has a plurality of GLC column effluent gas inlet holes 71 symmetrically spaced around the valve seat with one replaced by a narrow groove 72 on the outside which connects one of the inlet holes 69 in the female valve seat 2 to the detector outlet hole 70. The inlet holes 69 and 71 in the female and male valve seats are spaced so they exactly match. The effluent gas from all of the GLC columns but one pass to the center of the valve assembly through holes 69 and 71 in the female and male valve seat walls and on to waste through the hollow rod 8.

FIG. 4 shows the two alternate paths for the GLC column effluent gas as indicated by the arrows. For the effluent gas from the GLC column being passed to the detector, the effluent gas enters the female valve seat 2 through inlet 74 and hole 69 in flange 68, passes to the bottom of the valve assembly down groove 72 between walls 64 and 73 along path 75 as indicated by the arrows. It passes through hole 70 in the bottom of the valve assembly and out of the bottom of the female valve seat 2 through the detector outlet 6 along path 76 as indicated by the arrow. The effluent gas from each of the remaining GLC columns is passed by similar routes to waste. The effluent gas from this plurality of columns enters the female valve seat 2 through a plurality of inlets 77, passes to the center of the valve assembly through a matching set of inlet holes 71 in the wall 64 of the male valve seat 7 and along path 78 as indicated by the arrows up through the hollow rod 8 to waste along path 79 indicated by the arrow. Rod 8 is held in a vertical position by guide 67 which is attached to the female valve seat 2.

I claim:

1. An apparatus for performing simultaneous gas liquid chromatographic analyses on a plurality of samples comprising a plurality of micro ovens, a chromatography column contained in each of said ovens, said columns having an inlet and outlet means, said inlet having separate conduit means for sample and carrier gas, said outlet having a single conduit means for sample and carrier gas, a segment of conduit means for said carrier gas contained in each of said ovens and connected to the inlet of each of said chromatography columns; a valve assembly contained in an insulated chamber having an aperture to each of said ovens, said valve assembly having a plurality of inlets connected by conduit means to the outlet of each of said columns, said valve means containing passage means sequentially connecting one of said columns to a detector means and the other of said columns to a waste outlet means; a chromatography column micro oven, compressed air heating means comprising a tank for holding compressed and thermostated air with a plurality of outlets each connected to one of said ovens, an air temperature and pressure regulating means for said compressed air tank and a plurality of air flow regulating means in the said connections between said tank and each of said ovens.

2. The apparatus of claim 1, wherein the segment of conduit means for said carrier gas comprises a length of folded carrier gas conduit tubing located inside each chromatography column micro oven and connected to the inlet of each chromatography column.

3. The apparatus of claim 2, wherein the length of folded carrier gas conduit tubing located inside each chromatography column micro oven serves to preheat said carrier gas to the temperature of the said micro oven prior to said carrier gas entering said chromatography column.

4. The apparatus of claim 1, wherein the micro ovens are each just large enough to contain one chromatography column, a length of folded carrier gas tubing and just sufficient free space for circulation of compressed and thermostated air.

5. The apparatus of claim 1, wherein the valve assembly having a plurality of inlets connected by conduit means to the outlet of each of said columns is adjustable to pass a portion of the column effluent carrier gas from each of a plurality of chromatography columns sequentially to a detector means while passing the effluent carrier gas from all other said columns to waste.

6. The apparatus of claim 1, wherein the insulated

chamber for the said column effluent gas valve assembly contains conduit means for circulation of said compressed and thermostated air around said valve assembly comprising an aperture to each of said micro ovens and a single exhaust outlet.

7. The apparatus of claim 1, wherein the air temperature and pressure regulating means for said compressed air tank comprises a temperature sensing probe, a heating means, a cooling means, a temperature regulator means and an inlet from a compressed air source.

8. The apparatus of claim 7, wherein the inlet from a compressed air source contains a pressure regulating means which functions to open or close said inlet depending on the pressure inside said compressed and thermostated air tank and the pressure set on said pressure regulating means.

9. The apparatus of claim 1, wherein the air flow regulating means between said tank and each of said ovens comprises an air flow regulator valve, a motor-gear drive means to automatically open and close the said air flow regulator valve at one of several preset rates, each corresponding to a different rate of temperature increase inside said chromatography column micro oven, a mechanical stop means to disengage the said automatic motor-gear drive means from the said air flow regulator valve and a separate electrical feedback means to reverse the motor of each said air flow regulator valve motor-gear drive means depending on whether the temperature of the chromatography column is less or greater than the temperature set on a chromatography column temperature regulator means.

10. The apparatus of claim 9, wherein the electrical feedback means for each said air flow regulator valve motor-gear drive means comprises a motor-gear drive means which functions to vary a thermostat set temperature at various preset rates, a chromatography column temperature sensing probe connected by suitable conduit means to said thermostat, a suitable conduit means between said thermostat means and said air flow regulator valve drive motor, a suitable relay means contained in said conduit means between said thermostat means and said valve drive motor.

11. The apparatus of claim 10, wherein the suitable relay means functions to reverse the electrical current to the said air flow regulator valve drive motor depending on whether the temperature of the effluent carrier gas from said chromatography column is greater or less than the said thermostat means set temperature.

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