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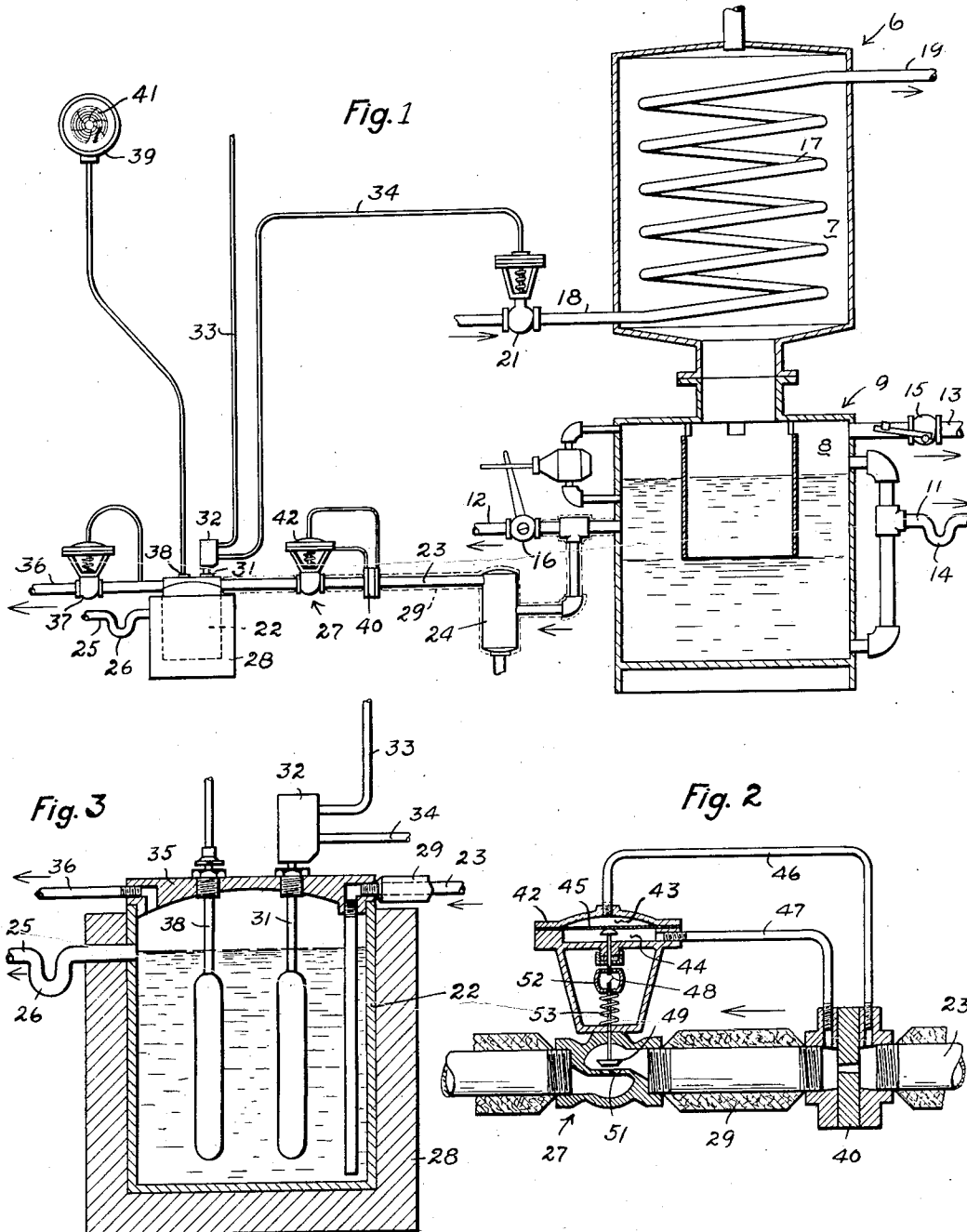
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1,940,803

CONDENSER CONTROL DEVICE

Filed Dec. 16, 1929

2 Sheets-Sheet 1



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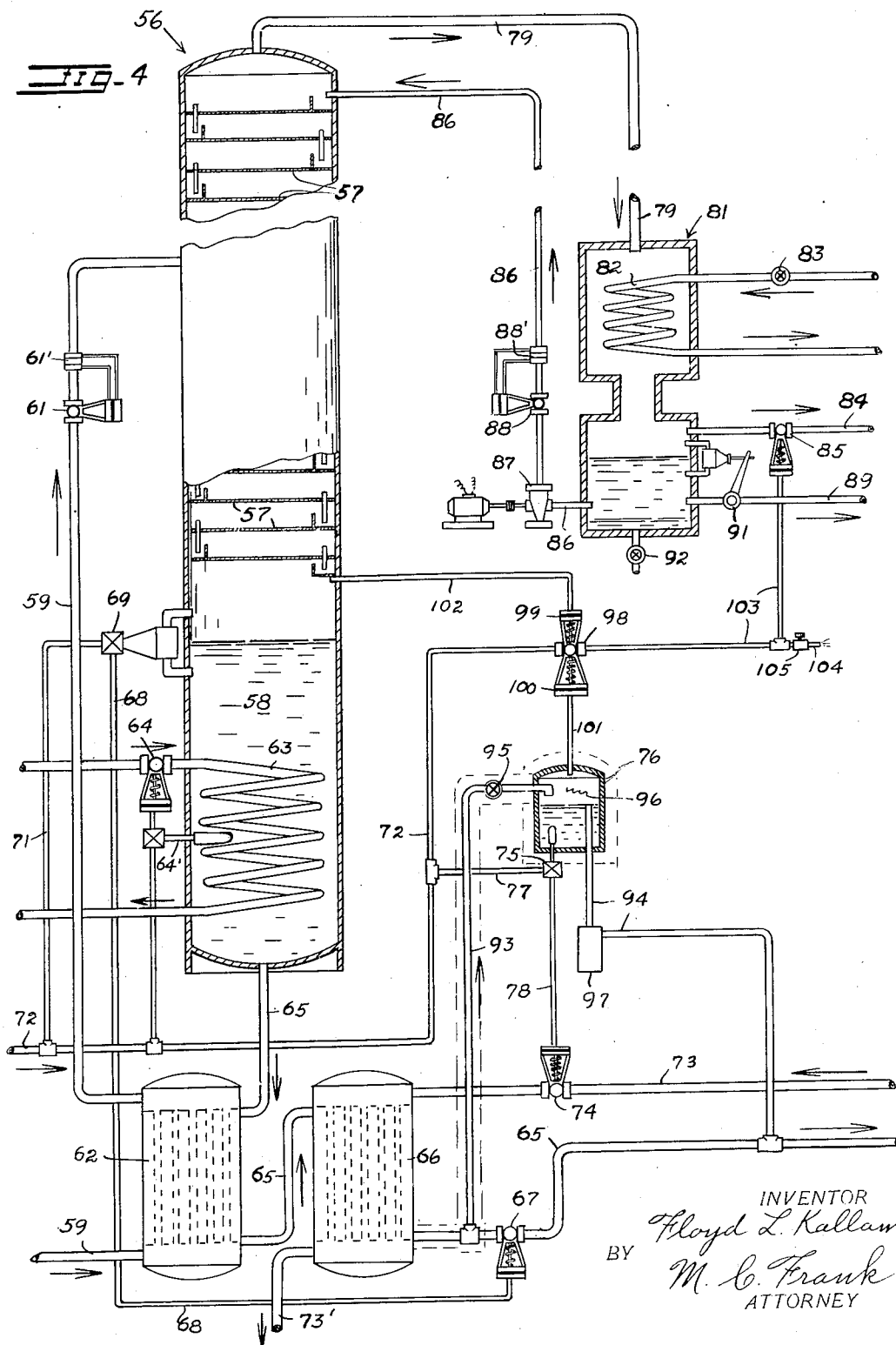
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UNITED STATES PATENT OFFICE

1,940,803

CONDENSER CONTROL DEVICE

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Application December 16, 1929

Serial No. 414,427

1 Claim. (Cl. 196—132)

The invention relates to a device for effecting the production by a continuously operating condenser or fractionator, of a product having a uniform composition.

An object of the invention is to provide a control method for producing a product of a fixed and unvarying volatility or vapor pressure, said method being disclosed in my pending application for United States Letters Patent on a Condenser control method and apparatus, Serial Number 330,121, filed January 3, 1929. The present application comprises, in part, a continuation of the aforesaid application.

Another object is to provide a control method of the character described which is readily applied in the control of the products of various types of fractionating apparatus now in use.

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 certain applications of the invention and in the accompanying drawings, in which:

Figure 1 is a generally diagrammatic elevation showing the device of the invention applied to one type of condensation apparatus, a condenser and accumulator of the apparatus being shown in section.

Figure 2 is an enlarged sectional elevation through a constant flow valve of the apparatus.

Figure 3 is an enlarged vertical section through an evaporation cup of the device and an associated thermostatic means for effecting a control of the flow of a cooling fluid through the condenser.

Fig. 4 discloses an application of the present device to a fractionator.

As particularly illustrated in Figures 1 to 3, the device of my invention is disclosed in operative association with a condensing unit arranged for continuous operation and in which a mixture of water and hydrocarbon vapors is arranged to be cooled for producing a blended hydro-carbon liquid. For convenience, gasoline for use in internal combustion engines will hereinafter be presumed as the desired product, and the following description will be directed accordingly. The unit described, it will be noted, would usually be one of a number of like units connected in series and differing essentially only in the condensation conditions therein, and a required number of the units would be provided with the device of my invention for the independent control of said condensation conditions.

More specifically, the invention is disclosed as

it would be applied to a condenser 6 providing a vapor receiving cavity 7 which discharges into the cavity 8 of an accumulator 9, the latter being provided with discharge pipes 11, 12 and 13 for the condensed water, condensed gasoline and uncondensed vapors, respectively. A suitable gas trap 14 is provided in the water pipe 11, while a suitable automatic back-pressure valve 15 is preferably provided in the vapor pipe 13 for maintaining the constancy of the vapor pressure in the condenser and accumulator. Preferably, and as shown, the gasoline discharge pipe 12 is provided with a float-controlled valve 16 for maintaining the constancy of the level of the gasoline above the outlet therefor whereby the gasoline discharge pressure will be held constant. A cooling fluid such as water is arranged to be circulated under pressure through a worm 17 disposed in the condenser cavity 7 and having inlet and outlet pipes 18 and 19 therefor, one of said pipes being provided with a valve 21 for regulating the flow rate of the cooling fluid through the worm.

It will now be noted that it has heretofore been customary to control the composition of the gasoline produced in a unit such as that now described by maintaining a constant temperature condition in the condenser cavity, regulation of such temperature being made in accordance with the temperature at some fixed point of the condenser or the temperature of the discharged liquid. Preferably, the aforesaid regulation would be effected through the valve 21, it being noted that the effective condensing temperature is raised when the valve is closed to lessen the quantity flow of cooling fluid through the worm and is lowered when the valve is opened. Such regulation in terms of temperature presupposes, however, that the various vapor fractions are present in the delivered vapor in unvarying proportions, which condition is seldom, if ever true, so that the resulting gasoline will vary somewhat in the proportions of the different gasoline fractions therein and will be neither constant as to composition nor as to other essential qualities thereof.

In many products which must be obtained by fractional distillation, one quality which is frequently an important feature in their use is that of volatility. Thus in gasoline and other liquids which are to be used in carburetted form as fuels, the question of volatility is vital and the production of such a liquid to have an unvarying and fixed volatility becomes of primary importance. Under these circumstances, the usual control in terms of temperature is markedly ineffective.

With the present invention, however, a product of constant volatility is obtained by controlling the composition thereof in terms of the volatility of the product as it is produced, and a preferred apparatus for this purpose will now be described.

As particularly illustrated in Figures 1 to 3 inclusive, an evaporation cup 22 is provided into the cavity of which a sampling pipe 23 connecting with the gasoline discharge pipe 12 is arranged to discharge. Preferably, the sampling pipe is connected to the pipe 12 at a point thereof between the float controlled valve 16 and the accumulator, whereby the effective pressure head at the intake thereof will be substantially constant. A suitable drier, or dewatering trap, 24 is desirably provided in the pipe 12 for reducing the water content of the sample to a minimum. Preferably, the liquid level in the cup 22 is arranged to be constant, and an overflow pipe 25 is provided for said cup whereby the gasoline sample may flow through the cup at a constant flow rate. To prevent the escape of vapors through the overflow pipe 25, the latter is preferably provided with a gas trap 26.

It will now be noted that evaporation is arranged to take place from the surface of the gasoline sample in the cup and that the rate of evaporation or volatility thereof is determined by the combined vapor pressures of the fractions in the sample, with the more volatile fraction a major factor in determining said evaporation rate. The heat of vaporization taken up by the resulting vapors will cool the liquid in the cup below the temperature at which it is supplied to the cup, the degree of cooling being determined by the degree of volatility of the gasoline, the quantity of liquid in the cup, and the rate at which the gasoline is supplied to the cup, the last two factors being constant. The flow rate of the gasoline sample into the cup is preferably a constant minimum which will insure an overflow therefrom, and an automatic flow control valve mechanism 27 is preferably interposed in the sampling pipe 23 for providing the desired constant flow rate. The mechanism 27 particularly disclosed is hereinafter described in detail, Figure 2 disclosing an enlarged section there-through.

Preferably, and as shown, the cup 22 is disposed in a heat insulating jacket 28 whereby the contents thereof may not obtain heat from the surroundings of the cup. Furthermore, the sampling pipe 23 is provided with a covering 29 of suitable heat insulation, as indicated in dash lines in Figure 1 and in full in Figures 2 and 3. In this manner, any appreciable cooling of the sample by radiation is prevented and the lowering of the temperature of the liquid in the cup will be determined by and vary with the volatility of said liquid. The pipe 23 is preferably made as short as possible for further reducing heat losses.

It will now be noted that the valve 21 is arranged to be automatically controlled by the temperature obtaining in the evaporation cup 22. As shown, the bulb of a suitable expansion thermometer 31 is disposed in the liquid in the cup and said thermometer is operatively connected to an air valve 32 having an inlet pipe 33 for connection with a suitable source of air under pressure. The outlet pipe 34 of the air valve is connected with the valve 21, which valve, it will now be noted, is a power valve of the diaphragm type and is so connected with the pipe 34 that the passage provided therethrough for the cool-

ing fluid will vary inversely with the pressure in the conduit. In this manner, a lowering in temperature of the liquid in the cup 22 from its desired constant value, indicating an increased volatility of said liquid, is arranged to decrease the quantity flow rate of the cooling fluid through the worm and so raise the effective condensing temperature for reducing the condensation of the more volatile fractions of the vapor mixture, thereby reducing the volatility of the gasoline subsequently produced. Correspondingly, a rise of the temperature of the liquid in the cup 22 is arranged to effect an increase in the quantity flow rate of the cooling fluid through the worm and so increase the volatility of the product. The air and water valves 32 and 21 respectively, it will now be noted, are initially cooperatively set for the maintenance of a predetermined temperature of the liquid in the cup 22, such temperature being determined in accordance with the desired volatility of the gasoline.

Means are preferably provided for insuring the maintenance of constant evaporation conditions in the cup 22. As particularly disclosed in the embodiment of Figures 1 to 3 inclusive, such means comprises the use of a tight cover 35 for the cup and creating a constant and very slight suction in the cup space by connecting the same with a suction pipe 36. Preferably, and as shown, an automatic pressure control valve 37 is interposed in the pipe 36 for insuring the required minimum suction in the cup. In this manner, the constancy of evaporation conditions in the cup is arranged to be automatically maintained.

Preferably, the bulb of a second thermometer 38 is disposed in the liquid of the cup 22, said thermometer being operatively connected with an automatic recording device 39 having a record chart 41 preferably calibrated in terms of volatility. In this manner, any necessary adjustment of the control means for the motor valve 21 to provide a product of required volatility may be made while the apparatus is in operation. The thermometers 31 and 38 preferably extend through and are mounted on the cover 35, as shown.

Referring now more particularly to the structure of the constant flow mechanism 27 associated with the sampling pipe 23, which is disclosed in detail in Figure 2, it will be noted that said mechanism essentially comprises an orifice plate 40 and a diaphragm valve 42 both interposed in said pipe, the latter being closer to the cup 22. The valve 42 provides pressure chambers 43 and 44 at opposite sides of a diaphragm 45 thereof, said chambers being connected with the pipe 23 at opposite sides of the plate 40 by means of pipes 46 and 47 respectively. A bipartite rod 48 of adjustable length extends from the diaphragm 45, said rod carrying a valve disc 49 for variable disposition with relation to the flow orifice 51 of the valve proper. The disc 49 is arranged to be disposed in accordance with the pressure differential at the opposite sides of the plate 40, adjustment for the desired minimum normal flow therethrough being effected by adjusting the length of the rod 48, as by means of the turnbuckle 52 shown. A spring 53 is provided for maintaining the contact of the valve rod with the diaphragm.

As particularly disclosed, the motor valve 21 and suction control valve 37 are constructed generally as is the valve 42 except that but one pressure chamber is provided, these chambers being

respectively connected with the pressure and suction pipes 34 and 36. It is to be noted, however, that valves of other types and structure might be used in lieu of these valves for accomplishing the various purposes thereof without departing from the spirit of the invention.

As particularly illustrated in Figure 4, the device of the present invention is operatively associated with fractionating apparatus of which the condenser 6 of the first described embodiment might be a part and in which the controlled product comprises a mixture of the less volatile fractions of hydro-carbon liquids such as fuel oils and gasolines. The apparatus shown is seen to comprise a conventional bubble-tray tower 56 having provided in the upper and major portion thereof a plurality of superimposed bubble-trays 57 of suitable structure. The lower tower portion is seen to provide a kettle-portion 58 to heat the liquid to be treated. A duct 59 supplies the raw liquor to the bubble trays at a constant rate; as shown, a valve 61 is provided for controlling the flow of liquor through the duct 59 and a heat-exchanger 62 is interposed in said duct whereby to preheat said liquor.

The liquid in the kettle 58 is arranged to be heated to a desired temperature by means of a heating coil 63 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 64 controls the fluid flow through the coil whereby, with the other operative factors of the apparatus constant, the rate of heat discharge from the coil may be adjusted to a desired value.

The unevaporated liquid is arranged to constantly escape at the bottom of the kettle through a duct 65. As particularly disclosed, the heat-exchanger 62 is interposed in the duct 65 whereby the inflowing liquor in the duct 59 is preheated and the liquid discharging through the duct 65 is partially cooled therein. A second heat-exchanger 66 is interposed in the duct 65 at the delivery side of the heat-exchanger 62 for completing the cooling of the discharged liquid.

For maintaining a constant liquid level in the kettle, a valve 67 is provided in the duct 65 at the discharge side of the heat-exchanger 66. The valve 67 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 68 with a float-controlled valve 69 which is operated by the liquid level in the kettle. A duct 71 supplies the operating air to the valve 69 from a compressed-air main 72 connected with a suitable source (not shown) of compressed air. It is noted, however, that the valve 67 might be arranged for mechanical, rather than pneumatic, operation by a suitable float actuated mechanism.

A cooling liquid from any suitable source (not shown) is arranged to flow to and from the heat-exchanger 66 through ducts 73 and 73' respectively, and a flow control valve 74 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 65 at a fixed and predetermined temperature, and automatic control of said temperature is conveniently arranged to be effected through the valve 74. As shown, the valve 74 is arranged for thermostatic control in accordance with the temperature of said product by means of a thermostat 75 having the bulb

thereof immersed in the liquid in a sampling cup 76 through which a continuous sample of the said product is arranged to pass. In the present instance, the valve 74 is of the diaphragm motor type for operation by air pressure and the thermostat 75 includes an air valve operably connected with the air main 72 by a duct 77 and to the valve 74 by a duct 78. In this manner, a product of constant temperature is arranged to be delivered from the duct 65 and through the cup 76.

The gaseous products resulting from the heating, and other treatments, of the raw liquor in the tower 56 are arranged to flow from the top of the tower through a duct 79 and to a dephlegmator or condenser 81 wherein a portion of the gases are condensed to form what is known in the art as a reflux liquid. The desired cooling in the condenser 81 is arranged to be effected by means of a cooling coil 82, a valve 83 controlling the fluid flow rate through the coil. The uncondensed gases from the condenser 81 are arranged to escape, as to waste or for use as fuel, through a duct 84 having interposed therein a back-pressure valve 85. Part of the condensate, or reflux, in the condenser 81 is arranged to be delivered back to the tower 56 through a duct 86, a motor driven pump 87 being interposed in the said duct for the purpose. A valve 88 is also interposed in said duct at the discharge side of the pump 87. Excess reflux is arranged to be discharged from the condenser through a duct 89, the latter duct having therein a float-controlled valve 91 for automatic operation to maintain a constant reflux level in the condenser. A drain valve 92 for removing condensed water is preferably provided at the bottom, or accumulator portion, of the condenser.

It will now be understood that the present apparatus is arranged to fractionate the raw liquor delivered thereto into three fractions, namely, a heavier, or low volatility fraction which is discharged through the duct 65 as a liquid product, an intermediate fraction which is discharged through the duct 89 as reflux liquid, and the lighter, or high volatility, fraction which is discharged through the duct 84 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 products.

As a matter of fact, raw liquors, such as crude oils and natural gasolines from wells, are very seldom of an unvarying composition, hence fractions thereof which are separated in unregulated refining apparatus are neither of constant composition nor volatility. No regulation of the apparatus is generally possible for the production of products which are of both constant composition and volatility, and adjustment of the apparatus must 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, the production of a product of constant volatility is of major importance, and it is to the provision of an automatically operable control means for continuously producing a product of constant volatility that the present invention particularly relates.

In the apparatus shown in Figure 4, the aforesaid operating conditions are seen to be chiefly controlled by the supply valve 61, the heating-coil valve 64, the condenser coil valve 83, the back-pressure valve 85, and the return-reflux valve 88, 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 operation of the apparatus, the volatility of one of the liquid products should change, appropriate adjustment of any one, or more, of said valves is required to bring the volatility of said product back to its desired value.

As particularly shown, the means of the present invention is applied for producing the heavier fraction to have a constant volatility through control of the back-pressure valve 85 in accordance with the volatility of the sample in the sample cup 76. In the present arrangement, the supply valve 61 is of a differential diaphragm motor type and is controlled from an orifice plate 61' in the supply duct 59 whereby to insure a constant flow rate through the valve 61 even though the supply pressure should vary. The heating-coil valve 64 is a diaphragm valve which is operated by air pressure and is controlled by a thermostat 64' in accordance with the temperature of the liquid in the kettle whereby to maintain a constant temperature of said liquid. The condenser coil valve 83 may be an ordinary manually set throttle valve, as is indicated. The return-reflux valve 88 is also arranged to maintain a constant flow rate therethrough, and, as shown, preferably comprises a differential diaphragm motor valve which is controlled by and from an orifice plate 88' in the duct 86.

As shown, the sampling cup 76 is interposed in a duct which by-passes the valve 67 of the duct 65, said duct having portions 93 and 94 respectively providing inlet and discharge ducts for the cup. A throttle valve 95 for manual setting is provided in the duct 93 to adjust the flow rate to the cup. The cup 76 is sealed and the intake end of the duct 94 extends upwardly in the cup to an intermediate point thereof whereby the liquid sample is retained in the cup to the level thereof and an evaporation space 96 is defined above said liquid. A trap 97 is provided in the duct 94, said trap being preferably of a structure to maintain a generally constant degree of liquid seal therein under any pressures which may obtain in the cup; the details of the trap structure are not disclosed, as the specific structure thereof is without the scope of the present invention.

It will now be noted that a vapor pressure will be set up in the constant-temperature sample in the sample cup in accordance with the volatility of the sample which constantly flows through the cup, said pressure changing if the sample volatility changes. Momentary changes in the volatility of the sample will, of course, produce a negligible effect on the cup pressure, but sustained changes in the volatility of the sample will change said 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 valve 74 by the thermostat 75, is, of course, an essential feature of the device.

The aforesaid vapor pressure in the sample cup

is arranged to control the back-pressure valve 85 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 product back to its required value. Thus, should the volatility of the controlled product increase to produce an increased pressure in the sample cup, the back-pressure valve would be opened to lower the tower pressure and thereby decrease the volatility of the product, the tower temperature being held constant by the hereinbefore described automatic operation of the heating-coil valve 64.

Since the pressure variations in the cup 76 are generally too slight to properly operate the motor valve 85, the cup pressure is preferably utilized to control an air valve 98 which in turn provides actuating air for the valve 85. As shown, the air valve 98 is of the double diaphragm type wherein a pair of pressure actuatable diaphragms 99 and 100 operate in opposition to control the setting of the valve. In the present instance, a duct 101 connects the cup 76 with the pressure chamber of the diaphragm 100, and the pressure chamber of the diaphragm 99 is connected to the vapor space of the tower 56 by means of a duct 102. The valve 98 is supplied with air from the air main 72. The size, or resistance to displacement, of the diaphragm 99 would be less than that of the diaphragm 100 to compensate for the general difference between the pressures in the tower and cup. A discharge duct 103 leads from the valve 98 to the pressure chamber of the back-pressure valve 85, and is provided with a constantly open branch 104 having an adjustable needle valve 105 operative therein.

It is noted that the present manner of jointly using the tower and sample pressures as a control means for the valve 98 is particularly sensitive and insures a close regulation of the product through the control provided for the back-pressure valve 85, or any other valve of the apparatus which controls the operating pressure in the apparatus.

The present use of the control method is disclosed in my pending application for United States Letters Patent on a Control device for fractionators and the like, Serial Number 412,846, filed December 9, 1929, wherein are further disclosed the operation from the sampling cup 76 of other valves than the back pressure valve 85 for producing a product of uniform volatility.

It will now be clear that both embodiments of self-regulating apparatus herein disclosed, are arranged to automatically effect the continuous production of products of constant and adjustably variable volatility by control means automatically operated by the vapor pressure of a sample and respectively through temperature and pressure effects in the different sample cups. And it will be further noted that the present device and control method is applicable to many other types of distillation apparatus for producing condensates of predetermined composition, reference being had to crude oil refining apparatus including topping plants, cracking plants, and pressure distillate stabilizing plants. Furthermore, the device may be used in the production of alcohols and other volatile liquids by distillation.

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 the device which I now consider to be the best embodiment thereof, I desire to have it understood that the device shown is merely illustrative, and that such changes may be made, when desired, as fall within the scope of the appended claim.

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

10 In continuously operating apparatus for fractionating a fluid mixture and having different means adjustable to regulate the operative factors of temperature and pressure therein to continuously produce a discharged sampled liquid product of substantially constant volatility, the method

of control which comprises directing a continuous sample of the product through an evaporation cup, maintaining either the pressure condition or the temperature condition in said cup at a constant value whereby either the temperature condition or pressure condition in said cup is respectively variable in accordance with the volatility of the sample, and actuating a said adjustable regulating means by means controlled by the said variable condition in the cup whereby the sampled said product may have a constant volatility, the setting of the other adjustable said regulating means remaining constant.

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