

March 25, 1941.

J. F. LUHRS

2,236,035

FRACTIONATING TOWER CONTROL

Filed Dec. 4, 1937

2 Sheets-Sheet 1

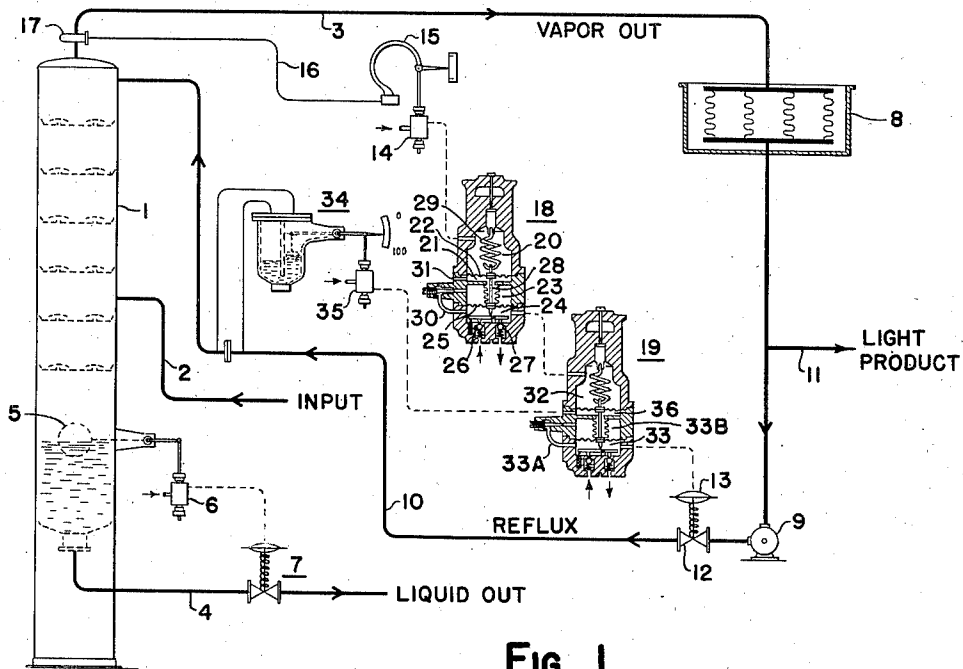


FIG. 1

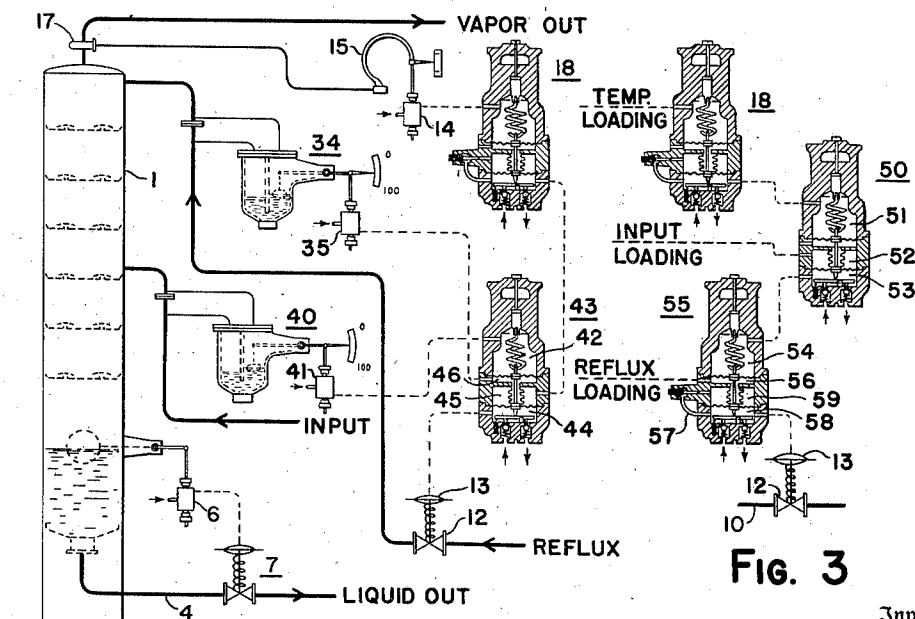


FIG. 2

FIG. 3

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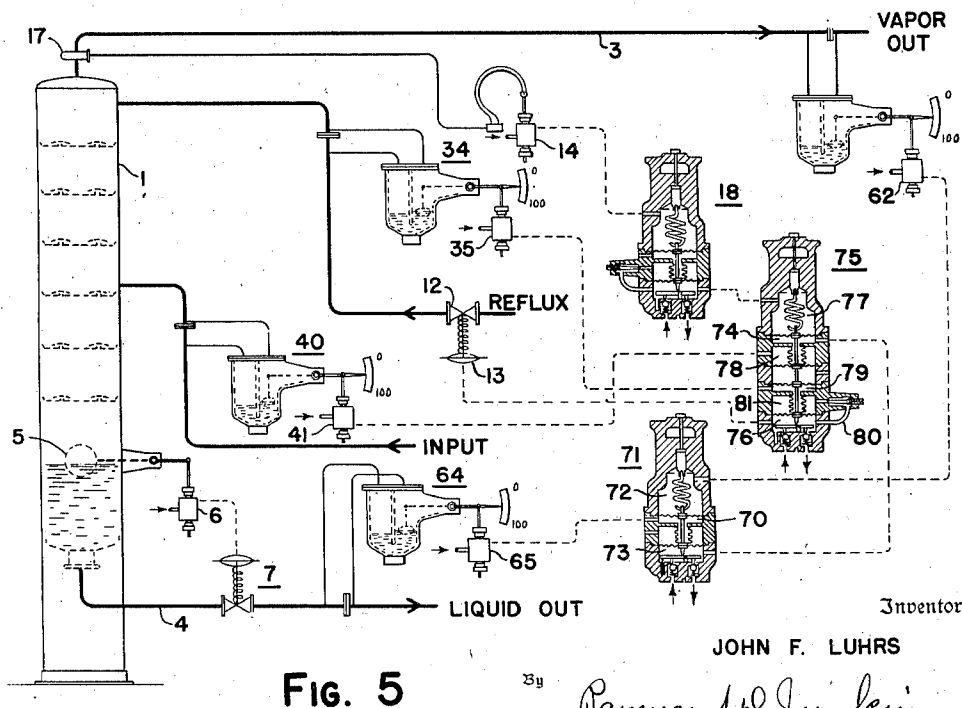
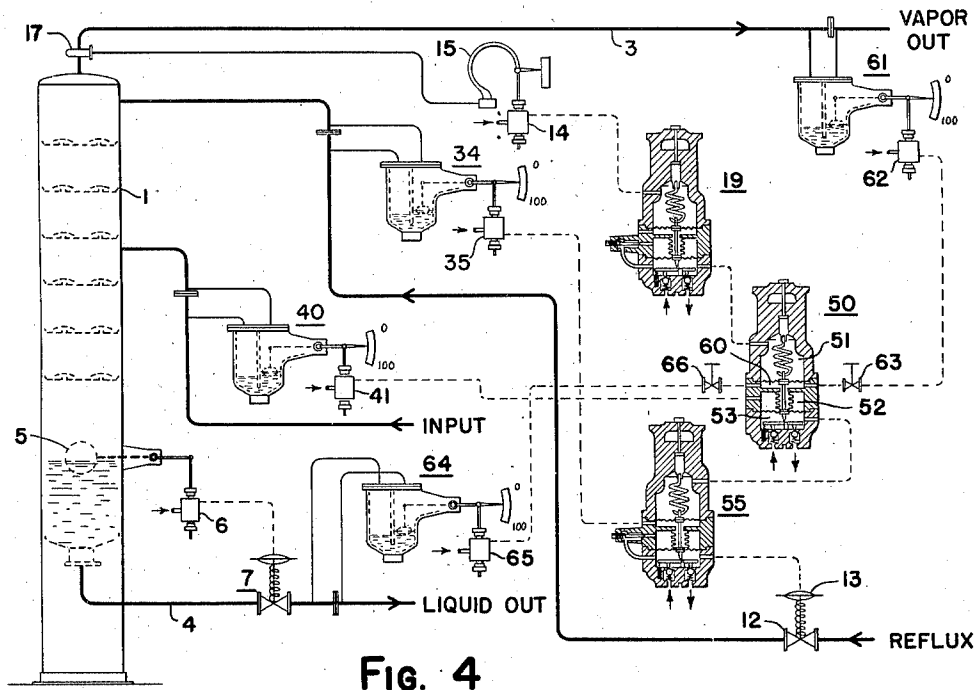
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FRACTIONATING TOWER CONTROL

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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FRACTIONATING TOWER CONTROL

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Delaware

Application December 4, 1937, Serial No. 178,173

26 Claims. (Cl. 202—160)

This invention relates to control systems for fractionating towers, such as are used in oil refineries to divide oil into desired boiling range products.

5 My invention is particularly applicable to that type of tower wherein fractionation between a light product and the remainder of the oil is obtained by maintaining a predetermined temperature at the top of the tower.

10 An object of my invention is to provide a control which will maintain the top tower temperature within close limits without oscillating or hunting.

A further object of my invention is to provide 15 a control which anticipates changes in the top tower temperature due to changes in load on the tower or composition of the oil, and corrects the flow of reflux before changes in temperature actually occur.

20 Still a further object is to provide a control wherein changes in top tower temperature produce predetermined quantitative changes in the rate of flow of reflux. That is, the control not only acts to produce changes in the rate of flow 25 of reflux in desired sense; but also to produce changes of an exact predetermined amount.

It is a further object to provide a control system which, while maintaining the top tower temperature at the desired value, will not produce violent 30 and rapid fluctuations in the rate of flow of reflux, to the end that a good fractionation of the oil is obtained, resulting in an improved product.

Further objects and advantages will be apparent from the description to follow and from 35 the drawings in which:

Fig. 1 is a diagrammatic illustration of one embodiment of my invention.

40 Fig. 2 is a diagrammatic illustration of a second embodiment of my invention.

Fig. 3 is a modification of a part of the control system illustrated in Fig. 2.

Figs. 4 and 5 are diagrammatic illustrations of 45 further embodiments of my invention.

Referring to Fig. 1, there is shown diagrammatically a fractionating tower 1 to which hot oil and vapor are admitted through an input line 2. Within the tower as understood in the art are suitable means, such as bubble trays, to produce repeated redistillation with repeated absorption of the oil. The lighter constituents, that is the more volatile constituents, are eventually discharged from the tower in a vapor state through a "vapor out" line 3. The liquified constituents pass to the bottom of the tower and are

discharged through a "liquid out" line 4. The bottom of the tower forms a reservoir for the liquid constituents, the level in which is maintained within desired limits by a float 5 actuating the movable stem of a pneumatic pilot valve 6 to establish a fluid pressure effective for actuating a control valve 7. The arrangement is such that as the level rises the fluid pressure established by the pilot changes in a direction to open the valve 7, thereby increasing the flow 10 through the line 4. The pilot valve may be of the type shown and described in patent to C. Johnson, Serial No. 2,054,464, dated September 15, 1936, whereby for each position assumed by the float 5 there is a definite loading pressure 15 established by the pilot 6, so that a functional relation will exist between rate of flow of liquid through the line 4 and level of liquid in the reservoir.

As understood by those familiar with the art, 20 in order to obtain a light product having a specified end point it is necessary that the temperature of the vapor leaving the tower 1 be maintained at a predetermined value. As is further understood, the temperature of the vapor at the tower top is affected by the rate at which reflux is returned to the tower. That is to say if the rate of reflux flow is increased, the temperature at the tower top will decrease, whereas if the flow is decreased the temperature will increase. Accordingly, by properly regulating the rate of flow of reflux the tower top temperature may be maintained at a predetermined value. The novelty of my invention resides in the particular means I have provided for varying the rate of 25 flow of reflux to maintain the top tower temperature continuously at the desired value.

As illustrated in Fig. 1 the reflux fluid may be obtained from the condensate of the vapor discharged through the vapor outlet 3. Therein I show the outlet 3 leading to a condenser box 8 wherein the vapor is condensed. The condensate is then carried to the inlet of a suitable pump 9, whence it is returned to the top of the tower through a reflux line 10. The condensate not utilized as reflux is withdrawn from the system through a pipe 11. 40

For controlling the flow of reflux to the tower I show positioned in the line 10 a valve 12 actuated by a fluid pressure servo-motor 13 sensitive 50 to changes in fluid pressure originated by a pilot valve 14. The movable stem of the pilot valve 14 is positioned by a temperature sensitive device such as a Bourdon spring 15 connected by means of a capillary 16 to a bulb 17 exposed to the tem- 55

perature of the vapor leaving the tower. As the temperature of the vapor increases, the free end of the Bourdon spring 15 moves upwardly, thereby increasing proportionately the loading pressure established by the pilot valve 14. Decreases in temperature of the vapor leaving the tower effect a proportionate decrease in the loading pressure established by the pilot 14.

Interposed between the pilot 14 and the servomotor 13 are standardizing relays 18 and 19 which may be of the type forming the subject matter of a United States Patent No. 2,098,914 to H. H. Gorrie issued November 9, 1937. The relay 18, which may be considered as typical of the type of relay I employ throughout the various embodiments of my invention, is essentially a pressure balancing device and comprises a pair of pressure sensitive chambers 20 and 21 separated by a diaphragm 22 and a second pair of pressure sensitive chambers 23 and 24 separated by a diaphragm 25. Within the chamber 24 is a fulcrumed lever adapted when tilted in one direction from the horizontal position to actuate a fluid pressure supply valve 26 (connected to any suitable source of pressure fluid, not shown) to admit fluid pressure to the chamber 24, and when tilted in opposite direction to actuate an atmospheric exhaust valve 27 to discharge pressure fluid therefrom. The diaphragms 22 and 23 are connected together for simultaneous movement by a member 28 secured at its upper end to a manually adjustable loading spring 29, and arranged when moved downwardly from the position shown to cause the supply valve 26 to open, and when moved upwardly to cause the exhaust valve 27 to open. The chambers 23 and 24 are shown in communication through an adjustable bleed connection 30, and chamber 21 in communication with the atmosphere through a port 31. In some instances, as will be described hereinafter, the chamber 21 may be connected to a source of fluid pressure. The arrangement is such that the force on the member 28 produced by the pressure within the chamber 24 is maintained equal and opposite to the algebraic sum of the forces produced by the spring 29 and pressures within chambers 20, 21 and 23.

The standardizing relay 18 acts to instantaneously reproduce changes in loading pressure occurring within chamber 20 in the chamber 24 and to continuously change the pressure within chamber 24 at a rate proportional to the deviation of the pressure within chamber 20 from a desired pressure. Accordingly, if as shown the loading pressure established by the pilot 14 is transmitted to the chamber 20 and initially adjusted to establish a predetermined loading pressure when the top tower temperature is at a desired value, then upon a change in top tower temperature from the predetermined value a proportional change in pressure within the chamber 24 will occur, and thereafter a continuing change until the top tower temperature is restored to the desired value. Such operation of the relay 18 results by virtue of its initial adjustment when with equal pressures in chambers 23 and 24 the tension of spring 29 is made to balance the force produced by the pressure within the chamber 20. Thereafter a change in pressure within the chamber 20 will produce an immediate and proportional change in chamber 24 which will restore the relay to balanced condition. Due however to the seepage of pressure fluid through the connection 30 the balance of forces acting upon the member 28 will be destroyed, thus causing a

further change in pressure within the chamber 24 to restore balance. This operation will continue so long as the pressure within the chamber 20 is other than that corresponding to the desired top tower temperature. Thus it is apparent that the standardizing relay 18 acts to regenerate pressure changes within the chamber 24. The rate at which pressure fluid seeps through the connection 30 is adjusted in accordance with the conditions incident to the particular apparatus to which it is applied, as will be evident to those familiar with the art.

Fluid pressures established within the chamber 24 are transmitted to a chamber 32 of the standardizing relay 19 and are effective for producing proportionate changes in pressure within a chamber 33 in communication with the diaphragm motor 13. The apparatus so far described will act to vary the position of the valve 12 in accordance with changes in top tower temperature and to continuously position the valve at a rate proportional to the deviation of the actual temperature from that desired. Thus upon a change in top tower temperature a corresponding change in the rate of flow of reflux will occur, tending to prevent a further change in top tower temperature in the same direction. Thereafter the rate of flow of reflux will continuously vary at a rate depending upon the adjustment of the bleed connection 30 until the top tower temperature is restored precisely to the desired value.

The rate of flow of reflux through the pipe 10 for a given position of the valve 12 depends upon the differential pressure existing across the valve, which in turn is dependent upon the pressure at the outlet of the pump 9 and the pressure within the tower 1, both of which may vary in operation. Thus it is possible with the control system so far described that notwithstanding that the temperature at the tower top is at the desired value, changes in the rate of flow of reflux to the tower will occur, thereby causing changes in the top tower temperature. Furthermore, the valve 12 may not produce equal changes in the rate of flow of reflux for equal changes in its position throughout its range in movement so that when the valve is near the closed position a change in top tower temperature of one degree, for example, may produce a greater or smaller change in the rate of flow of reflux than will a change in temperature of one degree when the valve 12 is near the wide open position.

A feature of my invention resides in the means I have provided for causing changes in loading pressure established by the pilot 14 to produce predetermined definite quantity changes in the rate of flow of reflux and further in the means I have provided for preventing extraneous changes in the rate of flow of reflux. Referring to Fig. 1 I therein show a meter 34 of the flow of reflux arranged to actuate a pilot valve 35 to establish changes in a loading pressure proportional to changes in the flow of reflux. The loading pressure established by the pilot 35 is transmitted to a chamber 36 of the standardizing relay 19. The arrangement may be such for example that upon an increase in the rate of flow of reflux the loading pressure produced by the pilot 35 increases, thereby causing a proportionate decrease in the pressure within chamber 33 and positioning the valve 12 a corresponding amount toward closed direction to restore the rate of flow of reflux to its former value. The meter 34 and associated control apparatus comprising the relay 19 and valve 12 accordingly acts as a constant flow con-

trol so that regardless of changes in conditions, such as changes in the differential across the valve 12, the rate of flow of reflux will remain constant.

Through the differential action of the relay 19 changes in loading pressure originated by the pilot 14 and standardizing relay 18 in effect determine the rate of flow maintained by the constant flow control. Thus upon a change in pressure within the chamber 32 the relay 19 will act to produce a proportional change in pressure within the chamber 33 causing a change in the rate of flow of reflux until the pressure within chamber 36 indicates that the desired change in rate of reflux flow has been consummated. That the rate of reflux flow will continue to change until the desired change is consummated will be evident from a consideration of the fact that ultimately the sole forces acting to maintain the relay 19 in balanced condition are those acting upon the diaphragm separating the chamber 32 from the chamber 36. With this arrangement, upon a change in pressure within the chamber 32, an immediate and proportionate change in the position of the valve 12 will occur and thereafter the position of the valve 12 will continuously change due to the bleed connection 33A and chamber 33B until the pressure within chamber 36 stands in predetermined relationship to that within the chamber 32. So long as the pressure within the chamber 32 remains constant, possible changes in the rate of flow of reflux due to extraneous causes hereinbefore mentioned are immediately corrected for by the control sensitive to the flow of reflux.

As apparent, changes in the rate of hot oil inflow to the tower 1 change the heat balance of the tower and necessitate corresponding changes in the rate of flow of reflux if the tower top temperature is to be maintained at the desired value. Further, as appreciated by those familiar with the art, considerable lag exists between a change in temperature and the sensing of that change by any thermometric device. For example, in the embodiment of my invention shown in Fig. 1 if the rate of hot oil input changes, the temperature at the tower top may change an appreciable amount for a considerable length of time before that change causes a positioning of the Bourdon spring 15. Such "thermometric lag" is present to a more or less marked degree in any temperature responsive device. By causing the valve 12 to be positioned in accordance with changes in the rate of hot oil input, such changes in temperature may be anticipated, and in Fig. 2 I show a modified form of my invention wherein I utilize changes in the rate of hot oil input to modify the rate of flow of reflux, thereby correcting for such changes before the top tower temperature is affected.

Referring now to Fig. 2, I therein show the input to the tower 1 measured by a meter 40 arranged to actuate a pilot valve 41. The loading pressure established by the pilot valve 41 which, as shown, varies directly with changes in the rate of input is transmitted to a chamber 42 of a relay 43, somewhat similar to the relay 18 but without a bleed connection between chambers 44 and 45, so that no regenerative action therebetween occurs. The loading pressure established by the pilot 14 and relay 18 is transmitted to the chamber 45, whereas the loading pressure established by the pilot 35 is transmitted to a chamber 46.

The servo-motor 13 positioning the valve 12 is therefore positioned in accordance with the

algebraic sum of the pressures established within chambers 42, 45 and 46. As shown, the pressures within chambers 42 and 45 act in the same direction and are counterbalanced by the pressures within chambers 44 and 46. Increases in top tower temperature or increases in the rate of inflow act to increase the pressure within the servo-motor 13, thereby causing the valve 12 to be positioned in an opening direction a proportionate amount. Increases in the rate of flow of reflux act to decrease the pressure within the servo-motor 13, thereby causing a decrease in the rate of flow of reflux. Thus for each sum of the loading pressures within chambers 42 and 45 the flow of reflux will change until the loading pressure established within chamber 44 has changed a proportionate amount. Upon a change in the rate of hot oil input to the tower 1 it will be noted that an immediate and proportionate change in the rate of flow of reflux will occur, thereby maintaining the top tower temperature constant, that is effecting a correction in the rate of flow of reflux before the change in the rate of hot oil input has been reflected by a change in top tower temperature.

In Fig. 3 I show a modified arrangement of relays, which in some instances it may be advantageous to employ over the arrangement shown in Fig. 2. As will be apparent from an inspection of Fig. 2, the force produced by the algebraic sum of the loading pressures established within chambers 42, 45 and 46 is balanced by that established in the chamber 44. Through proper adjustment of the control system, as will be apparent to those skilled in the art, the change in valve position 12 resulting from a given change in loading pressure within the chamber 44 may be made sufficient to maintain the proper relationship between the factors entering into the operation of the control system. However, due to stickiness of the valve stem of the valve 12, or other causes, a given change in loading pressure within the chamber 44 and servo-motor 13 may not always insure a predetermined definite change in the position of the valve 12. The arrangement I have shown in Fig. 3 obviates such a possibility.

Referring now to Fig. 3 I show a relay 50 having a chamber 51 to which the loading pressure established by the pilot 14 and relay 18 is transmitted; and having a chamber 52 to which the loading pressure established by the pilot 41 is transmitted. The pressure established within a chamber 53 is therefore proportional to the sum of the loading pressures established within chambers 51 and 52. The pressure within chamber 53 is transmitted to a chamber 54 of a relay 55. To a chamber 56 of this same relay is brought the loading pressure established by the pilot 35, producing a force, acting in opposite direction to the force produced by the pressure within chamber 54. The relay 55 is provided with a restricted connection 57 between chambers 58 and 59, so that the pressure within chamber 58 will continuously vary until the pressures within chambers 54 and 56 stand in predetermined relationship. Thus upon a change in pressure within the chamber 54 it will be necessary that the flow of reflux change a predetermined amount before the valve 12 will be brought to a stationary position. With this arrangement notwithstanding that stem friction in the valve 12, etc., may momentarily prevent the proper positioning, the pressure within the chamber 58 will continue to vary until sufficient pres-

sure is exerted within the servo-motor 13 to move the valve 12.

In Figs. 4 and 5 I show modified forms of my invention arranged to correct the rate of flow of reflux for changes in the composition of the hot oil input before such changes effect a change in top tower temperature. The amount of reflux necessary to maintain a predetermined top tower temperature is dependent upon the amount of condensation which occurs in the tower 1. Thus assuming that substantially all of the hot oil input is in vapor form, but that the oil is composed for the greater part of heavier constituents, then it is necessary that the rate of reflux be sufficient to absorb the heat of vaporization of such heavier constituents in order that they will condense in the tower. Accordingly, there is therefore a relation between the composition of the hot oil input and the quantity of reflux necessary to obtain proper fractionation.

In the arrangement shown in Fig. 4 I modify the rate of flow of reflux in accordance with the rate of vapor outflow from the tower top, or the rate of liquid outflow from the bottom of the tower. I utilize the arrangement of relays illustrated in Fig. 3 and introduce into a chamber 60 of relay 50 either a loading pressure varying directly with the rate of vapor outflow or inversely as the rate of liquid outflow. Thus I show a meter 61 of the vapor outflow arranged to actuate a pilot valve 62 for establishing a loading pressure varying directly with the rate of vapor outflow. A hand valve 63 is provided, which when open will permit the loading pressure established by the pilot 62 to be introduced in the chamber 60, and when closed will prohibit such admittance.

As the flow of vapor through the line 3 increases, the loading pressure within chamber 60 will increase, thereby causing a proportionate decrease in pressure within the chamber 53, which will serve to position the valve 12 in a closing direction, thereby decreasing the rate of flow of reflux. I preferably decrease the rate of flow of reflux, for assuming that the rate of hot oil input remains constant an increase in vapor outflow is an indication that there has been an increase in the lighter constituents of the oil, thereby decreasing the amount of condensation necessary in the tower 1, and accordingly necessitating a decrease in the rate of flow of reflux.

In some circumstances it may be desirable to employ the rate of liquid outflow as an indication of changes in the constituents of the hot oil input. As an increase in the rate of liquid outflow indicates that there has been an increase in the heavier constituents of the hot oil input requiring a greater flow of reflux, due to the greater heat absorption necessary, an increase in liquid outflow preferably causes an increase in the rate of reflux flow. In Fig. 4 I show a meter 64 of the rate of liquid outflow arranged to actuate a pilot valve 65 to produce a loading pressure varying inversely as the flow. This loading pressure may be introduced into chamber 60 through a hand valve 66. Accordingly, an operator has the possibility of modifying the flow or reflux in accordance with the rate of vapor outflow or liquid outflow. As the pressure established by the pilot 65 varies inversely with changes in liquid outflow the valve 12 will be positioned in direct proportion to changes in liquid outflow, and thereby tend to maintain a direct proportionality between rate of reflux flow and rate of liquid outflow.

In the modification of my invention shown in Fig. 5 I establish a loading pressure varying in proportion to changes in the ratio between vapor and liquid outflow and utilize this loading pressure to produce proportionate changes in the rate of reflux flow. The loading pressure established by the pilot 62 is introduced into a chamber 70 of a relay 71 and that established by the pilot 65 introduced into a chamber 72 of the relay 71. Changes in the difference between these loading pressures are effective for causing a proportionate change in the loading pressure within a chamber 73. Changes in loading pressure within the chamber 73 are transmitted to a chamber 74 of a relay 75.

The relay 75 acts to establish a pressure within a chamber 76 thereof proportional to the algebraic sum of the pressures established within chambers 74, 77, 78 and 79. The pressure within the chamber 77 is that established by the pilot 14 and relay 18 and will vary in accordance with changes in top tower temperature. The pressure established within the chamber 78 varies in accordance with the rate of flow of hot oil input, and that within the chamber 79 in accordance with changes in the rate of reflux flow. The relay 75 provides a means for establishing a definite rate of reflux flow for each relation between the factors of top tower temperature, hot oil input and changes in the ratio between vapor outlet and liquid output.

As explained with reference to Fig. 3 and relay 55 in particular, in order that the valve 12 may be positioned until a predetermined definite rate of reflux flow is established the relay 75 may be provided with a restricted connection 80 between the chambers 76 and a chamber 81, whereby the loading pressure effective within the servo-motor 13 will be varied until the actual flow of reflux agrees with the desired flow as established by temperature, rate of input and the ratio between rate of vapor outflow and liquid outflow.

While I have chosen to illustrate and describe certain embodiments of my invention, it will be apparent that further modifications may be made without departing from its spirit and scope. Accordingly, reference should be made to the appended claims rather than to the description to determine the true scope of the invention.

It will also be understood, that while I have illustrated and described my invention in connection with a fractionating tower and for the processing of a petroleum hydrocarbon, I am not to be limited thereby, as I may readily utilize my invention in connection with other types of towers or apparatus and for the processing of other fluids.

What I claim as new, and desire to secure by Letters Patent of the United States is:

1. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the rate of reflux input to the tower, and means under the joint control of said first two named means for regulating the rate of flow of reflux.

2. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the rate of fluid input to the tower, and means under the joint control

of said first two named means for regulating the rate of flow of reflux.

3. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow or reflux, in combination, means responsive to the tower top temperature, means responsive to the rate of vapor outflow from the tower, and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

4. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the rate of reflux input to the tower, means responsive to the rate of fluid input to the tower, and means under the joint control of said first three named means for regulating the rate of flow of reflux.

5. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the rate of liquid outflow from the tower, and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

6. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the ratio between the rate of vapor outflow from the tower and the rate of liquid outflow from the tower; and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

7. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means responsive to the relation between the instantaneous rates of flow of fluid input, vapor outflow, and liquid outflow; and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

8. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the tower top temperature, means continuously responsive to the relation between the rates of flow of fluid input, vapor outflow, liquid outflow, and reflux; and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

9. In a control system for a fractionating tower, in combination, means for establishing a first fluid pressure in accordance with the rate of flow of reflux to the tower, means for establishing a second fluid pressure in accordance with the temperature of the vapor outflow from the tower, and means under the joint control of said fluid pressures for regulating the rate of flow of reflux to the tower.

10. In a control system for a fractionating tower, in combination, means for establishing a first fluid pressure corresponding to the rate of flow of reflux to the tower, means for establishing a second fluid pressure corresponding to the temperature of the vapor outflow from the tower, means for establishing a third fluid pressure corresponding to the algebraic sum of the first and second fluid pressures, and regulating means of

the rate of flow of reflux actuated by the third fluid pressure.

11. In a control system for a fractionating tower, in combination, means for establishing a first fluid pressure in accordance with the rate of flow of reflux to the tower, means for establishing a second fluid pressure in accordance with the temperature of the outflow vapor from the tower, means under the control of the first fluid pressure to maintain the rate of flow of reflux constant, and means under the control of the second fluid pressure for varying the constant rate of flow of reflux maintained by the first fluid pressure.

12. In a control system for a fractionating tower, in combination, means for producing variations in a first fluid pressure corresponding to changes in the flow of reflux to the tower, means for producing variations in a second fluid pressure corresponding to changes in the temperature of the vapor at the tower top, means for producing immediate changes in a third fluid pressure in accordance with changes in the difference between said first and second fluid pressures and for thereafter producing a continuing change in the third fluid pressure until said difference attains a predetermined value, and regulating means of the rate of flow of reflux under the control of the third fluid pressure.

13. In a control system for a fractionating tower, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the temperature of the vapor at the tower top, means for producing a continuous change in the first fluid pressure corresponding to the deviation of the temperature at the tower top from a desired value, means for producing changes in a second fluid pressure corresponding to changes in the flow of reflux to the tower, means for producing changes in a third fluid pressure corresponding to changes in the difference between the first and second fluid pressures, and means actuated by the third fluid pressure to vary the rate of flow of reflux to maintain the difference between the first and second fluid pressures at a predetermined value.

14. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for varying the rate of flow of reflux and means for regulating said last named means comprising means responsive to the tower top temperature, means responsive to the rate of fluid input to the tower, and means responsive to the rate of flow of reflux.

15. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for establishing a first fluid pressure corresponding to the temperature at the tower top, means for establishing a second fluid pressure in accordance with the rate of fluid input to the tower, means for establishing a third fluid pressure in accordance with the rate of flow of reflux, means for producing a force proportional to the sum of the first and second fluid pressures, means for producing a force proportional to the third fluid pressure, and means responsive to the difference in said forces for varying the rate of flow of reflux to maintain the difference between the forces at a predetermined value.

16. In a control system for maintaining the tower top temperature of a fractionating tower at a predetermined value and wherein the tower

top temperature is regulated by varying the rate of flow of reflux, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the tower top temperature, means for producing a continuous change in the first fluid pressure at a rate corresponding to the difference between the actual and desired tower top temperatures, means for producing changes in a second fluid pressure in accordance with changes in fluid input to the tower, means for producing changes in a third fluid pressure corresponding to changes in the rate of flow of reflux, means for producing changes in a fourth fluid pressure corresponding to changes in the algebraic sum of the first three named fluid pressures, and regulating means of the rate of flow of reflux under the control of the fourth fluid pressure.

17. In a control system for maintaining the tower top temperature of a fractionating tower at a predetermined value and wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the tower top temperature, means for producing a continuous change in the first fluid pressure at a rate corresponding to the difference between the actual and the desired tower top temperatures, means for producing changes in a second fluid pressure in accordance with changes in the rate of vapor outflow from the tower, means for producing changes in a third fluid pressure corresponding to changes in the rate of flow of reflux, means for producing changes in a fourth fluid pressure corresponding to changes in the algebraic sum of the first three named fluid pressures, and regulating means of the rate of flow of reflux under the control of said fourth fluid pressure.

18. In a control system for maintaining the tower top temperature of a fractionating tower at a predetermined value and wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the tower top temperature, means for producing a continuous change in the first fluid pressure at a rate corresponding to the difference between the actual and the desired tower top temperatures, means for producing changes in a second fluid pressure in accordance with changes in the liquid outflow from the tower, means for producing changes in a third fluid pressure corresponding to changes in the rate of flow of reflux, means for producing changes in a fourth fluid pressure corresponding to changes in the algebraic sum of the first three named fluid pressures, and regulating means of the rate of flow of reflux under the control of said fourth fluid pressure.

19. In a control system for maintaining the tower top temperature of a fractionating tower at a predetermined value and wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the tower top temperature, means for producing a continuous change in the first fluid pressure at a rate corresponding to the difference between the actual and desired tower top temperatures, means for producing changes in a second fluid pressure in accordance with changes in the ratio between the rate of vapor and liquid outflow from the tower, means for producing changes in a third

fluid pressure corresponding to changes in the rate of flow of reflux, means for producing changes in a fourth fluid pressure corresponding to changes in the algebraic sum of the first three named fluid pressures, and regulating means of the rate of flow of reflux under the control of said fourth fluid pressure.

20. In a control system for maintaining the tower top temperature of a fractionating tower at a predetermined value and wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for producing immediate changes in a first fluid pressure corresponding to changes in the tower top temperature, means for producing a continuous change in the first fluid pressure at a rate corresponding to the difference between the actual and desired tower top temperatures, means for producing changes in a second fluid pressure in accordance with changes in the ratio between the rates of vapor and liquid outflow from the tower, means for producing changes in a third fluid pressure corresponding to changes in the rate of flow of reflux, means for producing changes in a fourth fluid pressure corresponding to changes in the rate of flow of fluid input, means for producing changes in a fifth fluid pressure corresponding to changes in the algebraic sum of the first four named fluid pressures, and regulating means of the rate of flow of reflux under the control of said fifth fluid pressure.

21. In a control system for a fractionating tower wherein the top tower temperature is regulated by varying the rate of flow of reflux, in combination, means for directly measuring the rate of vapor outflow from the tower, means for directly measuring the rate of liquid outflow from the tower, and means under the joint control of said first two named means for regulating the rate of flow of reflux to the tower.

22. In a control system for a fractionating tower wherein the top tower temperature is regulated by varying the rate of flow of reflux, in combination, means responsive to the rate of vapor outflow from the tower, means responsive to the rate of fluid input to the tower, means responsive to the rate of liquid outflow from the tower, and means under the joint control of said first three named means for regulating the rate of flow of reflux to the tower.

23. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for measuring the tower top temperature, means for measuring the rate of reflux input to the tower, and means under the joint control of said first two named means for regulating the rate of flow of reflux.

24. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for measuring the rate of flow of reflux to the tower, means for measuring the tower top temperature, regulating means under the control of the first named means to maintain the rate of flow of reflux constant, and means under the control of said second named means for varying the constant rate of flow of reflux maintained by the first named means selectively in accordance with variations in the tower top temperature.

25. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combination, means for maintaining a constant rate of

flow of reflux, means for producing immediate changes in the rate of flow of reflux maintained by said first named means selectively in accordance with changes in the tower top temperature, and means for continually changing the rate of flow of reflux maintained by said first named means at a rate proportional to the departure of the tower top temperature from a predetermined value and in sense dependent upon the sense of departure of the tower top temperature from a predetermined value.

26. In a control system for a fractionating tower wherein the tower top temperature is regulated by varying the rate of flow of reflux, in combina-

tion, means for maintaining a constant rate of flow of reflux, means for producing immediate changes in a fluid pressure corresponding to changes in the temperature of the vapor at the top of the tower, means for producing a continuous change in the fluid pressure corresponding to the deviation of said temperature at the tower top from a desired value, and means actuated by said fluid pressure for changing the constant rate of flow of reflux maintained by said first named means selectively in accordance with changes in the fluid pressure.

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