July 20, 1954 D. M. BOYD, JR 2,684,326

FRACTIONATION CONTROL

Original Filed May 11, 1949

FIG. 1

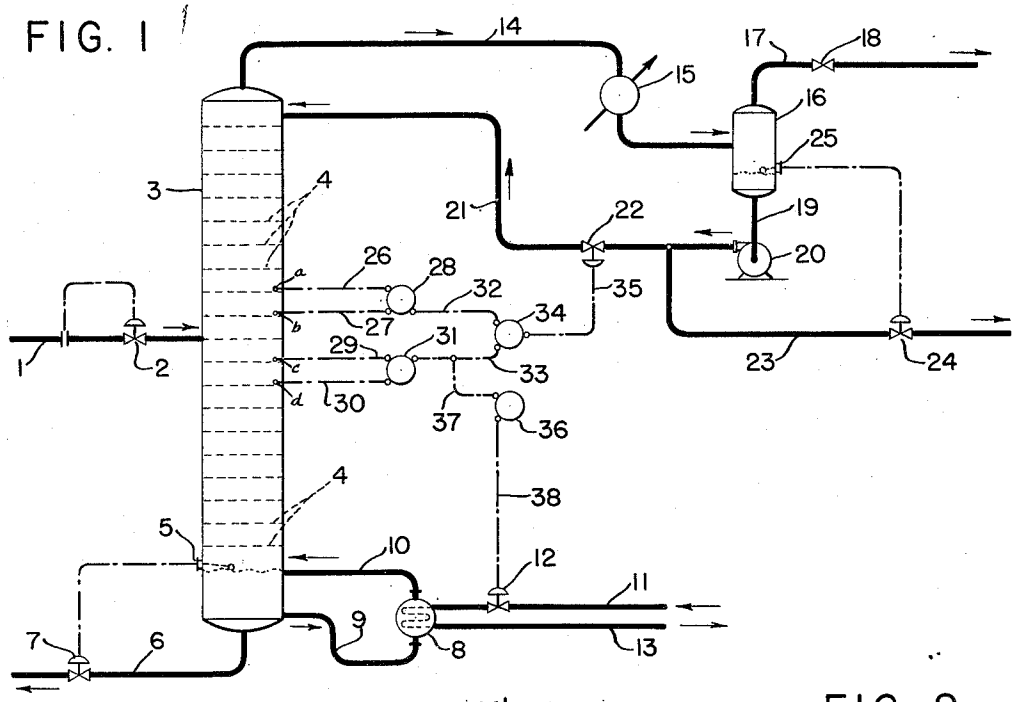
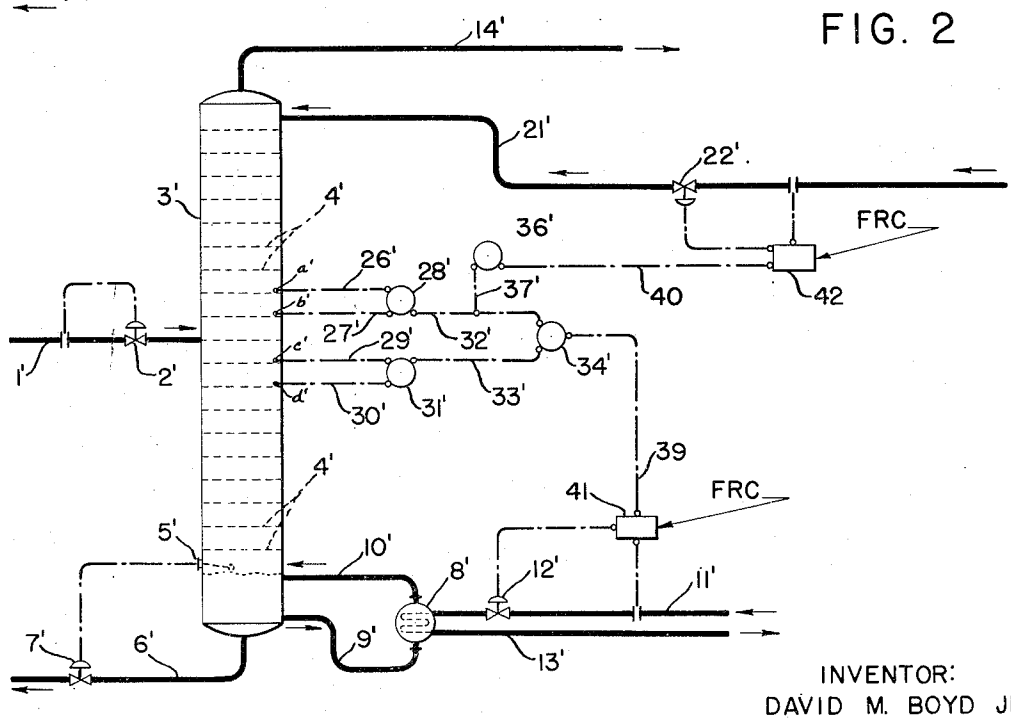


FIG. 2



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FRACTIONATION CONTROL

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7 Claims. (Cl. 202—40)

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This application is a continuation-in-part of my previously filed application, Serial No. 92,559, filed May 11, 1949, now Patent No. 2,580,651, January 1, 1952.

This invention relates to an improved method and means for operating a fractionating column to obtain the maximum separation of components for a given amount of heat consumption. More specifically, the present invention concerns automatic means for maintaining a substantially uniform temperature and composition gradient throughout the height of a fractionating column by the novel combined use of indicating and control means connecting with the column both above and below the feed point thereto and as a result provides improved efficiency from each of the trays of the column.

In a usual fractionating operation, the mixed or multi-component fluid stream is charged to approximately the mid-point of the column, which is a vertically disposed chamber having a plurality of spaced bubble trays or decks, or alternatively, a substantial depth of suitable packing material which will effect a desirable mixing of the counter-currently flowing liquid and vapor streams within the column. Heat is normally supplied to the column by means of a reboiler which connects with the lower portion of the column and to a liquid reservoir maintained therein by means of suitable level control means, while reflux is normally returned to the top of the column in a regulated quantity suitable to permit proper rectification within the upper portion of the column. Also, in present types of continuously operating fractionating column and control systems, a temperature or composition indicating and controlling device is connected to the interior of the column at either the stripping section or the rectification section, and the heat input to the column is regulated by this temperature controller through either varying the heat input at the reboiler, or changing the quantity of reflux returned to the top of the column. Alternatively, a material balance control system is sometimes utilized which provides a flow controller on the bottoms product that varies with changes in the flow rate in the feed stream to the column. Still another control method, is the use of a reference material at a selected control point in the column, whereby the differential between the vapor pressure in the column and that of the reference fluid controls the heat supplied to the fractionating column. Inasmuch as temperature is one means of measuring compositions, either temperature or

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composition measuring means may be utilized to provide an indication of temperature and composition gradient within the column.

While the foregoing methods of controlling fractionating by automatic means are in general satisfactory to effect fractionation and separation of the components of the feed stream, and to provide an overhead product of substantially constant composition, such methods do not necessarily maintain a desirable uniform temperature and composition gradient throughout the length of the column. In the event that the column is operating such as to move too much material overhead, the temperature gradient curve of the column will have a steep vertical rise just above the feed tray, while conversely, the column is operating so as to remove an insufficient amount overhead, the curve will have a steep vertical dip in it just below the feed tray. These vertical slopes in the temperature gradient curve column indicate that the trays in that zone are not operating at their maximum efficiency, and the given tower or column is not providing the maximum separation of the components for a given amount of heat consumption.

It is a principal object of the present improved invention to utilize differential temperature or composition measuring means both above and below the feed point of the column in a manner to measure differences in temperature gradient which may occur during operation, and to effect a control of the heat distribution to both the upper and lower portions of the column, whereby to provide a uniform temperature gradient and a maximum operating efficiency therein.

It is also an object of the present invention to control heat input to both the upper and lower portions of a fractionating column by means of control instruments which in turn connect with and are actuated by spaced temperature indicating means above and below the feed point to the column.

Broadly, the present improved arrangement provides a method and means for operating a fractionating column to effect the separation of a mixed feed stream, wherein at least overhead and bottom components are withdrawn from the column, in a manner which comprises, maintaining a pair of temperature indicating means at vertically spaced points above the level of introducing the feed stream to the column, maintaining a pair of temperature indicating means at vertically spaced points below the feed level to the column, measuring temperature gradient above and below said feed level from said indi-

cating means, measuring the differential between the temperature gradient above the feed level and the temperature gradient below the feed level and regulating the heat input to both the upper and lower portions of said column responsive to both a change in the differential between the temperature gradients and to a change in the gradient of one of said pairs of temperature indicating means.

In a preferred arrangement of the invention, automatic temperature or composition indicating and control means are used within the column as well as exteriorally thereof, such that an automatic indication and comparison of the temperature gradients is made in a continuous manner and so that the heat input to the column may be regulated continuously in a manner providing the desired uniform temperature and gradient throughout the entire length of the column, with a resulting improved efficiency in the separation of the desired components. The comparison controller may be utilized to vary and control the heat distribution to either the upper or lower portions of the column. For example, the controller may connect with the reflux line to the column and thus vary the quantity of cool reflux medium being returned to the upper portion of the column, in which case, an additional control instrument connects with the temperature gradient measuring instrument, which in turn connects with the temperature indicating means within the lower part of the column, and this latter control instrument connects with the reboiler or other heat supplying means connecting with the lower portion of the column. Alternatively, the comparison controller may connect with the heat supply means, or reboiler, at the lower portion of the fractionating column in order to effect a direct change in the heat supply to the lower portion of the column, while the additional control means is provided to connect with a flow control valve in the reflux line and regulate the quantity of cool reflux being returned to the upper portion of the column. This additional controller being connected to and controlled by the temperature differential measuring instrument, which in turn connects directly with the spaced temperature indicating means within the upper portion of the fractionating column.

While the operation of a preferred embodiment of the invention is effected through the use of automatic control instruments, it is not intended to limit the operation to the use of any one particular type of instrument or controller. The temperature or composition indicating means and the temperature differential measuring means may comprise any of the conventional types which are utilized in processing equipment and the output signals from such instruments may be indicated and compared by either electrical or pneumatic means, as utilized by the common types of instruments familiar to those persons who are designers and operators of processing units. In addition to temperature indicating devices, various types of vapor pressure devices or other means of indicating composition, may be utilized.

Reference to the accompanying drawing and the following description thereof will serve to further clarify the operation and the use of apparatus in the present improved fractionation control system, as well as point out additional features and advantages which may be derived therefrom.

Figure 1 of the drawing shows digrammatically a fractionating column which utilizes automatic means for closely controlling the temperature and composition gradient throughout, in accordance with one embodiment of the present invention.

Figure 2 of the drawing shows diagrammatically a fractionating column utilizing an alternative embodiment of the present invention for closely controlling and maintaining a uniform temperature and composition gradient throughout the height of the column.

Referring now to Figure 1 of the drawing, there is shown a feed line 1, having a suitable flow control valve 2, such that a mixed or multiple component feed stream may be introduced into the intermediate portion of the fractionating column 3. The fractionating column 3 is indicated as a vertically disposed column having a plurality of bubble decks or trays 4 at vertically spaced intervals and in a quantity sufficient to provide fractionation and separation of the feed stream. In the present embodiment, it may be assumed that the pressure is maintained substantially constant within the column and that the feed stream is regulated at a substantially constant flow rate by means of an automatic flow control valve 2. A body of liquid is maintained in the lower portion of the column 3 by means of a level controller 5 which in turn regulates the rate of liquid withdrawal from the bottoms outlet line 6, having control valve 7. The net heat input to the column is provided through a reboiler 8, which in turn is connected to the lower portion of the column by means of lines 9 and 10. In this instance, heat is supplied to the reboiler 8 by means of steam or other hot fluid medium passing through line 11 having control valve 12, and being discharged through outlet line 13.

The overhead product stream from the fractionating column 3 is passed by way of line 14 to a condenser 15 and to a condensate receiver 16. Uncondensed vapors and gases are vented through line 17 and control valve 18, while the resulting condensed overhead product stream is withdrawn from the lower end of receiver 16 by way of line 19 and pump 20. A portion of the liquid overhead is returned to the upper end of the column 3 as reflux, through line 21 and flow control valve 22, while the remaining portion of the condensate passes through line 23 and flow control valve 24 to storage, or to other process equipment. The quantity of condensate passing by way of line 23 and valve 24, in this particular embodiment, depends upon the operation of a liquid level controller 25 connecting with receiver 16.

In accordance with the present invention, two temperature measuring devices *a* and *b* are placed at vertically spaced points above the feed inlet to the column such that variations in the temperature gradient above the feed point may be noted and compared. Also, two temperature indicating devices *c* and *d* are placed at vertically spaced points below the feed point of the column such that variations in the temperature gradient below the feed point may be noted and compared. The temperature indicating devices *a* and *b* connect through suitable lines or transmitting means 26 and 27 to a differential temperature measuring instrument 28. Likewise, the temperature measuring or indicating means *c* and *d* connect through suitable lines or transmitting means 29 and 30 to a differential temperature measuring instrument 31. The differential temperature

measuring instruments 28 and 31 in turn transmit changes in temperature gradient above and below the feed level to the column through suitable lines 32 and 33 to a control instrument 34, which in turn is suitable to receive impulses corresponding to changes in temperature gradient and compare them for regulating heat input to the column. In other words, the control instrument 34 operates responsive to comparisons and variations in temperature differential transmitted thereto from the temperature gradient instruments 28 and 31.

In the present embodiment, the control instrument 34 connects by means of a line or transmitting means 35 directly to the flow control valve 22 in the reflux line 21, and thus operates to regulate the quantity of reflux passing to the top of column 3 and vary the heat thereto as is dictated by the changes in temperature gradients above and below the feed point to the column. Alternatively, the control instrument 34 may connect with a pneumatic set flow controller, which in turn would regulate the flow control valve 22. As a means of further controlling the heat input to the column, an additional control instrument 36 connects by means of line 37 with the transmitting line 33 so as to operate responsive to a change in temperature gradient within the lower portion of the fractionating column, and in this instance being indicated by the transmitting indicators c and d and instrument 31. The control instrument 36 in turn connects through line 38 with the flow control valve 12, in the heat supply line 11, so as to regulate the heat input into the lower portion of column 3, through reboiler 8, as dictated by variations in temperature gradient in the lower portion of the column. Here again, the control instrument 36 may connect with a pneumatic set flow controller, which in turn would regulate the flow control valve 12. This additional control instrument insures a closer temperature control on the fractionating column in that it provides temperature control within the lower portion of the column in addition to the overall control of heat distribution of the column as provided by controller 34 and reflux valve 22. For example, the control instrument 36 in the present arrangement would insure that substantially none of the lower boiling product would be carried into the bottom portion of the column and be withdrawn through the bottoms line 6.

It may be further explained and noted that where the differential temperature between points *a* and *b* is small or substantially less than between points *c* and *d*, that the comparison instrument 34, connecting to the valve 22, operates in a manner to open valve 22 and increase the quantity of reflux, to in turn reduce the temperature within the stripping section of the column and provide a reduction in the amount of overhead product being withdrawn. Conversely, where the temperature differential between points *c* and *d* is small or substantially less than between points *a* and *b*, then the comparison and regulating device 34 operates to decrease the quantity of reflux permitting an increase in temperature within the stripping section of the column and cause the production of more overhead from the column. Simultaneously, with the operation of controller 34 to reduce the reflux to the column, the controller 36 operates valve 12 responsive to the temperature differential measuring instrument 31, to increase the heat input to the lower portion of the column and bring back a more uniform temperature gradient in the lower portion thereof, and insure that none of the overhead product stream is permitted to reach the bottom of the column.

Referring now to Figure 2 of the drawing, there is indicated a fractionating column 3', which is similar to that shown in Figure 1 of the drawing, having an intermediate feed point for a mixed or multiple component feed stream entering by way of line 1' and valve 2'. Overhead product is indicated as being withdrawn by way of line 14' and reflux introduced by way of a line 21' having a suitable control valve 22', while bottoms product is withdrawn by way of line 6' having automatically controlled valve 7'. Also in a manner similar to Figure 1 of the drawing, heat is supplied to the lower portion of the column 3' by way of a reboiler 8', which in turn is supplied with heat through line 11' and an automatically controlled valve 12'.

In this instance, two temperature measuring devices *a'* and *b'* are placed at vertically spaced points above the feed inlet to column 3', and two vertically spaced temperature measuring devices *c'* and *d'* are placed below the feed point to the column, such that variations in the temperature gradient both above and below the feed level may be noted and compared to provide a portion of the regulation of the heat distribution to the column. A temperature measuring instrument 28' connects with the temperature sensitive means *a'* and *b'*, while another temperature gradient measuring instrument 31' connects with the temperature sensitive devices *c'* and *d'*. Also in a manner similar to the embodiment of Figure 1, a temperature gradient comparison and control instrument 34' connects with each of the differential temperature measuring instruments 28' and 31'. However, in this alternative embodiment, the controller 34' connects through a line or transmitting means 39 to an instrument 41, such as a pneumatic set flow controller, which in turn connects to the control valve 12' in heat supply line 11'. Thus, the heat input to the column, through reboiler 8', is regulated in direct response to the variations in the temperature gradients in the column, both above and below the feed point thereto, as measured and indicated through the temperature sensitive means *a'*, *b'*, *c'* and *d'*.

An additional controller 36' connects through a line 37' with line 32' and the temperature differential measuring instrument 28', so that it may operate responsively to variations in temperature gradient between points *a'* and *b'* within the upper portion of the fractionation column. The control instrument 36' connects through line 40 with an instrument 42, such as a pneumatic set flow controller, which in turn connects to the control valve 22' in reflux line 21', and may thus vary the quantity of reflux being returned to the top of the column.

In effecting the controlled operation of the fractionating column in accordance with the present alternative embodiment, where the differential temperature between points *a'* and *b'* is small or substantially less than between points *c'* and *d'*, then the comparison instrument 34' operates valve 12' in a manner to reduce the heat input to the reboiler 8' and in turn reduce the temperature within the stripping section of the column to provide a reduction in the amount of overhead product being withdrawn. At the same time controller 36' operates valve 22', responsive

to the temperature differential being indicated by instrument 28', and the quantity of reflux to the column through line 21' is increased to lower the temperature within the upper portion of the column.

Conversely, where the temperature differential between points c' and d' is small or substantially less than between points a' and b', then the comparison instrument 34' operates valve 12' to increase the heat input to the reboiler 8' and to the lower portion of the column, while at the same time controller 36' acting responsive to the temperature differential between points a' and b' and to the temperature differential instrument 28', operates valve 22' to decrease the quantity of reflux being returned to the top of the column, and thus permit an increase in temperature within that portion of the column.

It is generally agreed that single point temperature measuring devices or single control point instruments and their accompanying control systems, as used in many fractionating columns, do not avoid in any direct manner the steep vertical slopes in the temperature gradient curves and as a result do not control composition above and below the feed tray, as is accomplished by the present method of operation. By controlling temperature gradient in a close manner both above and below the feed level, as accomplished by the present embodiments, the trays above and below the feed point are maintained at a high operating efficiency and as a result there is a maximum amount of separation of components in the feed stream for a given amount of input to the column.

It may again be pointed out that it is not intended to limit the present improved operation to the use of any one type of control instrument or instruments, for any of the suitable and customary types of electrical or air-controlled instruments that measure temperature or composition differences, and will provide regulation and control in accordance with differential gradients may be used within the scope of the invention. Further, it is not intended to limit the spacing or positioning of the temperature or composition sensitive devices at the points above and below the feed level, for obviously, such points are preferably located so that they will provide a measure of temperature and composition gradient in the critical portions of the column above and below the feed level. This spacing will vary in accordance with the size of the column, as well as with the type of mixture which is fractionated therein.

I claim as my invention:

1. In the fractionation of a mixed feed stream within a fractionating column wherein at least overhead and bottom components are withdrawn, the improved method of obtaining a substantially uniform temperature and composition gradient throughout the column which comprises, maintaining a pair of temperature indicating means at vertically spaced points above the level of introducing said feed stream to the column, maintaining a pair of temperature indicating means at vertically spaced points below said feed level to the column, measuring temperature gradient above and below said feed level from said indicating means, measuring the differential between the temperature gradient above the feed level and the temperature gradient below the feed level, regulating the heat input to one end of said column responsive to changes in said differential between said temperature gradients and regulating the heat input to the other end of the column responsive to the change in the gradient of one of said pairs of temperature indicating means.

2. In the fractionation of a mixed feed stream within a fractionating column wherein at least overhead and bottom components are withdrawn, the improved method of obtaining a substantially uniform temperature and composition gradient throughout the column which comprises, maintaining a pair of temperature indicating means at vertically spaced points above the level of introducing said feed stream to the column, maintaining a pair of temperature indicating means at vertically spaced points below said feed level to the column, measuring temperature gradient above and below said feed level directly from said indicating means, measuring the differential between the temperature gradient above the feed level and the temperature gradient below the feed level and regulating the heat distribution to the upper portion of said column responsive to changes in said differential between said temperature gradients while simultaneously regulating the heat input to the lower portion of said column responsive to a change in temperature gradient below said feed level measured by said lower pair of temperature indicating means.

3. The method of claim 2 further characterized in that the differential between the temperature gradients above and below the feed level regulates the quantity of reflux material returned to the upper portion of said column as the means for regulating the heat distribution thereto.

4. In the fractionation of a mixed feed stream within a fractionating column wherein at least overhead and bottom components are withdrawn, the improved method of obtaining a substantially uniform temperature and composition gradient throughout the column which comprises, maintaining a pair of temperature indicating means at vertically spaced points above the level of introducing said feed stream to the column, maintaining a pair of temperature indicating means at vertically spaced points below said feed level to the column, measuring temperature gradient above and below said feed level directly from said indicating means, measuring the differential between the temperature gradient above the feed level and the temperature gradient below the feed level and regulating the heat input to the lower portion of said column responsive to changes in the differential between said temperature indicators while simultaneously regulating the quantity or reflux material returned to the upper portion of said column responsive to a change in temperature gradient above said feed level and measured by said upper pair of temperature indicating means.

5. In a fractionating column having a feed inlet at an intermediate point in the height thereof, the combination of a pair of temperature indicators at vertically spaced points above said inlet, a pair of temperature indicators at vertically spaced points below said inlet, a temperature gradient measuring device connected to each of said pairs of temperature indicators, means co-acting with said devices for regulating the heat distribution to one end of said column in response to the differential between the temperature gradient above said inlet and the temperature gradient below said inlet, and additional means co-acting with one of said devices regulating the heat distribution to the other end of said column in response to a variation in tem-

perature gradient therein and indicated by the pair of temperature indicators in that portion of the column.

6. In a fracitionating column having a feed inlet at an intermediate point in the height thereof, the combination of a pair of temperature indicators at vertically spaced points above said inlet, a pair of temperature indicators at vertically spaced points below said inlet, a temperature gradient measuring device connected to each of said pairs of temperature indicators, means co-acting with said devices for regulating the supply of heat to the upper portion of the column in response to the differential between the temperature gradient above said inlet and the temperature gradient below said inlet, and additional means co-acting with said device connecting to the pair of temperature indicators at spaced points below said inlet controlling the heat input to the lower portion of said column.

7. In a fractionating column having a feed inlet at an intermediate point in the height thereof, the combination of a pair of temperature indicators at vertically spaced points above said inlet, a pair of temperature indicators at vertically spaced points below said inlet, a temperature gradient measuring device connected with

each of said pairs of temperature indicators, means co-acting with said devices for regulating the supply of heat to the lower portion of said column in response to the differential between the temperature gradient above said inlet and the temperature gradient below said inlet, and additional means co-acting with said device connecting to said spaced pair of temperature indicators above said inlet controlling the quantity of reflux returned to the upper portion of said column.

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