

July 13, 1937.

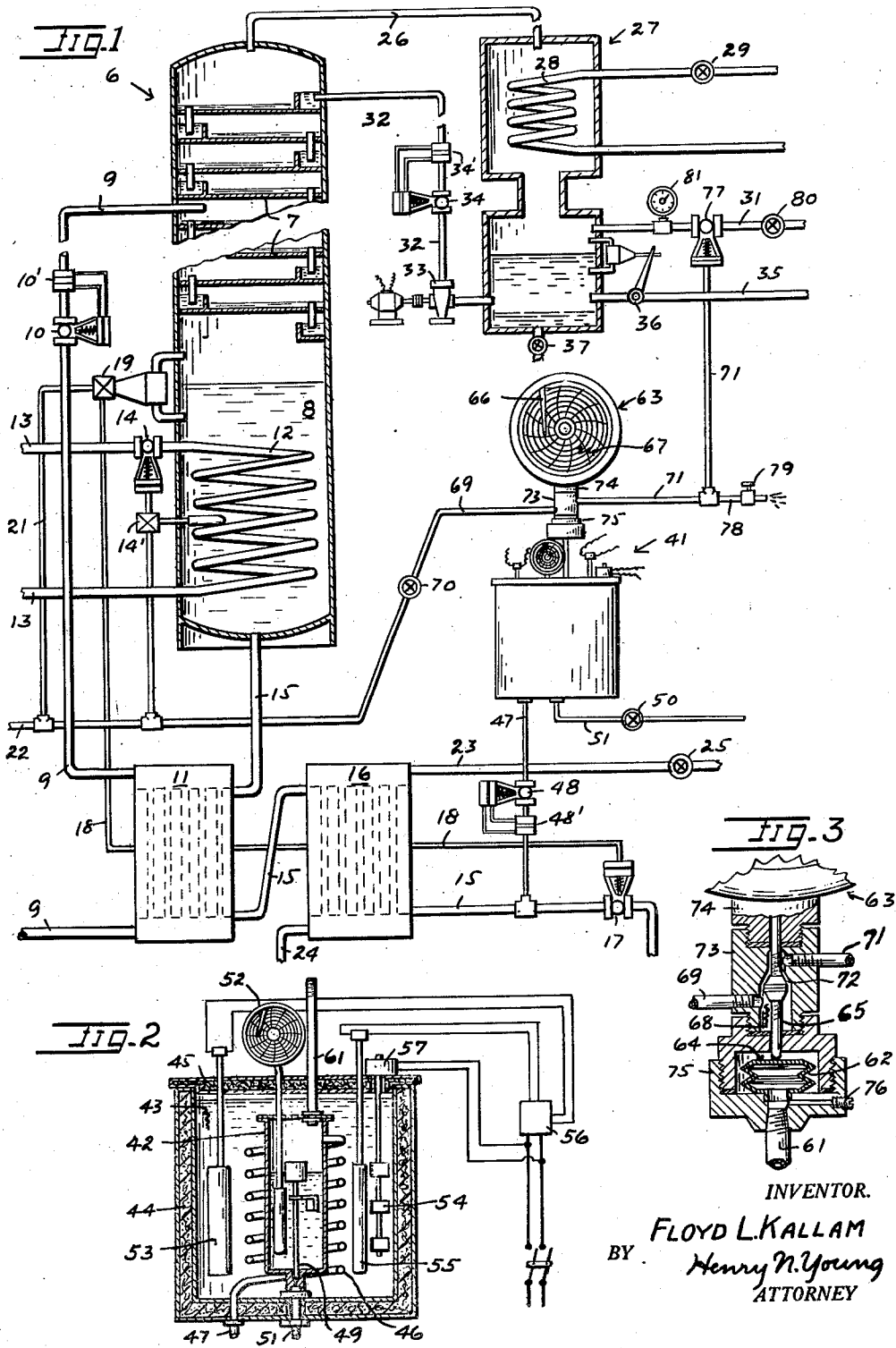
F. L. KALLAM

2,086,808

FRACTIONATOR CONTROL DEVICE

Filed Dec. 22, 1933

3 Sheets-Sheet 1



INVENTOR.  
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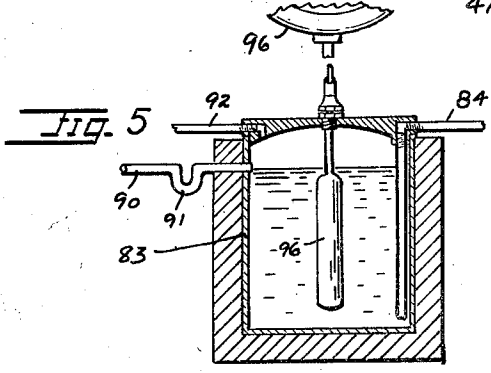
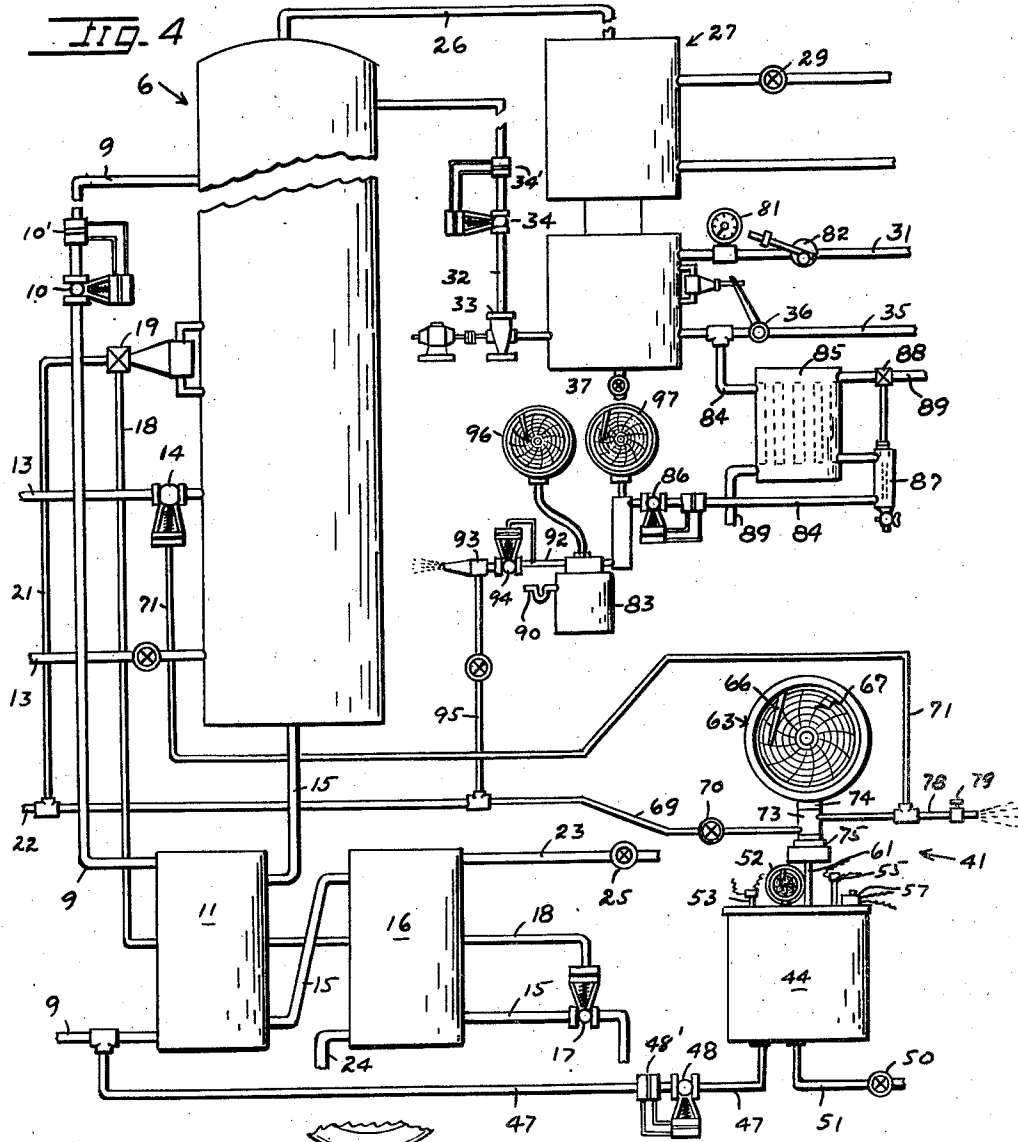
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3 Sheets-Sheet 2



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# UNITED STATES PATENT OFFICE

2,086,808

## FRACTIONATOR CONTROL DEVICE

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Application December 22, 1933, Serial No. 703,574

7 Claims. (Cl. 202-160)

The invention relates to a method and means for stabilizing a product of a continuously operating distilling fractionator to have a constant volatility, and the present application comprises a continuation in part of my copending application for United States Letters Patent on a Control device for fractionators and the like, Serial Number 412,646, filed Dec. 9, 1929, now U. S. Patent 1,940,802.

5 A general object of the invention is to provide, in association with a fractionating apparatus, improved means to so control a refined liquid product thereof that said product will be of constant volatility.

15 Another object of the invention is to directly and continuously indicate and/or record the volatility of a liquid in the apparatus for use in effecting a control of the apparatus for the specified purpose.

20 A further and more specific object is to automatically effect the stated control of a product in terms of the volatility of the liquid being treated in the fractionator.

Yet another object is to provide a device of the character described which is readily applicable as an accessory to present fractionators.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth or be apparent in the following description of typical applications of the invention which are illustrated in the accompanying drawings, in which,

Figure 1 is a generally diagrammatic elevation showing one application of a control unit of the present invention in a fractionating apparatus, certain elements of the apparatus being shown in sectional elevation.

Figures 2 and 3 are enlarged fragmentary and sectional views of different portions of the control unit.

Figure 4 is a generally diagrammatic elevation showing still another application of the present control unit to the aforesaid apparatus.

Figure 5 is an enlarged sectional view of a portion of a volatility testing unit which is used in the arrangement of Figure 4.

Figure 6 is a generally diagrammatic showing of another embodiment of the invention.

Figure 7 is a fragmentary and partly sectional view of a recording meter of the apparatus of Figure 7.

As particularly illustrated, the device of present invention is associated with fractionating apparatus in which the controlled product comprises a mixture of the less volatile fractions of hydro-

carbon liquids such as fuel oils and gasolines and alcohols, etc. The apparatus shown comprises a conventional bubble-tray tower 6 having provided in the upper and major portion thereof a plurality of superimposed bubble trays 7 of suitable structure. The lower tower portion is seen to provide a kettle portion 8 in which to heat the liquid being treated. A duct 9 supplies the raw liquor to the bubble trays at a constant rate; as shown, the valve 10 is provided for controlling the flow of liquor through the duct 9 and a heat-exchanger 11 is operatively interposed in said duct whereby to preheat said liquor.

The liquid in the kettle 8 may be heated to the desired temperature by means of a heating coil 12 interposed in a pipe 13 through which a heated fluid is continuously passed; in practice, the heating fluid is usually steam and the liquid in the kettle is heated to boiling therewith. A valve 14 controls the fluid flow through the pipe 13 and coil 12 whereby, with the other operative factors of the apparatus held constant, the rate of heat discharge from the coil may be adjusted to a desired degree.

The unevaporated liquid is arranged to constantly escape at the bottom of the kettle through a duct 15. As particularly disclosed, the heat-exchanger 11 is interposed in the duct 15 whereby the inflowing liquor to the fractionator is preheated and the liquid discharging through the duct 15 is partially cooled therein. A second heat-exchanger 16 is interposed in the duct 15 at the delivery side of the heat-exchanger 12 for completing the cooling of the discharged liquid.

For maintaining a constant liquid level in the kettle, a valve 17 is provided in the duct 15 at the discharge side of the heat-exchanger 16. The valve 17 is preferably arranged for automatic operation; as shown, this valve is of the diaphragm-motor type and is connected by means of an air duct 18 with a float-controlled valve 19 which is operated by the liquid level in the kettle. A duct 21 supplies the operating air to the valve 19 from a compressed-air main 22 connected with a suitable source (not shown) of compressed air. It is to be understood, however, that the valve 17 might be arranged for mechanical, rather than pneumatic, operation by means of a suitable float-actuated mechanism.

A cooling liquid from any suitable source is arranged to flow to and from the heat-exchanger 16 through ducts 23 and 24 respectively, and a flow control valve 25 is provided in a said duct. Both generally, and for a specific purpose to be hereinafter brought out, it is desirable that the

liquid product be delivered through the duct 15 at a substantially fixed and predetermined temperature, and control of said temperature is conveniently arranged to be effected through an automatic or manual adjustment of the valve 25.

The gaseous products resulting from the heating, and other treatments of the liquor in the tower 6 are arranged to flow from the top of the tower through a duct 26 and to a condenser 27 wherein a portion of the gases are condensed to form a distillation product which is known in the art as a reflux liquid. The desired cooling in the condenser 27 is arranged to be effected by means of a cooling coil 28, a valve 29 controlling the fluid flow rate through the coil. The uncondensed gases from the condenser 27 are arranged to escape, as to waste or for use as fuel, through a duct 31 having a suitable back-pressure valve therein.

Part of the condensate, or reflux, in the condenser 27 is arranged to be delivered back to the tower 6 through a duct 32, a motor driven pump 33 being interposed in the said duct for the purpose. A valve 34 is also interposed in said duct at the discharge side of the pump 33. Excess reflux is discharged from the receiver of the condenser through a duct 35, the latter duct having therein a float-controlled valve 36 for automatic operation to maintain a constant reflux level in the receiver of the condenser. A drain valve 37 for removing any condensed water is preferably provided at the bottom, or accumulator, portion of the condenser.

It will be understood that the present apparatus is particularly arranged to fractionate the raw liquor delivered thereto into three parts, namely, a bottom, or low-volatility fraction which is discharged through the duct 15 as a liquid product, an intermediate, or top, condensed fraction which is discharged through the duct 35 as a liquid top product, and the lighter, or high volatility, fraction which does not condense at ordinary temperatures and is discharged through the duct 31 in gaseous form. With the various control valves set, an operative balance of the pressure and temperatures in the apparatus is created and the aforesaid products are each produced under fixed conditions of pressure and temperature. If the raw liquor is of constant composition, the said products will all be of constant composition, and continuous operation of the apparatus would continuously produce uniform results.

As a matter of fact, raw liquors for fractionation, such as crude oils and natural gasolines from wells, are very seldom of an unvarying composition, hence fractions thereof which are separated in a refining apparatus without regulation to meet variations in their compositions are neither of constant composition or volatility. No regulation of fractionating apparatus is generally possible for the production of products which are of both constant composition and volatility, and adjustment must therefore be made for either one or the other of said qualities rather than for both. Generally, though not exclusively, in the art of refining natural liquid hydro-carbons to produce fuels, lubricants, etc., the production of a product of definite volatility is of major importance, and it is to the provision of means for insuring the continuous production of a product of constant volatility that the present invention particularly relates.

In the apparatus shown, the aforesaid operating conditions are seen to be chiefly controlled by the supply valve 10, the heating-coil valve 14,

the condenser coil valve 29, the valve means in the duct 31, and the return-reflux valve 34, all of said valves being constantly open to some degree. Assuming the system operatively balanced, a change in the setting of any one of the aforesaid valves will change the volatilities and compositions of all three products by causing a new pressure-temperature balance in the apparatus. It will be clear, therefore, that if, during the operation of the apparatus, the volatility of one of the liquid products should change, an appropriate adjustment of one or more of said valves is required to bring the volatility of said product back to its desired value.

For effecting the aforesaid regulation of a fractionator apparatus, a control unit 41 is provided, said unit arranged to have a continuous liquid sample from some part of the apparatus flow therethrough, and to measure and/or utilize the vapor pressure of the sample as a basis and/or means for appropriately setting a control valve of the apparatus to maintain a desired degree of volatility for a product. Essentially, and as is particularly brought out in the detail views of Figures 2 and 3, the control unit 41 comprises a closed evaporation cup 42 through which a sample stream is arranged to continuously flow at a constant rate while it is maintained at a constant temperature, and indicating and control means operated by the vapor pressure in the cup.

As particularly illustrated, the cup 42 is disposed centrally in a liquid bath 43 provided in a cylindrical heat-insulated vessel 44 having a cover 45. The bath 43 must be kept at a constant temperature while supplying any heat of vaporization needed in the cup or absorbing any heat of condensation emanating therefrom on account of a volatility change in the control sample. A further function of the bath 43 is to provide the sample to the cup at a constant temperature, and to this end the incoming sample is caused to flow through a coil 46 immersed in the bath and coaxially surrounding and discharging into the cup. The cup and coil are preferably formed of heat-conducting material for facilitating any heat transfers required for maintaining a constant temperature of the sample portion in the cup.

The control sample enters the coil 46 from a duct 47 extending into the vessel 44 and having a flow-control valve therein; as illustrated, the valve 48 is of a differential diaphragm motor type and is controlled from an orifice plate 48' whereby to automatically insure a fixed flow rate of the sample through the coil 46 and cup 42. A float-controlled valve 49 in the cup 42 operates to maintain a fixed liquid level in the cup, and discharges into a duct 51 for conveying the tested sample where desired. A recording thermometer 52 has its bulb immersed in the sample in the cup whereby the temperature conditions therein are both indicated and recorded for reference in adjusting the control unit.

Means are provided for automatically controlling the temperature of the bath 43 as may be required, said means comprising an electric heater 53, a motor driven stirrer 54, and a circuit closing thermostat 55, all operatively immersed in the bath. The heater 53 is arranged to derive power from a suitable source through a suitable relay switch 56 which is controlled by the thermostat 55 in such a manner that the heater is energized when, and only when, the bath temperature is below a certain predetermined value. The stirrer is constantly operated by an electric motor 57. As shown, the motor 57 is mounted on

the cover 45, and the heater 53 and stirrer 54 and control thermostat 55 all depend from said cover into the bath.

It will be noted that the bath 43 may be of water or oil or some other liquid, and will be suitably maintained at a proper depth in the vessel 44. Since it is a general practice in the art to test volatility at a temperature of 100 degrees Fahrenheit, the various control factors for the bath 43 are preferably so adjusted that the sample portion in the cup is automatically maintained at the aforesaid temperature; at such a temperature either water or an oil will be found satisfactory as a bath liquid for present purposes.

As is previously indicated, the vapor pressure generated and produced in the cup 42 is utilized for control purposes, and to this end the top of the cup cavity is connected through a duct 61 with an expansion, or diaphragm, chamber 62 forming part of the structure of a pressure recording meter 63. As is usual in such meters, a movable wall 64 of the chamber 62 is arranged to control the disposal of a push rod 65, which rod in turn is arranged to constantly engage the wall 64 with a degree of pressure which varies with the degree of displacement of the wall 64 as the chamber 62 is expanded and, through suitable connecting mechanism, controls the positioning of the meter hand 66 with respect to a rotary record dial 67.

The rod 65 is also operative as a valve stem in a suitably formed fluid passage 68 which it traverses, said passage being interposed between ducts 69 and 71 of a fluid pressure line which in the present instance is arranged to carry air. A valve plug 72 is adjustably carried on the rod portion within said passage, and is operative in the passage to vary the permitted air flow there-through as the rod is displaced. As particularly illustrated in Figure 3, the effective passage between the ducts 69 and 71 is arranged to be decreased as the meter indications are increased with an increased pressure in the cup whereby this valve is reverse-acting with respect to the meter.

In the described valve and meter combination, the same being known generally in the art as a recorder-controller, it will be noted that the passage 68 and the connections for the ducts 69 and 71 are provided in a member 73 which is threadedly and replaceably engaged with and between a tubular meter body portion 74 and a housing 75 for the expansion chamber 62. If only a recording meter is desired, the member 73 may be omitted and the housing 75 may be directly secured to the extension 74; in this case, an appropriate shorter rod 65' lacking a valve plug would be substituted for the rod 65 as shown in Figure 7. As particularly shown in the installations of Figures 1, 4 and 6, a shut-off valve 70 is provided in the duct 69 for closing to render the valve ineffective as a control means should such be desired.

For most dependable results with the evaporation cup 42, it is desirable that the vapor space provided by the cup 42 and the duct 61 and the expansion chamber 62 contain a minimum of air. Accordingly, when the unit 41 is first connected in a line to be sampled, a valve 50 in the cup discharge line 51 is closed and the said vapor space opened as high therein as is practically possible to permit an initial filling of the space with the liquid sample. As particularly shown, that portion of the expansion chamber housing 75 which engages the upper end of the duct 61 and mounts the expansion chamber 62 is provided

with a passage extending radially from said space and normally closed by a screw plug 76, the removal of said plug permitting the aforesaid flow of liquid into the vapor space to expel substantially all of the air therefrom. When the vapor space is filled with the sample liquid, the plug 76 is replaced, and a subsequent opening of the valve 50 permits a lowering of the liquid to its normal level in the cup as controlled by the float valve 49. Should air afterwards accumulate in the aforesaid vapor space, such air may be removed by proceeding in the manner described for rendering the device initially operative. It will be understood that the valve 50 is normally open to a constant degree whereby the resistance in the line 51 may be and remain constant, said pressure being necessarily less than that in the cup 42.

As particularly shown in the assembly of Figure 1, the control unit 41 is applied for producing the bottom, or heavier, fraction to have a constant volatility through control of a back-pressure valve in the duct 31 in direct accordance with the volatility of a sample taken from the product in the duct 15. In the present arrangement, the supply valve 10 is of a differential diaphragm motor type and is controlled from an orifice plate 10' in the supply duct 9 whereby to insure a constant flow rate through the valve 10 even though the supply pressure should vary. The heating-coil valve 14 is a diaphragm valve which is operated by air pressure and is controlled by a thermostat 14' in accordance with the temperature of the liquid in the kettle whereby to maintain a constant temperature of said liquid. The condenser coil valve may be an ordinary manually set throttle valve, as is indicated. The return-reflux valve 34 is also arranged to maintain a constant flow rate therethrough, and, as shown, may comprise a differential diaphragm motor valve which is controlled by and from an orifice plate 34' in the duct 32.

Referring now to the application of the control unit to the described fractionating apparatus, a reference to Figure 1 discloses that the unit 41 is therein arranged to control the volatility of the discharged bottom product through utilizing a sample from the duct 15 as a control means for the gas escape duct 31. Accordingly, the duct 47 is connected to the duct 15 as a bypass therefrom and for receiving a continuous sample flowing through the sample cup 42, the valve duct 69 is connected with the compressed air main 22, and the valve duct 71 is connected to an air controlled diaphragm motor valve 77 which is interposed in the duct 31 as a back-pressure valve therein. The duct 71 is provided with a constantly open branch 78 having a needle valve 79 operative therein; in this manner, regulation of the actuation of the valve 77 may be effected in adjusted proportion to the actuation of the meter control rod 65 and the vapor pressure which actuates it. It will be understood that the valve 72 is never fully closed and that, by reason of the back pressure created in the duct 71 by the needle valve 79, any difference in the air pressure against the different sides of the valve 72 is not sufficient to appreciably affect the movement of the diaphragm 64 and the meter indications which are controlled by the rod.

The duct 31 may also have therein a hand-operated throttle valve 80 and a pressure gauge 81. When the valve 77 is controlled from the unit 41 in the described manner, the valve 80 is left open. If the valve 77 is not to be used, the

valve 80 would be appropriately set as a back-pressure valve for the system.

It will now be noted that a vapor pressure will be set up in the constant-temperature sample in the cup 42 in direct accordance with that of the sample portion in the cup, said pressure changing if the volatility changes. Momentary changes in the volatility of the sample will, of course, produce but a negligible effect on the cup pressure, but sustained changes in the volatility of the sample will effect the cup pressure in accordance therewith. Since the volatility of a liquid changes with the temperature thereof, the automatic maintenance of a constant sample temperature, as by the previously described operation of the unit 41, is obviously an essential feature of the device.

The aforesaid vapor pressure in the sample cup is arranged to control the back-pressure valve 77 in such a manner that a change in the volatility of the sample will cause such a change in the tower pressure as will bring the volatility of the sampled product back to its required value. Thus, should the volatility of the controlled product increase to produce an increased pressure in the cup 42, the back-pressure valve 77 would be opened to lower the tower pressure and thereby decrease the volatility of the product, the kettle temperature being held constant by the hereinbefore described automatic operation of the heating-coil valve 14.

In some arrangements of fractionating apparatus, a volatility control through a product sample may introduce an undesirable element of control lag, and in such a case it may be desirable to effect the control with a sample of untreated liquid from the system. One such application of the unit 41 is disclosed in Figure 4 wherein a sample of raw liquor taken from the feed duct 9 is utilized to control the supply of heating fluid to the heating coil 12. In this instance, the air duct 71 from the unit 41 is connected directly to the valve 14 in lieu of the thermometer 14', and the sample supply duct 47 is connected as a bypass from the duct 9 at a point thereof ahead of the heat-exchanger 11. In lieu of the valves 77 and 80, an automatic relief valve 82 is provided in the duct 31 whereby the pressure in the system may be held constant. The record and control afforded is, of course, similar to that where a sample is taken from a product.

Since it is a product which is to be controlled, either a top or bottom product must be continuously tested for volatility, it being noted that a sample not a product might well have a different volatility than the product to be controlled. In the arrangement of Figure 4, it is the reflux product which is to have a constant volatility, and a sample is accordingly taken from a point of the duct 35 ahead of the valve 36 and delivered to an evaporation cup 83 at a constant temperature and flow rate; as particularly illustrated, a duct 84 conducts the sample to the cup through a controlled heat-exchanger 85 and an automatic flow control valve 86.

The temperature of the sample leaving the heat-exchanger 85 is operative through a thermostat 87 interposed in the duct 84 to so regulate a valve 88 in the heating fluid duct 89 as to discharge the sample from the heat-exchanger at a constant temperature. The sample is arranged to flow from the cup 83 through an overflow duct 90 having a liquid trap 91 therein to prevent the escape of vapors from the cup therethrough. The

cup 83 is sealed except for a vapor-discharge duct 92 in which a constant degree of suction is maintained, as by means of an ejector 93 and an automatic flow control valve 94 operative in the duct. The ejector 93 may be actuated by air derived from the air main 22 through a valved duct 95 connected therewith.

Through the aspiration of the vapors from the sample in the cup 83, said sample will be cooled, and the difference in the temperatures of the sample in the duct 84 and cup 83 is a measure of the volatility of the sampled product. Accordingly, recording thermometers 96 and 97 are operatively installed in the cup and duct respectively whereby the necessary information is available for determining the results of the control afforded by the unit 41. In this manner, a proper control of a product may be assured through a non-product sample from the system and with an avoidance of control lag. It will be noted that the present volatility testing arrangement is a modification and adaptation of that disclosed in my United States Patent No. 1,901,104, dated March 14, 1933.

With the control arrangement of Figure 4, it will be understood that if the volatility of the sample of raw liquor increases, the resulting increased pressure in the cup 42 should effect an opening of the valve 14 to increase the rate of heat supply from the coil 12 and so increase the heating in the kettle; in this manner the volatility of the tested top product may be held at the desired value through the automatic addition of further lower fractions thereto because of the increased kettle heat. Under these circumstances, the valve provided in the member 73 of the recorder-controller 63 would be reverse-acting as is shown in Figure 3. If, on the other hand, it is the bottom product which is to have a constant volatility, and the volatility of the raw liquor increases, the same valve would be used at the recorder-controller, since under these circumstances the kettle heat should be increased to hold the bottom product volatility down by removing further light fractions therefrom.

In the embodiment of Figure 6, the control sample is taken from a bubble tray 7, and the control of the system is effected from a control and recording unit 41 at the valve 14 as in Figure 4. In the present arrangement, the gas discharge pipe 31 is provided with the pressure meter 81 and an automatic back-pressure valve 82 as in Figure 4, the discharge pipe 35 for the top product contains only the float-controlled valve 36 as in Figure 1, and the arrangement is otherwise as in Figures 1 and 4. Through the automatic control provided at the heating coil 12 in terms of a partly fractionated liquid in the system, the control lag is further minimized whereby this arrangement is particularly sensitive and dependable for the controlled treatment of a variable raw liquor.

In this instance, it is the bottom product which is to have a constant volatility, and a sample is accordingly taken from the discharge line 15 for continuous testing. For testing the bottom product, only the cup and meter portions of the previously described testing and control unit 41 are utilized, the connecting portion 73 providing the control valve and connections being omitted in the present assembly 41', and a shorter push rod 65' being used in lieu of the rod 65; the test unit 41' thus provided is shown in detail in Figure 7.

Figure 7 also shows the details of a recording

meter 63' wherein a link-and-lever system connects the rod 65' with the indicator hand 66, and a weight 60 on a lever of said system is gravitationally operative to constantly hold the rod 65' in bearing contact with the diaphragm 64. The walls of the expansion chamber 62 act as a spring to resiliently resist an expansion of the chamber in such manner that the restoring force on the chamber wall 64 is proportional to the chamber-expansion displacement thereof. The present arrangement may also be that for the meter 63 of the meter and control unit 41.

Essentially, the invention now disclosed is understood to concern devices for automatically maintaining the volatility of a mixed fraction which is continuously produced by any suitable fractionating and/or cracking apparatus, and to be generally applicable to other types of apparatus than that particularly illustrated for setting forth the present features of invention.

In illustrating the control operations of the various described embodiments, an increase above the desired volatility has been assumed in each case; it will be understood, however, that the disclosed control means will operate in an appropriate manner if the volatility of a product should become less than that desired.

From the foregoing description taken in connection with the accompanying drawings, the advantages of the construction and method of operation will be readily understood by those skilled in the art to which the invention appertains, and while I have described the principle of operation, together with forms of the device which I now consider preferred embodiments thereof, I desire to have it understood that the showings are primarily illustrative, and that such changes may be made, when desired, as fall within the scope of the appended claims.

Having thus described my invention, I claim as new and desire to secure by Letters Patent of the United States the following:

1. In a continuously operable system for fractionating an initially liquid mixture, means adjustable for stabilizing the fractionizing operation of the system, means continuously sampling a liquid other than a final product in the system and including an evaporation cup, and means directly utilizing the vapor pressure generated in said cup by reason of the evaporation of the liquid sample in the cup to control said stabilizing means for providing a fractionator product of constant volatility.

2. In a continuously operable system for fractionating a liquid mixture by distillation to provide a plurality of products, control means of the system adjustable for stabilizing the operation of the system, means continuously sampling the liquid mixture and including a closed evaporation cup through which a continuous sample is arranged to flow at a constant rate, means automatically operative to maintain the temperature of the liquid in said cup at a constant value for

partially evaporating the sample, and means continuously utilizing the vapor pressure generated in said cup to so regulate said control means of the system that a said product thereof will have a constant vapor pressure as it is produced by the system.

3. In a continuously operable system for fractionating a liquid mixture by distillation to provide a plurality of fraction products, control means of the system adjustable for stabilizing the operation of the system, means continuously sampling the liquid mixture and including a closed evaporation cup through which a continuous sample is directed at a constant rate, means automatically operative to maintain the temperature of the liquid in said cup at a constant value, and means continuously utilizing the vapor pressure in said cup to so regulate said control means of the system that a said product thereof will have a constant vapor pressure as it is produced by the system.

4. In a continuously operating fractionating system having elements cooperative to control the qualities of a product derived from a variable raw liquor, the method of controlling the product for constant volatility thereof which comprises utilizing the vapor pressure of a continuous sample of unfractionated liquid from the system to automatically control said regulating means for the production of said product with a constant vapor pressure.

5. In a continuously operating fractionating system having elements cooperative to control the qualities of a product derived from a variable raw liquor, the method of controlling the product for constant volatility thereof which comprises utilizing the vapor pressure of a continuous sample of unfractionated liquid from the system to automatically control said regulating means for maintaining the constancy of the vapor pressure of said product.

6. In a continuously operable system for fractionating an initially liquid mixture, means adjustable for stabilizing the fractionizing operation of the system, means continuously sampling a partly treated liquid in the system and including a closed evaporation cup, and means directly utilizing the vapor pressure generated in said cup by reason of the evaporation of the liquid sample in the cup to control said stabilizing means for providing a fractionator product of constant volatility.

7. In a continuously operating fractionating system having elements cooperative to control the quantities of a product derived from a variable raw liquor, the method of controlling the product for constant volatility thereof which comprises utilizing the vapor pressure of a continuous sample of partly treated liquid from the system to automatically control said regulating means for the production of said product with a constant vapor pressure.

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