

Oct. 3, 1961

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3,002,818

PROCESS CONTROL SYSTEM

Filed Nov. 28, 1956

2 Sheets-Sheet 1

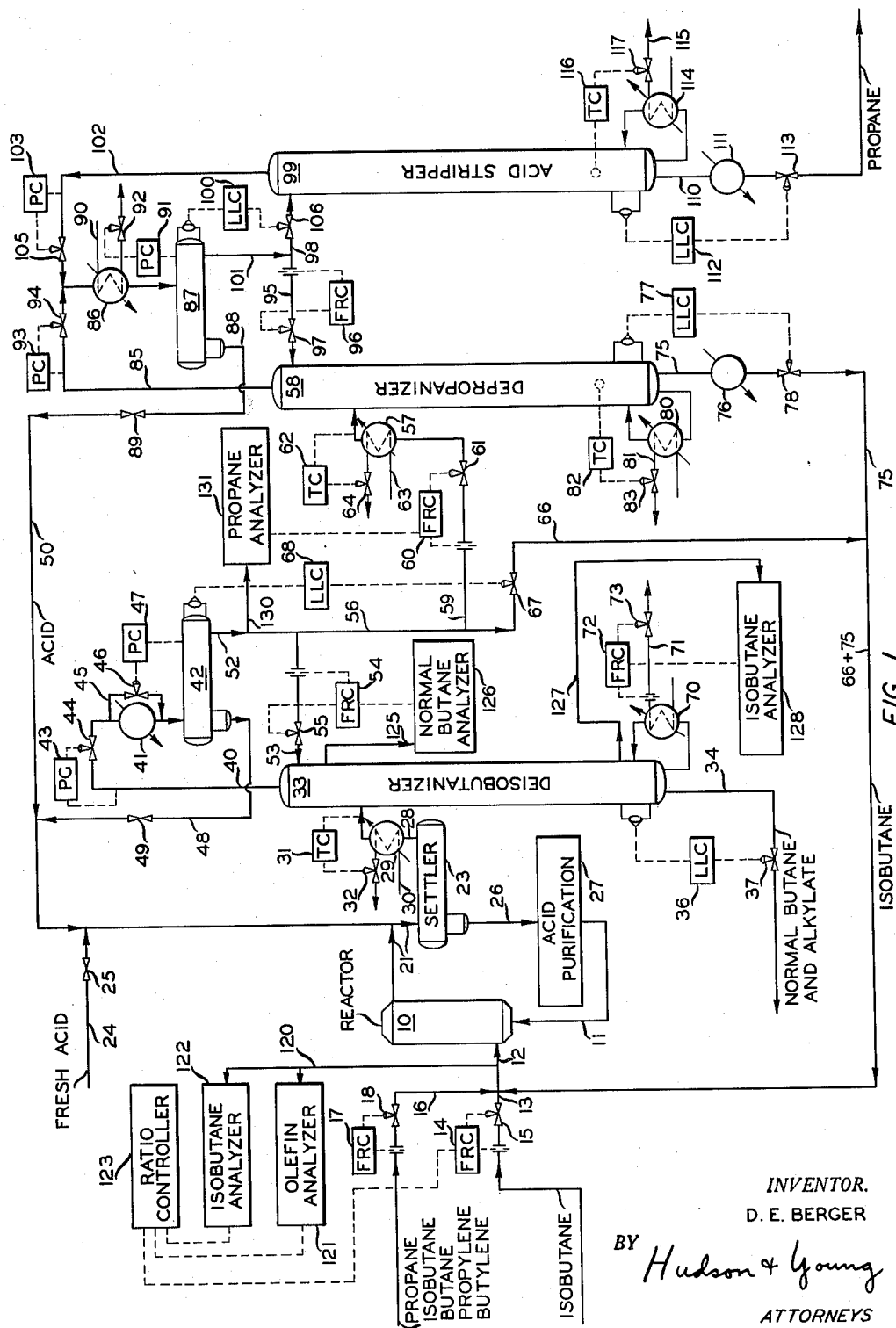


FIG. 1

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2 Sheets-Sheet 2

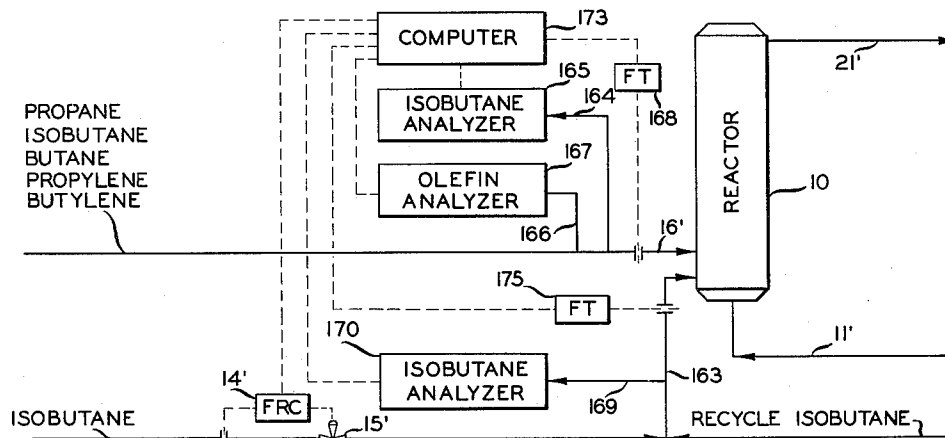


FIG. 3

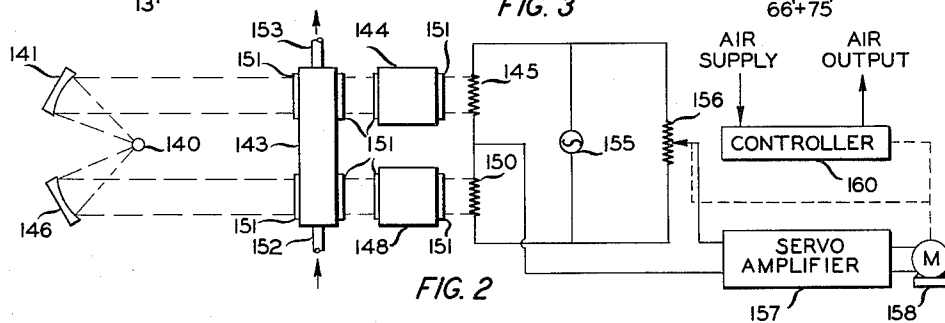


FIG. 2

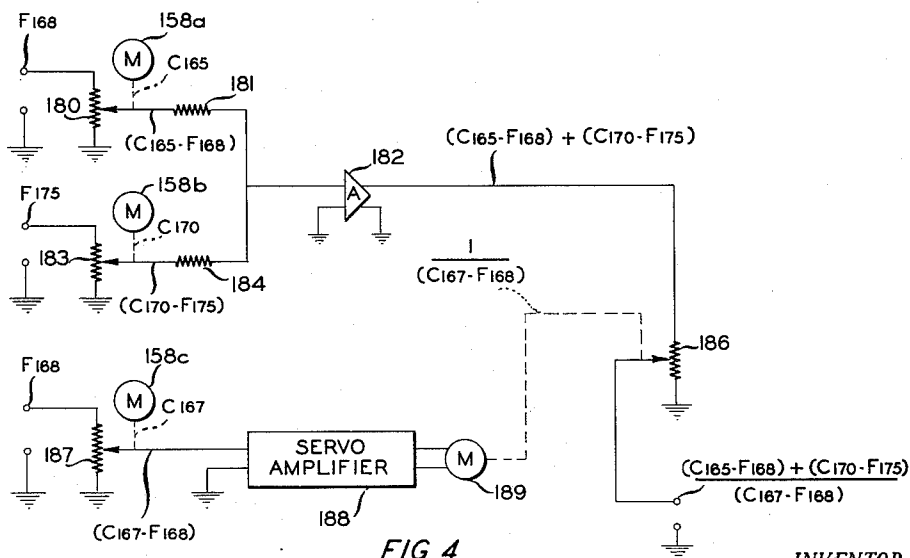


FIG. 4

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3,002,818

PROCESS CONTROL SYSTEM

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12 Claims. (Cl. 23-253)

This invention relates to an improved control system for alkylation processes. In another aspect, it relates to an improved control system for a fractionation column.

The demand for large volumes of high quality gasolines has brought about the development and commercialization of a number of processes for the conversion of non-gasoline range hydrocarbons into high octane blending stocks. One of these processes, the alkylation of light olefins, such as propylene and butylenes, with isobutane, using liquid hydrofluoric acid as the catalyst, has proved to be particularly effective in producing alkylates for aviation and motor fuel blending. As the result of considerable operational experience, this process has now been developed to such an extent that a commercial plant can be controlled by two men per shift to obtain desired product quality with safety. However, a substantial expenditure of laboratory and process engineering time still is required to coordinate the operations and to manipulate the process variables toward the economic optimum.

In accordance with the present invention, an improved control system for such an alkylation process is provided. The combined feed stream to the reactor, which comprises paraffin and olefin hydrocarbons, is analyzed to determine the ratio of isoparaffins to olefins. A ratio controller is provided to adjust the flow of one or more of the feed streams in response to the analysis ratio so that the isoparaffins and olefins supplied to the reactor can be maintained at a desired ratio to obtain optimum economic operation. In accordance with another aspect of this invention, an improved control system for a fractionation column is provided. This control is based upon analyses of sample streams removed from both the upper and lower regions of the column. The heat and material balances of the column are adjusted in response to these analyses so as to provide two output product streams of desired composition. The alkylation process is also controlled in accordance with this invention to limit the amount of non-reactive constituents, such as propane and normal butane in the system.

Accordingly, it is an object of this invention to provide an improved control system for an alkylation process.

Another object is to provide a control system to adjust ratio of isoparaffins to olefins supplied to an alkylation reactor.

A further object is to provide a control system for a fractionation column which operates to provide two product streams of desired compositions.

Other objects, advantages, and features of this invention should become apparent from the following detailed description which is taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a schematic representation of a hydrofluoric acid alkylation process having the control system of this invention incorporated therein.

FIGURE 2 is a schematic representation of an infrared analyzer which can be employed in the control system of FIGURE 1.

FIGURE 3 is a schematic representation of a second embodiment of the control system which regulates the ratio of isoparaffins to olefins supplied to the alkylation reactor.

FIGURE 4 is a schematic representation of a computer which can be employed in the control system of FIGURE 3.

Referring to the drawing in detail and to FIGURE 1

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in particular, there is shown an alkylation reactor 10 which has an inlet conduit 11 communicating therewith to supply liquid hydrofluoric acid. A hydrocarbon feed stream is introduced into reactor 10 through a conduit 12. An isobutane feed stream is supplied to inlet conduit 12 through a conduit 13. The flow through conduit 13 is regulated by a rate-of-flow controller 14 which adjusts a valve 15. An olefin feed stream, which can be a mixture of propylene and butylenes, for example, is supplied to conduit 12 through a conduit 16. The flow through conduit 16 is regulated by a rate-of-flow controller 17 which adjusts a valve 18. The alkylation reaction is completed in reactor 10 by intimately contacting the hydrocarbons with the hydrofluoric acid catalyst. The hydrofluoric acid-hydrocarbon mixture is removed from reactor 10 through a conduit 21 which communicates with a settler 23. The acid phase in settler 23 is withdrawn through a conduit 26 which communicates with an acid purification unit 27. All, or a part, of this acid is purified in unit 27 by distilling the acid from water and acid soluble oils. The ratio of acid to hydrocarbons supplied to reactor 10 is generally controlled at a selected level between approximately 0.2:1 to 1:1, parts by weight.

The hydrocarbon phase, which contains some soluble hydrofluoric acid, is removed from settler 23 through a conduit 28 which communicates with the inlet of a fractionation column 33 that is operated as a deisobutanizer. Conduit 28 passes through a heat exchanger 29. A heating medium is circulated through exchanger 29 by means of a conduit 30. The flow of heating material through conduit 30 is regulated by a temperature controller 31 which adjusts a valve 32 in response to a measurement of the temperature of the fluid entering column 33. This insures that the feed stream is supplied to column 33 at substantially a constant temperature.

Column 33 is operated so as to separate the isobutane and lighter components from normal butane and the alkylate product. The normal butane and alkylate product are withdrawn as a kettle product from column 33 through a conduit 34. The rate of withdrawal of kettle product is regulated by a liquid level controller 36 which adjusts a valve 37 so as to maintain a constant liquid level in column 33. Column 33 is provided with a reboiler 70. A heating medium is circulated through reboiler 70 by means of a conduit 71 which is provided with a rate-of-flow controller 72 that adjusts a valve 73. The isobutane and lighter hydrocarbon components and soluble hydrofluoric acid are removed from the top of column 33 through a conduit 40 which communicates with an accumulator 42 through a condenser 41. The flow through conduit 40 is controlled by means of a pressure controller 43 which adjusts a valve 44. A by-pass conduit 45 is provided around condenser 41. A pressure controller 47 adjusts a valve 46 in conduit 45 to regulate the amount of material condensed and cooled in order to maintain a predetermined pressure in accumulator 42.

Hydrofluoric acid which settles out in accumulator 42 can be returned to the reactor system through a conduit 48 which communicates with a conduit 50, the latter communicating with conduit 21. Conduit 48 is provided with a valve 49 so that the return of acid can be adjusted. The condensed hydrocarbons in accumulator 42 are withdrawn through a conduit 52. A portion of these condensed hydrocarbons is returned to column 33 as reflux through a conduit 53. The flow through conduit 53 is regulated by a rate-of-flow controller 54 which adjusts a valve 55. The remainder of the condensed hydrocarbons withdrawn from accumulator 42 is directed through a conduit 56. A portion of this material is directed through a conduit 59 to a second fractionation column 58 which is operated as a depropanizer. The flow through conduit 59

is regulated by a rate-of-flow controller 60 which adjusts a valve 61. A heater 57 is provided in conduit 59. Heat is supplied to heater 57 by means of a conduit 63 and at a rate which is regulated by a temperature controller 62 which adjusts a valve 64. Temperature controller 62 responds to the temperature of the fluid passed through conduit 59 so that the feed to column 53 is maintained at a constant temperature.

The major portion of the overhead product from column 33 is returned to reactor 10 through conduits 66, 75, and 12. The rate of flow through conduit 66 is adjusted by a liquid level controller 68 which regulates a valve 67 to maintain a constant liquid level in accumulator 42.

Column 58 is operated so as to separate propane and any hydrofluoric acid which remains in the system from the unreacted isobutane. A kettle product stream, which comprises principally the unreacted isobutane, is removed from column 58 through a conduit 75 which communicates with conduit 12. A cooler 76 is provided in conduit 75 to cool the isobutane that is recycled to reactor 10. The flow through conduit 75 is adjusted by a liquid level controller 77 which adjusts a valve 78 in conduit 75 in response to the liquid level in column 58. Column 58 is provided with a reboiler 80. A heating medium is circulated through reboiler 80 by a conduit 81 at a rate which is regulated by a temperature controller 82 which adjusts a valve 83 in response to the temperature in the lower region of column 58. The overhead stream from column 58 is removed through a conduit 85 which communicates with an accumulator 87 through a condenser 86. A pressure controller 93 regulates a valve 94 in conduit 85 so as to maintain a predetermined pressure in column 58. Coolant is circulated through condenser 86 by means of a conduit 90. The flow through conduit 90 is regulated by a pressure controller 91 that adjusts a valve 92 to maintain a predetermined pressure in accumulator 87. Any acid which may settle out in accumulator 87 can be returned to the reactor system through conduit 88. A valve 89 is provided in conduit 88 to permit adjustment of the rate acid is returned to settler 23. The condensed hydrocarbon liquid in accumulator 87 is removed through a conduit 101. A portion of this condensed liquid is returned to column 53 as reflux through a conduit 95. The flow through conduit 95 is regulated by a rate-of-flow controller 96 which adjusts a valve 97. The remainder of the liquid removed from accumulator 87 is directed through a conduit 98 to an acid stripper 99. The rate of flow through conduit 98 is adjusted by a liquid level controller 100 which regulates a valve 106 in conduit 98 so as to maintain a constant liquid level in accumulator 87.

Heat is supplied to the lower region of stripper 99 by means of a reboiler 114. A heating medium is circulated through reboiler 114 by means of a conduit 115. A temperature controller 116, which is responsive to the temperature in the lower region of stripper 99, regulates a valve 117 in conduit 115. Any hydrofluoric acid which is introduced into stripper 99 is vaporized and removed through a conduit 102 which communicates with accumulator 87. A predetermined pressure is maintained in stripper 99 by means of a pressure controller 103 which adjusts a valve 105 in conduit 102. Propane is withdrawn as the kettle product from stripper 99 through a conduit 110 which has a cooler 111 therein. The rate of withdrawal of propane through conduit 110 is adjusted by a liquid level controller 112 which regulates a valve 113 so as to maintain a constant liquid level in stripper 99.

Since the alkylation reaction is a chemical combination of one molecule of isobutane with each molecule of olefin fed into the system, sufficient fresh isobutane must be added to match this consumption and fractionation losses. Also, for the purpose of operating the unit so as to produce a maximum amount of high quality product, a

considerable volume of isobutane is recycled within the unit so that at the reactor inlet the volume ratio of isobutane to total olefins is maintained at a predetermined ratio. This ratio is of the order of 4-6 to 1 for the maximum economic production of motor fuel constituents, although this ratio varies with different operations. The control system of the present invention is provided to maintain this ratio at a desired value. To this end, a sample of the feed stream 12 to reactor 10 is removed through a sample conduit 120 which communicates with an olefin analyzer 121 and an isobutane analyzer 122. Analyzer 121 provides a first output signal which is representative of the concentration of olefins supplied to reactor 10. Analyzer 122 provides a second output signal which is representative of the concentration of isobutane supplied to reactor 10. These two output signals are applied as the respective inputs to a ratio controller 123. Ratio controller 123 provides an output signal which resets one of the flow controllers 14 or 17. In this manner, the ratio of isobutane to olefins supplied to reactor 10 through conduit 12 is adjusted as necessary to maintain a predetermined ratio. This control can conveniently be made by regulating the isobutane flow through conduit 13. Controller 123 can be any conventional commercially available instrument which provides an output signal that is a function of the ratio of the two input signals applied thereto, such as, for example, the instrument described in Catalog 20-1 (1945) of the Brown Instrument Company, Philadelphia, Pa. This controller can conveniently operate by pneumatic pressure, for example. By means of this control system, the ratio of isobutane to total olefins supplied to reactor 10 is maintained at a desired value which results in the optimum economic production of motor fuel alkylates.

The operation of column 33 is controlled in accordance with this invention in order to maintain the desired separation between normal butane and isobutane. To this end, a first sample stream is removed from the upper region of column 33 through a conduit 125 which communicates with the inlet of a normal butane analyzer 126. A second sample stream is withdrawn from a lower region of column 33 through a conduit 127 which communicates with an isobutane analyzer 128. Analyzer 126 provides an output signal which is employed to reset rate-of-flow controller 54 on reflux conduit 53. Analyzer 128 provides an output signal which is employed to reset rate-of-flow controller 72 which regulates the amount of heating medium supplied to reboiler 70. The concentration of normal butane in the sample stream removed through conduit 125 normally is quite small because column 33 is operated to remove the normal butane through conduit 34. Analyzer 126 provides an output signal which is representative of this concentration. If normal butane concentration should exceed a predetermined value, for example, rate-of-flow controller 54 is reset so as to open valve 55 further to increase the reflux rate. This serves to decrease the amount of normal butane in the upper region of column 33. Similarly, it is desired that the kettle product contain a minimum amount of isobutane. Analyzer 128 provides an output signal which is representative of the isobutane concentration of the lower region of column 33. If the measured isobutane concentration should increase above a preselected value, for example, analyzer 128 resets rate-of-flow controller 72 so as to open valve 73 further. This increases the amount of heat supplied to reboiler 70 so as to vaporize more of the liquid in column 33, which results in a greater amount of isobutane being removed as overhead product. It should thus be evident that the two analyzers 126 and 128 cooperate with one another in a manner so as to accomplish an efficient separation between the normal butane and isobutane in column 33.

For satisfactory operation of the alkylation unit, propane must be removed from the system at the same rate it may be fed into the system by the inlet feed streams.

A sample conduit 130 communicates between conduit 56 and the inlet of a propane analyzer 131. This analyzer provides an output signal which is representative of the propane concentration in the stream directed through conduit 56. The output signal of analyzer 131 resets rate-of-flow controller 60 so as to regulate the flow rate through conduit 59. If the measured propane concentration should increase, for example, rate-of-flow controller 60 is reset to open valve 61 further. This allows additional propane and isobutane to be directed to columns 58 and 99. The propane is eventually removed from the system as the kettle product from stripper 99. In this manner, a build-up of propane in the alkylation unit is prevented.

The five analyzers employed in the control system of FIGURE 1 can advantageously be infrared analyzers. A suitable analyzer of this type is illustrated schematically in FIGURE 2. A first beam of radiation from an infrared source 140 is directed by means of a reflector 141 through a sample cell 143 and a filter cell 144 to impinge upon a first temperature sensitive electrical resistance element 145. A second beam of radiation from source 140 is directed by a reflector 146 through sample cell 143 and a filter cell 148 to impinge upon a second temperature sensitive electrical resistance element 150. Cells 143, 144, and 148 are provided with windows 151 that are transparent to the infrared radiation in the region of interest. These windows can be formed of quartz, for example. The sample stream to be analyzed is introduced into cell 143 by means of an inlet conduit 152 and is removed through a vent conduit 153. A voltage source 155 is connected across resistance elements 145 and 150 which are connected in series relationship. The end terminals of a potentiometer 156 are connected to the respective terminals of voltage source 155. The junction between resistances 145 and 150, and the contactor of potentiometer 156 are connected to the respective input terminals of a servo amplifier 157. The output of amplifier 157 is connected to a reversible servo motor 158. The drive shaft of motor 158 is connected to the contactor of potentiometer 156 and to the input of a controller 160. Motor 158 can adjust a flapper valve in controller 160 to establish a pneumatic pressure representative of the motor rotation.

It should be evident that the illustrated electrical circuit comprises a modified form of alternating current Wheatstone bridge. Any electrical unbalance of the bridge is amplified by amplifier 157 which drives motor 158 in a direction to move the contactor of potentiometer 156 until the bridge is again in a balanced condition. The analyzer operates in a manner well known to those skilled in the art. For example, if the analyzer of FIGURE 2 is to be employed to detect isobutane in sample streams 120 and 127, cell 144 can be filled with a pure sample of isobutane. Cell 148 can be filled with air or other non-absorbing gas or normal butane. The purpose of cell 148 is to compensate for the radiation absorbed by the windows of filter cell 144 and absorption due to other components. The wave lengths of radiation which are absorbed by isobutane are removed from the radiation beam which is directed through filter cell 144. The amount of radiation transmitted through cell 148 and which impinges upon element 150 is a function of the isobutane concentration in sample cell 143. Any change in this concentration changes the ratio of the amounts of radiation impinging upon elements 145 and 150. Such a change in the electrical resistances of these elements changes the electrical unbalance of the bridge network. The amount of rotation of motor 158 which is needed to restore a balanced condition in the bridge is thus representative of the change in isobutane concentration in sample cell 143. The rotation of motor 158 is applied to controller 160. If controller 160 is a pneumatic instrument, for example, the drive shaft of motor 158 can be connected through suitable mechanical linkages to regulate a flapper valve in controller 160 to adjust the output air pressure. A telemetering potentiometer can

be employed if it is desired to utilize an electrical controller. In any event, controller 160 provides an output signal which is representative of the concentration of isobutane in the sample cell.

When the analyzer in FIGURE 2 is employed as analyzer 126 of FIGURE 1, normal butane is positioned in filter cell 144. Similarly, an olefin or a mixture of olefins to be detected is positioned in filter cell 144 when the analyzer is employed as instrument 121 of FIGURE 1 to measure the concentration of olefins. Sample cell 144 can be filled with propane when the instrument of FIGURE 2 is employed at analyzer 131 of FIGURE 1.

In FIGURE 3 there is shown a second embodiment of the control system of this invention which is particularly useful if it is desired that the feed streams not be combined prior to their introduction into the alkylation reactor. In the system of FIGURE 3, the recycle isobutane conduit 66+73 and the fresh isobutane conduit 13' are connected to a common inlet conduit 163 of reactor 10. The olefins are introduced into reactor 10 through a conduit 16'. Sample conduits 164 and 166 communicate between inlet conduit 16' and the inlets of an isobutane analyzer 165 and an olefin analyzer 167, respectively. A third sample conduit 169 communicates between conduit 163 and the inlet of an isobutane analyzer 170. Isobutane analyzer 165 is provided because there are moderate amounts of isobutane in the olefin feed stream. The output signals of analyzers 165, 167, and 170, which represent the concentrations of isobutane, olefins, and isobutane, respectively, are applied to the inputs of a computer network 173. A flow transmitter 168 provides a fourth input signal to computer 173 which is representative of the flow rate through conduit 16'. A second flow transmitter 175 provides a fifth input signal to computer 173 which is representative of the flow rate through conduit 163. The computer 173, which can be an analogue or a digital computer, provides an output signal which is representative of the ratio by volume of the isobutane to total olefins supplied to reactor 10. This computer effectively solves the following equation and provides an output signal representative thereof:

$$\frac{\text{Volume of isobutane}}{\text{Volume of olefins}} = \frac{(C_{165} \cdot F_{168}) + (C_{170} \cdot F_{175})}{(C_{167} \cdot F_{168})}$$

where C_{165} is the isobutane concentration measured by analyzer 165, C_{170} is the isobutane concentration measured by analyzer 170, C_{167} is the olefins concentration measured by analyzer 167, F_{168} is the rate of flow through conduit 16', and F_{175} is the rate of flow through conduit 163. In this manner, the desired volumetric ratio between isobutane and olefins to reactor 10 is maintained by controller 14' being reset by the output signal of computer 173.

A computer 173 which can be employed in the control system of FIGURE 3 is illustrated schematically in FIGURE 4. Flow indicators 168 and 175 of FIGURE 3 provide electrical output signals representative of the respective measured flows. These input voltages F_{168} and F_{175} are applied to the illustrated input terminals of FIGURE 4. The upper terminal F_{168} is connected to ground through a potentiometer 180. The contactor of potentiometer 180 is connected through a high value isolating resistor 181 to the input of a summing amplifier 182. Terminal F_{175} is connected to ground through a potentiometer 183. The contactor of potentiometer 183 is connected through a high value isolating resistor 184 to the input of summing amplifier 182. The contactors of potentiometers 180 and 183 are adjusted by motors 158a and 158b, respectively, which represent the motors 158 of analyzers 165 and 170, respectively. The motors are connected to the contactors of the potentiometers so as to move upwardly if the analyzer outputs increase and downwardly if the analyzer outputs decrease, thereby to perform the indicated multiplications. The output of amplifier 182 is connected to ground through

a potentiometer 186. The second terminal F_{168} is connected to ground through a potentiometer 187. The contactor of potentiometer 187 is connected to the input of a servo amplifier 188 which energizes a reversible servo motor 189. Amplifier 188 can be a conventional instrument which compares the input voltage with a reference voltage, converts the difference to a corresponding A.C. signal, and provides an output signal of phase representative of the input signal being greater or less than a reference value. Such an amplifier is described in detail in *Electronic Control Handbook*, Batcher and Moulic, 1946, page 298. The contactor of potentiometer 187 is adjusted by a motor 189c which represents the output of analyzer 167. Motor 189 is set to move the contactor of potentiometer 186 in a direction to divide the voltage across the potentiometer by the input voltage to amplifier 188. Thus, if the input voltage to amplifier 188 increases, the contactor of potentiometer 186 is moved downwardly to decrease the quotient voltage at the contactor of potentiometer 186. The magnitudes of the various voltages are calibrated to provide the indicated output signal. This signal resets controller 14'.

As a specific example of this invention, reactor 10 is operated at 90° F. and at a sufficient pressure to maintain a liquid state. The ratio of isobutane to olefins supplied to reactor 10, based on parts by weight, is six to one. Hydrofluoric acid of 92 weight per cent purity is employed as the catalyst. This acid is supplied to reactor 10 at a ratio of one-half to one, based on catalyst to hydrocarbon parts by weight. Column 33 is operated at 160 p.s.i.g., 165° F. top temperature, 280° F. bottom temperature, and a reflux to feed ratio of two to one. Column 58 is operated at 285 p.s.i.g., there being a pump, not shown, between columns 33 and 58, 140° F. top temperature, and 220° F. bottom temperature. The compositions and flow rates through the several conduits are as follows:

	Conduit						
	16	13	23	34	56	110	60+75
Propylene.....	2,021						
Propane.....	971	54	1,559		1,559	1,025	544
Butylenes.....	2,363						
Isobutane.....	1,496	3,028	17,536	120	17,416	20	17,396
Normal Butane.....	2,341	166	4,007	2,447	1,560		1,560
Alkylate.....			7,460	7,460			

The above figures are in barrels per day, based on condensed liquids

From the foregoing it should be evident that there is provided in accordance with this invention an improved control system for an alkylation unit. By controlling the ratio of reactants fed to the alkylation reactor, it is possible to operate the unit in an automatic manner so as to provide a maximum amount of desired product. While the invention has been described in conjunction with a particular reaction of isobutane with light olefins, it should be evident that it is not limited to this specific reaction. Also, the fractionation column control system is adaptable to any system wherein it is desired to separate a fluid mixture into two or more product streams of desired composition.

While the invention has been described in conjunction with a present preferred embodiment, it should be evident that it is not limited thereto.

What is claimed is:

1. In an alkylation unit wherein a mixture of olefins and isoparaffins is contacted by a catalyst in a reactor; a control system to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor comprising first conduit means communicating with said reactor to supply olefins, second conduit means communicating with said reactor to supply isoparaffins, first analyzing means to measure the flow of olefins by detecting the concentration of olefins supplied through

said first conduit means, second analyzing means to measure the flow of isoparaffins by detecting the concentration of isoparaffins supplied through said second conduit means, and means responsive to said first and second analyzing means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

2. In an alkylation unit wherein a mixture of olefins and isoparaffins is contacted by a catalyst in a reactor; a control system to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor comprising a first conduit communicating with said reactor to introduce the hydrocarbon feed mixture, first conduit means communicating with said first conduit to supply olefins, second conduit means communicating with said first conduit to supply isoparaffins, first analyzing means to measure the flow of olefins by detecting the concentration of olefins supplied through said first conduit, second analyzing means to measure the flow of isoparaffins by detecting the concentration of isoparaffins supplied through said first conduit, and means responsive to said first and second analyzing means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

3. In an alkylation unit wherein a mixture of olefins and isoparaffins is contacted by a catalyst in a reactor, and wherein at least a portion of the unreacted isoparaffins is separated from the reactor effluent and recycled to the reactor; a control system to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor comprising an inlet conduit communicating with said reactor, first conduit means communicating with said inlet conduit to supply olefins, second conduit means communicating with said inlet conduit to supply fresh isoparaffins, third conduit means communicating with said inlet conduit to supply recycled isoparaffins, first analyzing means to measure the flow of olefins by detecting the concentration of olefins supplied through said inlet conduit, second analyzing means to measure the flow of isoparaffins by detecting the concentration of isoparaffins supplied through said inlet conduit, and means responsive to said first and second analyzing means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

4. In an alkylation unit wherein a mixture of olefins and isoparaffins is contacted by a catalyst in a reactor, and wherein at least a portion of the unreacted isoparaffins is separated from the reactor effluent and recycled to the reactor; a control system to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor comprising first conduit means communicating with said reactor to supply olefins, second conduit means communicating with said reactor, third conduit means communicating with said second conduit means to supply fresh isoparaffins, fourth conduit means communicating with said second conduit means to supply recycled isoparaffins, first analyzing means to measure the flow of olefins by detecting the concentration of olefins supplied through said first conduit means, second analyzing means to measure the flow of isoparaffins by detecting the concentration of isoparaffins supplied through said second conduit means, and means responsive to said first and second analyzing means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

5. In an alkylation unit wherein a mixture of olefins and isoparaffins is contacted by a catalyst in a reactor, and wherein at least a portion of the unreacted isoparaffins is separated from the reactor effluent and recycled to the reactor; a control system to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to

the reactor comprising first conduit means communicating with said reactor to supply olefins, second conduit means communicating with said reactor, third conduit means communicating with said second conduit means to supply fresh isoparaffins, fourth conduit means communicating with said second conduit means to supply recycled isoparaffins, first analyzing means to measure the concentration of olefins in said first conduit means, second analyzing means to measure the concentration of isoparaffins in said second conduit means, first flow measuring means to measure the flow through said first conduit means, second flow measuring means to measure the flow through said second conduit means, and means responsive to said first and second analyzing means and said first and second flow measuring means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

6. Apparatus for separating a fluid mixture of at least two components having different boiling points into first and second streams comprising a fractionation column, means to introduce the fluid mixture to be separated into said column, means to supply heat to said column, means to withdraw a kettle product stream from said column, an accumulator, a condenser, means to pass vapors from the upper region of said column through said condenser to said accumulator, means to pass fluid from said accumulator to said column as reflux, means to withdraw a first sample stream from the upper region of said column, first means to analyze said first stream to measure the concentration of the higher boiling component of the mixture being separated, means responsive to said first means to analyze to adjust the reflux flow to maintain the measured concentration of said higher boiling component less than a predetermined value, means to withdraw a second sample stream from the lower region of said column, second means to analyze said second stream to measure the concentration of the lower boiling component of the mixture being separated, and means responsive to said second means to analyze to adjust the heat supplied to said column to maintain the measured concentration of the lower boiling component less than a predetermined value.

7. Apparatus for separating a fluid mixture of at least two components having different boiling points into first and second streams comprising a fractionation column, means to introduce the fluid mixture to be separated into said column, means to supply heat to said column, means to withdraw a kettle product stream from said column, an accumulator, a condenser, means to pass vapors from the upper region of said column through said condenser to said accumulator, means to pass fluid from said accumulator to said column as reflux, means to remove fluid from said accumulator as a second product, means responsive to the liquid level in said accumulator to regulate the rate of removal of said second product to maintain a predetermined liquid level in said accumulator, means responsive to the liquid level in said column to regulate the rate of withdrawal of said kettle product to maintain a predetermined liquid level in said column, means to withdraw a first sample stream from the upper region of said column, first means to analyze said first stream to measure the concentration of the higher boiling component of the mixture being separated, means responsive to said first means to analyze to adjust the reflux flow to maintain the measured concentration of said higher boiling component less than a predetermined value, means to withdraw a second sample stream from the lower region of said column, second means to analyze said second stream to measure the concentration of the lower boiling component of the mixture being separated, and means responsive to said second means to analyze to adjust the heat supplied to said column to maintain the measured concentration of the lower boiling component less than a predetermined value.

8. An alkylation unit comprising a reactor; means to supply olefins and isoparaffins to said reactor; a first fractionation column adapted to separate normal butane and higher boiling constituents from isobutane and lower boiling constituents; means to pass the reaction products from said reactor to said first fractionation column; a second fractionation column adapted to separate propane and lower boiling constituents from isobutane and higher boiling constituents; means to direct a first part of the overhead product from said first column to said second column as a first stream; means to direct a second part of the overhead product from said first column to said reactor as a second stream; means to measure the propane concentrations of the overhead product of said first column; and means responsive to said means to measure to control the ratio of said first and second streams to maintain the measured propane concentration less than a predetermined value.

9. An alkylation unit comprising a reactor; means to supply olefins and isoparaffins to said reactor; a first fractionation column adapted to separate normal butane and higher boiling constituents from isobutane and lower boiling constituents; means to pass the reaction products from said reactor to said first fractionation column; means to remove a first part of the overhead product from said first column as a first stream; means to direct a second part of the overhead product from said first column to said reactor as a second stream; means to measure the propane concentration of the overhead product of said first column; and means responsive to said means to measure to control the ratio of said first and second streams to maintain the measured propane concentration less than a predetermined value.

10. An alkylation unit comprising a reactor; means to supply olefins and isoparaffins to said reactor; a first fractionation column adapted to separate normal butane and higher boiling constituents from isobutane and lower boiling constituents; means to pass the reaction products from said reactor to said first fractionation column; a condenser; a reflux accumulator; means to remove fluid from the top of said first column and pass same through said condenser to said accumulator; means to return a portion of the liquid in said accumulator to said first column as reflux; means to remove a second part of the liquid from said accumulator as a first stream; means to direct a third part of liquid from said accumulator to said reactor at a rate to maintain a predetermined liquid level in said accumulator; means to measure the propane concentration in the liquid removed from said accumulator; and means responsive to said means to measure to control the flow of said first stream to maintain the measured propane concentration less than a predetermined value.

11. An alkylation unit comprising a reactor, an inlet conduit communicating with said reactor, first conduit means communicating with said inlet conduit to supply olefins, second conduit means communicating with said inlet conduit to supply isoparaffins, a fractionation column, means to pass the reaction products from said reactor to said fractionation column, means to supply heat to said column, means to withdraw a kettle product stream from said column, an accumulator, a condenser, means to pass vapors from the upper region of said column through said condenser to said accumulator, means to pass fluid from said accumulator to said column as reflux, means to withdraw a first sample stream from the upper region of said column, first means to analyze said first stream to measure the concentration of the higher boiling component of the mixture being separated, means responsive to said first means to analyze to adjust the reflux flow to maintain the measured concentration of said higher boiling component less than a predetermined value, means to withdraw a second sample stream from the lower region of said column, second means to analyze

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said second stream to measure the concentration of the lower boiling component of the mixture being separated, means responsive to said second means to analyze to adjust the heat supplied to said column to maintain the measured concentration of the lower boiling component less than a predetermined value, means to withdraw a first product stream from said accumulator, means to pass fluid from said accumulator to said reactor, means to measure the propane concentration in the fluid withdrawn from said accumulator, and means responsive to said means to measure to control one of the fluid streams withdrawn from said accumulator to maintain the measured propane concentration less than a predetermined value.

12. An alkylation unit comprising a reactor, an inlet conduit communicating with said reactor, first conduit means communicating with said inlet conduit to supply olefins, second conduit means communicating with said inlet conduit to supply isoparaffins, a fractionation column, means to pass the reaction products from said reactor to said fractionation column, means to supply heat to said column, means to withdraw a Kettle product stream from said column, an accumulator, a condenser, means to pass vapors from the upper region of said column through said condenser to said accumulator, means to pass fluid from said accumulator to said column as reflux, means to withdraw a first sample stream from the upper region of said column, first means to analyze said first stream to measure the concentration of the higher boiling component of the mixture being separated, means responsive to said first means to analyze to adjust the reflux flow to maintain the measured concentration of said higher boiling component less than a predetermined value, means to withdraw a second sample stream from the lower region of said column, second means to analyze said second stream to measure the concentration of the lower boiling component of the mixture being separated, means responsive to said second means to analyze to adjust the heat supplied to said column to maintain

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the measured concentration of the lower boiling component less than a predetermined value, means to withdraw a first product stream from said accumulator, means to pass fluid from said accumulator to said reactor, means to measure the propane concentration in the fluid withdrawn from said accumulator, means responsive to said means to measure to control one of the fluid streams withdrawn from said accumulator to maintain the measured propane concentration less than a predetermined value, third analyzing means to measure the flow of olefins by detecting the concentration of olefins supplied through said inlet conduit, fourth analyzing means to measure the flow of isoparaffins by detecting the concentration of isoparaffins supplied through said inlet conduit, and means responsive to said third and fourth analyzing means to adjust the flow through at least one of said conduit means to maintain a predetermined ratio of olefins to isoparaffins in the hydrocarbon feed to the reactor.

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