July 18, 1967 L. H. FOESTER ET AL 3,331,753

HEAT REMOVED FROM REFLUXED FLUIDS AS A RATIO OF WITHDRAWN PRODUCT IN FRACTIONATION CONTROL

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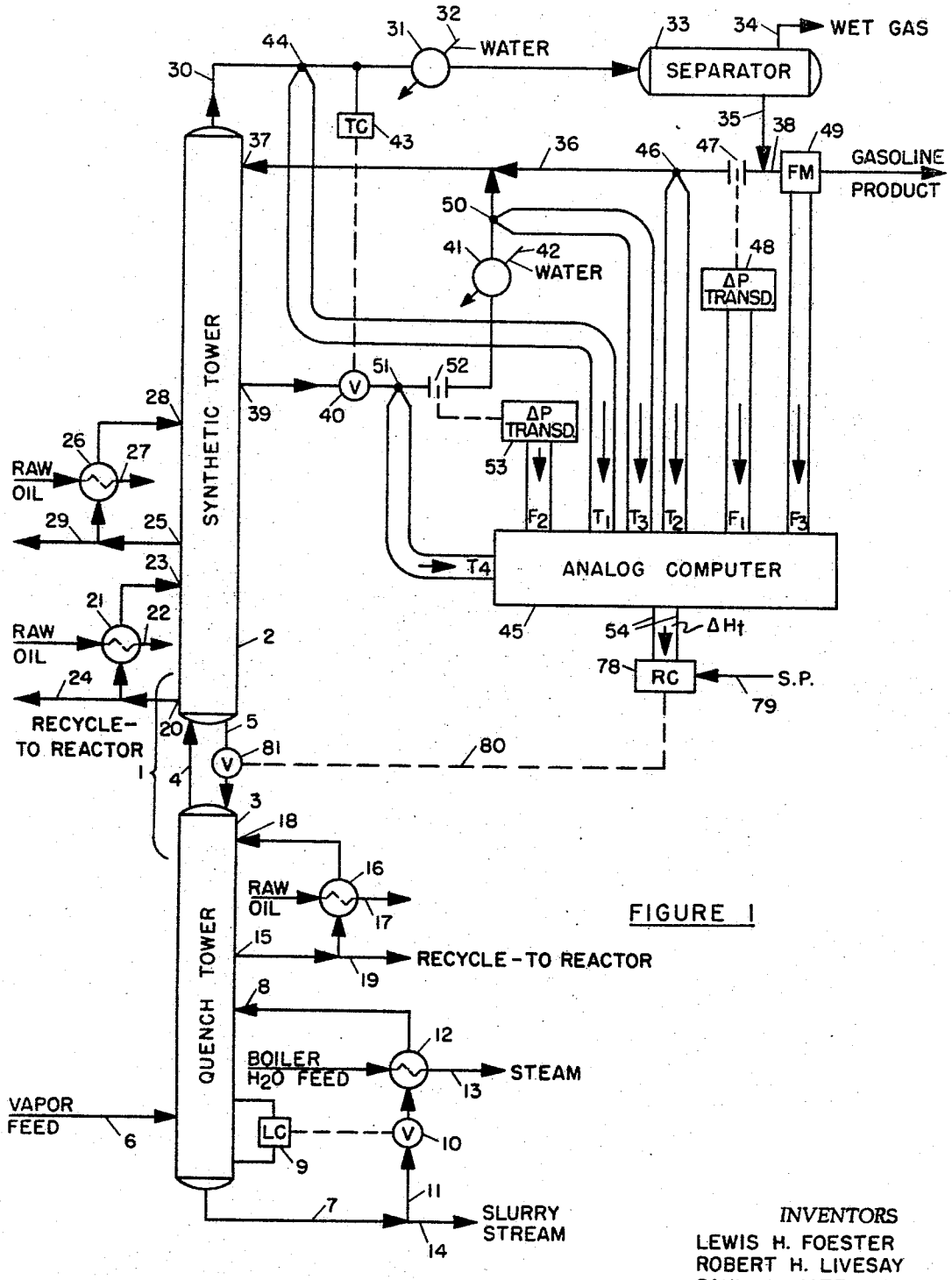


FIGURE 1

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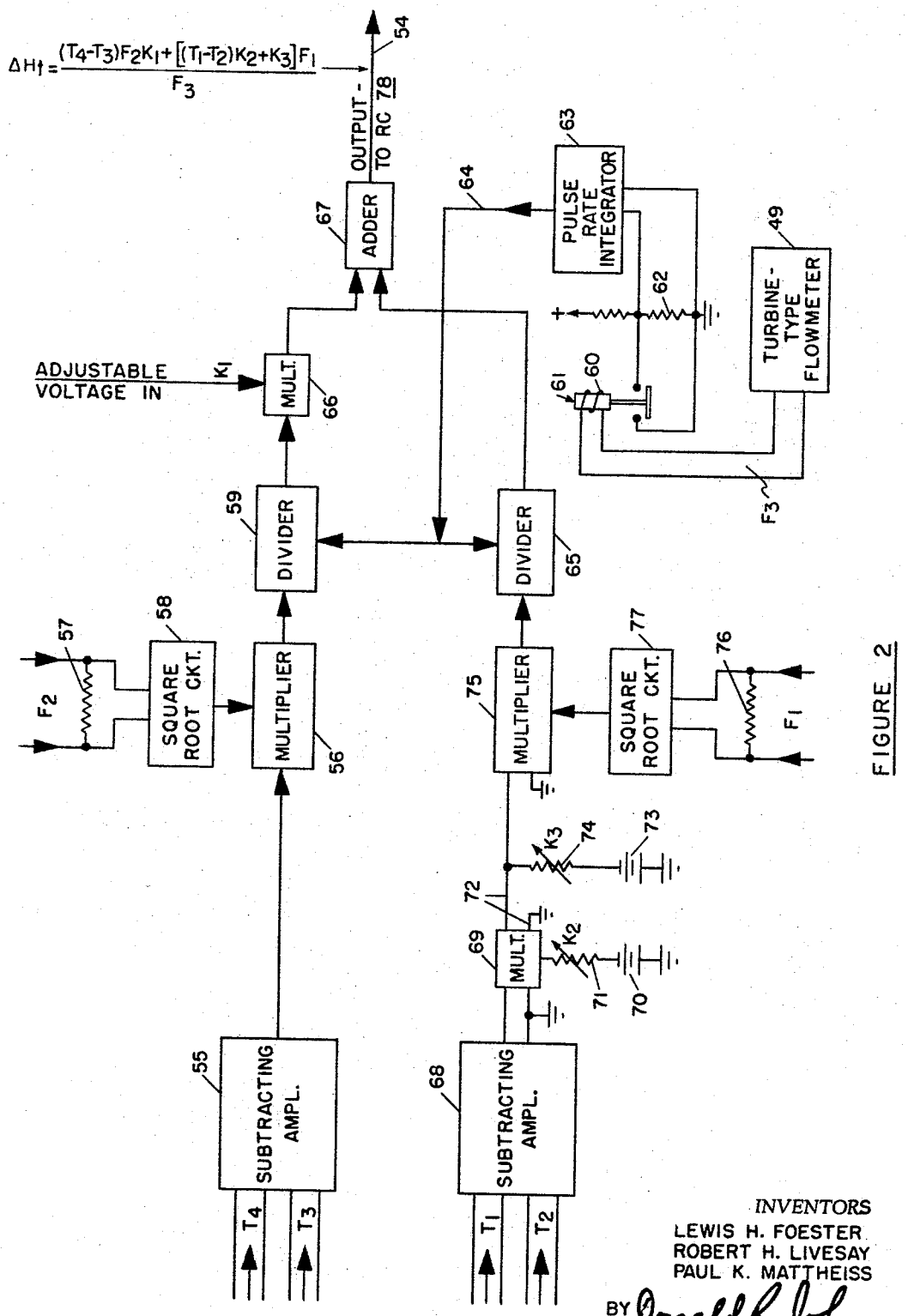


FIGURE 2

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HEAT REMOVED FROM REFLUXED FLUIDS AS A RATIO OF WITHDRAWN PRODUCT IN FRACTIONATION CONTROL

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This invention relates to a fractionation control system. It is particularly applicable to the fractionation of catalytic cracking product vapors, especially vapors obtained from a so-called fluidized or fluid catalytic cracking operation.

The invention relates to a fractionation unit which is provided with means for refluxing the top of the fractionator, and means for cycling hot liquid from the upper part of the unit, by way of a heat exchanger, to the same point at which overhead condensate is returned to the unit. Cooling water is used to condense and cool the overhead vapors to provide product and reflux, and is also used, in the heat exchanger, to cool the hot liquid which is refluxed or cycled. For reasons which will become apparent hereinafter, the overhead condensate which is refluxed may be termed the "separator reflux," and the hot liquid which is refluxed may be termed the "recirculating reflux." The overhead condensate not refluxed (hence used as product) may be termed the "separator product."

As previously described, heat is removed from the "separator" and "recirculating" streams by means of cooling water. It will be appreciated that it is desirable to reduce the cooling water used for this purpose, or in other words to minimize the heat removed from these two streams, since heat given up to cooling water cannot be recovered and hence is an economic loss.

It has been found, according to this invention, that the aforementioned heat removal may be minimized, consistent with an optimum degree of fractionation in the fractionation unit, by establishing a signal representative of the sum of: (1) the ratio of the heat removed from the "separator reflux" stream to the flow of "separator product," and (2) the ratio of the heat removed from the "recirculating" stream to the flow of "separator product"; this signal is used to control the movement (flow) of some particular liquid stream, in the fractionation unit, which affects the sum of the two heat removal ratios aforementioned. The said signal is developed by an analog computer to which are fed, as inputs, signals representative of temperatures and flows in the "recirculating" and "separator reflux" streams, and of the flow in the "separator product" stream. In a specific aspect of the invention, the fractionation unit comprises two tower portions connected together in cascade, and what is controlled (by the signal established by, say, the computer) is the flow of liquid in the connection between these two tower portions.

An object of this invention is to provide a novel fractionation control system.

Another object is to provide a vapor fractionating means wherein the heat lost to cooling water may be minimized, while maintaining an optimum degree of fractionation.

A further object is to provide a fractionation control system wherein the total heat removed from two reflux streams which are fed into the fractionation unit at a common point is automatically maintained substantially at a minimum value.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic representation of a fractionation control system according to this invention; and

FIG. 2 is a schematic circuit drawing of the computer employed in the control system of FIG. 1.

The fluidized catalytic conversion of hydrocarbons is well known. In such a conversion, a hydrocarbon oil is contacted (in a reactor) with a hot fresh or regenerated catalyst mass which travels essentially as a fluid because it is fluidized with a fluidizing vapor; usually, the fluidizing vapor is the hydrocarbon to be converted. After a suitable period of contact of the hydrocarbon with the finely sub-divided fluidized catalyst particles, during which period catalytic cracking takes place, there is performed a separation, usually with the aid of a cyclone or equivalent apparatus, in which the fluidized particles are stripped of residual hydrocarbons, following which the particles are regenerated and reused. Unavoidably, some of the finely divided catalyst is entrained in the separated hydrocarbon vapors. This catalyst accumulates in a fractionation unit, in which the vapors are condensed and fractionated. The slurry of hydrocarbon liquid and finely divided catalyst is usually accumulated and removed as product or returned to the reactor. The control system of the present invention is associated with the fractionation section, which is one of the three main sections (the other two being the reactor section and the regeneration section) of a complete or overall fluid catalytic conversion apparatus.

Referring now to FIG. 1 of the drawings, a fractionation unit, indicated generally by numeral **1**, comprises two tower portions, to wit, a so-called synthetic tower portion **2** and a so-called quench tower portion **3**, which are connected together in cascade to operate as a single fractionation unit. The connection of these two tower portions is by way of a first pipe **4**, in which vapors move from quench tower portion **3** (the "lower" or higher-temperature portion of the fractionation unit **1**) to synthetic tower portion **2** (the "upper" or lower-temperature portion of the fractionation unit **1**), and a second pipe **5**, in which liquid moves from synthetic tower portion **2** to quench tower portion **3**. In actual practice, the tower portions **2** and **3** could be positioned physically side-by-side, though they act in combination as a single fractionation unit.

Hot vapor feed **6** at about 900° F., resulting from the contacting of a hydrocarbon oil such as a heavy gas oil with a cracking catalyst consisting essentially of silica-alumina, enters the bottom section of unit **1**, just above the liquid therein. A bottoms or slurry draw-off pipe **7** draws off a slurry stream from the bottom of unit **1**. A portion of this stream is refluxed to a point **8** in the unit **1** above the point at which the vapor feed **6** enters, under the control of a liquid level controller **9** which actuates a valve **10** in the slurry reflux pipe **11**. The hot slurry liquid from the bottom of unit **1**, under the control of valve **10**, is cooled in heat exchange zone **12** wherein boiler water is converted into product steam **13**. That portion of the slurry stream which is not recycled or refluxed back into unit **1** (via pipe **11**) is removed from the unit **1** at **14** and is either returned to the reactor (not shown), or else removed as product.

A "heavy recycle" stream is drawn off from a point **15** in unit **1** above point **8**. A portion of this stream is cooled in heat exchange zone **16** to which raw oil is fed for preheating, this raw oil becoming hot raw oil at **17**. After passing through heat exchange zone **16**, this "heavy recycle" stream portion is refluxed to a point **18** in unit **1** above point **15**. Point **18** is near the top of quench tower portion **3**. That portion of the "heavy recycle" stream which is not recycled or refluxed back into unit **1** (by way of heat exchange zone **16**) is removed as recycle from unit **1** at **19**, and is sent back to the reactor (not shown).

From a point **20** in unit **1** above point **18** (point **20** being located, more specifically, in the lower section of

synthetic tower portion 2), a "light recycle" stream is drawn off. A portion of this stream is cooled in heat exchange zone 21 to which raw oil is fed for preheating, this raw oil becoming hot raw oil at 22. After passing through heat exchange zone 21, this "light recycle" stream portion is refluxed to a point 23 in unit 1 above point 20. That portion of the "light recycle" stream which is not recycled or refluxed back into unit 1 (by way of heat exchange zone 21) is removed as recycle from unit 1 at 24, and is sent back to the reactor (not shown).

From a point 25 in unit 1 above point 23, a "light catalytic gas oil" (LCGO) stream is drawn off. A portion of this stream is cooled in heat exchange zone 26 to which raw oil is fed for preheating, this raw oil becoming hot raw oil at 27. After passing through heat exchange zone 26, this LCGO stream portion is refluxed to a point 28 in unit 1 above point 25. That portion of the LCGO stream which is not recycled or refluxed back into unit 1 (by way of heat exchange zone 26) is removed as product from unit 1 at 29, and is sent on to other processing units in the refinery.

Overhead vapors which are drawn off at 30 from the top of unit 1 (which is also, of course, the top of synthetic tower portion 2), are condensed in a condenser 31 to which cooling water is supplied at 32, and are then passed to a separator 33. Wet gas is drawn off from the separator at 34 and is sent on to other processing units. The liquid condensate (which in this case comprises gasoline) is drawn off from the separator at 35. A portion of the gasoline flowing through the pipe 35 (the "separator reflux") is returned to unit 1 as reflux, the return being made via a pipe 36 to a point 37 in unit 1 below the top thereof. The remaining portion of the gasoline flowing through pipe 35 (the "separator product") is removed as product from unit 1 by pipe 38, and is sent on to other processing units.

From a point 39 in unit 1 intermediate points 37 and 28, a recirculating reflux stream (which is slightly heavier than gasoline) is drawn off under the control of a valve 40, is cooled in a heat exchanger 41 to which cooling water is supplied at 42, and is then mixed with the liquid flowing in pipe 36, for reflux or recycling back into unit 1 at 37, along with the separator reflux. The recirculating reflux is controlled by the valve 40 in response to the temperature of the overhead vapors 30 sensed through temperature controller 43.

A thermocouple 44 senses the temperature of the overhead vapors 30 and establishes a signal T_1 representative of the temperature of the vapor stream; signal T_1 is fed as a first input to an analog computer 45. A thermocouple 46 senses the temperature of the "separator reflux" stream flowing in pipe 36 and establishes a signal T_2 representative of the temperature of the overhead condensate used as reflux; signal T_2 is fed as a second input to computer 45. An orifice-type flowmeter 47 is located in pipe 36 to sense the flow of "separator reflux" through this pipe; this flowmeter is coupled to a differential pressure transducer 48 which produces a signal F_1 representative of the rate of flow of "separator reflux." Signal F_1 (representative of the rate of flow of the overhead condensate used as reflux) is fed as a third input to computer 45.

A turbine-type flowmeter 49 measures the flow of "separator product" in pipe 38 and produces a signal F_3 (in the form of pulses) representative of the rate of flow of the overhead condensate not used as reflux; signal F_3 is fed as a fourth input to computer 45.

A thermocouple 50 senses the temperature of the cooled "recirculating reflux" stream and establishes a signal T_3 representative of the temperature of this cooled liquid stream; signal T_3 is fed as a fifth input to computer 45. A thermocouple 51 senses the temperature of the "recirculating reflux" stream going into the heat exchanger 41 and establishes a signal T_4 representative of the temperature of this hot liquid stream; signal T_4 is fed as a sixth input to computer 45. An orifice-type flowmeter 52 is

located in the line between valve 40 and heat exchanger 41 to sense the flow of "recirculating reflux" through this line; this flowmeter is coupled to a differential pressure transducer 53 which produces a signal F_2 representative of the rate of flow of the (hot) "recirculating reflux" liquid stream. Signal F_2 is fed as a seventh input to computer 45.

The analog computer 45 operates to establish on its output leads 54 a signal ΔH_t representative of the total heat removed from the two gasoline streams refluxed at 37, divided by the rate of flow of the "separator product" in pipe 38. That is to say, the computer output signal ΔH_t represents the sum of the heat removed from the portion of the vapor stream which is refluxed and the heat removed from the hot liquid stream taken out at point 39, both per unit volume of the condensate not used as reflux (the latter being the so-called "separator product," which is the gasoline product derived from separator 33 and flowing in pipe 38). To establish this output signal ΔH_t, the analog computer operates on the seven input signals previously referred to (to wit, temperatures T_1, T_2, T_3, and T_4, and flows F_1, F_2, and F_3), and also takes into account three knob-set coefficients K_1, K_2, and K_3 (constants) which will be referred to hereinafter.

The heat removed from the recirculating reflux stream is $(T_4-T_3)F_2K_1$, where K_1 is the specific heat of the recirculating reflux stream. The factor K_1 is known or can be readily determined, and is assumed to remain substantially constant.

The heat removed from the separator reflux stream is

$$[(T_1-T_2)K_2+K_3]F_1$$

where K_2 is the specific heat of the separator reflux stream, and K_3 is the heat of vaporization of liquid on the top tray of unit 1.

The sum of the heats removed from the portion of the vapor stream which is refluxed and from the hot liquid stream, per unit volume of separator product, is given by

$$\Delta H_t=\frac{(T_4-T_3)F_2K_1+[(T_1-T_2)K_2+K_3]F_1}{F_3} \quad (1)$$

The computer 45 solves Equation 1.

Refer now to FIG. 2, wherein computer 45 is schematically illustrated. The output electrical signal T_4 of thermocouple 51 is applied as one of the two inputs to a substracting amplifier 55, the other input to this amplifier being the output electrical signal T_3 of thermocouple 50. The subtracting amplifier 55 takes the difference between T_4 and T_3, and this difference is applied as one of the two inputs to a multiplier circuit 56.

The output electrical signal from differential pressure transducer 53 appears across a resistor 57 which provides one of the inputs to the computer 45. As is well known, the differential pressure measurement across an orifice is proportional to the square of the flow through the conduit. Therefore, the signal across resistor 57 is applied to the input of a square root circuit 58, so that the output of this circuit is proportional to the flow F_2 itself. The output F_2 of circuit 58 is applied as the other of the two inputs to multiplier circuit 56. The output of circut 56 represents the product of the two input signals applied thereto, and this output is fed as one input to a divider circuit 59.

The turbine-type flowmeter 49 produces pulses proportional to the flow F_3 of "separator product" in pipe 38, and these pulses are applied to the operating winding 60 of a relay 61, which pulsatingly short-circuits a resistor 62 connected in a voltage divider circuit across a suitable voltage source. The resulting voltage pulses appearing across resistor 62 are integrated by a pulse rate integrator 63, to produce a steady voltage proportional to F_3 on output connection 64. This latter voltage is fed as the other input to divider 59, and is also fed as one input to another divider circuit 65.

Divider circuit 59 divides the product $F_2(T_4-T_3)$, which product is the output signal of circuit 56, by F_3, and the resulting quotient signal goes to one input of a

multiplier circuit **66**. The other input to circuit **66** is a knob-set adjustable voltage K_1, which is manually set to a value representative of the specific heat of the "recirculating reflux" stream. The product signal output of multiplier **66** thus represents the heat removed from the "recirculating reflux" stream per barrel of "separator product," and this signal is fed to an adder **67**.

The output electrical signal T_1 of thermocouple **44** is applied as one of the two inputs to a substracting amplifier **68**, the other input to this amplifier being the output electrical signal T_2 of thermocouple **46**. The subtracting amplifier **68** takes the difference between T_1 and T_2, and this difference is applied as one of the two inputs to a multiplier **69**. The other input to multiplier **69** is a knob-set adjustable voltage K_2 (supplied for example from a suitable voltage source **70** by way of a knob-adjustable potentiometer **71**), which is manually set to a value representative of the specific heat of the "separator reflux" stream. The output of circuit **69** represents the product of the two input signals applied thereto, and this output signal appears on output leads **72**.

A knob-set adjustable voltage K_3 is supplied in additive fashion to the leads **72**, the voltage K_3 being supplied for example from a voltage source **73** by way of a knob-adjustable potentiometer **74** and being manually set to a value representative of the heat of vaporization of liquid on the top tray of unit **1** (FIG. 1). The resulting sum (which is the output of multiplier **69** plus K_3) is fed as one input to another multiplier **75**.

The output electrical signal from differential pressure transducer **48** appears across a resistor **76**, and this signal is fed through a square root circuit **77** to provide a resultant signal proportional to flow F_1; this resultant signal is fed as the other input to multiplier **75**. The output of multiplier **75** represents the product of the two input signals applied thereto, and this output is fed as one input to the divider circuit **65**. The output of multiplier **75** is $[(T_1-T_2)K_2+K_3]F_1$.

As previously stated, a voltage proportional to F_3 (from integrator **63**) is also fed as input to divider **65**. Divider circuit **65** divides the product output signal of multiplier **75** by F_3, and the resulting quotient signal is fed to adder **67**. The quotient signal output of divider **65** represents the heat removed from the "separator reflux" stream per barrel of "separator product."

Adder **67** adds together the two signals fed thereto, to provide an analog computer output signal ΔH_t (Equation 1) on connection **54**, which signal represents the total heat removed from the two gasoline streams refluxed at **37** (FIG. 1), divided by the rate of flow of "separator product."

By way of example, typical values for the various factors contained in Equation 1 will now be given. These are values typical of an actual (operating) fractionation system according to the invention. Such values are, all temperatures being in degrees Fahrenheit: temperature T_1, 290; temperature T_2, 85; temperature T_3, 90; temperature T_4, 325; flow F_1, 2.0; flow F_2, 6.0; flow F_3, 7.5. Typical ranges for the constants are: K_1, 0–0.5; K_2, 0–0.2; K_3, 0–30.0. In this connection, it is noted that it is desirable to have the final result (ΔH_t, the output signal of computer **45**) in the form of a 10–50 millivolt signal, corresponding to heat removal of 40–80 M B.t.u.'s per barrel; the constants in Equation 1 are scaled to take care of a "thousand" factor in the B.t.u.'s. Also, the numbers given for flows in the example are for the flows after the square rooting which takes place in **58** and **77** (FIG. 2).

Referring back to FIG. 1, the output signal of the computer **45** is fed at **54** to a recorder-controller **78** having a set point adjustment **79**. The recorder-controller **78** controls by means of a coupling schematically indicated at **80**, a control valve **81** which is located in the liquid-downflow pipe **5** (between synthetic tower portion **2** and quench tower portion **3**). By means of this valve, the computer output signal ΔH_t controls (through the recorder-controller **78**) the movement (flow) of liquid, in the fractionation unit **1**, from a region of lower temperature (to wit, the synthetic tower portion **2**) to a region of higher temperature (to wit, the quench tower portion **3**). More specifically, the computer output controls the downward flow of liquid in the connection **5** between the tower portions **2** and **3**. In brief, the recorder-controller **78** operates to compare the value of the computer output signal ΔH_t (representing the total heat removal in the two gasoline reflux streams, per barrel of "separator product") with the value represented by the set point **79**. If there is a difference between these two values, the controller **78** operates to change the setting of valve **81**, the sense of this change of setting depending upon the direction of the error of the computer output signal with respect to the set point of the controller.

The set point of controller **78** is manually adjusted to some value which has been found to be a practical minimum, consistent with good fractionation in the unit **1**. If the total heat removal, per barrel of "separator product," in the two gasoline reflux streams tends to increase above the desired minimum value (as a result, for example, of a change in composition of the feed to the fractionation unit, or as a result of some other change), the computer output signal ΔH_t will of course increase accordingly (since the computer solves the heat removal equation set forth hereinabove), resulting in an output from the controller **78** which will adjust valve **81** toward the closed position. (At this juncture, it is desired to be pointed out that if the heat removal decreases below the desired minimum value, the controller **78** will adjust valve **81** toward the open position.) The flow of liquid through pipe **5**, in a direction from tower section **2** to tower section **3**, has the effect of a cooling of tower section **3**. When valve **81** moves toward closed position, there will be less cooling action on tower section **3**, and consequently more cooling effect on tower section **2**. This means that the overhead temperature of the fractionation unit **1** will start to decrease. This decrease is sensed by temperature controller **43**, resulting in a closing of valve **40** to reduce the flow F_2 of recirculating reflux. This reduction in the flow of reflux reduces the heat removal per barrel of product, since F_2 is in the numerator of Equation 1. Thus, the heat removal is brought back down to the desired minimum value.

Another way of explaining the foregoing action is that, when valve **81** moves toward closed position, the liquid tends to "back up" in synthetic tower portion **2**, tending to decrease the overhead temperature of the fractionation unit **1**, which results in a closing of valve **40**, as previously described.

An action which is the reverse of that described above occurs when the heat removal tends to decrease below the desired minimum value; in this event, as previously stated, valve **81** will be adjusted toward the open position.

According to this invention, the computer output signal at **54** (which represents the sum of the heat removed from the two stream portions refluxed at **37**, each of the two heat removals being expressed as a ratio taken per unit volume of condensate not used as reflux) is used to control the movement of liquid in some particular, selected stream in unit **1** which has the property of affecting the said sum of the two ratios, i.e., of affecting the heat removal in the total stream refluxed at **37**. The heat removal effect of the stream flowing through valve **81** has previously been described. That is to say, the liquid stream flowing through pipe **5** affects the heat removal, per barrel of product, in the total stream refluxed at **37**.

Another stream in unit **1** which has the heat removal effect referred to in the preceding paragraph is that flowing from heat exchanger **21** to reflux point **23**. It may be desirable, in some cases, to control this stream in response to the output signal of computer **45**, rather than controlling the stream in pipe **5**. To do this, the control valve **81** would be removed from pipe **5** and placed, instead,

in the line between heat exchanger **21** and reflux point **23**.

The system of this invention operates to maintain the total heat removal from the "separator reflux" and the "recirculating reflux" streams at a minimum value; this reduces the gasoline reflux and shifts a considerable part of the heat removal to a lower section of the fractionation unit **1**, making this heat recoverable in the form of generated steam or raw oil preheat, rather than being lost by being used merely to heat cooling water. However, the control system of this invention produces additional beneficial results. Since the invention operates to minimize the overhead heat removal, it reduces the liquid loading at the top of unit **1** (and this liquid loading is often a problem), it reduces the vapor loading at the top of the unit (this, also, often being a problem), and may reduce the catalyst "fines" which are carried over from the fractionation unit into the various product streams.

The invention claimed is:

1. In a fractionation system wherein a feed mixture of two or more components is directed to a fractionation unit, a vapor stream is withdrawn from the top of the unit, said vapor stream is cooled to condense at least a part of same, a part of the resulting condensate is returned to said unit as reflux, a hot liquid stream is withdrawn from said unit at a point removed from the top thereof, said liquid stream is cooled, and the cooled liquid stream is mixed with said part of said condensate for reflux into said unit: a control system comprising means for establishing a signal representative of the sum of the heat removed from said refluxed part of said vapor stream and the heat removed from said hot liquid stream, each taken as a ratio of the heat removed to the flow of the condensate not used as reflux, and means responsive to said signal for controlling the flow of a selected liquid stream, in said unit, characterized in that it affects the aforementioned sum of the ratios.

2. System according to claim **1**, wherein the first-mentioned means includes an analog computer to the input of which are fed signals representative of various temperatures and flow rates characteristic of the vapor stream, of the condensate reflux stream, of the hot liquid stream, of the cooled liquid stream, and of the stream of the condensate not used as reflux.

3. System according to claim **1**, wherein the first-mentioned means includes an analog computer to the input of which are fed a first signal representative of the temperature of said vapor stream, a second signal representative of the temperature of said part of said condensate, a third signal representative of the rate of flow of said part of said condensate, a fourth signal representative of the rate of flow of the condensate not used as reflux, a fifth signal representative of the temperature of said cooled liquid stream, a sixth signal representative of the temperature of said hot liquid stream, and a seventh signal representative of the rate of flow of said hot liquid stream.

4. System according to claim **1**, wherein the first-mentioned means includes an analog computer to the input of which are fed a first signal T_1 representative of the temperature of said vapor stream, a second signal T_2 representative of the temperature of said part of said condensate, a third signal F_1 representative of the rate of flow of said part of said condensate, a fourth signal F_3 representative of the rate of flow of the condensate not used as reflux, a fifth signal T_3 representative of the temperature of said cooled liquid stream, a sixth signal T_4 representative of the temperature of said hot liquid stream, and a seventh signal F_2 representative of the rate of flow of said hot liquid stream; and wherein said computer operates on the input signals fed thereto to establish an eighth signal

$$\frac{(T_4-T_3)F_2K_1+[(T_1-T_2)K_2+K_3]F_1}{F_3}$$

where K_1, K_2, and K_3 are constants characteristic of the compositions of the reflux streams, wherein K_1 is the specific heat of said hot liquid stream, K_2 is the specific heat of said condensate, and K_3 is the heat of vaporization of said vapor stream.

5. System as defined in claim **1**, wherein said unit comprises two tower portions connected together in cascade to operate as one fractionation unit, and wherein the last-mentioned means operates to control the flow of liquid in the connection between said two tower portions.

6. In a fractionation system wherein a feed mixture of two or more components is directed to a fractionation unit, a vapor stream is withdrawn from the top of the unit, said vapor stream is cooled to condense at least a part of same, a part of the resulting condensate is returned to said unit as reflux, a hot liquid stream is withdrawn from said unit at a point removed from the top thereof, said liquid stream is cooled, and the cooled liquid stream is mixed with said part of said condensate for reflux into said unit: a control system comprising means to establish a first signal representative of the temperature of said vapor stream, means to establish a second signal representative of the temperature of said part of said condensate, means to establish a third signal representative of the rate of flow of said part of said condensate, means to establish a fourth signal representative of the rate of flow of the condensate not used as reflux, means to establish a fifth signal representative of the temperature of said cooled liquid stream, means to establish a sixth signal representative of the temperature of said hot liquid stream, means to establish a seventh signal representative of the rate of flow of said hot liquid stream, means receptive of said first through seventh signals for establishing an eighth signal representative of the sum of the heat removed from said refluxed part of said vapor stream and the heat removed from said hot liquid stream, each taken as a ratio of the heat removed to the flow of the condensate not used as reflux, and means responsive to said eighth signal for controlling the flow of a selected liquid stream, in said unit, characterized in that it affects the aforementioned sum of the ratios.

7. System according to claim **6**, wherein said unit comprises two tower portions connected together in cascade to operate as one fractionation unit, and wherein the last-mentioned means operates to control the flow of liquid in the connection between said two tower portions.

8. In a fractionation system wherein a feed mixture of two or more components is directed to a fractionation unit, a vapor stream is withdrawn from the top of the unit, said vapor stream is cooled to condense at least a part of same, a part of the resulting condensate is returned to said unit as reflux, a hot liquid stream is withdrawn from said unit at a point removed from the top thereof, said liquid stream is cooled, and the cooled liquid stream is mixed with said part of said condensate for reflux into said unit: a control system comprising means to establish a first signal T_1 representative of the temperature of said vapor stream, means to establish a second signal T_2 representative of the temperature of said part of said condensate, means to establish a third signal F_1 representative of the rate of flow of said part of said condensate, means to establish a fourth signal F_3 representative of the rate of flow of the condensate not used as reflux, means to establish a fifth signal T_3 representative of the temperature of said cooled liquid stream, means to establish a sixth signal T_4 representative of the temperature of said hot liquid stream, means to establish a seventh signal F_2 representative of the rate of flow of said hot liquid stream, means receptive of said first through seventh signals for establishing an eighth signal

$$\frac{T_4-T_3)F_2K_1+[(T_1-T_2)K_2+K_3]F_1}{F_3}$$

where K_1, K_2, and K_3 are constants characteristic of the compositions of the reflux streams wherein K_1 is the specific heat of said hot liquid stream, K_2 is the specific heat of said condensate, and K_3 is the heat of vaporiza-

tion of said vapor stream; and means responsive to said eighth signal for controlling the flow of a selected liquid stream, in said unit, characterized in that it affects the magnitude of said eighth signal.

9. System as defined in claim 8, wherein said unit comprises two tower portions connected together in cascade to operate as one fractionation unit, and wherein the last-mentioned means operates to control the flow of liquid in the connection between said two tower portions.

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