June 1, 1971 E. R. FENSKE 3,582,280

METHOD AND APPARATUS FOR DETERMINING A COMPOSITION CHARACTERISTIC OF A COMBUSTIBLE FLUID

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Figure 2

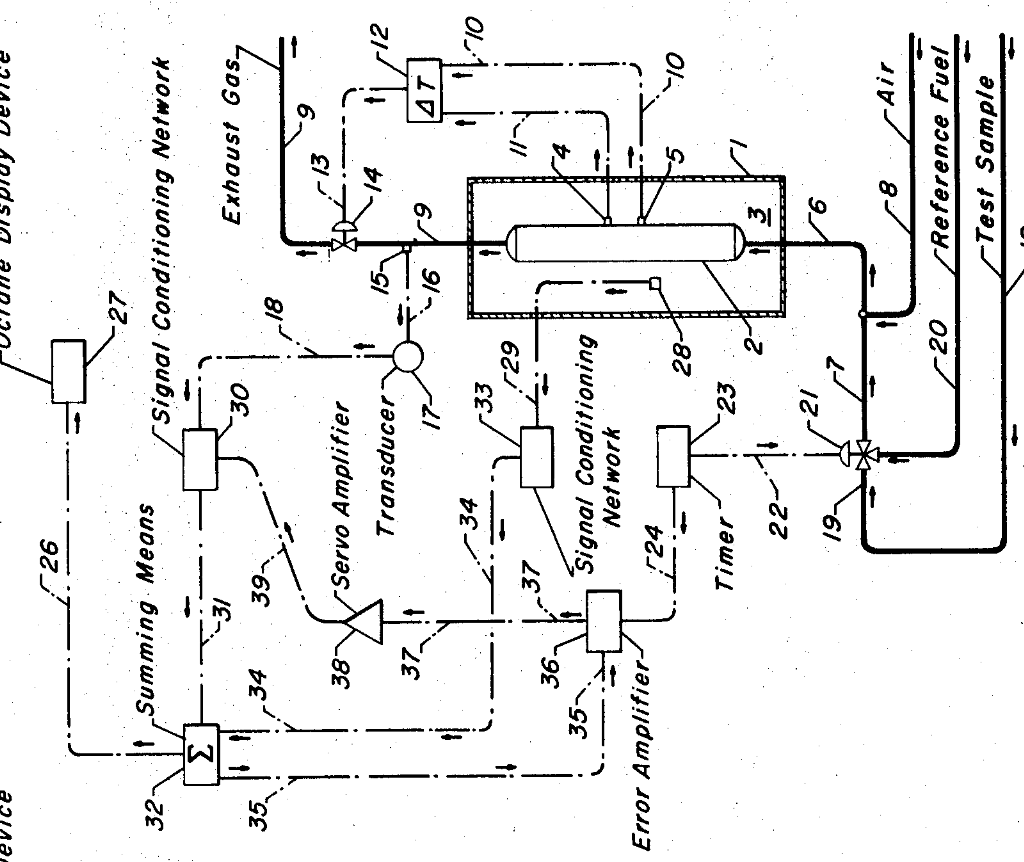
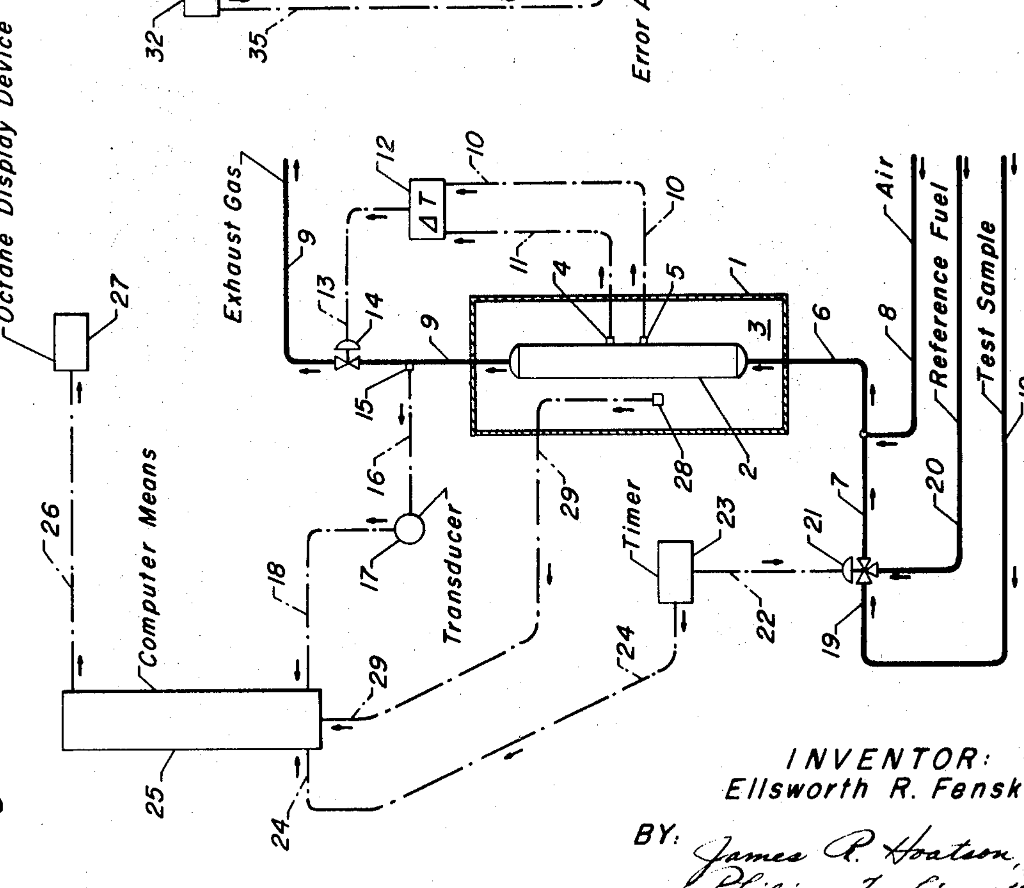


Figure 1



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METHOD AND APPARATUS FOR DETERMINING A COMPOSITION CHARACTERISTIC OF A COMBUSTIBLE FLUID

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ABSTRACT OF THE DISCLOSURE

Method and apparatus for continuously determining a composition characteristic of a combustible fluid, such as the octane rating of a gasoline boiling range hydrocarbon-containing fluid. A sample of the fluid is oxidized in an analyzer comprising a stabilized cool flame generator with a servo-positioned flame front. The position of the flame front is automatically detected and utilized to manipulate a combustion parameter, such as pressure, temperature, fluid flow, or oxidizer flow, in a manner sufficient to immobilize the flame front regardless of fluctuations in composition characteristic of the fluid sample. Changes in combustion parameter which are required to immobilize the flame front are correlatable with changes in composition characteristic, and means is provided for sensing the manipulated combustion parameter and developing therefrom a condition output signal which is functionally representative of and correlatable with composition characteristic. A suitable reference fuel of known composition characteristic is periodically passed to the analyzer in place of the fluid sample and an analyzer temperature is sensed. Means is provided to compensate the condition output signal for any deviation in the signal between apparent reference fuel signal and a signal corresponding to the true known value of reference fuel composition characteristic, and to further compensate the condition output signal for temperature fluctuations, whereby the condition output signal is compensated for combustion effects not indicative of composition characteristic, and is thereby functionally representative of and correlatable with the true composition characteristic of the fluid sample.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of co-pending application Ser. No. 679,328 filed on Oct. 31, 1967, now U.S. Pat. No. 3,533,746.

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for determining a composition characteristic of a combustible fluid. It further relates to an improvement in the method and apparatus for determining a composition characteristic of a combustible fluid utilizing a stabilized cool flame generator with a servo-positioned flame front. It particularly relates to an improvement in the method and apparatus for determining a composition characteristic of a hydrocarbon composition. It more specifically relates to an improved method and apparatus for determining the octane number of a gasoline boiling range hydrocarbon fluid.

Those skilled in the art are familiar wth the phenomenon 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, it is believed, also 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.

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Implicit in this definition is the fact that the phenomenon of cool flame generation is short of total combustion and short of total ignition and explosion. The work of Barusch and Payne 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 phenomenon in the practice of the present invention is one of manipulating a combustion parameter in a manner sufficient to immobilize the cool flame relative to one end of the combustion chamber. The manipulated combustion parameter is sensed and utilized to develop a condition output signal which is functionally representative of and correlatable with the composition of the fluid being oxidized in the combustion chamber.

A more complete explanation and description of the basic apparatus and basic method for detecting composition characteristics utilizing cool flames is contained in U.S. Pat. 3,463,613, issued on Aug. 26, 1969, to E. R. Fenske and J. H. McLaughlin. The contents of said patent 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 patent for additional and specific details as to the construction of a preferred embodiment 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 patent.

One of the difficulties encountered in the method and apparatus disclosed in U.S. Pat. 3,463,613 is concerned with calibration of the apparatus to compensate for combustion effects which are not indicative of composition characteristics of the fluid being analyzed.

For example, it has been found that when the apparatus disclosed in the U.S. Pat. 3,463,613 has been operated on a combustible fluid for a substantial length of time, the apparatus occasionally begins to produce condition output signals which reflect "aging" of the apparatus. This aging may be introduced due to plugging of preheaters or plugging of a flow diffusor element which is mounted in the interior of the combustion chamber a short distance above the combustion nozzle. Additionally, it has been found that where a leaded gasoline is the combustile fluid being analyzed, deposits of lead oxides within the combustion chamber introduce combustion effects which are not indicative of the composition characteristic of the gasoline fraction being burned within the chamber.

It has further been discovered that fluctuations in the oxidizer passing into the combustion chamber will introduce combustion effects which will result in a condition output signal containing an error which is not correlatable with the composition characteristics of the fluid being burned within the chamber. For example, the typical oxidizer passing into the combustion chamber is derived from a compressed air system, and the compressed air will contain microscopic quantities of entrained lubricating oil which have been picked up at the air compressor.

Additionally, it has been found upon occasion that a shift in the wind direction will introduce flue gas from nearby furnace stacks so that the air compressor is periodically picking up air containing combustion products. This results in an oxidizer passing into the combustion chamber of the instant analyzer which is not only deficient in oxygen, but which also may contain a considerable proportion of further combustible material such as carbon monoxide and unburned hydrocarbons contained in the flue gas.

Furthermore, it is typical in the art to place the combustion analyzer of the instant invention in a local mounting near the product stream which is to be analyzed, and to transmit condition output signals therefrom to the control house in the refinery or chemical plant wherein the apparatus is utilized for monitoring or controlling service. Consequently, the combustion chamber of the apparatus is located out-of-doors and is subject to thermal fluctuations due to atmospheric conditions. These fluctuations in atmospheric conditions produce thermal effects within the combustion chamber which are not indicative of the composition characteristic of the fluid being analyzed therein.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved method and apparatus for analyzing a combustible fluid.

It is another object of the present invention to provide an improved method and apparatus for analyzing a combustible fluid in a stabilized cool flame generator.

It is still another object of the present invention to provide a method and apparatus for determining a composition characteristic of a hydrocarbon composition.

It is a still further object of the present invention to provide an improved method and apparatus for determining the octane rating of a gasoline boiling range hydrocarbon fluid.

Therefore, in its method aspects, a broad embodiment of the present invention provides a method for detecting composition characteristic of a combustible fluid which comprises: (a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone including an induction section maintained at elevated temperature; (b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characterized by a relatively narrow well-defined flame front spaced from said one end; (c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal; (d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygen-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream; (e) sensing the adjusted parameter and passing a first parameter signal into signal conditioning means; (f) manipulating said first parameter signal in said signal conditioning means and therefrom producing a first condition output signal functionally representative of the apparent composition characteristic of said fluid sample stream, and functionally responsive to changes in composition characteristic of said sample stream; (g) periodically isolating said sample stream from said combustion zone, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said zone in a manner sufficient to continue the generation of said immobilized flame front; (h) sensing the adjusted parametes during the period of isolation and passing a second parameter signal into said signal conditioning means, said second parameter signal being functionally representative of the apparent composition characteristic of said reference fuel; (i) comparing said second parameter signal with a reference value of parameter signal functionally corresponding to the actual known value of composition characteristic of said reference fuel; (j) adjusting said signal conditioning means in a manner sufficient to produce a second condition output signal which is compensated to reflect the elimination of the difference between said second parameter signal and said reference value parameter signal, and which is thereby functionally representative of the actual known composition characteristic of said reference fuel; and, (k) periodically isolating said reference fuel stream from said combustion zone while retaining the signal conditioning adjustment of step (j), and simultaneously passing said fluid sample stream into said zone in a manner sufficient to maintain said flame front, whereby said signal conditioning means receives a third parameter signal and therefrom develops a third condition output signal compensated for combustion effects not indicative of composition characteristic, and said third condition output signal is thereby functionally representative of the actual composition characteristic of said sample stream.

Furthermore, in its method aspects, an additional broad embodiment of the present invention provides a method for detecting composition characteristic of a combustible fluid which comprises: (a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone encompassed by a zone of elevated temperature, said combustion zone including an induction section maintained at elevated temperatures; (b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characterized by a relatively narrow well-defined flame front spaced from said one end; (c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal; (d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygen-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream; (e) sensing the adjusted parameter and developing a parameter signal responsive to changes in said composition characteristic; (f) sensing a temperature selected from the group consisting of induction section temperature and a temperature of said elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature; (g) passing said parameter signal and said temperature signal into signal conditioning means, and producing therefrom a condition output signal functionally representative of the composition characteristic of said fluid sample stream, said condition output signal being indicative of said composition characteristic as corrected for fluctuations in sensed temperature.

In addition, in its apparatus aspects, a broad embodiment of the present invention provides a composition analyzer for detecting a composition characteristic of a combustible chemical fluid which comprises in combination: (a) a combustion chamber, including an induction section; (b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber; (c) means sensing the physical position of said flame front within said combustion chamber; (d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion pressure, induction section temperature, fluid stream flow rate, and oxidizer stream flow rate, in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber; (e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the composition characteristic of said fluid stream; (f) signal conditioning means receiving said parameter output signal; (g) condition signal generating means within said signal conditioning means producing a condition output signal representative of said composition characteristic; (h) means periodically isolating said fluid stream from said flame generating means, and for simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said flame generating means in a manner sufficient to continue the generation of said immobilized flame front; (i) means passing to said signal conditioning means, a timing signal indicative of the passage of reference fuel to said flame generating means; (j) comparison meanse within said signal conditioning means, responsive to said timing signal, adapted to compare the condition output signal generated due to reference fuel flame front with a reference value signal functionally corresponding to the actual known value of composition characteristic of said reference fuel, and developing therefrom a comparison signal; (k) adjusting means within said signal conditioning means responsive to said comparison signal, and adapted to adjust said condition signal generating means to compensate for deviation between the condition output signal generated due to reference fuel flame front and said reference value signal; and (l) means for retaining said adjustment to said condition signal generating means when said isolation period is ended and said fluid stream is returned to said flame generating means in place of said reference fuel, whereby the condition output signal generated by said fluid stream flame front is compensated for combustion effects not indicative of composition characteristic, and said condition output signal is thereby functionally representative of and correlatable with the actual composition characteristic of said combustible chemical fluid.

Still further, in its apparatus aspect, a broad embodiment of the present invention provides a composition analyzer for detecting a composition characteristic of a combustible chemical fluid which comprises in combination: (a) a combustion chamber encompassed by an outer chamber confining a zone of elevated temperature therebetween, said combustion chamber including an induction section maintained at elevated temperature; (b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber; (c) means sensing the physical position of said flame front within said combustion chamber; (d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion pressure induction section temperature, fluid stream flow rate, and oxidizer stream flow rate in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber; (e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the composition characteristic of said fluid stream; (f) means sensing a temperature selected from the group consisting of a temperature within said induction section and a temperature of said confined elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature; and (g) signal conditioning means receiving said parameter output signal and said sensed temperature signal, and producing therefrom a condition output signal which is functionally representative of and correlatable with said composition characteristic of the combustible chemical fluid, said condition output signal being indicative of said composition characteristic as corrected for fluctuations in sensed temperature.

In essence, therefore, the present invention provides a method and apparatus which determines the composition characteristic of a combustible fluid by oxidizing the fluid in a stabilized cool flame generator with a servo-positioned flame front, to develop a condition output signal which is temperature compensated, and which is periodically recalibrated to compensate for deviations in condition output signal generated by a reference fuel of known composition characteristic. In this manner then, the condition output signal is continuously compensated for combustion effects which are not indicative of composition characteristic, and the condition output signal is thereby rendered functionally representative of and correlatable with the true composition characteristic of the combustible fluid being analyzed.

As used herein, the term "composition characteristic" does not refer to a compound by compound analysis of the type presented by instruments such as mass spectrometers or vapor phase chromatographs. Rather, the composition characteristic is represented by a continuous, or substantially continuous, output signal which is responsive to and indicative of the fluid composition, and which is more specifically, empirically correlatable with one or more conventional composition identifications or specifications. For example, when the fluid to be analyzed is a hydrocarbon composition, the composition characteristic which is represented by the condition output signal may be a conventional identification or specification such as the Reid Vapor Pressure, ASTM or Engler distillation, initial boiling point, end boiling point, etc. In particular, when the fluid being analyzed comprises gasoline boiling range hydrocarbon, the composition characteristic which is functionally represented by the condition output signal will typically comprise a knock characteristic such as research octane number or motor octane number.

The specific nature of the correlation between the condition output signal and the actual value of composition characteristic is a function of the actual composition of the fluid being analyzed. Where the fluid being analyzed comprises a hydrocarbon, the correlation between the condition output signal and the composition characteristic will be a function of the hydrocarbon fluid composition and the carbon number of the hydrocarbon constituents present therein. Furthermore, the correlation is further influenced by the presence or absence of paraffins, isoparaffins, olefins, diolefins, polyolefins, aromatics, long-chain substituted aromatics, polynuclear aromatics, etc. Thus as presently operated in commercial practice, the apparatus of the present invention is capable of continuously calibrating itself for a particular hydrocarbon blend or charge stock and relatively small deviations due to fluctuations in molecular species can be accounted for.

However, as noted hereinabove, the apparatus of the present invention must be continuously recalibrated and compensated for combustion effects which are not indicative of the composition of the fluid being analyzed or of the composition characteristic being developed as the condition output signal. In order to achieve this compensation in the condition output signal, there is provided means for periodically isolating the fluid being tested from the combustion chamber of the apparatus, and for simultaneously introducing therein a sample of reference fuel. Those skilled in the art are familiar with the procedures for obtaining reference fuels of known composition. Since the reference fuel is being compared to the unknown fluid, it is particularly desirable that the hydrocarbon species of the reference fuel be similar to those of the unknown fluid being tested. Thus for example, if the fluid being analyzed is a hydrocarbon comprising a gasoline fraction having an octane number of about 95 and consisting primarily of a reformate gasoline, it is particularly desirable that the reference fuel also be a reformate gasoline having an octane number of about 95.

Under such conditions then, the condition output signal generated by the combustion of the reference fuel will be indicative of the detected composition characteristic of the reference fuel and provide a valid basis for comparison to the sample of unknown fuel being tested. Therefore, any deviation of the condition output signal of the reference fuel from the known condition output signal corresponding to the known composition characteristic of the reference fuel will be a deviation in the system which is due to combustion effects which are not indicative of the composition characteristic. Accordingly, then, the apparatus of the present invention will make a corrective adjustment in the condition output signal to produce a signal which is truly representative of the actual composition characteristic of the reference fuel. Therefore, when the unknown sample is again introduced into the combustion chamber, the condition output signal thereby generated will have been compensated and corrected for the deviations found in the testing of the apparatus with reference fuel.

As used herein, the terms "output signal," and "condition output signal" are to be construed in their most meaningful sense and include 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 thereof. These terms are 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-diaphragm, 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 condition 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. More commonly, however, the condition output signal will pass to a readout device which 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 characteristic of the fluid 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 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 activate 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 normally gaseous and normally liquid combustible chemicals. In a particularly preferred embodiment, the test samples comprise hydrocarbon-containing mixtures. These mixtures typically comprise 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. Alternatively, these mixtures will comprise 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 operational procedure whereby the test sample and the reference fuel sample are 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 terms "combustible chemical fluid" and "combustible fluid" are intended to embody all forms of combustible fluids which are capable of vaporization within the apparatus, and particularly hydrocarbon mixtures in which hydrocarbons predominate, but which may also contain significant amounts of non-hydrocarbon materials. In particular, the hydrocarbon fluids may contain such items as tetraethyl lead, tetramethyl lead, and other known antiknock compounds for use in motor fuel compositions. In the preferred and practical embodiment of this invention, wherein the determined composition characteristic is the measurement of octane rating, the feedstocks or test samples of unknown octane number which are 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 oxidizer or 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 of from about 550° F. to about 850° F. Control of induction zone temperature can be effected by the amount of preheat imparted to the air or oxidizer stream and to the incoming sample stream, including the test sample and the reference sample. Furthermore, induction zone temperature may be manipulated by adjusting the input of heat from an external source to the combustion zone 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 combustible fluid 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 as to completely and substantially traverse the length-wise direction of the combusition chamber in order to locate the position of the stabilized cool flame within the 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 the 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 the 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 combustion zone.

The present invention may be more fully understood by now referring to the accompanying drawings.

FIG. 1 comprises a simplified schematic representation of the apparatus for practicing the present invention wherein the signal conditioning mean is a computer means, which may be an analog computer or a digital computer.

FIG. 2 illustrates a schematic representation of the apparatus for practicing the present invention wherein the signal conditioning means comprises an analog or a digital network.

DESCRIPTION OF THE DRAWINGS

With reference now to the accompanying FIG. 1, there is shown the apparatus of the present invention which comprises in combination a canister **1** enclosing a combustion chamber **2**. The canister has means for introducing a heat transfer fluid to surround the combustion chamber so that proper temperature conditions may be maintained within the combustion zone, by controlling temperature in an elevated temperature zone **3** which is confined between the canister **1** and the combustion chamber **2**. The configuration of the apparatus will be similar to that described in the cited U.S. Pat. 3,463,613. Thus the temperature within the elevated temperature zone **3** may be maintained by a constant circulation of a heat transfer fluid from an external source, or by conduction and natural convection of the heat transfer fluid as provided by immersion heaters contained within the canister and within the zone **3**, or heating elements encompassing the canister. If desired, the exterior of the enclosing canister **1** may be encased in one or more layers of insulation, not shown, and typically this will be done since the canister is normally located out-of-doors and exposed to atmospheric conditions. Those skilled in the art being familiar with the teachings presented herein and with the teachings presented in the cited patent will understand the appropriate manner of enclosing the combustion chamber in a suitable canister having appropriate temperature control means and having appropriate thermal insulation in order to minimize the thermal effects of atmospheric conditions.

With reference to the combustion chamber **2**, there is provided temperature sensing means **4** and **5** which are capable of sensing the location of the stabilized cool flame front generated within the combustion chamber by the oxidation of the sample being introduced therein. The combustion chamber **2** is provided with inlet means **6** which introduces a mixture of air, or other oxidizing agent, and a combustible fuel into a burner nozzle, not shown, contained within the lower section of the combustion chamber **2**. The air or oxidizing agent is introduced into the system via line **8** and the combustible fluid is introduced into the system via line **7**. The net combustion products are ultimately discharged from the combustion chamber via line **9**.

The mixture of air and combustible fluid passes into the chamber **2** via line **6** wherein it is ignited due to the elevated temperature. The region of the combustion chamber **2** which is located between the inlet line **6** and the temperature sensing means **5** is known as the induction section. The induction section is defined as that portion of the combustion zone wherein oxidation of the combustible fluid is initiated. Therefore the induction section more particularly comprises that portion of the combustion chamber **2** located between the burner nozzle and the cool flame front which is generated by the combustion.

In a preferred embodiment of the present invention the apparatus shown in the attached FIG. 1 is utilized to detect the octane number of a gasoline fraction of unknown composition. The gasoline fraction is introduced into the system via line **19** and control means **21**, and the fraction enters line **7** wherein it is contacted with a stream of air passing into the system via line **8**. The air and the gasoline fraction pass into the combustion chamber **2** via line **6**. The mixture of air and gasoline passes through the burner nozzle at the bottom of chamber **2**, not shown, and enters the induction section of the combustion chamber. The temperature of the induction section is about 630° F. and is maintained thereat by the heated fluid medium which completely surrounds the combustion chamber in the elevated temperature zone **3**. The oxygen and the gasoline react within the induction section producing an exothermic reaction resulting finally in a temperature elevation to a peak of about 750° F., whereat there is developed a cool flame front. At this point, the temperature of the combustion mixture falls off rapidly to about 640° F. When the cool flame front is stabilized, the temperature sensing means **4** and **5** will sense an identical temperature due to the fact that the combustion produces a peak temperature with a rapid tailing off of temperature. The exhaust gases from the combustion then leave the combustion chamber **2** via line **9**.

With reference to the combustion parameter which is manipulated and adjusted in order to stabilize or immobilize the cool flame front between temperature sensing means **4** and **5**, the preferred embodiment is to adjust the pressure within the combustion zone, as was previously mentioned hereinabove. In other words, an increase in pressure will cause the flame front to recede towards the burner end of combustion chamber and a decrease in pressure will cause the flame front to advance away from the burner end of the chamber and more closely approach the discharge end thereof. Therefore, if the flame front attempts to move toward the burner end of the chamber, the temperature sensing means **5** will reflect a temperature rise. Temperature sensing means **4** and **5** will transmit the sensed temperatures via transmitting means **10** and **11** to a differential temperature controller **12**, which will then activate a pressure controller **14** by passing a pressure control signal thereto via line **13**. The pressure controller will be activated in order to decrease combustion pressure until the flame front is restored to its original position between the axially spaced temperature sensing means **4** and **5**. Conversely, if the hydrocarbon composition changes so that the flame front attempts to move away from the burner end of the chamber, temperature sensing element **4** will sense a temperature rise and the differential temperature controller will activate the pressure controller **14** to increase combustion chamber pressure until the front is restored to the original position.

Although the preferred embodiment of the invention comprises the manipulation of pressure as the controlled combustion parameter, other combustion conditions may be adjusted, with equally satisfactory results, in a manner sufficient to immobilize the flame front to a constant position within the combustion chamber. Thus, as disclosed in the cited U.S. Pat. 3,463,613, a combustion parameter which may be adjusted by the control signal **13** from the differential temperature controller **12** includes the hydrocarbon sample flow rate in line **7**, the oxygen containing gas flow rate in line **8**, and the induction zone temperature. In either case, regardless of which combustion condition parameter is manipulated, the apparatus operates with the selected combustion parameter being adjusted in a manner to immobilize the flame front relative to its position within the combustion chamber 2, regardless of changes in the test sample composition. Thus the combustion parameter is sensed and utilized to develop an output signal which is then indicative of the composition characteristic of the combustible fluid being analyzed, which in a preferred embodiment is the octane number of a gasoline sample.

The temperature sensing means for determining the location of the stabilized cool flame is preferably a thermal-electric means such as a pair of axially spaced thermocouples **4** and **5**. However, 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 tightly across the combustion zone, connected in a standard bridge circuit, instead of the previously described thermalelectric 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 may 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 stabilized cool flame in the combustion zone of the present invention.

In a preferred embodiment of the inventive apparatus, the cool flame front for the combustible fluid sample is positioned between a pair of thermocouples **4** and **5** placed in the combustion zone. Both thermocouples will be at about the same temperature and the voltage appearing at the input of the differential temperature controller **12** 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 the combustion chamber **2** is then slightly asymmetrical with respect to the thermocouples **4** and **5**. 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 the device **12**.

In any event, the sensing means **4** and **5**, the transmitting means **10** and **11**, and the differential temperature controller **12** will enable one to determine the exact position of the cool flame front by a differential temperature measurement. Controller **12** will then activate the pressure control means **14** in order to adjust the flame front to a position where there is, as previously mentioned, typically a zero temperature differential. Therefore, 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 the fuel which is being oxidized within the combustion chamber **2**.

Accordingly, then, there is provided within the apparatus a pressure sensing means **15** which develops a continuous pressure signal transmitted via line **16** to a transducer **17**. The transducer **17** converts the pneumatic or mechanical pressure signal **16** into an electrical signal which may be a voltage signal or an amperage signal. The transducer **17** transmits a converted parameter output signal via line **18** into a signal conditioning means **25**, which in this embodiment comprises a digital or an analog computer means. Computer means **25** contains an internal computer program by which the converted parameter signal **18** is continuously converted into an output signal **26** which is functionally representative of and correlatable with the octane rating of the combustible gasoline fuel introduced into the system via line **19**. The condition output signal **26** is thereupon transmitted to an octane display device **27** which may comprise a recording chart device, or a tape print-out device, or any other type of indicating means. In addition, the octane display device **27** may comprise a control system whereby an output signal for control of octane number is transmitted to means not shown for controlling the octaine rating of the fluid which provides the test sample entering via line **19**.

As previously noted, the apparatus of the present invention is typically located out-of-doors. Accordingly, it is subject to combustion effects created by changes in atmospheric conditions. In order to compensate for changing atmospheric conditions, there is provided within the apparatus of the present invention a temperature sensing means **28** which is capable of sensing any fluctuations in temperature within the elevated temperature zone **3**. Alternatively, temperature sensing means **28** may be positioned within combustion chamber **2** in order to sense actual fluctuations in induction section temperature. Temperature sensing means **28** passes a temperature output signal via transmitting means **29** to the signal conditioning means **25**. The internal program of the computer means **25** thereupon makes a temperature correction to the condition output signal passing via line **26**, whereby the octane value thereafter indicated by octane display device **27** is continuously compensated for any error in the indicated composition characteristic which is due to temperature fluctuations in the induction section of chamber **2** or in the elevated temperature zone **3**, caused by changes in atmospheric conditions.

In addition, the apparatus of the present invention provides for a recalibration or a re-zoning of the system for deviations created by other combustion effects which are not reflective of the composition characteristic of the fuel being tested. Accordingly, there is provided means for periodically passing into the combustion chamber **2** a reference fuel by which the system may be recalibrated.

Thus, there is shown in FIG. 1 a reference fuel passing into the system via line **20**. A timing device **23** passes a timing signal via line **22** into a control valve **21**. During the period of isolation, the control valve **21** receives a timing signal by which the test sample of line **19** is switched out of the system and the reference fuel of line **20** is switched into the system. Thereafter, during the isolation or reference period, reference fuel passes via line **7** into line **6** in admixture with the air entering via line **8**.

The reference fuel produces a stabilized cool flame which is indicative of the octane rating, or other composition characteristic being determined, of the reference fuel. The temperature sensing means **4** and **5** transmit the sensed temperature signals via means **10** and **11** into the differential temperature controller **12**, whereupon differential temperature controller **12** passes a control signal via line **13** to pressure control means **14**. The pressure sensing means **15** passes the pressure signal via line **16** into transducer **17** which in turn passes a converted parameter signal **18** into the computer means **25**. The internal program of computer means **25** compares the signal **18** with a reference signal contained within the program. The reference signal is indicative of the known actual octane rating of the reference fuel. The timing device **23** sends a signal via line **24** to the computer means **25** during those periods of time when the reference fuel is being burned within combustion chamber **2**.

Accordingly then, the computer program will make a compensating adjustment to the condition output signal **26** in order to eliminate any deviation of converted parameter signal **18** from the known signal which is reflective of the actual composition characteristic or octane number of the reference fuel. When the period of isolation is ended, timer **23** sends a signal via line **22** to valve **21** to swing the valve in a manner sufficient to isolate the reference fuel of line **20** from the system and to continue the introduction of test sample via line **19**. At this point then, the timing signal passing via line **24** to computer means **25**, informs the computer means that the reference fuel has been cut out of the system and that the test sample has been reintroduced. The internal computer program of the computer means **25** at this point retains any reference fuel correction which was made within the system. Consequently, the resulting condition output signal passing via line **26** to octane display device **27** when the test sample is being tested, will reflect a compensation or recalibration of the system for the reference fuel.

Accordingly, then, the indicated octane number of the test sample will have been corrected for temperature conditions and for other combustion conditions which were not truly indicative of composition characteristic or octane number and, therefore, the indicated condition output signal **26** will be truly indicative of and directly correlatable with the octane number or other composition characteristic of the test sample being oxidized in combustion chamber **2**.

Referring now to FIG. 2, there is shown a second embodiment of the present invention wherein the signal conditioning means of FIG. 1, the computer means **25**, and its internally contained program is replaced by a signal conditioning means preferably comprising a network of analog elements, although a network of digital elements may be used.

The basic elements of the analytical apparatus, which are disclosed in FIG. 1, are again illustrated in FIG. 2. However, the transducer output signal leaving transducer **17** is transmitted via means **18** into a signal conditioning network **30**. The signaling conditioning network **30** is a type of apparatus which is well known in the art. The converted parameter signal **18** passing from transducer **17** has a fixed correlation between the pressure which is sensed in the combustion chamber **2** by the pressure sensing means **15**, and the resulting electrical output signal which is passed through the signaling conditioning network. The conditioning network **30** either multiplies, or it adds and substracts to the received transducer signal **18** in order to produce a net output signal which is correlatable with octane rating or any other composition characteristic being determined. In the preferred embodiment, signal conditioning network **30** will add and subtract to the signal **18**. The resulting pressure output signal is transmitted from signal conditioning network **30** via transmitting means **31** into a summing means **32**.

In addition, in the embodiment illustrated in FIG. 2, the temperature signal which is sensed in the elevated temperature zone **3** by the sensing means **28** is transmitted via line **29** into a signal conditioning network **33**. Again, the signal conditioning network **33** is a type of network which is well known in the art. The temperature signal has a fixed correlation between the temperature in the elevated temperature zone **3** and the octane rating or other composition characteristic being determined within the combustion chamber **2**. The conditioning network **33**, therefore, adds or subtracts to the signal **29** in a manner sufficient to compensate for any temperature deviations from a fixed temperature which is the standard base temperature for the elevated temperature zone **3**. Alternatively, induction section temperature may be sensed by means **28**, and network **33** may compensate for any deviations from the base induction section temperature. The resulting signal is passed from the signal conditioning network **33** with a compensation for any temperature deviation, into summing means **32** via transmitting means **34**.

Summing means **32** receiving the temperature signal **34** and the pressure output signal **31**, thereupon algebraically sums the two signals. The net result of the algebraic summation accomplished by summing means **32** is a modified parameter signal which is, in fact, the net output signal which is indicative of the apparent composition characteristic as compensated for any temperature fluctuations. Thus, when the test sample of line **19** is oxidized in combustion chamber **2**, the summing means **32** sends a condition output signal **26** to the octane display device **27** which gives the apparent octane rating of the test sample.

When reference fuel is being oxidized in chamber **2**, summing means **32** sends a condition output signal via transmitting means **35** to an error amplifier **36**, as well as the condition output signal **26** to the display device **27**. The error amplifier **36** is a device which is well known in the art. The error amplifier contains a manual setpoint which is representative of the actual known octane number of the reference fuel. Accordingly, the error amplifier receives the timing signal from timer **23** via transmitting means **24** when the reference fuel is being oxdized within the combustion chamber **2**. At this point then, the error amplifier compares the condition output signal **35** with the known setpoint which is correlatable with the known actual composition characteristic, such as octane number, of the reference fuel. Thereupon the error amplifier develops an output signal which is a function of the difference between the setpoint and the actual summation or condition output signal **35**.

The error amplifier **36** transmits its output signal via transmitting means **37** to a servo amplifier **38**. The servo amplifier is a device which is well known in the art. The servo amplifier upon receiving the error amplifier output signal, responds to the error output signal in order to make a correction to bring the condition output signal **35** into balance with the setpoint contained within the error amplifier. Accordingly, the servo amplifier **38** develops an output signal which is proportional to the error amplifier output signal which has been received. The servo amplifier is a power amplifier sending a power signal via means **39** to a servo-motor located within signal conditioning network **30**. The servo-motor mechanically adjusts the signal conditioning network **30** to produce an ultimate summation or condition output signal **35** which is identical to the manual setpoint which is contained in the error amplifier **36**. Thus the system is corrected to the known octane value or other base line composition characteristic of the reference fuel.

The resulting pressure output signal transmitted via line **31** thereupon becomes directly correlatable with the octane number or other measured composition characteristic of the reference fuel being oxidized within combustion chamber **2**. Summing means **32** thereupon develops an output signal **35** which passes to the error amplifier and is therein indicated to be in balance with the manual setpoint. At this juncture then, the modified condition output signal which is transmitted via means **26** to the octane display device **27** will indicate the true octane number for the reference fuel as corrected for combustion effects which are not indicative of the composition characteristic being determined.

When the system reaches a time when the period of isolation is over, timer **23** will switch valve **21** by means of a signal passing via line **22** in order to cut out the reference fuel **20** and reintroduce the test sample **19** into the analyzer of the present invention. At this point then, the timer **23** sends a signal via transmitting means **24** to the error amplifier which will enable the system to hold the compensating adjustment which was made in signal conditioning network **30** to balance out the reference fuel output signal **35** with the manual setpoint. In this manner then, when the test sample of line **19** is being oxidized the modified condition output signal **26** passing to the display device **27** is indicative of the composition characteristic being measured, such as octane number, while being compensated for temperature fluctuation and for any deviations of the reference fuel signal from the known base reference signal.

PREFERRED EMBODIMENTS

Those skilled in the art will readily preceive the apparatus configuration of the present invention and the method of operation which have been disclosed hereinabove. Additionally, those skilled in the art can readily preceive the advantages of the present invention as disclosed hereinabove.

However, even though those skilled in the art will easily recognize the distinction between the terms "signal conditioning means" and "signal conditioning network," it is deemed advantageous to define and distinguish these terms as used herein. Referring to FIG. 1, the signal conditioning means comprises the computer means **25**, which contains an internal computer program for making compensating adjustments to produce the corrected condition output signal. Referring to FIG. 2, the signal conditioning means comprises the network of elements **30** through **39**, which is, in fact, a computing system for making the compensating adjustments. Thus, the signal conditioning networks **30** and **33** which are disclosed in FIG. 2, are individual elements contained within the signal conditioning means of that embodiment.

Furthermore, it is to be noted that the composition characteristic being determined by the present invention, typically octane rating, is indicated by a condition output signal which is a function of and correlatable with the composition characteristic being determined. However, those skilled in the art will realize that the condition output signal, as illustrated by the elements **26** and **35**, is in fact a modified parameter output signal which in the preferred embodiment is a pressure signal. Thus, when the reference fuel is passing to the combustion chamber **2** and condition output signal **35** is compared with the reference value signal in error amplifier **36**, the reference value signal is, in fact, being matched with a modified parameter signal **35**.

Therefore, from the above description it may now be summarized that one preferred embodiment of the present invention provides a method for detecting composition characteristic of a combustible fluid which comprises. (a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone encompassed by a zone of elevated temperature, said combustion zone including an induction section maintained at elevated temperature; (b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characteristized by a relatively narrow well-defined flame front spaced from said one end; (c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal; (d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygen-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream; (e) sensing the adjusted parameter and passing a first parameter signal into signal conditioning means; (f) manipulating said first parameter signal in said signal conditioning means and therefrom producing a first condition output signal functionally representative of the apparent composition characteristic of said fluid sample stream, and functionally responsive to changes in composition characteristic of said sample stream; (g) periodically isolating said sample stream from said combustion zone, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into siad zone in a manner sufficient to continue the generation of said immobilized flame front; (h) sensing the adjusted parameter during the period of isolation and passing a second parameter signal into said signal conditioning means, said second parameter signal being functionally representative of the apparent composition characteristic of said reference fuel; (i) comparing said second parameter signal with a reference value of parameter signal functionally corresponding to the actual known value of composition characteristic of said reference fuel; (j) adjusting said signal conditioning means in a manner sufficient to produce a second condition output signal which is compensated to reflect the elimination of the difference between said second parameter signal and said reference value parameter signal, and which is thereby functionally representative of the actual known composition characteristic of said reference fuel; (k) periodically isolating said reference fuel stream from said combustion zone while retaining the signal conditioning adjustment of step (j), and simultaneously passing said fluid sample stream into said zone in a manner sufficient to maintain said flame front, whereby said signal conditioning means receives a third parameter signal and therefrom develops a third condition output signal compensated for the deviation of said second parameter signal from said reference value parameter signal, and said third condition output signal is thereby functionally representative of the apparent composition characteristic of said sample stream as adjusted for reference fuel deviation; (l) sensing a temperature selected from the group consisting of a temperature in said induction section and a temperature in said elevated temperature zone, and passing a signal representative of sensed temperature into said signal conditioning means; (m) adjusting said signal conditioning means responsive to said sensed temperature signal, whereby said signal conditioning means develops a modified third condition output signal compensated for combustion effects not indicative of composition characteristic, and said modified third condition output signal is thereby functionally representative of the actual composition characteristic of said sample stream.

In addition, from the above description it may be further summarized that a preferred embodiment of the present invention is a composition analyzer for detecting a composition characteristic of a combustible chemical fluid which comprises in combination: (a) a combustion chamber encompassed by an outer chamber confining a zone of elevated temperature thereinbetween, said combustion chamber including an induction section maintained at elevated temperature; (b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber; (c) means sensing the physical position of said flame front within said combustion chamber; (d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion presure, induction section temperature, fluid stream flow rate, and oxidizer stream flow rate in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber; (e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the compstion characteristic of said fluid stream; (f) signal conditioning means receiving said parameter output signal; (g) condition signal generating means within said signal conditioning means producing a condition output signal representative of said composition characteristics; (h) means periodically isolating said fluid stream from said flame generating means, and for simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said flame generating means in a manner sufficient to continue the generation of said immobilized flame front; (i) means passing to said signal conditioning means, a timing signal indicative of the passage of reference fuel to said flame generating means; (j) comparison means within said signal conditioning means, responsive to said timing signal, adapted to compare the condition output signal generated due to reference fuel flame front with a reference value signal functionally corresponding to the actual known value of composition characteristic of said reference fuel, and therefrom developing a comparison signal; (k) adjusting means within said signal conditioning means, responsive to said comparison signal, and adapted to adjust said condition signal generating means to compensate for deviation between the condition output signal generated due to reference fuel flame front and said reference value signal; (l) means for retaining said adjustment to said condition signal generating means when said isolation period is ended and said fluid stream is returned to said flame generating means in place of said reference fuel, whereby the condition output signal generated by said fluid stream flame front is compensated for deviation between the parameter signal generated due to the reference fuel flame front and said reference value of parameter signal; (m) means sensing a temperature selected from the group consisting of a temperature within said induction section and a temperature within said confined elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature; (n) means transmitting said sensed temperature signal to said signal conditioning means; and (o) means within said signal conditioning means, modifying said condition output signal generated by said fluid stream flame front responsive to fluctuations in said sensed temperature and thereby compensating saidcondition output signal for combustion effects not indicative of composition characteristic, thereby resulting in a condition output signal functionally representative of and correlatable with the composition characteristic of said combustible chemical fluid.

The invention claimed:

1. Method for detecting composition characteristic of a combustible fluid which comprises:

(a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone including an induction section maintained at elevated temperature;

(b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characterized by a relatively narrow well-defined flame front spaced from said one end;

(c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal;

(d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygen-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream;

(e) sensing the adjusted parameter and passing a first parameter signal into signal conditioning means;

(f) manipulating said first parameter signal in said signal conditioning means and therefrom producting a first condition output signal functionally representative of the apparent composition characteristic of said fluid sample stream, and functionally responsive to changes in composition characteristic of said sample stream;

(g) periodically isolating said sample stream from said combustion zone, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said zone in a manner sufficient to continue the generation of said immobilized flame front;

(h) sensing the adjusted parameter during the period of isolation and passing a second parameter signal into said signal conditioning means, said second parameter signal being functionally representative of the apparent composition characteristic of said reference fuel;

(i) comparing said second parameter signal with a reference value of parameter signal functionally corresponding to the actual known value of composition characteristic of said reference fuel;

(j) adjusting said signal conditioning means in a manner sufficient to produce a second condition output signal which is compensated to reflect the elimination of the difference between said second parameter signal and said reference value parameter signal, and which is thereby functionally representative of the actual known composition characteristic of said reference fuel; and,

(k) periodically isolating said reference fuel stream from said combustion zone while retaining the signal conditioning adjustment of step (j), and simultaneously passing said fluid sample stream into said zone in a manner sufficient to maintain said flame front, whereby said signal conditioning means receive a third parameter signal and therefrom develops a third condition output signal compensated for combustion effects not indicative of composition charcteristic, and said third condition output signal is thereby functionally representative of the actual composition characteristic of said sample stream.

2. Method of claim 1 wherein said combustible fluid comprises at least one gasoline boiling range hydrocarbon, and said reference fuel comprises at least one gasoline boiling range hydrocarbon.

3. Method of claim 2 wherein said adjusted combustion parameter is combustion zone pressure.

4. Method of claim 2 wherein said composition characteristic is octane rating.

5. Method for detecting composition characteristic of a combustible fluid which comprises:

(a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone encompassed by a zone of elevated temperature, said combustion zone including an induction section maintained at elevated temperature;

(b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characterized by a relatively narrow well-defined flame front spaced from said one end;

(c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal;

(d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygen-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream;

(e) sensing the adjusted parameter and passing a first parameter signal into signal conditioning means;

(f) manipulating said first parameter signal in said signal conditioning means and therefrom producing a first condition output signal functionally representative of the apparent composition characteristic of said fluid sample stream, and functionally responsive to changes in composition characteristic of said sample stream;

(g) periodically isolating said sample stream from said combustion zone, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said zone in a manner sufficient to continue the generation of said immobilized flame front;

(h) sensing the adjusted parameter during the period of isolation and passing a second parameter signal into said signal conditioning means, said second parameter signal being functionally representative of the apparent composition characteristic of said reference fuel;

(i) comparing said second parameter signal with a reference value of parameter signal functionally corresponding to the actual known value of composition characteristic of said reference fuel;

(j) adjusting said signal conditioning means in a manner sufficient to produce a second condition output signal which is compensated to reflect the elimination of the difference between said second parameter signal and said reference value parameter signal, and which is thereby functionally representative of the actual known composition characteristic of said reference fuel;

(k) periodically isolating said reference fuel stream from said combustion zone while retaining the signal conditioning adjustment of step (j), and simultaneously passing said fluid sample stream into said zone in a manner sufficient to maintain said flame front, whereby said signal conditioning means receives a third parameter signal and therefrom develops a third condition output signal compensated for the deviation of said second parameter signal from said reference value parameter signal, and said third condition output signal is thereby functionally representative of the apparent composition characteristic of said sample stream as adjusted for reference fuel deviation;

(l) sensing a temperature selected from the group consisting of a temperature in said induction section and a temperature in said elevated temperature zone, and passing a signal representative of sensed temperature into said signal conditioning means;

(m) adjusting said signal conditioning means responsive to said sensed temperature signal, whereby said signal conditioning means develops a modified third condition output signal compensated for combustion effects not indicative of composition characteristic, and said modified third condition output signal is thereby functionally representative of the actual composition characteristic of said sample stream.

6. Method of claim **5** wherein said temperature in the elevated temperature zone is continuously sensed, said sensed temperature signal is continuously passed into said signal conditioning means, and said signal conditioning means is continuously adjusted responsive to said sensed temperature signal, whereby said first, second and third condition output signals are continuously modified to compensate for temperature fluctuation in said elevated temperature zone.

7. Method of claim **6** wherein said combustible fluid comprises at least one gasoline boiling range hydrocarbon, and said reference fuel comprises at least one gasoline boiling range hydrocarbon.

8. Method of claim **7** wherein said adjusted combustion parameter is combustion zone pressure.

9. Method of claim **7** wherein said composition characteristic is octane rating.

10. Method of claim **5** wherein said combustible fluid comprises at least one gasoline boiling range hydrocarbon, and said reference fuel comprises at least one gasoline boling range hydrocarbon.

11. Method of claim **10** wherein said adjusted combustion parameter is combustion zone pressure.

12. Method of claim **10** wherein said composition characteristic is octane rating.

13. Method for detacting composition characteristic of a combustible fluid which comprises:

(a) introducing a sample stream of said fluid and a stream of oxygen-containing gas into one end of a combustion zone encompassed by a zone of elevated temperature, said combustion zone including an induction section maintained at elvated temperature;

(b) partially oxidizing said sample stream in said combustion zone under conditions sufficient to generate and maintain therein, a cool flame characterized by a relatively narrow well-defined flame front spaced from said one end;

(c) sensing the position of said flame front relative to said one end, and developing therefrom a control signal;

(d) utilizing said control signal to adjust a combustion parameter selected from the group consisting of combustion zone pressure, induction section temperature, sample stream flow rate, and oxygne-containing gas stream flow rate, in a manner sufficient to immobilize said flame front relative to said one end regardless of fluctuations in the composition characteristic of said sample stream;

(e) sensing the adjusted parameter and developing a parameter signal responsive to changes in said composition characteristic;

(f) sensing a temperature selected from the group consisting of induction section temperature and a temperature of said elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature;

(g) passing said parameter signal and said temperature signal into signal conditioning means, and producing therefrom a condition output signal functionally representative of the composition characteristic of said fluid sample stream, said condition output signal being indicative of said composition characteristic as corrected for fluctuations in sensed temperature.

14. Method of claim **13** wherein said combustible fluid comprises at least one gasoline boiling range hydrocarbon.

15. Method of claim **14** wherein said adjusted combustion parameter is combustion zone pressure.

16. Method of claim **14** wherein said composition characteristic is octane rating.

17. A composition analyzer for detecing a composition characteristic of a combustible chemical fluid which comprises in combination:

(a) a combustion chamber, including an induction section;

(b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber;

(c) means sensing the physical position of said flame front within said combustion chamber;

(d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion pressure, induction section temperature, fluid stream flow rate, and oxidizer stream flow rate, in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber;

(e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the composition characteristic of said fluid stream;

(f) signal conditioning means receiving said parameter output signal;

(g) condition signal generating means within said signal conditioning means, producing a condition output signal functionally represntative of said composition characteristic;

(h) means periodically isolating said fluid stream from said flame generating means, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said flame generating means in a manner sufficient to continue the generation of said immobilized flame front;

(i) means passing to said signal conditioning means, a timing signal indicative of the passage of reference fuel to said flame generating means;

(j) comparison means within said signal conditioning means, responsive to said timing signal, adapted to compare the condition output signal generated due to reference fuel flame front with a reference value signal fuctionally corresponding to the actual known value of composition characteristic of said reference fuel, and therefrom developing a comparison signal;

(k) adjusting means within said signal conditioning means, responsive to said comparison signal, and adapted to adjust said condition signal generating means to compensate for reviation between the condition output signal generated due to reference fuel flame front and said reference value signal; and

(l) means for retaining said adjustment to said condition signal generating means when said isolation period is ended and said fluid stream is returned to said flame generating means in place of said reference fuel, whereby the condition output signal generated by said fluid stream flame front is compensated for combustion effects not indicative of composition characteristic, and said condition output signal is thereby functionally representative of and correlatable with the actual composition characteristic of said combustible chemical fluid.

18. Apparatus of claim **17** wherein said signal conditioning means comprises computer means.

19. Apparatus of claim **17** wherein said flame position sensing means comprises a pair of axially spaced temperature sensing elements.

20. A composition analyzer for detecting a composition characteristic of a combustible chemical fluid which comprises in combination:

(a) a combustion chamber encompassed by an outer chamber confining a zone of elevated temperature thereinbetween, said combustion chamber including an induction section maintained at elevated temperature;

(b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber;

(c) means sensing the physical position of said flame front within said combustion chamber;

(d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion pressure, induction section temperature, fluid stream flow rate, and oxidizer stream flow rate, in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber;

(e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the composition characteristic of said fluid stream;

(f) means sensing a temperature selected from the group consisting of a temperature within said induction section and a temperature of said confined elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature; and,

(g) signal conditioning means receiving said parameter output signal and said sensed temperature signal, and producing therefrom a condition output signal which is functionally representative of and correlatable with said composition characteristic of the combustible chemical fluid, said condition output signal being indicative of said composition characteristic as corrected for fluctuations in sensed temperature.

21. Apparatus of claim **20** wherein said signal conditioning means comprises computer means.

22. Apparatus of claim **20** wherein said flame position sensing means comprises a pair of axially spaced temperature sensing elements.

23. A composition analyzer for detecting a composition characteristic of a combustible chemical fluid which comprises in combination:

(a) a combustion chamber encompassed by an outer chamber confining a zone of elevated temperature thereinbetween, said combustion chamber including an induction section maintained at elevated temperature;

(b) means for generating within said combustion chamber, a cool flame characterized by a relatively narrow well-defined flame front, utilizing as fuel therefor said combustible chemical fluid to be analyzed, said generating means including means passing a stream of said fluid and a stream of oxidizer into said combustion chamber;

(c) means sensing the physical position of said flame front within said combustion chamber;

(d) control means coupled to said position sensing means, and adapted to adjust a combustion parameter selected from the group consisting of combustion pressure, induction section temperature, fluid stream flow rate, and oxidizer stream flow rate, in a manner sufficient to immobilize said flame front in a constant physical position relative to said combustion chamber;

(e) means sensing the adjusted parameter and developing a parameter output signal which is functionally representative of the composition characteristic of said fluid stream;

(f) signal conditioning means receiving said parameter output signal;

(g) condition signal generating means within said signal conditioning means, producing a condition output signal functionally representative of said composition characteristic;

(h) means periodically isolating said fluid stream from said flame generating means, and simultaneously passing a stream of reference fuel having a known value of composition characteristic, into said flame generating means in a manner sufficient to continue the generation of said immobilized flame front;

(i) means passing to said signal conditioning means, a timing signal indicative of the passage of reference fuel to said flame generating means;

(j) comparison means within said signal conditioning means, responsive to said timing signal, adapted to compare the condition output signal generated due to reference fuel flame front with a reference value signal functionally corresponding to the actual known value of composition characteristic of said reference fuel, and therefrom developing a comparison signal;

(k) adjusting means within said signal conditioning means, responsive to said comparison signal, and adapted to adjust said condition signal generating means to compensate for deviation between the condition output signal generated due to reference fuel flame front and said reference value signal;

(l) means for retaining said adjustment to said condition signal generating means when said isolation period is ended and said fluid stream is returned to said flame generating means in place of said reference fuel, whereby the condition output signal generated by said fluid stream flame front is compensated for deviation between the condition output signal generated due to the reference fuel flame front and said reference value signal;

(m) means sensing a temperature selected from the group consisting of a temperature within said induction section and a temperature within said confined elevated temperature zone, and developing a temperature signal responsive to fluctuations in sensed temperature;

(n) means transmitting said sensed temperature signal to said signal conditioning means; and,

(o) means within said signal conditioning means, modifying said condition output signal generated by said fluid stream flame front responsive to fluctuations in said sensed temperature and thereby compensating said condition output signal for combustion effects not indicative of composition characteristic, thereby resulting in a condition output signal functionally representative of and correlatable with the composition characteristic of said combustible chemical fluid.

24. Apparatus of claim **23** wherein said signal conditioning means comprises computer means.

25. Apparatus of claim **23** wherein said flame position sensing means comprises a pair of axially spaced temperature sensing elements.

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