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METHOD AND APPARATUS FOR ANALYZING HYDROCARBON COMPOSITIONS

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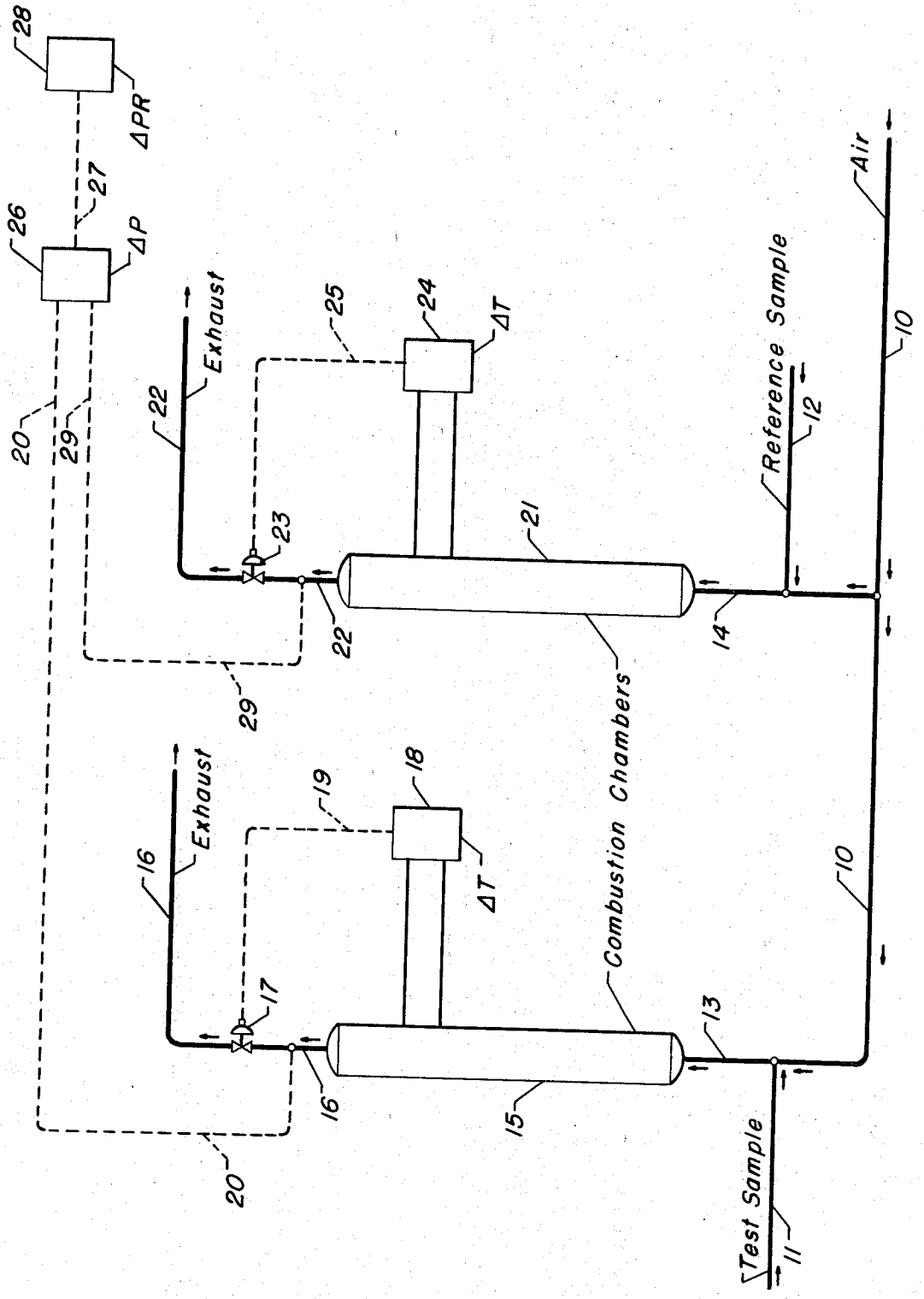

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METHOD AND APPARATUS FOR ANALYZING HYDROCARBON COMPOSITIONS

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ABSTRACT OF THE DISCLOSURE

Method for analyzing hydrocarbon compositions whereby, for example, octane rating of a hydrocarbon-containing stream is obtained. The stream to be analyzed is oxidized in an apparatus under conditions which produce a cool flame. Simultaneously, a reference fuel of known composition is also oxidized in a similar apparatus under conditions which produce a cool flame. The positions of the flame in both combustion chambers is located and an output signal representative of the relative positions of the cool flames to each other is correlated with a composition parameter of the unknown sample, such as octane number.

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for analyzing hydrocarbon compositions. It particularly relates to an improvement in the method and apparatus for analyzing hydrocarbon mixtures utilizing a stabilized cool flame generator. It specifically relates to an improvement in the method for determining a composition parameter, such as octane number, of a hydrocarbon composition while simultaneously comparing the results obtained therefrom with the results obtained from the simultaneous treatment of a reference fuel having a known composition parameter.

Those skilled in the art are familiar with the phenomena of cool flame generation. Briefly, when a mixture of hydrocarbon vapor and oxygen at a composition within the explosion limit is held at conditions of pressure and temperature below the normal ignition point, partial oxidation reactions occur which generally result in the formation of by-products, such as aldehydes, carbon monoxide, and other partially oxidized combustion products. These products are apparently produced via a chain reaction which also, it is believed, produces ions which then in some manner continue the reaction chain. If such a mixture of hydrocarbon vapor and oxygen is isolated and compressed and/or heated so that these chain reactions proceed at significant reaction rates, then "cool flames" are observed within the chamber. The cool flames are characterized as light emissions accompanied by the evolution of relatively minor amounts of heat. Implicit in this definition is the fact that the phenomena of cool flame generation is short of total combustion and short of total ignition and explosion. The work of Barush and Paine in "Industrial and Engineering Chemistry," volume 43, pages 2329–2332, 1951, describes in detail the results which can be obtained from continuous or stabilized cool flames. Basically, the utilization of this phenomena in the practice of the present invention is one of correlating the distances of the cool flame from the end of the combustion chamber with a composition parameter of the chamber to be analyzed, such as octane number.

A more complete explanation and description of the basic apparatus and basic method for detecting composition parameters utilizing cool flames is contained in copending patent application, Ser. No. 471,670, filed July 13, 1965, now U.S. Pat. 3,463,613 issued Aug. 26, 1969. The contents of said copending application are incorporated herein by reference so that a greater detailed discussion need not be presented in this application. Those skilled in the art are referred directly to the entire teaching contained in said copending application for additional and specific details as to the construction of the basic apparatus and method of operation thereof. As will be more fully developed hereinafter, the present invention describes and claims an improvement in the basic method and apparatus disclosed and claimed in said copending application.

One of the difficulties described in the method and apparatus of the copending application is concerned with calibration of the apparatus for various types of hydrocarbon samples. One system of calibration, of course, would be to operate the apparatus for a predetermined length of time on a reference sample of known composition and establishing therefrom suitable information for calibration purposes. The frequency of such calibration would depend, of course, on the needs and/or desires of the user. Conceivably, the system could be operated in cyclic fashion with operation on the reference sample being periodically alternated with operation on the unknown sample or test sample. Those skilled in the art will recognize that the cyclic operation is undesirable for monitoring a process stream especially if the cyclic operation is used on closed looped control. Therefore, it would be desirable to develop a method and apparatus for continuously detecting changes in the composition of a hydrocarbon fluid mixture without the necessity of periodic or intermittent calibration thereof.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an improved apparatus and an improved method for analyzing hydrocarbon mixtures.

It is another object of this invention to provide an improved apparatus and an improved method for measuring a composition parameter of a hydrocarbon-containing mixture, such as octane number, utilizing the cool flame phenomena.

It is still another object of this invention to provide an apparatus and method for continuously detecting changes in the composition of a hydrocarbon fluid mixture while simultaneously and continuously calibrating such operation against a reference sample of known composition.

Therefore, in its method aspects, the present invention provides a method of detecting changes in the composition of a hydrocarbon-containing fluid mixture which comprises: (a) introducing said mixture into one end of a first elongated combustion zone under conditions sufficient to produce a cool flame therein; (b) simultaneously and continuously introducing a reference fluid mixture of known composition into one end of a second elongated combustion zone under conditions sufficient to produce a cool flame therein; (c) sensing the position of the cool flame in each of said combustion zones; and, (d) developing from said cool flames an output signal representative

of the relative positions of the cool flames to each other, said signal correlatable to a change in the composition of the said hydrocarbon fluid mixture.

In another method aspects of the present invention there is also provided a method for detecting changes in composition of a fluid mixture of unknown composition which comprises the steps of: (a) continuously introducing a sample stream of a hydrocarbon-containing mixture of unknown composition into one end of a first elongated combustion chamber maintained under conditions to generate a cool flame front therein; (b) simultaneously and continuously introducing a sample stream of material of known composition into one end of a second elongated combustion chamber maintained under conditions sufficient to generate a cool flame front therein; (c) sensing the position of each said flame front and developing therefrom a control signal; (d) utilizing each developed control signal to adjust a combustion condition in each respective chamber in a manner to position each said flame front at a predetermined location within each chamber respectively; and, (e) sensing each adjusted condition and developing therefrom an output signal correlatable to changes in said composition.

In its apparatus aspects, the present invention provides apparatus comprising: (a) a first combustion chamber; (b) a second combustion chamber operationally connected with said first chamber; (c) means for generating a stabilized cool flame within the first chamber utilizing as fuel therefor a hydrocarbon-containing mixture to be analyzed as to composition; (d) means for generating a stabilized cool flame within the second chamber utilizing as fuel therefor a reference sample of known composition; (e) means for sensing the physical position of the cool flame within said first combustion chamber and means for sensing the physical position of the cool flame within said second combustion chamber; (f) first control means associated with said sensing means of the first combustion chamber adapted to adjust a combustion parameter in a manner to maintain the physical position of the flame constant relative to said first combustion chamber; (g) second control means associated with said sensing means of the second combustion chamber adapted to adjust a combustion parameter in a manner to maintain the physical position of the flame constant relative to said second combustion chamber; and, (h) readout means developing a signal responsive to said adjusted parameters in a manner correlatable with an analysis of the composition of the fuel to said first combustion chamber.

In essence, therefore, the present invention provides a method and apparatus which simultaneously compares the physical position of a cool flame generated by a reference sample with the cool flame generated by the test sample. The positions of these flames are preferably immobilized the same distance from the end of the combustion zone by proper adjustment of the combustion zone pressure. The differences in pressure between the two zones is recorded and a signal is developed from this difference which is correlatable with the composition of the test sample. Broadly, then, the present invention provides a method and apparatus for continuously controlling a commercial process stream and comparing the process stream with a reference sample of known composition in order to continuously monitor a change in the composition of the process stream. Such an operation is, of course, readily adaptable for closed loop control of a commercial process unit.

It is to be noted that the present invention as related to the analysis of hydrocarbon mixtures is to be distinguished from chemical analysis means whereby a hydrocarbon mixture is analyzed or broken down into its chemical components. In other words, the present invention does not necessarily relate to a method for analyzing, for example, a paraffinic hydrocarbon mixture so as to determine the relative amounts of propane, butane, pentane, etc. therein. Rather, the present invention is uniquely related to a method which utilizes an output signal which is empirically correlatable with one or more conventional identifications or specifications of composition, such as Reid Vapor Pressure, ASTM Distillation, knock or detonation characteristics of a motor fuel, such as Research Octane Number, Motor Octane Number, etc. The specific manner of the correlation is basically a function of composition and is further influenced by the presence or absence of hydrocarbon types, such as isoparaffins, paraffins, olefins, diolefins, aromatics, and the like. Thus, as presently conceived it is contemplated that the present invention will continuously calibrate itself for a particular hydrocarbon blend or charge stock and relatively small composition deviations can be accounted for. Those skilled in the art are familiar with the procedure for obtaining reference fuels of known composition. These reference samples may be similar or completely different hydrocarbon type compositions. It is only important in the practice of this invention that the desired composition of the reference sample be similar to the test sample and, of course, be of known composition or identification, which composition is the one to be determined is the test sample. Thus, for example, the reference fuel may be a 95 octane number when it is desired to monitor a process stream producing a gasoline fraction desirably of 95 octane number.

Furthermore, as used herein, the term "output signal" or "signal developed by the readout means" is to be construed in its most meaningful sense and includes analog signals of all types, such as amplitude-modulated, phase-modulated, or frequency-modulated electrical signals or pressure signals by conventional pneumatic transmission media, as well as digital representations of the foregoing. The output signal is further intended to include simple mechanical motion or displacement of a transducer member (whether or not mechanically, electrically, or pneumatically coupled to a physical display means, such as an indicating arm, recorder pin, or digital display board) including by way of illustration, the expansion or contraction of a Bourdon tube, pressure spiral or helix, the displacement of a bellows-flapper, nozzle-diagram, or differential transformer-core assembly, the movement of a bimetallic temperature responsive element, the motion of a slider of a self-balancing potentiometer, etc. The output signal may be transmitted without physical display directly to reset a final control unit, such as a diaphragm motor valve or a sub-control loop in a cascade system.

Frequently, however, the readout device will comprise or will be coupled to an indicating or recording means, the scale or chart of which may be calibrated in terms of the desired identifying composition parameter of the hydrocarbon sample, such as octane number, initial boiling point, 90% boiling point, vapor pressure, and the like. In the practice of this invention, the location of the cool flame front is, preferably, determined by temperature sensing devices, such as a pair of axially spaced thermocouples fixed at a known distance from one end of the combustion zone in question and at a known and fixed distance from each other, e.g. one (1) inch. As will be more fully developed hereinbelow, the signal developed by the thermocouple means activates appropriate control means for adjusting a combustion zone parameter or condition so as to immobilize the cool flame front at a position generally between the two spaced thermocouples. A most satisfactory combustion condition which can be used as the control means is the combustion zone pressure.

Test samples which can be continuously analyzed by this invention include those normally gaseous and normally liquid hydrocarbon-containing mixtures comprising either at least one hydrocarbon containing from 1 to about 22 carbon atoms per molecule in admixture with one or more non-hydrocarbons such as hydrogen, nitrogen, carbon monoxide, carbon dioxide, water, and hydrogen sulfide or at least two different hydrocarbons containing from 1 to about 22 carbon atoms per molecule. The upper limit on carbon number is fixed generally by the preferred

operation procedure that the sample (and the reference sample) be vaporized in an air stream under combustion conditions without undergoing any substantial thermal decomposition prior to the oxidation thereof. Therefore, in the context of the present invention, the term "hydrocarbon composition" is intended to embody all forms of hydrocarbon mixtures in which hydrocarbons predominate, but which may also contain significant amounts of non-hydrocarbon materials and, in particular, may contain such items as tetraethyl lead, tetramethyl lead, and other known anti-knock compounds for use in motor fuel compositions. In the preferred and practical embodiment of this invention, for measurement of octane number, the feedstock or test sample or process stream of unknown octane number chargeable to the apparatus of the present invention include those within the gasoline boiling range including such process streams as straight-run gasoline, cracked gasoline, motor alkylate, catalytically reformed gasoline, thermally reformed gasoline, hydrocracker gasoline, etc.

The oxidizing agent utilized in the apparatus of the present invention is preferably an oxygen-containing gas, such as air, substantially pure oxygen, etc. or it may be a synthetic blend of oxygen with an inert or equilibrium effecting diluent, such as nitrogen, carbon dioxide or steam.

The generation of the stabilized cool flame is effected under combustion conditions generally including superatmospheric pressure and elevated temperature; although, in some cases, it may be desirable to use atmospheric pressure or sub-atmospheric pressure. For example, the pressure may be in the range from about 15 p.s.i.a. to about 165 p.s.i.a. with a maximum flame front temperature in the range of 600° F. to 1000° F. For measuring the composition of a gasoline boiling range fraction it is preferable to employ pressures in the range from 16 p.s.i.a. to 65 p.s.i.a., more preferably, in the range from 16 p.s.i.a. to 30 p.s.i.a., together with an induction zone temperature from 550° F. to 850° F. Control of induction zone temperature can be effected by the amount of preheat imparted to the incoming sample stream, including reference sample and air streams and also by supplying heat from an external source to the combustion zones proper. In any case, the permissible limits within which temperature and pressure may be individually varied without departure from stable operation, even outside of the specific operational limits referred to herein, can be determined by simple experiment for a particular type and quantity of test sample.

As previously mentioned, the detection of the position within the combustion chamber for the test sample and for the reference sample is preferably effected by temperature responsive thermoelectrical means, although, other equivalent means can be used. The thermocouple sensing device may be placed within the combustion chambers as discussed hereinabove or outside of the combustion chamber and may be either fixed or may be movable in such a manner to completely and substantially traverse the length-wise direction of the combustion chamber in order to locate the position of the stabilized cool flame within each combustion chamber.

The output signal from the thermocouple sensing means is fed through signal means to suitable control means such as a motor activated control valve for regulating, preferably, the pressure within each combustion zone. Generally, the output signal from the thermocouple sensing means is not lead to a readout device, such as a strip chart or *x–y* recorder for to do so would deplete the strength of the signal to such an extent that operational efficiency might be impaired. Preferably, the thermocouple sensing device comprises a pair of axially spaced thermocouple leads which are inserted into thin-walled thermal type pencil wells and may be constructed of any materials known to those skilled in the art, such as for example, iron-constantan. The lead wires from the thermowells are connected to a suitable differential temperature controller. Such controller may be a conventional self-balancing potentiometer in combination with pneumatic control means. A suitable input span for each controller may be from −5 to +5 millivolts and the output signal thereof transmitted may be a conventional 3–15 p.s.i.a. air signal. This control signal is used, for example, to reset the set point on a back pressure controller or can be used to directly control the pressure within the respective combustion zone. The resulting pressure is passed into a standard DP (differential pressure) cell. In other words, the reference fuel combustion zone pressure is fed by means of suitable tubing or piping pneumatically into one side of the cell while the pressure on the test sample combustion zone is fed by means of tubing or piping pneumatically into the other side of the cell. The output signal from the DP cell is correlatable with a composition parameter, such as octane number, in the practice of the preferred embodiment of the invention.

The invention may be more fully understood with reference to the accompanying drawing which is a schematic representation of apparatus for practicing one embodiment of the invention.

DESCRIPTION OF THE DRAWING

With reference to the attached drawing, the apparatus comprises, in combination, a first combustion chamber **15** and a second combustion chamber **21**. Both of these combustion chambers are contained in a canister, not shown, having means for the introduction of a heat transfer fluid to surround the combustion chambers so that the proper temperature conditions may be maintained within each combustion zone. The configuration of the apparatus will be similar to that described in said copending application with the exception that a second combustion zone is inserted into a common canister having common heat transfer means therebetween. If desired, the exterior of the enclosing canister may be incased in one or more layers of insulation, again not shown. Those skilled in the art being familiar with the teachings presented herein and with the teachings presented in said copending application, can devise appropriate ways of enclosing these combustion chambers in a suitable canister having appropriate temperature control means.

With reference to the first combustion chamber **15**, there is provided inlet means **11** for the test sample and air introduction means **10** for adding the required oxygen. Both test sample and air are introduced into combustion chamber **15** via conduit **13**. Also associated with the first combustion chamber **15** is thermocouple sensing means **18** having associated therewith suitable differential temperature controller means, not shown, having appropriate lead **19** connected with back pressure valve **17** in conduit **16** which provides passage for the exhaust gases from combustion chamber **15**. Appropriate conduit **20** is attached to a pressure tap in line **16**.

With reference to the second combustion chamber, there is provided conduit **12** for the introduction of the reference sample and conduit **10** for adding the requisite amount of oxygen. The reference sample and air are introduced into combustion chamber **21** via conduit **14**. Similarly, thermocouple sensing device (ΔT) **24** having associated therewith suitable differential temperature control means, not shown, is connected via lead **25** to back pressure control valve **23** located in conduit **22** which provides passage for the exhaust gases from combustion chamber **21**. Pressure conduit **29** is attached to a pressure tap in line **22**.

The combustion chamber **15** and combustion chamber **21** are operationally connected by having pressure conduit **20** connected to one side of a DP (differential pressure—ΔP) cell **26** while pressure conduit **29** is con-

nected to the other side of DP cell **26**. In operation, DP cell **26** will read the differences in pressure, if any, between the two combustion chambers. The output signal from DP signal **26** is passed via lead **27** into a pressure recorder or differential pressure recorder (ΔPR) **28** which may be directly calibrated in terms of a predetermined composition parameter. For example, differential pressure recorder **28** may be calibrated directly in octane number thereby providing a continuous monitor of the octane number of the test sample.

The front of the stabilized cool flame in each combustion chamber is a relatively narrow, well defined traverse section, spaced a predetermined distance from one end of the combustion chamber generally defined as the end containing a burner assembly, not shown. In the present embodiment, the distance of the physical position of the flame in each combustion chamber is detected by temperature responsive thermoelectric means, generally shown as items **18** and **24**, respectively, on the drawing.

In the operation of the inventive apparatus, the flame front for the test sample is positioned between the thermocouples placed in the combustion zone. Both thermocouples will be about the same temperature and the voltage appearing at the input of the differential temperature controller **18** will be approximately zero. However, equally satisfactory operation can be achieved by having a net voltage difference if the positive or negative corresponding to a temperature differential is in the order of 10° F. to 40° F. This means that the flame front in combustion chamber **15** is then slightly asymmetrical with respect to the thermocouple. While this mode achieves greater sensitivity, it is not a critical requirement and one may still get good results with the apparatus if a zero temperature differential is maintained within device **18**.

Similarily, the flame front for the reference sample in combination zone **21** is positioned between the thermocouples placed at that zone. Operation of thermocouple sensing device **24** is preferably the same as for sensing device **18**, previously discussed. In operation, differential temperature controller **18** will preferably adjust the pressure within combination chamber **15** by activating pressure control valve **17** in order to move the flame front into its fixed predetermined location. Similarly, differential temperature controller **24** activates control valve **23** in order to move the flame front therein into its fixed predetermined location. The degree of change necessary in both respects to position the respective flame fronts at their appropriate locations is directly correlatable with the desired composition parameter of the test sample charged into the system.

With reference to the combustion parameter which is adjusted, the preferred embodiment is to adjust the pressure within the combustion zone, as previously mentioned. In other words, an increase in pressure will cause the flame front to recede towards the burner end of the combustion chamber and a decrease in pressure will cause the flame front to advance away from the burner end of the chamber. Therefore, in each respective combustion chamber, if the flame front attempts to move towards the burner end of the chamber, the thermocouples will reflect a temperature rise and the temperature differential controller will activate the pressure controller to decrease combustion pressure until the front is restored to its position between the axially spaced thermocouples. Conversely, if the hydrocarbon composition changes so that the front attempts to move away from the burner end of the chamber, differential temperature controller will activate the pressures controller to increase combustion chamber pressure until the front is restored to its original position. In the present instance, the sensing device will be able to determine the exact position of the flame front by a differential temperature measurement and will then activate the pressure control means in order to adjust the flame front of a position where there is, as previously mentioned, zero temperature differential. In any even, the change in combustion pressure which is required to immobilize the flame front in its predetermined location is a correlatable function with the composition of fuel used within the combustion chamber.

In the practice of the invention utilizing the apparatus shown in the attached drawing, a gasoline fraction of unknown composition is introduced via line **11**, admixed with air from line **10** and introduced into combustion chamber **15** via line **12**. Continuously and simultaneously therewith a reference sample fuel is introduced via line **12**, admixed with air also from line **10** and introduced into combustion chamber **21** via line **14**. The temperature of the induction zone of both combustion chambers is about 630° F. and is maintained thereat by a heated fluid medium which completely surrounds both combustion chambers, not shown, in the drawing. In general, in the region of the flame front, the temperature climbs rapidly, peaks at about 750° F., and then falls off rapidly to about 640° F. When each flame front is stabilized, thermocouple sensing device **18** and thermocouple sensing device **24** will be approximately zero. Exhaust gases from combustion chamber **15** are removed via line **16** and the exhaust gases from combustion chamber **21** are removed via line **22**. The difference in pressure between the two zones at zero temperature differential in each zone is correlated with, say, the octane number of the test sample.

Thus, it is seen that changes in the composition of the test sample may be detected in a continuous manner by simultaneous comparison of the test sample with a reference sample under substantially the same conditions thereby giving a continuous means for controlling the quality of a given process stream.

Even though the invention has been described in one of its preferred embodiments as being practiced with control of a combustion zone parameter, such as combustion zone pressure, other combustion conditions may be adjusted with equally satisfactory results. Thus, as disclosed in said copending application, a combustion parameter which may be adjusted by the control signal from the sensing device includes test sample flow rate, oxygen-containing gas flow rate, and induction zone temperature with the selected combustion parameter being adjusted in a manner to immobilize the flame front relative to its position within the combustion chamber regardless of changes in the test sample composition.

Additionally, the sensing means for determining the cool flame location has been preferably described as being thermoelectric means. Other means for determining the flame position will be apparent to those skilled in the control arts and are deemed embraced in the broad scope of this invention. For example, one may employ spaced resistance bulbs or simply a pair of spaced resistance wires stretched taut across the combustion tube, connected in a standard bridge circuit, instead of the previously described thermoelectric elements. Alternatively, optical-electric means, such as radiation pyrometers may be used. Since the flame front contains an appreciable concentration of organic radicals and ions, its position could also be detected by ion sensitive means, such as a capacitor in the tank circuit of a high frequency oscillator whereby linear displacement of the flame will change the dielectric constant of the capacitor and hence the resonance characteristic of the oscillator; or the flame region may comprise a direct current ionization gap. Those skilled in the art may readily determine the appropriate sensing means for determining the position of the cool flame in each of the combustion zones of the present invention.

Additionally, the apparatus of this invention can include provisions for periodically switching reference fuel from one combustion chamber to the other combustion chamber and vice versa to ascertain or cancel other combustion chamber differences, if any.

PREFERRED EMBODIMENT

Therefore, from the above description, the preferred embodiment of the present invention is a method for determining the octane rating of a gasoline sample which comprises the steps of: (a) continuously introducing a preheated vaporized stream of said gasoline sample and a preheated stream of air into one end of a first elongated combustion zone maintained at elevated temperature; (b) simultaneously and continuously introducing a preheated vaporized stream of reference sample having known octane number and a preheated stream of air into one end of a second elongated combustion zone maintained at elevated temperature; (c) partially oxidizing said gasoline sample within the first zone under conditions sufficient to generate therein a cool flame characterized by a relatively narrow, well defined flame front spaced from said one end of the first zone; (d) partially oxidizing said reference sample within the second zone under conditions sufficient to generate therein a cool flame characterized by a relatively narrow, well defined flame front spaced from said one end of the second zone; (e) sensing the position of the flame front within the first zone and developing therefrom a first control signal; (f) sensing the position of the flame front within the second zone and developing therefrom a second control signal; (g) varying the pressure within the first zone responsive to said first control signal in a manner to immobilize the flame front relative to said one end of the first zone; (h) varying the pressure within the second zone responsive to said second control signal in a manner to immobilize the flame front relative to said one end of the second zone; and, (i) sensing the first combustion zone pressure and the second combustion zone pressure, and developing therefrom an output signal responsive to differences between the sensed pressures and correlatable with the octane rating of said gasoline sample.

The preferred apparatus includes the apparatus, previously described, wherein said sensing means associated with said first and second combustion chambers comprises in each such chamber a pair of axially spaced thermocouples.

I claim:

1. Method for detecting changes in composition of a fluid mixture of unknown composition which comprises the steps of:

(a) continuously introducing a sample stream of a hydrocarbon-containing mixture of unknown composition into one end of a first elongated combustion chamber maintained under conditions sufficient to generate a cool flame front therein;

(b) simultaneously and continuously introducing a sample stream of material of known composition into one end of a second elongated combustion chamber maintained under conditions sufficient to generate a cool flame front therein;

(c) surrounding both of said chambers with a common heating fluid whereby to maintain said chambers at substantially the same temperature;

(d) sensing the position of each said flame front and developing therefrom a control signal;

(e) utilizing each developed control signal to adjust a combustion condition in each respective chamber in a manner to position each said front at a predetermined location within each chamber, respectively; and,

(f) sensing each adjusted condition and developing therefrom an output signal correlatable to changes in said unknown composition.

2. Method according to claim 1 wherein said change in composition is a change in the octane number of the fluid mixture of unknown composition.

3. Method according to claim 1 wherein said combustion condition adjusted in step (e) is the combustion zone pressure.

4. Method for determining the octane rating of a gasoline sample which comprises the steps of:

(a) continuously introducing a preheated vaporized stream of said gasoline sample and a preheated stream of air into one end of a first elongated combustion zone maintained at elevated temperature;

(b) simultaneously and continuously introducing a preheated vaporized stream of reference sample having known octane number and a preheated stream of air into one end of a second elongated combustion zone at elevated temperature;

(c) surrounding both of said zones with a common heating fluid whereby to maintain said zones at substantially the same temperature;

(d) partially oxidizing said gasoline sample within the first zone under conditions sufficient to generate a cool flame characterized by a relatively narrow, well defined flame front spaced from said one end of the first zone;

(e) partially oxidizing said reference sample within the second zone under conditions sufficient to generate therein a cool flame characterized by a relatively narrow, well defined flame front spaced from said one end of the second zone;

(f) sensing the position of the flame front within the first zone and developing therefrom a first control signal;

(g) sensing the position of the flame front within the second zone and developing therefrom a second control signal;

(h) varying the pressure within the first zone responsive to said first control signal in a manner to immobilize the flame front relative to said one end of the first zone;

(i) varying the pressure within the second zone responsive to said second control signal in a manner to immobilize the flame front relative to said one end of the second zone; and,

(j) sensing the first combustion zone pressure and the second combustion zone pressure, and developing therefrom an output signal responsive to differences between the sensed pressures and correlatable with the octane rating of said gasoline sample.

5. Apparatus comprising:

(a) a first combustion chamber;

(b) a second combustion chamber operationally connected with said first chamber;

(c) means for generating a stabilized cool flame within the first chamber utilizing as fuel therefor a hydrocarbon-containing mixture to be analyzed as to composition;

(d) means for generating a stabilized cool flame within the second chamber utilizing as fuel therefor a reference sample of known composition;

(e) a common heating means operatively associated with both of said combustion chambers to maintain the chambers at substantially equal temperature;

(f) means for sensing the physical position of the cool flame within said first combustion chamber and means for sensing the physical position of the cool flame within said second combustion chamber;

(g) first control means associated with said sensing means of the first combustion chamber adapted to adjust a combustion parameter in a manner to maintain the physical position of the flame constant relative to said first combustion chamber;

(h) second control means associated with said sensing means of the second combustion chamber adapted to adjust a combustion parameter in a manner to maintain the physical position of the flame constant relative to said second combustion chamber; and,

(i) readout means developing a signal responsive to both of said adjusted parameters in a manner correlatable with an analysis of the composition of the fuel to said first combustion chamber.

6. Apparatus according to claim 5 wherein said sensing means associated with said first and second combustion chambers comprises, in each such chamber, a pair of axially spaced thermocouples.

7. Apparatus according to claim 5 wherein said first and second control means are adapted to adjust the pressure, respectively, in said first and second combustion chambers.

8. Apparatus according to claim 7 wherein said sensing means associated with said first and second combustion chambers comprises, in each such chamber, a pair of axially spaced thermocouples.

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