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Child et al.

[11] **3,733,473**

[45] **May 15, 1973**

[54] **MEANS AND METHOD FOR CONTROLLING THE STRENGTH OF ACID IN AN ALKYLATION UNIT**

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[73] Assignee: **Texaco Inc.**, New York, N.Y.

[22] Filed: **Aug. 5, 1971**

[21] Appl. No.: **169,385**

[52] **U.S. Cl.** ....**235/151.12**, 23/253 A, 23/230 A, 260/683.59

[51] **Int. Cl.** **C07c 3/14**

[58] **Field of Search** 235/151.12; 260/683.59, 683.46

[56] **References Cited**

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Primary Examiner—Eugene G. Botz

Attorney—Thomas H. Whaley and Carl G. Ries

[57] **ABSTRACT**

The strength of acid in an alkylation unit is controlled by a system using a signal corresponding to the anticipated demand on the acid by the reaction of olefin and isoparaffin in the presence of the acid. The reaction weakens the acid so that it is necessary to replace some of the weakened acid with fresh acid to maintain a desired acid strength. The control system includes apparatus sampling the olefin and isoparaffin entering the alkylation unit which provides a signal corresponding to the percent volume of acid degrading constituents formed during alkylation. A water analyzer samples the olefin and isoparaffin and provides a signal corresponding to their water content. Signals corresponding to sensed flow rates of fresh and discharged acid entering and leaving, respectively, the alkylation unit and of the olefin and isoparaffin are provided by sensors. A control circuit using analog computers develop the control signal in accordance with the signals from the sensors, the volume signal and the signal from the analyzer and equations hereinafter disclosed. The control signal is applied to a flow recorder controller which controls the flow rate of the fresh acid entering the alkylation unit so as to maintain the desired acid strength.

4 Claims, 11 Drawing Figures

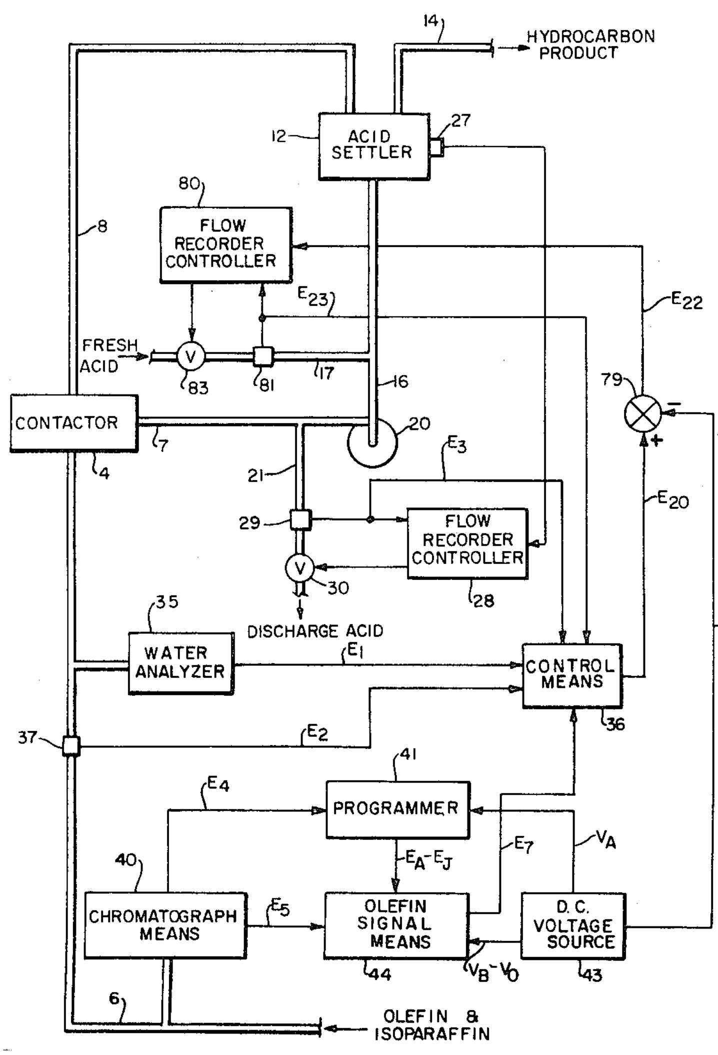


FIG. 1

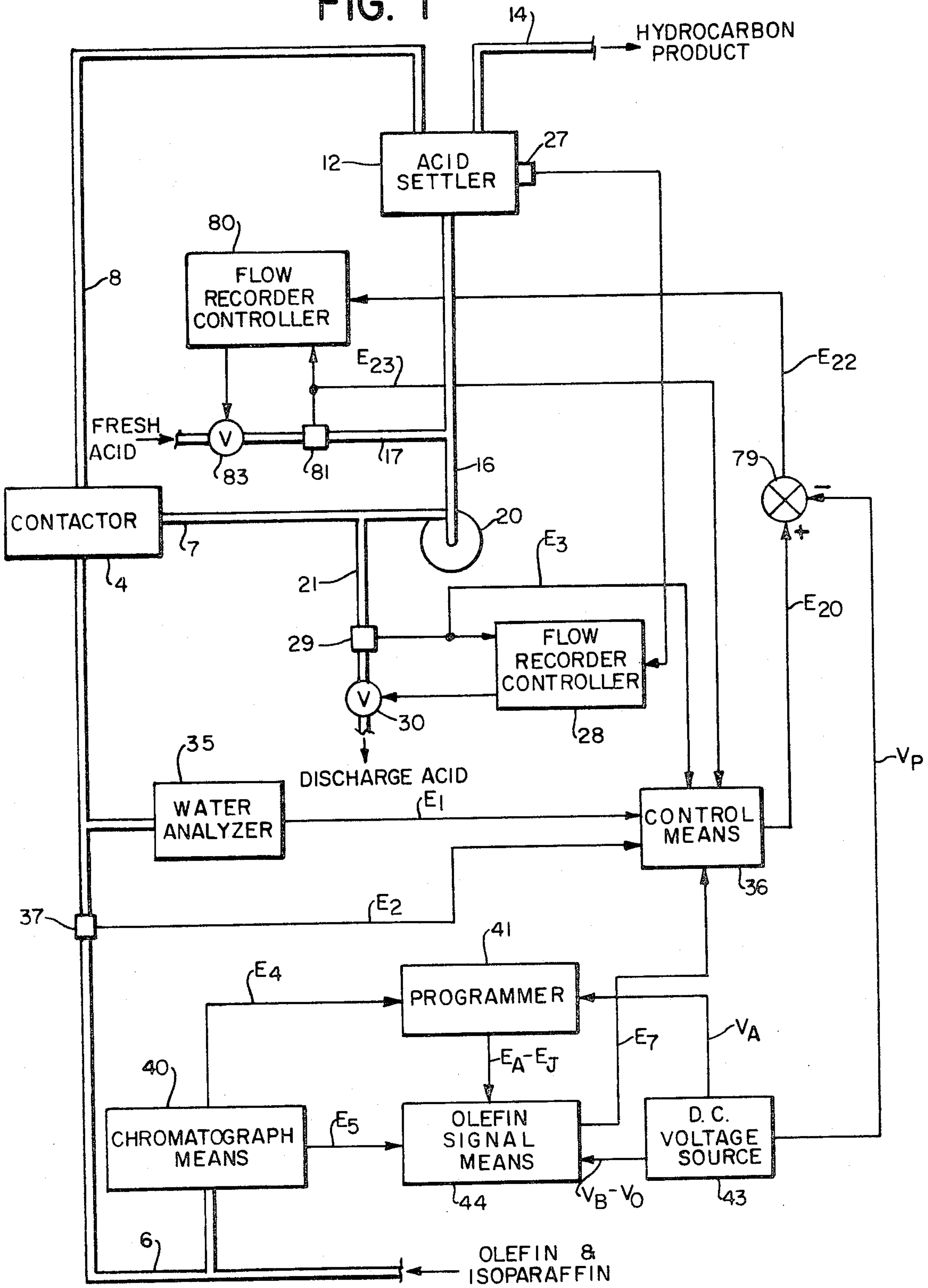

14
HYDROCARBON PRODUCT
ACID SETTLER
12
27
80
FLOW RECORDER CONTROLLER
8
E23
E22
FRESH ACID
V
83
81
17
16
79
CONTACTOR
7
4
20
E3
21
29
FLOW RECORDER CONTROLLER
28
V
30
DISCHARGE ACID
35
WATER ANALYZER
E1
CONTROL MEANS
36
E20
VP
37
E2
41
PROGRAMMER
E4
E7
VA
EA-EJ
40
CHROMATOGRAPH MEANS
E5
OLEFIN SIGNAL MEANS
44
VB-VO
D. C. VOLTAGE SOURCE
43
6
OLEFIN & ISOPARAFFIN

FIG. 2

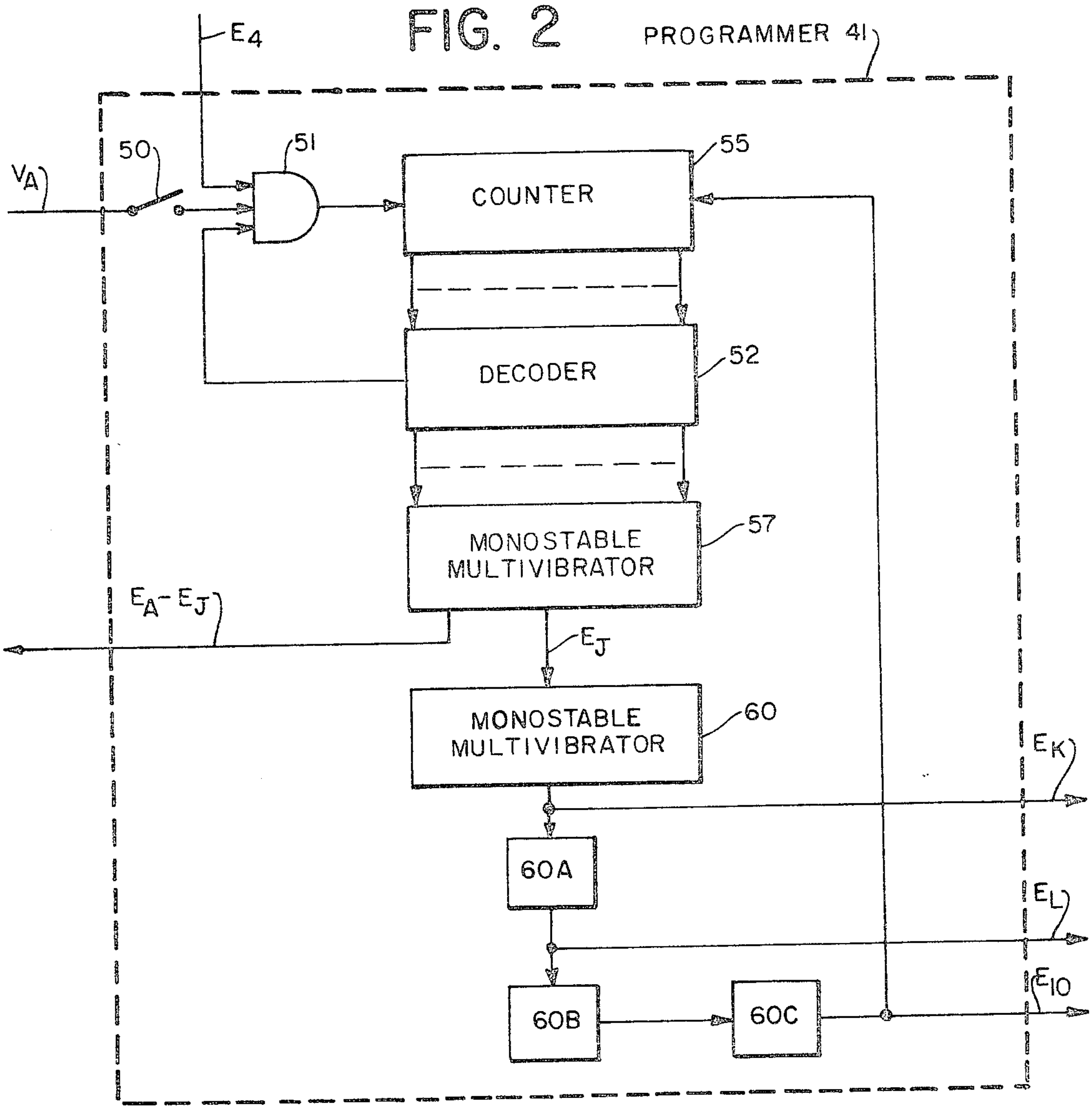
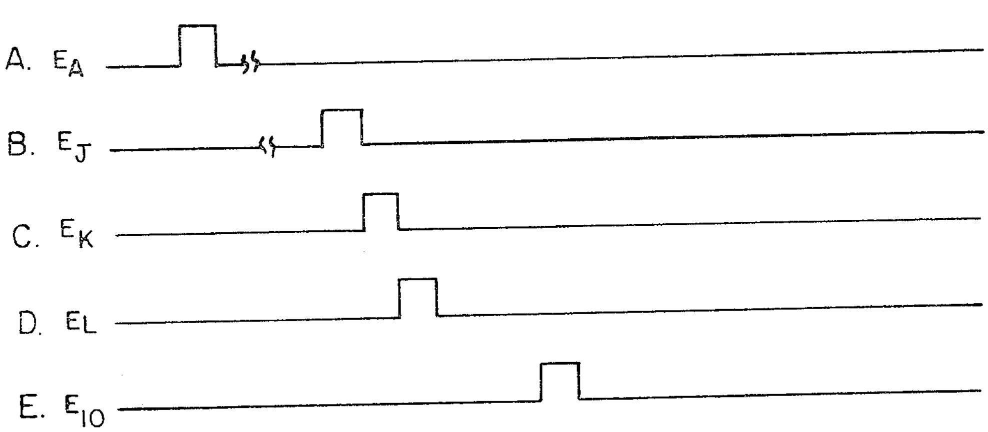

PROGRAMMER 41
E_4
50
51
55
V_A
COUNTER
DECODER
52
MONOSTABLE MULTIVIBRATOR
57
$E_A - E_J$
E_J
MONOSTABLE MULTIVIBRATOR
60
E_K
60A
E_L
60B
60C
E_{10}

FIG. 3


A. E_A
B. E_J
C. E_K
D. E_L
E. E_{10}

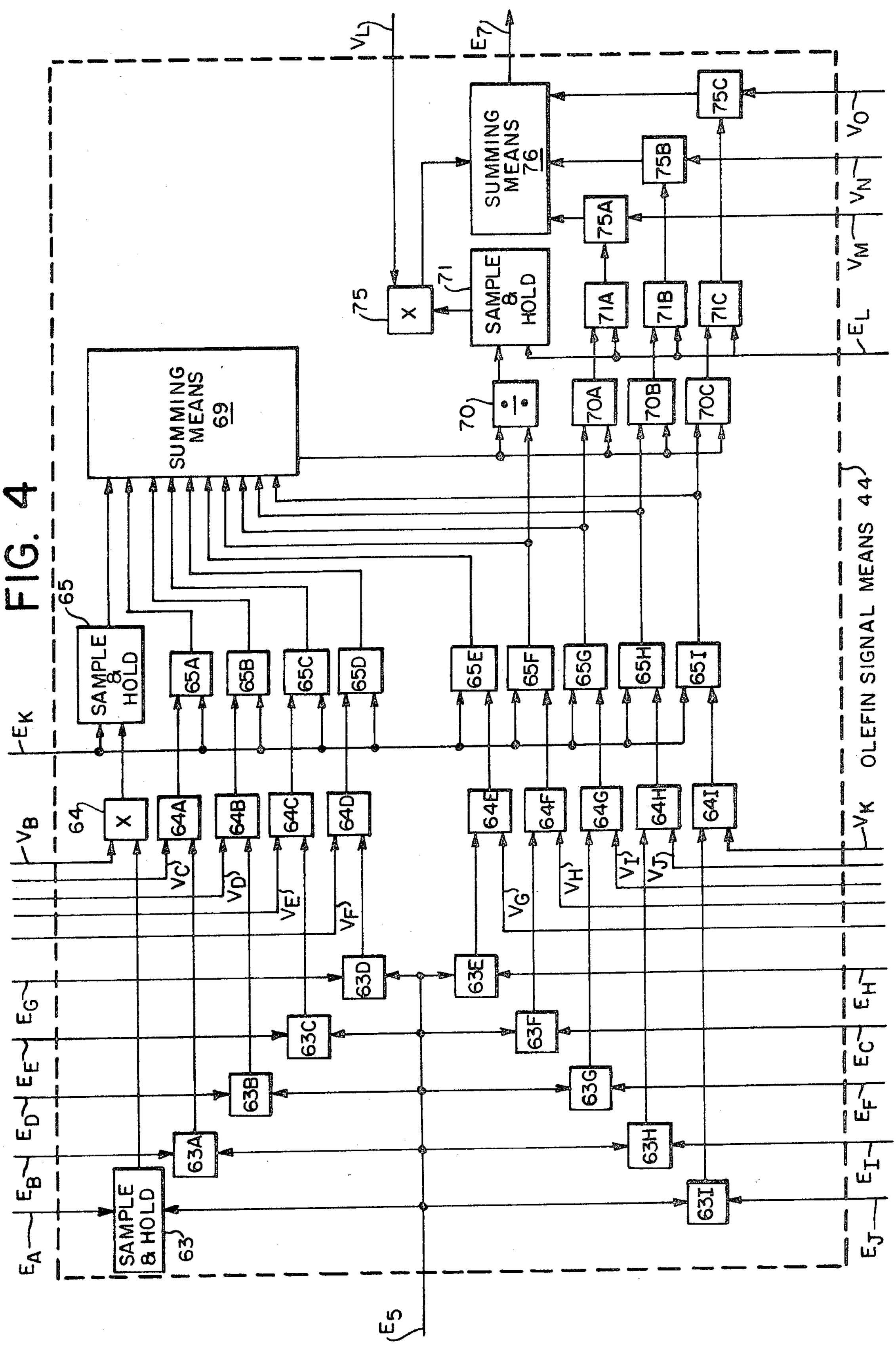

SUMMING MEANS 69
SUMMING MEANS 76
SAMPLE & HOLD
OLEFIN SIGNAL MEANS 44

FIG. 4

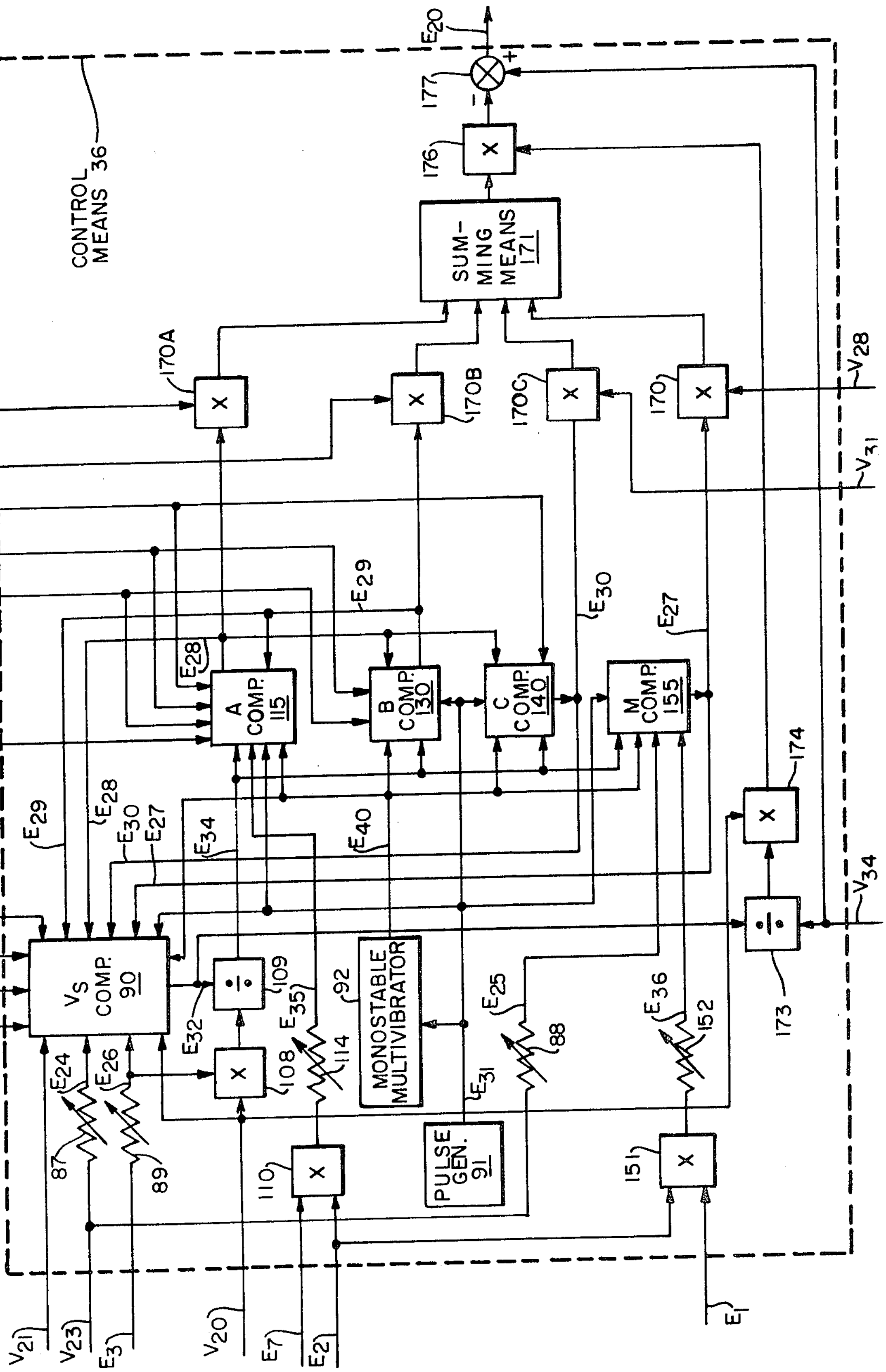

CONTROL MEANS 36
SUM-MING MEANS 171
VS COMP. 90
A COMP. 115
B COMP. 130
C COMP. 140
M COMP. 155
MONOSTABLE MULTIVIBRATOR
PULSE GEN. 91
X
÷
170A
170B
170C
170
176
177
174
173
108
109
110
151
114
152
87
88
89
92
E20
E24
E25
E26
E27
E28
E29
E30
E31
E32
E34
E35
E36
E40
E1
E2
E3
E7
V16
V17
V18
V19
V20
V21
V23
V24
V25
V26
V27
V28
V29
V30
V31
V34

FIG. 5

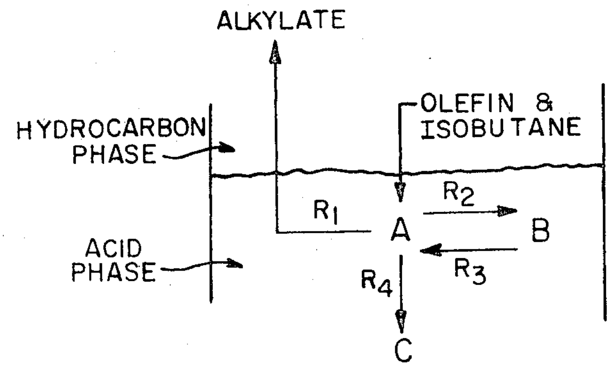

ALKYLATE
HYDROCARBON PHASE
OLEFIN & ISOBUTANE
R1
R2
A
B
ACID PHASE
R3
R4
C

FIG. 6

FIG. 7

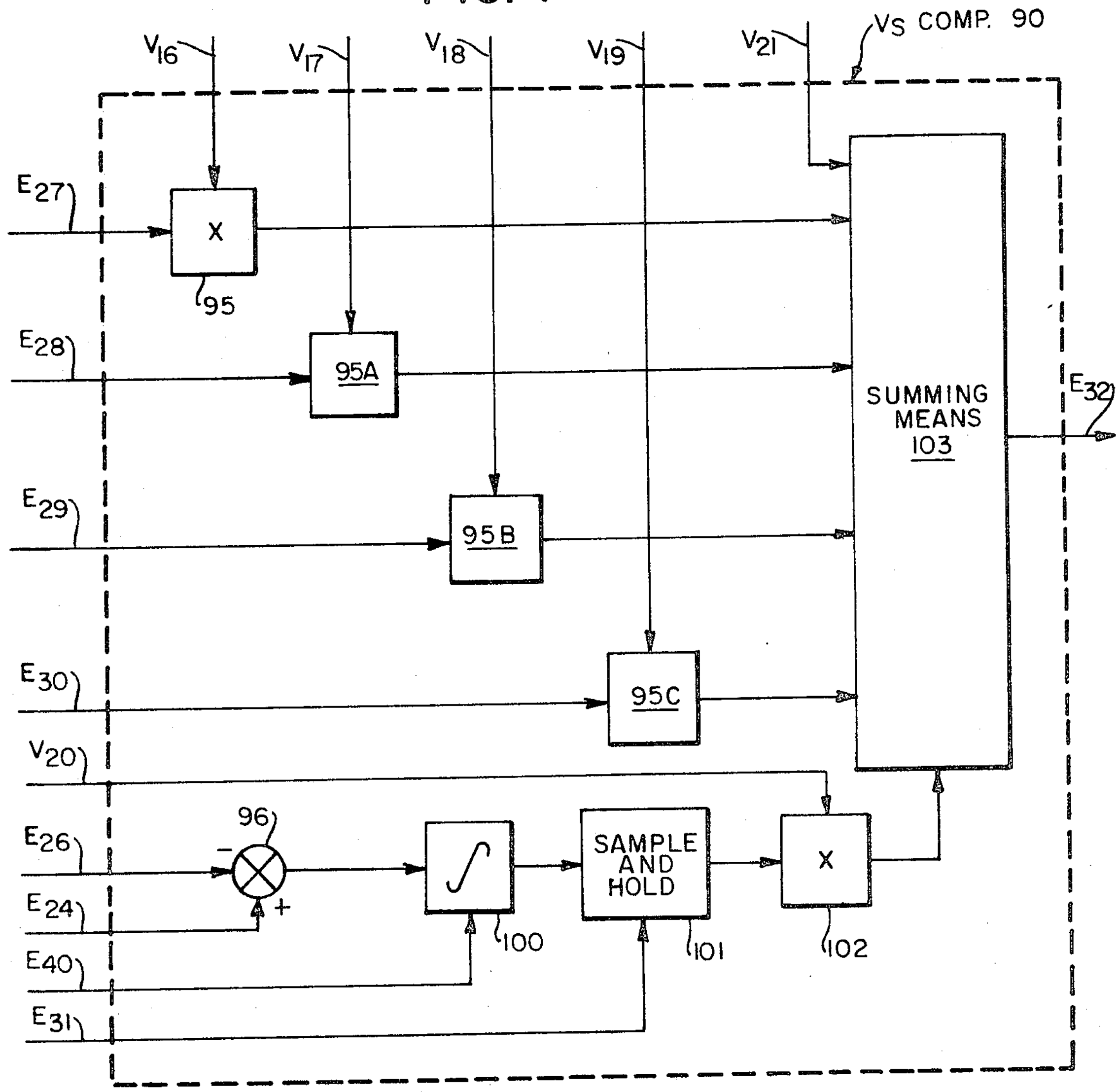

V16
V17
V18
V19
V21
VS COMP. 90
E27
X
95
E28
95A
E29
95B
E30
95C
SUMMING MEANS 103
E32
V20
96
E26
E24
E40
E31
SAMPLE AND HOLD
X
100
101
102

FIG. 8

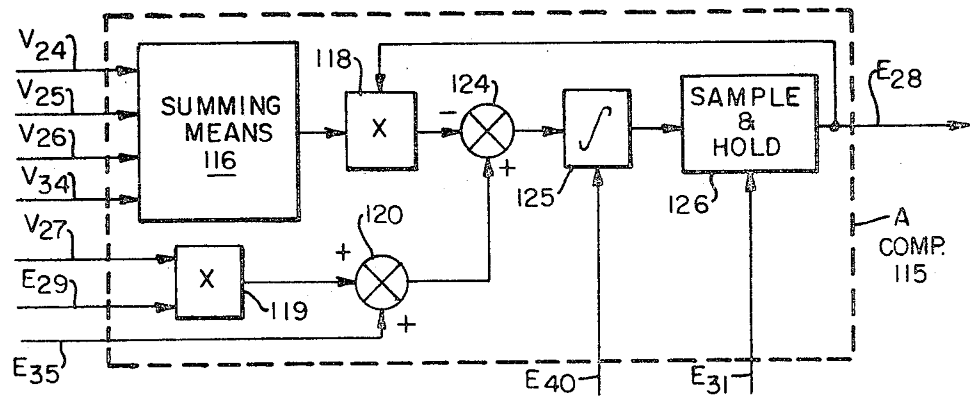


FIG. 9

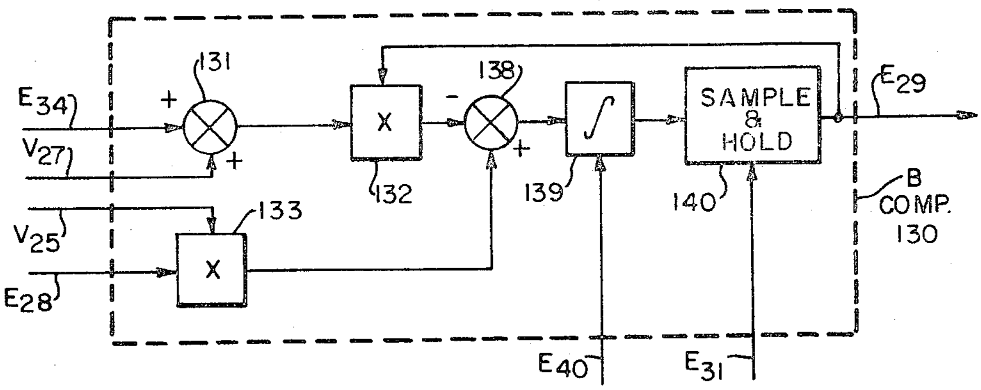


FIG. 10

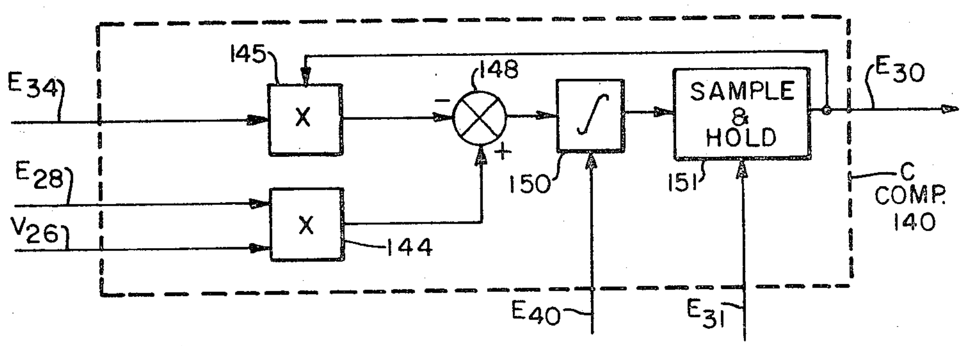
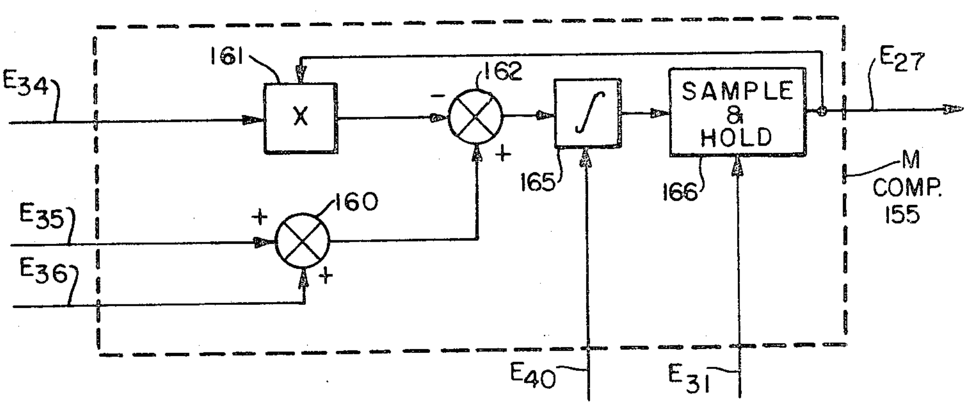


FIG. 11



MEANS AND METHOD FOR CONTROLLING THE STRENGTH OF ACID IN AN ALKYLATION UNIT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to alkylation units in general and, more particularly, to a control system for an alkylation unit.

SUMMARY OF THE INVENTION

A control system controls the strength of acid in an alkylation unit so as to maintain the acid's strength at a predetermined level. The alkylation unit reacts an isoparaffin with olefin in the presence of the acid to provide an acid-hydrocarbon mixture to a settler where the hydrocarbon is separated from the acid to provide a hydrocarbon product. A portion of the acid is recycled while the remaining acid is discharged from the alkylation unit. Fresh acid is added to the recycled acid to affect the strength of the acid. The control system includes apparatus for controlling the strength of the acid in accordance with a control signal. A water analyzer samples the olefin and isoparaffin to provide a signal corresponding to the water content of the olefin and isoparaffin. A network samples the olefin and isoparaffin and provides a signal corresponding to the composition of the olefin. The flow rates of the olefin and isoparaffin, the fresh acid and the discharge acid are sensed by flow sensors which provide corresponding signals. A control circuit develops the control signal in accordance with the signals from the analyzer, the composition determining circuit and the sensors.

One object of the present invention is to control the strength of acid in an alkylation unit by determining the demand that will be made on the acid durinc an alkylation process which reacts olefins with an isoparaffin in the presence of acid.

Another object of the present invention is to sense the composition of an olefin prior to being reacted with an isoparaffin in the presence of acid to determine the quantity of acid degrading compounds formed during alkylation.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified block diagram of a control system, constructed in accordance with the present invention, for controlling the strength of acid in an alkylation unit which is also partially shown in schematic form.

FIG. 2 is a detailed block diagram of the programmer shown in FIG. 1.

FIGS. 3A through 3E are diagrammatic representations of pulse voltages provided by the programmer shown in FIG. 1 during one cycle of operation.

FIGS. 4 and 5 are detailed block diagrams of the olefin signal means and the control means shown in FIG. 1.

FIG. 6 is a diagrammatic representation of the reaction of an olefin and an isoparaffin in the presence of acid.

FIGS. 7 through 11 are detailed block diagrams of the V_S computer, the A computer, the B computer, the C computer and the M computer, respectively, shown in FIG. 1.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown a portion of an alkylation unit in which an olefin is reacted with isoparaffin in the presence of a catalyst, such as sulfuric or hydrofluoric acid, to form a higher molecular weight isoparaffin. For purpose of explanation, the acid in the following description shall be sulfuric acid. The olefin may be butylene, propylene or a mixture of butylene and propylene, while the isoparaffin may be isobutane. The control system shown in FIG. 1 anticipates changes in the acid strength due to changes in the quantities of acid degrading compounds formed during alkylation to control the acid strength accordingly so as to speed up the control process.

The charge olefin and isoparaffin enters a contactor 4, by way of a line 6, where the charge olefin and isoparaffin are contacted with acid entering by way of a line 7. Contactor 4 provides an acid-hydrocarbon mix by way of a line 8 to an acid settler 12. Settler 12 separates the hydrocarbon product from the acid and the hydrocarbon product is discharged through a line 14 while the acid is removed by way of a line 16. Acid settler 12 may be the only acid settler in the alkylation unit or it may be the last acid settler of a group of acid settlers. Fresh acid enters line 16 by way of a line 17 as needed to maintain a desired acid strength. A pump 20 pumps the acid from line 16 into line 7. A portion of the acid in line 7 is discharged by way of a line 21. The discharge acid may be provided to another alkylation unit or disposed of.

The level in acid settler 12 is maintained by a conventional level sensor 27, a level recorder controller 28, a flow sensor 29 and a valve 30. Sensor 27 provides a signal to flow recorder controller 28 corresponding to the sensed acid level in settler 12. Flow sensor 29 and valve 30 are located in line 21. Sensor 29 provides signal E_3 to flow recorder controller 28 corresponding to the discharge acid flow rate. The set point of controller 28 is adjusted by the signal from level sensor 27. When the acid level in settler 12 is high, the set point of flow recorder controller is adjusted by the signal from sensor 27 for an increased discharge acid flow rate. Controller 28 provides a signal to valve 30 causing it to pass more discharge acid until the sensed flow rate in line 21 corresponds to the target flow rate determined by the set point position of controller 28. By increasing the flow rate of the discharge acid while maintaining the fresh acid flow rate, the acid level in acid settler 12 decreases. Conversely, when the acid in level settler 12 is low, sensor 27 and controller 28 control valve 30 to decrease the discharge acid flow rate thereby increasing the acid level in acid settler 12.

A water analyzer 35 senses the water content of the olefin and isoparaffin in line 6 and provides a corresponding signal E_1. Analyzer 35 may be of the type manufactured by Panametrics Inc. as their part No. 1000. Signal E_1 is applied to control means 36 which also receives a signal E_2 corresponding to the flow rate of the olefin and isoparaffin in line 6 from a sensor 37.

Chromatograph means **40**, which may be of the type manufactured by Bendix-Greenbriar Co. as their part No. C–118, provides signals E_4 and E_5. Signal E_4 is a pulse signal whose pulses coincide with the peaks of signal E_5 which corresponds to the composition of the olefin and isoparaffin. Pulse signal E_4 is applied to a programmer **41** which provides control pulses E_A through E_J to olefin signal means **44.** Programmer **41** also receives a direct current voltage V_A from a source **45** of direct current voltages.

Programmer **41**, which is shown in detail in FIG. **2**, includes a manually-operable switch **50** which controls the starting and the stopping of the control operation. When closed, switch **50** passes direct current voltage V_A to an AND gate **51** which enables AND gate **51** along with a high level direct current output from a logic decoder **52.** When open, switch **50** blocks voltage V_A thereby disabling AND gate **51.** AND gate **51** controls the counting by a counter **55** of pulses in pulse signal E_4. AND gate **51** when enabled passes pulse signal E_4 to counter **55** and blocks pulse signal E_4 when disabled. Counter **55** provides a plurality of outputs to decoder **52.** Decoder **52** includes a plurality of AND gates receiving the outputs from counter **55**, each AND gate providing an output when a particular count is reached so that decoder **52** provides a plurality of outputs corresponding to different counts in counter **55.**

When the number of pulses of pulse signal E_4 equals the number of peaks to be sampled and held, decoder **52** provides a low level direct current output to AND gate **51** thereby disabling AND gate **51** to prevent further counting by counter **55**, until counter **55** is reset by a reset pulse E_{10}.

A plurality of monostable multivibrators **57** provides pulse voltages E_A through E_J. Each multivibrator of multivibrators **57** is triggered by a different output from decoder **56** to provide a pulse voltage which coincides with a different peak in signal E_5. Pulse voltages E_A and E_J are shown in FIGS. 3A and 3B, respectively. The breaks in FIGS. 3A, 3B signify a break in time during which pulse voltages E_B through E_I occur. The trailing edge of pulse voltage E_J triggers a monostable multivibrator **60** to provide a pulse voltage E_K. The trailing edge of pulse voltage E_K triggers a monostable multivibrator **60A** causing multivibrator **60A** to provide a pulse voltage E_L. Pulse voltage E_L triggers multivibrator **60B** which operates as a time delay to provide a pulse to multivibrator **60C.** The width of the pulse from multivibrator **60B** is such as to allow sufficient time for the operation of the analog computers. Multivibrator **60C** provides reset pulse E_{10} which resets counter **55** so that the control operation may be recycled again.

Referring to FIG. **4**, there is shown in detail, olefin signal means **44** providing a signal E_7, which corresponds to the percent volume of acid consuming constituents in the olefin, to control means **36.** Signal E_5 from chromatograph means **40** is applied to sample and hold circuits **63** through **63I.** Pulses E_A through E_J from programmer **41** control sample and hold circuits **63** through **63I**, respectively, to hold different peaks of signal E_5.

The following Table relates a particular sample and hold circuit to a corresponding constituent.

Circuit	Constituent	Circuit	Constituent
63	Ethane	63E	Normal Pentane
63A	Propane	63F	Propylene
63B	Iso-Butane	63G	Butylene
63C	Normal Butane	63H	Pentylene
63D	Iso-Pentane	63I	All compounds with six or more carbon atoms

The outputs from sample and hold circuits **63** through **63I** are applied to multipliers **64** through **64I**, respectively, where they are multiplied with direct current voltages V_B through V_K which correspond to various chromatograph means **40** scaling factors pertaining to the particular constituents. By way of example, voltages V_B through V_K may correspond to 0.02, 0.2, 1.0, 0.2, 0.15, 0.02, 0.2, 0.1, 0.02 and 0.1 volts, respectively.

Sample and hold circuits **65** through **65I** are controlled by pulse E_K from programmer **41** to sample and hold the outputs from multipliers **64** through **64I.** Summing means **69** sums all of the outputs from sample and hold circuits **65** through **65I** to provide a signal to dividers **70** through **70C.** Dividers **70** through **70C** also receive the outputs from sample and hold circuits **65F** through **65I**, respectively and divide those outputs by the signal from summing means **69** to effectively normalize the outputs corresponding to the acid degrading constituents of the olefin. The signals from dividers **70** through **70C** are sample and held by sample and hold circuits **71** through **71C**, respectively, in response to pulse E_L from programmer **41.** The outputs from sample and hold circuits **71** through **71C** are multiplied with direct current voltages V_L through V_O which correspond to ratios of pounds of acid consumed per gallon of olefin for the acid consuming constituents, by multipliers **75** through **75C**, respectively. Summing means **76** sums the outputs of multipliers **75** through **75C** to provide signal E_7 to control means **36.**

Control means **36** as shown in detail in FIG. **5** develops a control signal E_{20} which is used to control the fresh acid entering the alkylation unit. Control E_{20} subtracted from a direct current voltage V_P provided by source **43,** which corresponds to a predetermined target acid strength, by subtracting means **79.** Subtracting means **79** provides an error signal E_{22} to a conventional type flow recorder controller **80** which receives a signal E_{23} from a sensor **81** in line **17.** Signal E_{20} adjusts the set points of controller **80.** Signal E_{23} corresponds to the flow rate of the fresh acid entering the alkylation unit. Controller **80** controls a valve **83** to regulate the fresh acid flow rate in accordance with the difference between the sensed flow rate signal E_{23} and the desired flow rate as determined by the set points positions. Control means **36** develops signal E_{20} in accordance with signals E_1, E_2, E_7 and E_{23}, direct current voltages V_{16} through V_{21}, V_{24} through V_{31} and V_{34} and the following equations:

1. $$A=\int_0^T\left\{\alpha_0-\left(R_1+R_2+R_4+\frac{F_s}{\rho_s V_s}\right)A+R_3B\right\}dt$$

2. $$B=\int_0^T\left\{R_2A-\left(R_3+\frac{F_s}{\rho_s V_s}\right)B\right\}dt$$

3. $$C=\int_0^T\left\{R_4A-\left(\frac{F_s}{\rho_s V_s}\right)C\right\}dt$$

4. $$M=\int_0^T\left\{\alpha_m+\gamma_m-\left(\frac{F_s}{\rho_s V_s}\right)M\right\}dt$$

5. $$\frac{\text{Wt. \% acid}}{100}=1.0-(W_M M+W_A A+W_B B+W_C C)\frac{1}{\rho_s V_s}\text{ and}$$

6. $$V_s=V_{so}+\frac{W_M M}{\rho_m}+\frac{W_A A}{\rho_A}+\frac{W_B B}{\rho_B}+\frac{W_C C}{\rho_C}+\frac{1}{\rho_s}\int_0^T (F_F-F_s)dt$$

where A, B, C are quantities of three compounds occurring within contactor **4**, i.e. the first compound results from an ultimate reaction of the olefin with the isoparaffin to form an alkylate, the second compound is an acid contaminate which is formed from a reversible reaction with the first compound, and the third compound is an acid contaminate resulting from an irreversible reaction with the first compound. The second and third compounds remaining in the acid in line **16**, respectively, M is the water in the acid phase and the olefin and isobutane in line **6**; R_1, R_2, R_3 and R_4 are reaction rates constants which are predetermined from a laboratory analysis of the reaction of the olefin with the isobutane in the presence of the acid. A math model is shown in FIG. **6** from which equations 1 through 6 were obtained; V_o and V_s are the initial volume and the present volume, respectively, of acid phase in c.c.; ρ_s, ρ_A, ρ_B, ρ_C and ρ_M are the densities of the acid in the contactor **4**, the three compounds and water, respectively; W_A, W_B, W_C and W_M are the molecular weight of the three compounds and water, respectively, F_F corresponds to the fresh acid flow rate and F_s corresponds to the discharge acid flow rate. Values for W_A, W_B, W_C, W_M, ρ_S, ρ_A, ρ_B, ρ_C and ρ_M may be predetermined from laboratory analysis of the olefin, the isobutane and the acid, while the density ρ_M and the molecular weight W_M of the water are known.

Referring to FIG. **5**, variable resistors **87**, **88** reduce signal E_{23} to provide signals E_{24}, E_{25} which correspond to the terms F_F and γ_m, respectively, in the aforementioned equations, having units of grams/sec and moles of water in the fresh acid per second. Signal E_3 is conditioned by a variable resistor **89** to provide a signal E_{26}, which corresponds to the term F_s in equation 6 having units of gms/sec.

A V_s computer **90** receives signals E_{24}, E_{26} from resistors **87** and **89**, respectively, control pulses E_{31} from a pulse generator **91**, direct current voltages V_{16} through V_{21} from source **43**, and signals E_{27}, E_{28}, E_{29} and E_{30}. The development of signals E_{27}, E_{28}, E_{29} and E_{30} which correspond to the M, A, B and C terms in the aforementioned equation, will be hereinafter disclosed. Multivibrator **94** is triggered by the trailing edge of each control pulse E_{31} to provide a pulse E_{40} so that a pulse E_{31} immediately precedes each pulse E_{40}. Computer **90** provides a signal E_{32} corresponding to the present volume V_s of the acid phase in accordance with the received signals and voltages, and equation **6**. Referring to FIGS. **5** and **7**, voltages V_{16} through V_{19} are multiplied with signals E_{27} through E_{30}, respectively by multipliers **95** through **95C**, respectively. Voltages V_{16}, V_{17}, V_{18} and V_{19} correspond to the predetermined ratios of molecular weight to density W_M/ρ_M, $W_A A \rho_A$, W_B/ρ_B and W_C/ρ_C of the three compounds and the water in the acid phase, respectively; while signals E_{27}, E_{28}, E_{29} and E_{30} correspond to the terms M, A, B and C, respectively. Subtracting means **96** subtracts signal E_{26} from signal E_{27} to provide an output, corresponding to the term (F_F-F_s) in equation 6, to an integrator **100**.

A sample and hold circuit **101** samples and holds the output of integrator **100** just prior to pulse E_{40}. Pulses E_{40} control integrator **100** causing integrator **100** output to go to zero when a timing pulse E_{40} occurs. The output from sample and hold circuit **101** corresponds to the integral

$$\int_0^T (F_F-F_s)$$

. A multiplier **102** multiplies the output from sample and hold circuit **101** with voltage V_{20}, which corresponds to the reciprocal $1/\rho_s$ of the density of the acid to provide an output corresponding to the term

$$\frac{1}{\rho_s}\int_0^T (F_F-F_s)$$

in equation 6. Summing means **103** sums the outputs from multipliers **95** through **95C** and **101** with voltage V_{21}, which corresponds to the initial volume V_{so}, to provide signal E_{32}.

Referring again to FIG. **5**, a multiplier **108** multiplies voltage V_{20} from source **43** with signal E_{26} from resistor **89** to provide a signal corresponding to F_s/P_sV_s in the aforementioned equations. Signals E_7 and E_2 are multiplied together by a multiplier **110** whose output is reduced by a variable resistor **114** to provide a signal E_{35} corresponding to the term α_O in equation **1**. Resistor **114** is used so as to conform units of measurement, the term α_O is in gms/sec.

An A computer **115** provides signal E_{28} in accordance with signals E_{29}, E_{31}, E_{35}, and E_{40} direct current voltages V_{24} through V_{27} from source **43** and equation 1. Referring now to FIG. **5** and **8** voltages V_{24} through V_{26}, which correspond to the terms R_1, R_2 and R_4, respectively, are summed along with signal E_{34} by summing means **116** to provide a signal corresponding to the quantity $(R_1+R_2+R_4+F_s/\rho_sV_s)$. A multiplier **118** multiplies the output from summing means **116** with signal E_{28}, which corresponds to the term A. Another multiplier **119** multiplies direct current voltage V_{27}, which corresponds to the term R_3, with signal E_{29}, which corresponds to the term B, to provide a signal which is summed with signal E_{35} by summing means **120**. Subtracting means **124** subtracts the output provided by multiplier **118** from the output provided by summing means **120**. The output from subtracting means **124** is operated upon by an integrator **125** and a sample and hold circuit **126** receiving pulses receiving pulses E_{40} and E_{31}, respectively, to provide signal E_{28} which is also fed back to multiplier **118**.

Referring to FIGS. **5** and **9**, signal E_{29}, which corresponds to the term B, is provided by a B computer **130** in accordance with direct current voltages V_{25} and V_{27}, signals E_{28} and E_{34} and equation 2. Signal E_{34} is summed with direct current voltage V_{27}, which corresponds to the term R_3, by summing means **131** to provide a signal corresponding to R_3+F_S/ρ_sV_s which is multiplied with signal E_{29} by a multiplier **132**. Another multiplier **133** multiplies signal E_{28} with voltage V_{25} to provide an output corresponding to the term R_2A. Subtracting means **138** subtracts the output provided by multiplier **132** from the output provided by multiplier **133**. An integrator **139** and a sample and hold circuit **140**, receiving pulses E_{40} and E_{31}, respectively, operates on the output from subtracting means **138** to provide signal E_{29} which is also fed back to multiplier **132**.

Signal E_{30} which corresponds to the term C in the aforementioned equations, is provided by a C computer **140** in accordance with signals E_{28} and E_{34} and direct current voltage V_{26}. Referring to FIGS. **5** and **10**, signal E_{28} is multiplied with voltage V_{26} by a multiplier **144** to provide a signal corresponding to the term R_4A. Another multiplier **145** multiplies signal E_{34} with signal

E_{30} to provide an output corresponding to the term $(F_s/\rho_s V_s)C$. Subtracting means **148** subtracts the output provided by multiplier **145** from the output provided by multiplier **144**. An integrator **150** and a sample and hold circuit **151**, receiving pulses E_{40} and E_{31}, respectively, operates on the output from subtracting means **148** to provide signal E_{30} which is also fedback to multiplier **145**.

Referring back to FIG. **5**, a multiplier **151** multiplies signals E_1, E_2 together and the resulting output is reduced by variable resistor **152** to provide a signal E_{36} corresponding to the term α_m.

Signal E_{27} is provided by an M computer **155** in accordance with signals E_{25}, E_{34} and E_{36} and equation 4. Referring now to FIG. **11**, summing means **160** sums signals E_{25} and E_{36} to provide an output corresponding to the term $\alpha_m\gamma_m$. Signal E_{34} is multiplied with signal E_{27} by a multiplier **161** to provide an output corresponding to the term $(F_s/\rho_s V_s)M$. Subtracting means **162** subtracts the output provided by multiplier **161** from the output provided by summing means **160** to provide a signal which is operated on by an integrator **165** and a sample and hold circuit **166**, receiving pulses E_{40} and E_{31}, respectively, to provide signal E_{30}. Signal E_{30} is also fed back to multiplier **161**.

Referring back to FIG. **5**, signals E_{27}, E_{28}, E_{29} and E_{30} from computers **115**, **130**, **140** and **155**, respectively, are multiplied with direct current voltages V_{28} through V_{31}, respectively, by multipliers **170** through **170C**. Voltages V_{28} through V_{31} correspond to the predetermined molecular weights of water and the first, second and third compounds, respectively. Summing means **171** sums the outputs of multipliers **170** through **170C**. Direct current voltage V_{34} which corresponds to the term 1 in equation 5 is divided by signal E_{32} by a divider **173**. The output from divider **173** is multiplied with voltage V_{20} by a multiplier **174** to provide an output corresponding to the term $1/\rho_s V_s$. Another multiplier **176** multiplies the same signal from summing means **171** with the signal from multiplier **174** and the resulting output is subtracted from voltage V_{34} by subtracting means **177** to provide control signal E_{20}.

A digital computer may be used instead of control means **36**, programmer **41** and olefin signal means **44**. Signals E_1, E_2, E_3, E_5 and E_{23} are converted to digital signals by conventional type analog-to-digital converters and the digital signals are applied to the digital computer. The digital computer provides a digital control signal in accordance with the aforementioned equations. The digital control signal is then converted to analog signal E_{20} by a conventional type digital-to-analog converter.

The system of the present invention as heretofore described controls the strength of acid in an alkylation unit by determining the demand that will be made on the acid during the alkylation process. The alkylation process reacts an olefin with an isoparaffin in the presence of acid. The composition of the olefin is sensed and the quantity of acid consuming constituent of the olefin is determined from the sensed composition of the olefin.

What is claimed is:

1. A system for controlling the strength of an acid in an alkylation unit wherein an isoparaffin is reacted with olefin in the presence of the acid to provide an acid-hydrocarbon mixture to a settler where the hydrocarbon is separated from the acid to provide a hydrocarbon product and a portion of the acid is recycled while the remaining acid is discharged from the alkylation unit, wherein fresh acid is added to the recycle acid to affect the strength of the acid and wherein the reaction of the olefin with the isoparaffin in the presence of the acid results in a first compound being formed from the olefin and isoparaffin in the acid phase and immediately leaving the acid phase after formation, a second compound being formed in the acid phase from the first compound and which may return to the first compound, and a third compound in the acid phase formed from the first compound and which cannot return to the first compound, comprising means for controlling the strength of the acid in accordance with a control signal, means for sensing the water content of the olefin and the isoparaffin and providing a signal corresponding thereto, means for determining the composition of the olefin and providing a corresponding composition signal, means for sensing the flow rate of the olefin and providing a signal corresponding thereto, means for sensing the flow rates of the fresh acid and the discharged acid and providing signals corresponding thereto, said control signal means includes a first circuit connected to the olefin and isoparaffin flow rate sensor and to the composition signal means provides a signal corresponding to the quantity α_o of acid consuming constituents contacting the acid; a second circuit connected to the analyzer and to the olefin and isoparaffin flow rate sensing means provides a signal corresponding to the quantity α_m of water in the olefin and isoparaffin contacting the acid; means connected to the fresh acid flow rate sensing means for providing a signal corresponding to the quantity γ_m of water in the fresh acid entering the alkylation unit; means for providing direct current voltages corresponding to the reaction rates R_1, R_2, R_3 and R_4 between the olefin, the isoparaffin, the acid, the first, second and third compounds, to the initial volume V_o of acid in the alkylation unit, to the molecular weights W_A, W_B and W_C of the first, second and third compounds, respectively, to the molecular weight W_M of water, to the densities ρ_A, ρ_B and ρ_C of the first, second and third compounds, respectively, to the densities ρ_s, and ρ_M of the acid and of water, respectively, and to a unit value 1; first analog computing means for providing signals corresponding to the quantities A, B and C of the first, second and third compounds, respectively, and to the quantity M of water in accordance with the α_o, α_m and γ_m signals and the discharged acid flow rate and the following equations:

$$A=\int_0^T\left\{\alpha_o-\left(R_1+R_2+R_4+\frac{F_s}{\rho_s V_s}\right)A+R_3B\right\}dt$$

$$B=\int_0^T\left\{R_2A-\left(R_3+\frac{F_s}{\rho_s V_s}\right)B\right\}dt$$

$$C=\int_0^T\left\{R_4A-\frac{F_s}{\rho_s V_s}C\right\}dt$$

$$M\int_0^T\left\{\alpha_m+\gamma_m-\frac{F_s}{\rho_s V_s}M\right\}dt$$

and

$$V_s=V_{so}+\frac{W_M M}{\rho_M}+\frac{W_A A}{\rho_A}+\frac{W_B B}{\rho_B}+\frac{W_C C}{\rho_C}+\frac{1}{\rho_s}\int_0^T(F_F-F_s)\,dt$$

where T is a predetermined time; and an analog computing circuit receiving some of the direct current voltages and the signals from the last mentioned computing means for providing a signal corresponding to the weight of the acid as the control signal in accordance with the following equation:

Wt. % acid/100 = $1.0-(W_M M+W_A A+W_B B+W_C C)(1/\rho_s V_s)$.

2. A system as described in claim 1 in which the determining means includes chromatograph means periodically sampling the olefin and isoparaffin for providing a first signal, whose amplitude peaks correspond to different constituents of the olefin and isoparaffin, and a pulse signal, each pulse in the pulse signal coincides with a different peak of the signal from the chromatograph means, program means connected to the chromatograph means and responsive to the pulse signal for providing control pulses, and means connected to the chromatograph means, to the control signal means and to the program means and controlled by the control pulses, for providing a signal which corresponds to the portion of the olefin that is acid consuming as the composition signal in accordance with the first signal from the chromatograph means.

3. A method for controlling the strength of an acid in an alkylation processing unit wherein an isoparaffin is reacted with olefin in the presence of the acid to provide an acid-hydrocarbon mixture to a settler where the hydrocarbon is separated from the acid to provide a hydrocarbon product and a portion of the acid is recycled while the remaining acid is discharged from the alkylation unit, wherein fresh acid is added to the recycle acid to affect the strength of the acid and wherein the reaction of olefin with isoparaffin in the presence of acid results in the first compound being formed from the olefin and isoparaffin in the acid phase and which leaves the acid phase upon formation, a second compound in the acid phase being formed from the first compound and which may return to the first compound, and a third compound in the acid phase formed from the first compound and which cannot return to the first compound, which comprises determining the composition of the olefin; sensing the flow rates of the olefin and isoparaffin, the fresh acid and the discharge acid; providing a signal corresponding to the quantity α_o of acid consuming constituents contacting the acid in accordance with the sensed olefin and isoparaffin flow rate and with the determination of the olefin composition; providing a signal corresponding to the quantity α_m of water in the olefin and isoparaffin contacting the acid, providing a signal corresponding to the quantity γ_m of water in the fresh acid entering the alkylation unit; providing direct current voltages corresponding to the reaction rates R_1, R_2, R_3 and R_4 between the olefin, the isoparaffin, the acid, the first, second and third compounds, to the initial volume V_o of acid in the alkylation unit, to the molecular weights W_A, W_B and W_C of the first, second and third compounds, respectively, to the molecular weight W_M of water, to the densities ρ_A, ρ_B and ρ_C of the first, second and third compounds, respectively, the densities ρ_s and ρ_M of acid and water, respectively, and to a unit value 1; providing signals corresponding to the quantities A, B and C of the first, second and third compounds, respectively, formed during the reaction and to the quantity M of water in accordance with the α_o, α_m and γ_m signals and the discharged acid flow rate and the following equations:

$$A=\int_0^T\left\{\alpha_o-\left(R_1+R_2+R_4+\frac{F_s}{\rho_s V_s}\right)A+R_3B\right\}dt$$

$$B=\int_0^T\left\{R_2A-\left(R_3+\frac{F_s}{\rho_s V_s}\right)B\right\}dt$$

$$C=\int_0^T\left\{R_4A-\left(\frac{F_s}{\rho_s V_s}\right)C\right\}dt$$

$$M=\int_0^T\left\{\alpha_m+\gamma_m-\left(\frac{F_s}{\rho_s V_s}\right)M\right\}dt$$

and

$$V_s=V_{so}+\frac{W_M M}{\rho_M}+\frac{W_A A}{\rho_A}+\frac{W_B B}{\rho_B}+\frac{W_C C}{\rho_C}+\frac{1}{\rho_s}\int_c^T(F_F-F_s)dt$$

where T is a predetermined time and providing a signal corresponding to the weight of the acid as the control signal in accordance with 1.0, W_M, W_A, W_B and $_s$ voltages, the A, B, C, M and V_s signals and the following equation:

Wt. % acid/100 = $1.0-(W_M M+W_A A+W_B B+W_C C)(1/\rho_s V_s)$.

4. A method as described in claim 3 in which the determination step includes sampling the olefin and isoparaffin; providing a signal, whose amplitude peaks correspond to different constituents of the olefin and isoparaffin; providing control pulses, each control pulse coinciding with a different peak of the last mentioned provided signal, and providing a signal which corresponds to the portion of the olefin that is acid consuming as the composition signal in accordance with the last mentioned provided signal.

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