# United States Patent [19]

**White et al.**

[11] **3,748,894**

[45] **July 31, 1973**


[54] **MEANS AND METHOD FOR AN ON-LINE DETERMINATION OF THE FLASH POINT OF LUBE OIL FRACTIONS**


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[52] **U.S. Cl.** ................................ **73/36,** 235/151.12

[51] **Int. Cl.** ........................................... **G01n 25/52**

[58] **Field of Search** ................................ 73/32, 36; 235/151.12 MO, 151.34



[56] **References Cited**

UNITED STATES PATENTS

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*Primary Examiner*—Herbert Goldstein

*Attorney*—Thomas H. Whaley et al.



[57] **ABSTRACT**

Apparatus provides for an on-line determination of the flash point of lube oil fractions. The hydrocarbon is continuously sampled by a viscosity analyzer and a density analyzer which provides signals corresponding to the viscosity and the API gravity of the lube oil fractions. A computer circuit provides a signal corresponding to the flash point of the lube oil fractions in accordance with the viscosity signal and the gravity signal.


**8 Claims, 2 Drawing Figures**

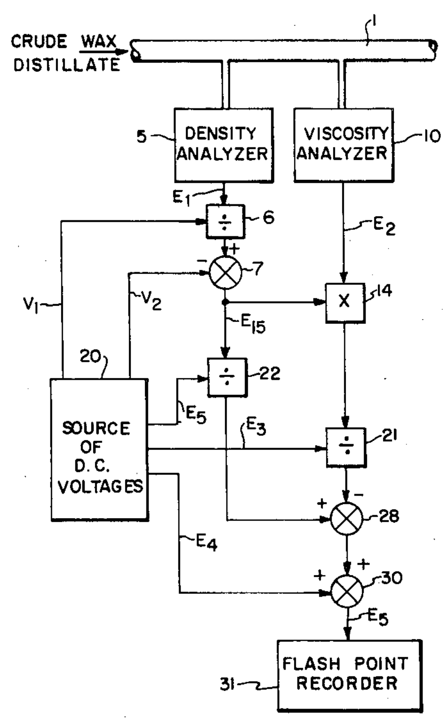


FIG. 2

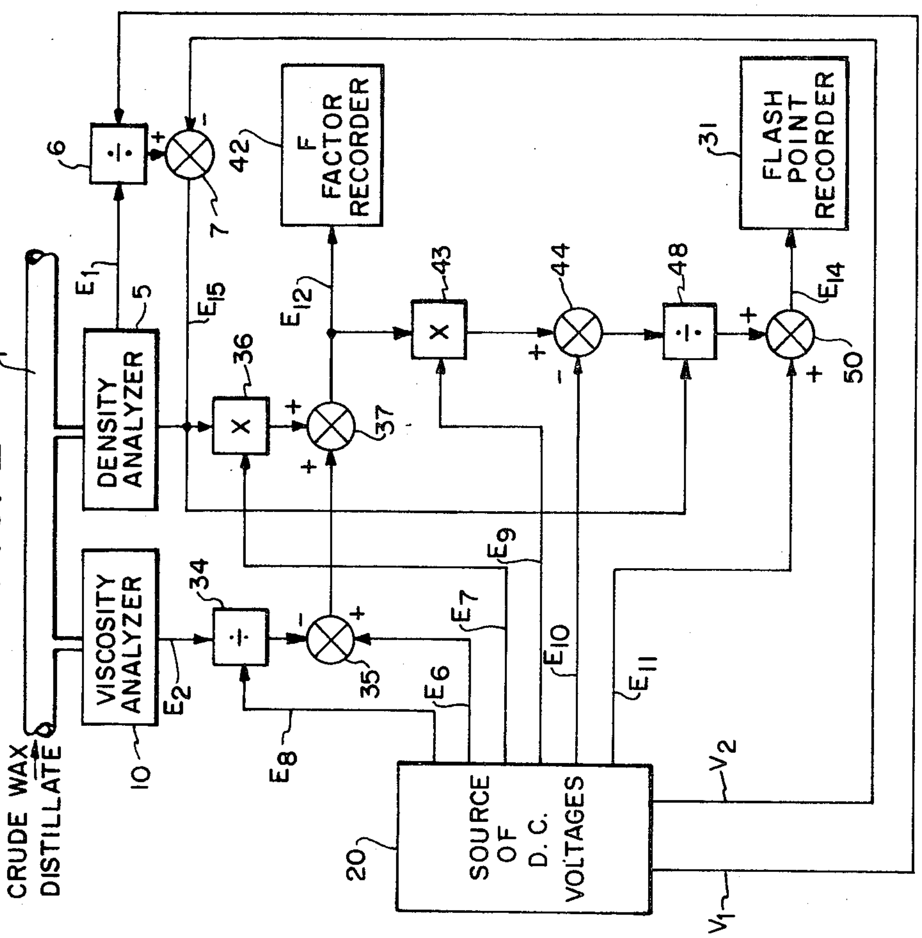
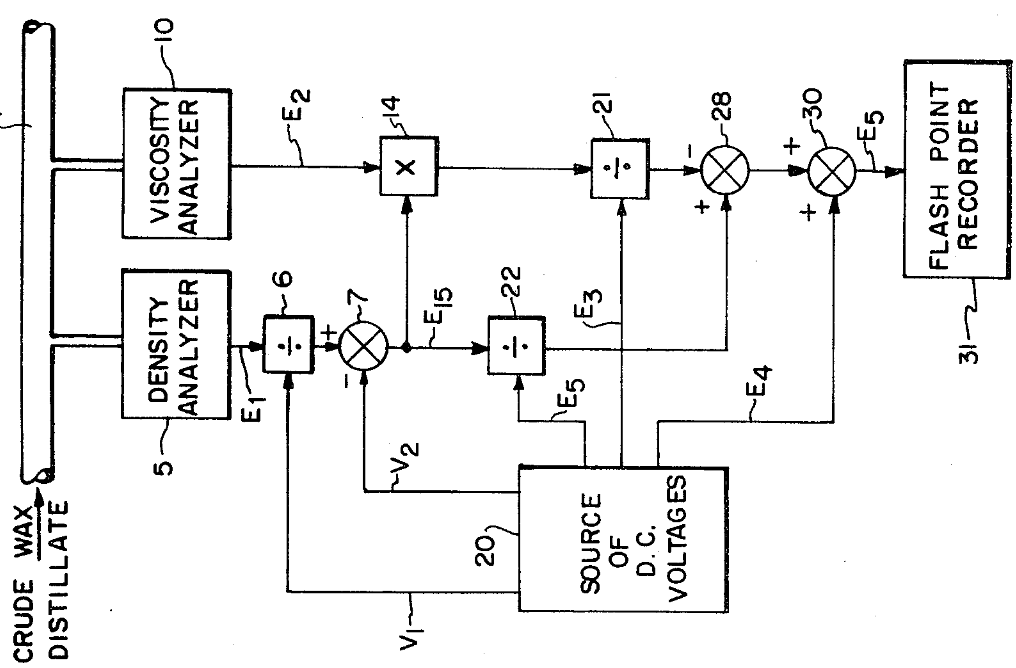

CRUDE WAX DISTILLATE
VISCOSITY ANALYZER
DENSITY ANALYZER
F FACTOR RECORDER
FLASH POINT RECORDER
SOURCE OF D.C. VOLTAGES
E1
E2
E6
E7
E8
E9
E10
E11
E12
E14
E15
V1
V2
1
5
6
7
10
20
31
34
35
36
37
42
43
44
48
50

FIG. 1


CRUDE WAX DISTILLATE
DENSITY ANALYZER
VISCOSITY ANALYZER
SOURCE OF D.C. VOLTAGES
FLASH POINT RECORDER
E1
E2
E3
E4
E5
E15
V1
V2
1
5
6
7
10
14
20
21
22
28
30
31

# MEANS AND METHOD FOR AN ON-LINE DETERMINATION OF THE FLASH POINT OF LUBE OIL FRACTIONS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to monitoring methods and systems in general and, more particularly, to a method and system for monitoring the flash point of lube oil fractions.

2. Description of the Prior Art

In the operation of a unit in a refinery which provides lube oil fractions, it is economically important to maintain the quality of the lube oil fractions within a relatively narrow range of specification. This is done by monitoring the viscosity and flash point of the lube oil fractions. Heretofore, two methods were used: one method was to manually sample the lube oil fractions and determine in a laboratory the viscosity and flash point of the lube oil fractions. A decided disadvantage in this method is the appreciable time lag which exists between the time when the samples were taken and the time the results became available for control of the unit.

Another way is to provide on-line viscosity and flash point analysis. This is a relatively new area. The flash point analyzers presently available provide results corresponding to the Pensky-Martin flash point rather than the Cleveland Open Cup flash point. The reproducibility of the commercial flash point analyzers is considered to be poor. Also, the analyzers have an excessive maintenance requirement due to the coking tendency of the lube oil fractions.

The apparatus of the present invention substantially overcomes the problems of maintenance and reproducibility while providing an output corresponding to the Cleveland Open Cup flash point of lube oil fractions being analyzed.

## SUMMARY OF THE INVENTION

A flash point analyzer provides an output corresponding to the flash point of lube oil fractions from a unit in a refinery. The analyzer includes circuitry which senses the density and viscosity of the lube oil fractions and provides a density signal and a viscosity signal. A network provides the output corresponding to the flash point of the lube oil fractions in accordance with the density signal and the viscosity signal from the circuitry.

The objectives and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the following drawings wherein two embodiments of the invention are 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 apparatus, constructed in accordance with the present invention, for providing an output corresponding to the Cleveland Open Cup flash point of lube oil fractions from a unit in a refinery being monitored by the apparatus.

FIG. 2 is a simplified block diagram of another embodiment of the invention.

## DESCRIPTION OF THE INVENTION

In a preferred embodiment of the present invention, the Cleveland Open Cup flash point of lube oil fractions is estimated in accordance with the following equation:

1. Flash Point $= k_1 + k_2/G - k_3/VG$

where $V$ is the Saybolt Universal Viscosity, $G$ is the API gravity at 60° F and $k_1$, $k_2$ and $k_3$ are factors. By way of example $k_1$, $k_2$ and $k_3$ may have the following values: 437.2, 664.76 and 197579.2, respectively, when the viscosity is measured at 100° F. The values for $k_1$, $k_2$ and $k_3$ will differ for different viscosity temperatures.

Referring now to FIG. **1**, lube oil fractions leaving a unit (not shown) in a refinery by way of a line **1**, is sampled by a viscosity analyzer **10** and a density analyzer **5**. Analyzer **10** may be of the type manufactured by the Hallikainen Company which is a continuous viscometer model 1077S7 while density analyzer **1** may be a Dynatrol density analyzer series 200G. Density analyzer **5** senses the density of the lube oil fractions and provides a signal $E_1$, corresponding to the specific gravity of the crude wax distillate in line **1**. The API gravity is determined in accordance with the following equation:

2. API = 141.5/Specific Gravity − 131.5

A divider **6** divides a direct current voltage $V_1$, which corresponds to the term 141.5, with signal $E_1$ to provide an output. Subtracting means **7** subtracts a direct current voltage $V_2$ from the output from divider **6** to provide a signal $E_{15}$ corresponding to the API gravity G of the lube oil fractions. The specific gravity of a hydrocarbon is a function of the density of the hydrocarbon. Viscosity analyzer **10** provides a signal $E_2$ corresponding to the Saybolt Universal Viscosity of the lube oil fractions in line **1**.

A multiplier **14** multiplies signals $E_{15}$, $E_2$ with each other to provide a signal corresponding to the term VG in equation 1. A divider **21** divides a direct current voltage $E_3$, corresponding to the factor $k_3$ in equation 1, provided by a source **20** of direct current voltages by the signal from multiplier **14**. Divider **21** provides a signal corresponding to the term $k_3$/VG in equation 1.

Source **20** also provides direct current voltages $E_4$ and $E_5$ corresponding to $k_1$ and $k_2$, respectively, in equation 1 as well as voltages $V_1$, $V_2$. A divider **22** divides voltage $E_5$ by signal $E_{15}$ to provide a signal corresponding to the term $k_2/G$. Subtracting means **28** subtracts the signal provided by divider **21** from the signal provided by divider **22** to provide an output to summing means **30**. Summing means **30** sums the output from subtracting means **28** with voltage $E_4$ to provide signal $E_5$ corresponding to the estimated Cleveland Open Cup flash point. A conventional type recorder **31** records signal $E_6$ to provide a record of the flash point of the lube oil fractions.

In monitoring the properties of lube oil fractions, a useful parameter is the Watson-Nelson characterization factor F. The factor $F$ may be determined in accordance with an equation 2 and used to estimate the Cleveland Open Cup flash point of the lube oil fractions in accordance with an equation 3.

3. $F = k_4 + k_5G - k_6/V$,

and

4. Flash Point $= (k_7F - k_8)/G + k_9$

where $k_4$ through $k_9$ are factors.

The values for $k_4$ through $k_9$, associated with a viscosity measurement made at 100° F are shown in the following table:

| Factor | Value | Factor | Value |
|---|---|---|---|
| $k_4$ | 10.04 | $k_7$ | 5369 |
| $k_5$ | 0.0794 | $k_8$ | 53240 |
| $k_6$ | 36.8 | $k_9$ | 11.1 |

Although the determination of the factor F is thoroughly discussed in U.S. Pat. No. 3,557,609, which is assigned to Texaco Inc., assignee of the present invention, for convenience the determination of the factor F will be discussed hereafter. Referring to FIG. 2, viscosity analyzer **10** provides signal $E_2$ to a divider **34**. Divider **34** divides a direct current voltage $E_8$ corresponding to the factor $k_6$ in equation 3 from source **20** to provide a signal corresponding to the term $k_6/V$. Source **20** provides direct current voltages $E_6$ *through* $E_{11}$ which correspond to factors $k_4$ through $k_9$, respectively, in equations 3 and 4. Subtracting means **35** subtracts the signal from divider **34** from voltage $E_6$.

Signal $E_{15}$ from subtracting means **7** is applied to a multiplier **36**. Multiplier **36** multiplies signal $E_{15}$ with voltage $E_7$ to provide an output corresponding to the term $k_5G$ in equation 3. Summing means **37** sums the outputs provided by subtracting means **35** and multiplier **36** to provide a signal $E_{12}$ corresponding to the Watson-Nelson characterization factor F. Signal $E_{12}$ is applied to a conventional type recorder **42** and to a multiplier **43**. Multiplier **43** multiplies signal $E_{12}$ with voltage $E_9$ to provide a signal, corresponding to $k_7F$ in equation 4, to subtracting means **44**. Subtracting means **44** subtracts voltage $E_{10}$ from the signal provided by multiplier **43** to provide a signal corresponding to the term $k_7F-k_8$ in equation 4. The signal from subtracting means **44** is divided by signal $E_1$ by a divider **48** to provide a signal corresponding to the term $(k_7F-k_8)/G$. Summing means **50** sums the signal from divider **48** with voltage $E_{11}$ to provide a signal $E_{14}$ corresponding to the estimated Cleveland Open Cup Flash Point of the crude wax distillate in line **1**. Recorder **31** records signal $E_{14}$ to provide a record of the flash point of the lube oil fractions.

The following table shows the relationship between an estimated flash point for lube oil fractions from a unit in a refinery as determined by apparatus of the preferred embodiment, as heretofore described, and the flash point as measured in a laboratory. The numbers in parentheses represent the number of laboratory measurements upon which the average measured flash point is based.

| Sample No. | Average Lab. Measured Flash POINT (°F) | Estimated Flash Point (°F) |
|---|---|---|
| 1 | 391 (4) | 388 |
| 2 | 385 (8) | 390 |
| 3 | 392 (10) | 394 |
| 4 | 393 (10) | 394 |
| 5 | 403 (9) | 402 |
| 6 | 405 (11) | 406 |

The apparatus of the present invention, as heretofore described, provides an output corresponding to the flash point of lube oil fractions from a unit in a refinery. The apparatus senses the density and viscosity of the lube oil fractions and uses the sensed density and viscosity to determine the flash point.

What is claimed is:



1. A flash point analyzer comprising means for sensing the density of lube oil fractions and providing a first signal representative thereof, means for sensing the viscosity of the lube oil fractions and providing a second signal corresponding thereto, means connected to the density and the viscosity sensing means for providing a signal corresponding to a flash point of the lube oil fractions by combining said first and second signals in accordance with a predetermined emperical relationship relating said flash point with said density and viscosity.

2. An on-line analyzer for providing an output corresponding to a flash point of lube oil fractions from a unit in a refinery, comprising means for sensing the density of the lube oil fractions and providing a first signal representative thereof, means for sensing the viscosity of the lube oil fractions and providing a second signal corresponding thereto, and means connected to the density and the viscosity sensing means for providing the output corresponding to the flash point of the lube oil fractions by combining said first and second signals in accordance with a predetermined emperical relationship relating said flash point with the density and the viscosity.

3. A flash point analyzer as described in claim 2 in which the signal from the density sensing means corresponds to the API gravity of the lube oil fractions and the signal from the viscosity sensing means corresponds to the Saybolt Universal Viscosity of the lube oil fractions.

4. A flash point analyzer as described in claim 3 in which the means for providing the flash point output provides the output in accordance with the API gravity and Saybolt Universal Viscosity signals and the following equation:

$$\text{Flash Point} = k_1 + k_2/G - k_3/VG$$

where $G$ is the API gravity, $V$ is the Saybolt Universal Viscosity and $k_1$ through $k_3$ are factors.

5. A flash point analyzer as described in claim 3 in which the flash point signal means include means connected to the density signal means and to the viscosity signal means for providing a signal corresponding to a Watson-Nelson characterization factor F in accordance with the API gravity signal, the Saybolt Universal Viscosity signal and the following equation:

$$F = k_4 + k_{5G} - k_6/V$$

where $G$ is the API gravity, $V$ is the Saybolt Universal Viscosity, and $k_4$ through $k_6$ are factors, and means connected to the $F$ factor signal means and to the API gravity signal means for providing the output corresponding to the flash point in accordance with the API gravity signal and the $F$ factor signal from the factor signal means in accordance with the API gravity signal, the $F$ factor signal and the following equation:

$$\text{Flash Point} = k_7F-k_8/G + k_9$$

where $k_7$ through $k_9$ are factors.

6. A method for providing an output corresponding to a flash point of lube oil fractions from a unit in a refinery, which comprises the following steps: sensing the density of the lube oil fractions, providing a first signal corresponding to the API gravity of the lube oil fractions in accordance with the sensed density, sensing the viscosity of the lube oil fractions providing a second signal corresponding to the Saybolt Universal Viscosity in accordance with the sensed viscosity, and deriving the output corresponding to the flash point of the lube oil fractions by combining said first and second signals

in accordance with a predetermined emperical relationship relating said flash point with said API gravity and Saybolt Universal Viscosity.

**7.** A method as described in claim **6** in which the output providing step includes providing the flash point output in accordance with the API gravity signal, Saybolt Universal Viscosity signal and the following equation:

$$\text{Flash Point} = k_1 + k_2/G - k_3/VG$$

where $G$ is the API gravity, $V$ is a Saybolt Universal Viscosity and $k_1$ through $k_3$ are factors.

**8.** A method as described in claim **6** in which the output providing step includes providing a signal corresponding to the Watson-Nelson characterization factor F in accordance with the API gravity signal, the Saybolt Universal Viscosity signal and the following equation:

$$F = k_4 + k_{5G} - k_6/V$$

where $G$ is the API gravity, $V$ is the Saybolt Universal Viscosity, and $k_4$ through $k_6$ are factors, and providing the output corresponding to the flash point in accordance with the API gravity signal, the $F$ factor signal and the following equation:

$$\text{Flash Point} = k_7F - k_8/G + k_9$$

where $k_7$ through $k_9$ are factors.

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