

[54] VAPOR PRESSURE MEASURING APPARATUS

[75] Inventors: Charles R. Lynch, Arthur; Charles W. Harrison, Nederland; Charles L. Kimtantas, Groves; William D. White, Nederland, all of Tex.

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

[22] Filed: June 28, 1974

[21] Appl. No.: 484,003

[52] U.S. Cl. 73/64.2

[51] Int. Cl. G01n 7/16

[58] Field of Search 73/64.2, 53, 61.3, 36, 73/29

[56] References Cited

UNITED STATES PATENTS

2,126,052	8/1938	Smith.....	73/36
2,949,768	8/1960	Ryant, Jr. et al.	73/53
3,037,375	6/1962	Jacobs et al.	74/64.2
3,191,428	6/1965	Piros.....	73/53
3,247,708	4/1966	Luther.....	73/53
3,332,856	7/1967	Hart.....	73/53 X

Primary Examiner—Jerry W. Myracle

Assistant Examiner—Joseph W. Roskos

Attorney, Agent, or Firm—T. H. Whaley; C. G. Ries; Ronald G. Gillespie

[57] ABSTRACT

Apparatus measures the vapor pressure of raw crude oil entering a flash tower by measuring operating parameters of the flash tower and its output streams. Flow rates of light component vapor provided by the flash tower and of the flashed crude oil are provided to a vapor pressure sensing network, which also receives signals corresponding to the pressure within the flash tower, to the temperature of the liquid in the flash tower and to the molecular weight and specific gravity of the flashed crude oil. The pressure of the flashed crude oil is then determined utilizing the received signals and equations hereinafter described. The vapor pressure of the flashed crude oil and the vapor pressure of the light component stream, which is substantially constant, is then apportioned according to the relation of the mole flow rates of the light hydrocarbon vapor and the flashed crude oil. The sum of the apportionment is then used to determine the vapor pressure of the raw crude oil.

9 Claims, 2 Drawing Figures

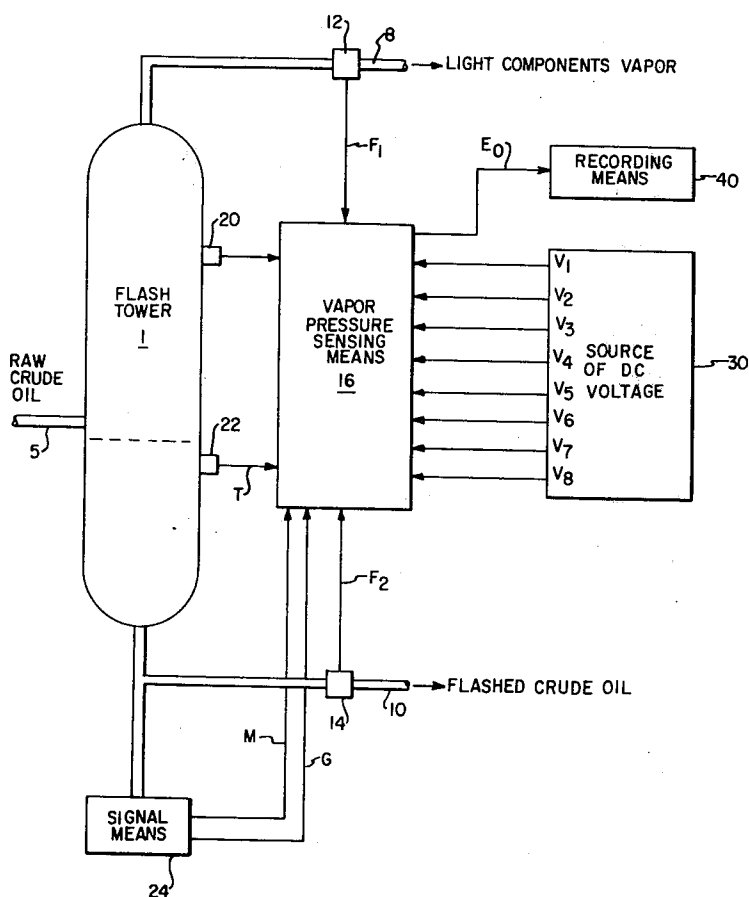
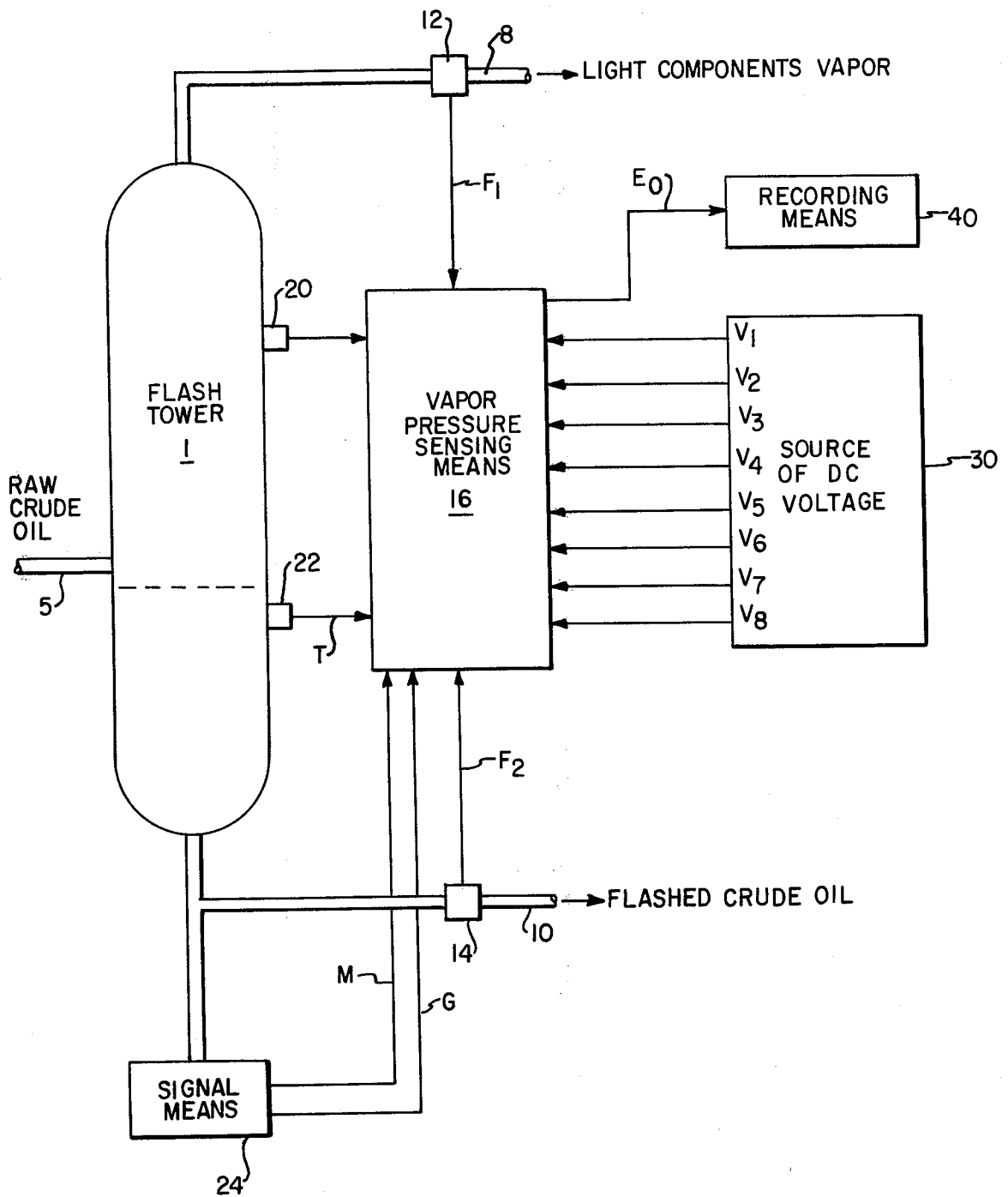
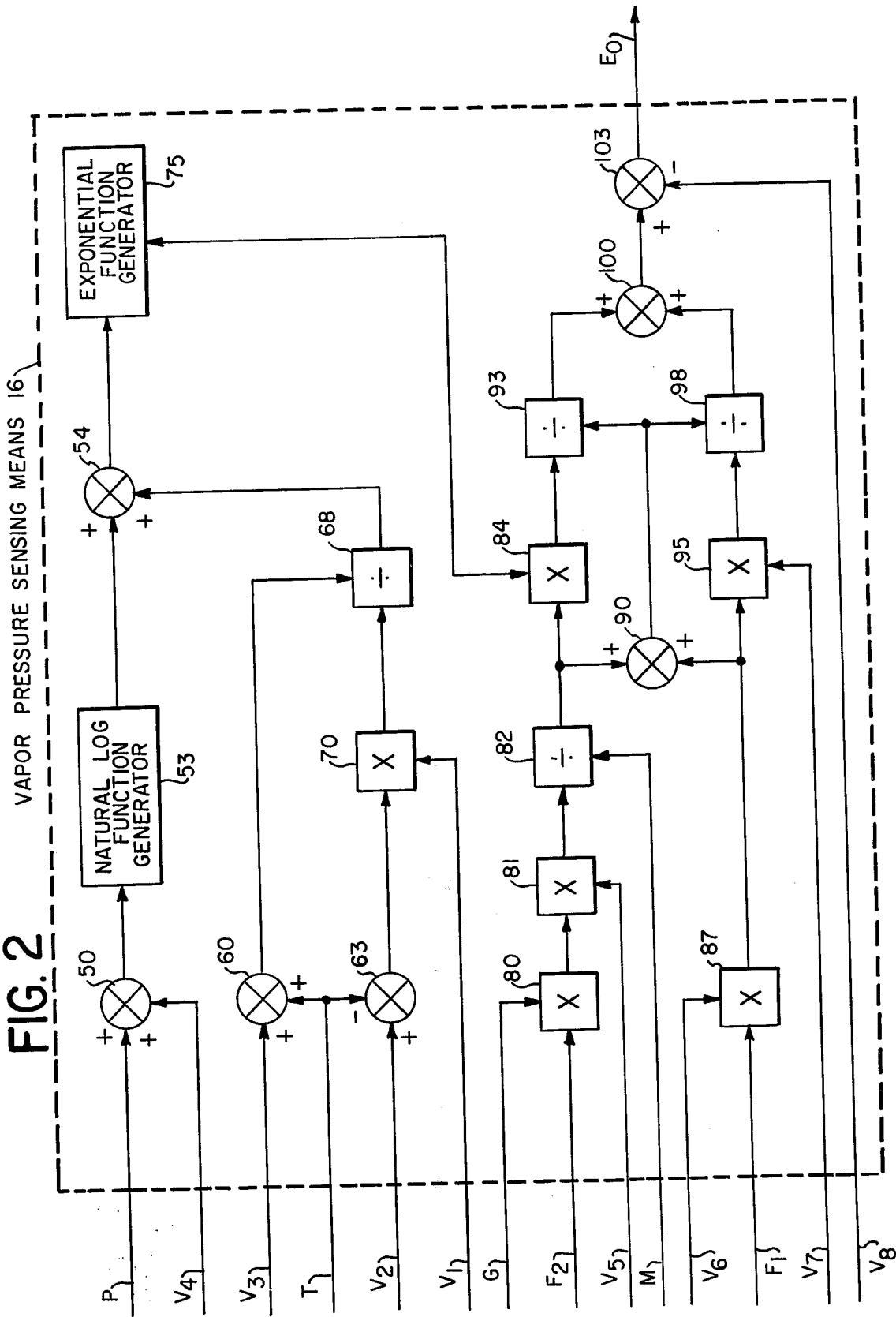


FIG. 1





VAPOR PRESSURE MEASURING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The apparatus of the present invention relates to measuring apparatus in general and, more particularly, to measuring apparatus for refinery units.

SUMMARY OF THE INVENTION

Apparatus provides a signal corresponding to the vapor pressure of a feed hydrocarbon entering a process vessel which yields a vapor and a processed hydrocarbon liquid. The apparatus includes a network which samples the processed hydrocarbon liquid and provides signals corresponding to the molecular weight and the specific gravity of the processed hydrocarbon liquid. Sensors sense the flow rates of the vapor and of the processed hydrocarbon liquid and provide corresponding signals. Other sensors provide signals corresponding to the sensed pressure of vapor in the vessel and the sensed temperature of the hydrocarbon liquid in the vessel. A circuit receiving signals from the network and from the sensors provides the feed hydrocarbon vapor pressure signal in accordance with the received signals.

The 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 shows a simplified block diagram of apparatus, constructed in accordance with the present invention, for determining the vapor pressure of crude oil which is being flashed by a flash system also shown in partial schematic form.

FIG. 2 is a block diagram of the vapor pressure sensing means shown in FIG. 1.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a flash tower 1 receives raw crude oil through a line 5. The crude oil separates into light components vapor and into flashed crude oil. The light components vapor is removed from flash tower 1 by way of a line 8 while the flashed crude oil is removed from flash tower 1 by way of a line 10. Flow rate sensors 12, 14 provide signals F_1 and F_2 , respectively, corresponding to the flow rates of the light components vapor and the flashed crude oil, respectively, to vapor pressure sensing means 16.

A conventional type pressure transmitter 20 provides a signal P corresponding to the sensed pressure in flash tower 1 to vapor pressure sensing means 16 while a conventional type temperature transmitter 22 provides a signal T , corresponding to the sensed temperature of the liquid in flash tower 1, to vapor pressure sensing means 16.

Signal means 24 samples the flashed crude oil in line 10 and provides signals M and G , corresponding to the average molecular weight and to the specific gravity, respectively, of the flashed crude oil. Signal means 24 may be of the same type shown as signal means 24 in U.S. Pat. No. 3,733,476. Signals M , G are provided to vapor pressure sensing means 16.

Equations 1 through 5 describe the various relationships that vapor pressure sensing means 16 uses in determining the vapor pressure of the raw crude oil in line 5.

$$1. \text{ AHVP} = e^A$$

$$2. \quad A = K_1 \frac{(K_2 - T)}{(T + K_3)} + 1_n(P + K_4)$$

$$3. \quad \text{MRO} = \frac{(F_2)(K_5)(G)}{M}$$

$$4. \quad \text{MRV} = F_1 K_6$$

$$5. \quad \text{RVP} = \frac{(\text{AHVP})(\text{MRO})}{\text{MRO} + \text{MRV}} + \frac{(K_7)(\text{MRV})}{\text{MRO} + \text{MRV}} - K_8$$

where K_1 through K_8 are constants having values of 9.97606, 100, 460, 14.7, 350, 2.6385, 20.0 and 0.46 for a particular process system; AHVP is an adjusted hydrocarbon vapor pressure in the flash tower corrected to 100°F; MRO is a molar rate of the flashed crude oil in units of lb. moles of liquid per hour; MRV is the molar rate of the vapor in units of lb. moles of gas per hour and RVP is the Reid Vapor Pressure of the raw crude oil.

Vapor pressure sensing means 16 receives direct current voltages V_1 to V_8 from a source 30 of direct current voltages and provides a signal E_0 corresponding to the vapor pressure of a petroleum fraction to recording means 40. Voltages V_1 to V_8 correspond to the constants K_1 through K_8 described in Equations 1 through 5, above. Recording means 40 records signal E_0 from vapor pressure sensing means 16.

Referring now to FIG. 2 vapor pressure sensing means 16 includes summing means 50 which sums pressure signal P with voltage V_4 to provide a signal corresponding to the term $P + K_4$ to a natural log function generator 53. Generator 53 provides a signal corresponding to the term $\ln(P + K_4)$ to summing means 54.

Summing means 60 and subtracting means 63 sums signal T with voltage V_3 and subtracts signal T from voltage V_2 , respectively. Summing means 60 provides a signal, corresponding to the term $(T + K_3)$, to a divider 68 while subtracting means 63 provides a signal, corresponding to the term $(K_2 - T)$, to a multiplier 70. Multiplier 70 multiplies voltage V_1 with the signal from subtracting means 63 to provide a signal to divider 68. Divider 68 divides the signal from multiplier 70 with the signal from summing means 60 to provide a signal to summing means 54.

Summing means 54 sums the received signals to provide a signal, corresponding to the term A , to a conventional type exponential function generator 75 which in turn provides a signal corresponding to the term AHVP in equation 1.

A multiplier 80 multiplies flow rate signal F_2 with specific gravity signal G to provide a signal to a multiplier 81. Multiplier 81 multiplies the signal from multiplier 80 with voltage V_5 to provide a signal to divider 82. Divider 82 divides the signal from multiplier 81 with signal M to provide a signal corresponding to the molar rate MRO of the flash crude oil. A multiplier 84 multiplies the signal from divider 82 with the signal

from generator 75 to provide a signal corresponding to the term (AHVP)(MRO) in equation 5.

A multiplier 87 multiplies flow rate signal F_1 with voltage V_6 to provide a signal corresponding to the molar rate MRV for the vapor in line 8. Summing means 90 sums the signal from divider 82 with the signal from multiplier 87 to provide a signal corresponding to the term (MRO+MRV). A divider 93 divides the signal provided by multiplier 84 with the signal from summing means 90 to provide a signal corresponding to the term

$$\frac{(AHVP)(MRO)}{(MRO)(MRV)}$$

A multiplier 95 multiplies the signal from multiplier 87 with voltage V_7 to provide a signal corresponding to the term $(K_7)MRV$ in equation 5. A divider 98 divides the signal provided by multiplier 95 with the signal provided by summing means 90 to provide a signal corresponding to the term

$$\frac{(K_7)(MRV)}{(MRO + MRV)}$$

Summing means 100 sums the signals from dividers 93, 98 to provide a signal to subtracting means 103. Subtracting means 103 subtracts voltage V_8 from the signal provided by summing means 100 to provide signal E_0 corresponding to the Reid Vapor Pressure RVP of the raw crude oil.

The apparatus of the present invention as hereinbefore described provides an output corresponding to the Reid Vapor Pressure of raw crude oil entering a flash tower while monitoring the operation of the flash tower so as to provide an on-line determination of the Reid Vapor Pressure. The apparatus of the present invention as heretofore described is not restricted to the determination of the Reid Vapor Pressure of raw crude oil but is also applicable to the vapor pressure of any hydrocarbon liquid entering a process vessel which provides a vapor and a processed hydrocarbon liquid as well as other chemical processes.

It would be obvious to one skilled in the art that a general purpose digital computer could be utilized to determine the Reid Vapor Pressure of the raw crude oil. Signals F_1 , F_2 , T , G , M and P would be converted to digital signals using conventional type analog-to-digital converters. The digital computer may provide its own record or output digital signals. The output digital signals would then be converted to signal E_0 by a digital-to-analog converter.

What is claimed is:

1. Apparatus for providing an output signal corresponding to the vapor pressure of a feed fluid entering a process vessel which yields a vapor and a processed liquid, comprising means for sampling the processed liquid and providing signals corresponding to the molecular weight M and the specific gravity G of the processed liquid, means for sensing the flow rates F_1 and F_2 of the vapor and the processed liquid and providing signals corresponding thereto, means for sensing the pressure P of vapor in the vessel and providing a corresponding signal, means for sensing the temperature T

of liquid in the vessel, and means connected to sampling means and to all the sensing means for providing the output signal corresponding to the vapor pressure of the feed fluid in accordance with the F_1 , F_2 , P , T , M and G signals from the sampling means and the sensing means.

2. Apparatus as defined in claim 1 in which the feed fluid is a hydrocarbon liquid, and the processed liquid is a processed hydrocarbon liquid.

3. Apparatus as defined in claim 2, in which the output signal means includes means connected to the pressure and temperature sensing means for providing a signal corresponding to a term A in accordance with the P and T signals from the pressure and temperature sensing means and the following equation:

$$A = K_1 \frac{(K_2 - T)}{(T + K_3)} + \ln(P + K_4)$$

where K_1 through K_4 are constants, and network means connected to the A signal means for providing the AHVP signal in accordance with the A signal and the following equation:

$$AHVP = e^A$$

4. Apparatus as defined in claim 3 in which the output signal means includes means connected to the sampling means and to the flow rate sensing means for providing a signal corresponding to the molar rate MRO of the processed hydrocarbon liquid in accordance with M and G signals from sampling means and the F_2 signal from the flow rate sensing means, and means connected to the flow rate sensing means for providing a signal corresponding to the molar rate MRV of the vapor in accordance with the F_1 signal from the flow rate sensing means.

5. Apparatus as defined in claim 4 in which the MRO signal means provides the MRO signal in accordance with the F_2 , M and G signals and the following equation:

$$MRO = \frac{(F_2)(K_5)(G)}{M}$$

where K_5 is a constant, and the MRV signal means provides the MRV signal in accordance with the F_1 signal and the following equation:

$$MRV = F_1(K_6)$$

where K_6 is a constant.

6. Apparatus as defined in claim 5 in which the output signal means includes summing means connected to the MRO and the MRV signal means for providing the output signal in accordance with the sum of the MRV and MRO signals.

7. Apparatus as defined in claim 6 further comprising means connected to the summing means for recording the output signal.

8. Apparatus as defined in claim 6 in which the process vessel is a flash tower, the feed hydrocarbon is raw crude oil, the processed hydrocarbon is flashed crude oil, and the vapor is light components gas.

9. Apparatus as defined in claim 5 in which the constants K_1 through K_6 have values of 9.97606, 100, 460, 350 and 2.6385, respectively.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3901062

DATED : AUGUST 26, 1975

INVENTOR(S) : CHARLES R. LYNCH; CHARLES W. HARRISON; CHARLES L.
KIMTANTAS; WILLIAM D. WHITE

It is certified that error appears in the above-identified patent and that said Letters Patent
are hereby corrected as shown below:

Claim 3, line 25 "AHVP= e^1 " should read --AHVP= e^A --

Signed and Sealed this

eight Day of June 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks