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FLAME PROPAGATION ANALYZER

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2 Sheets-Sheet 1

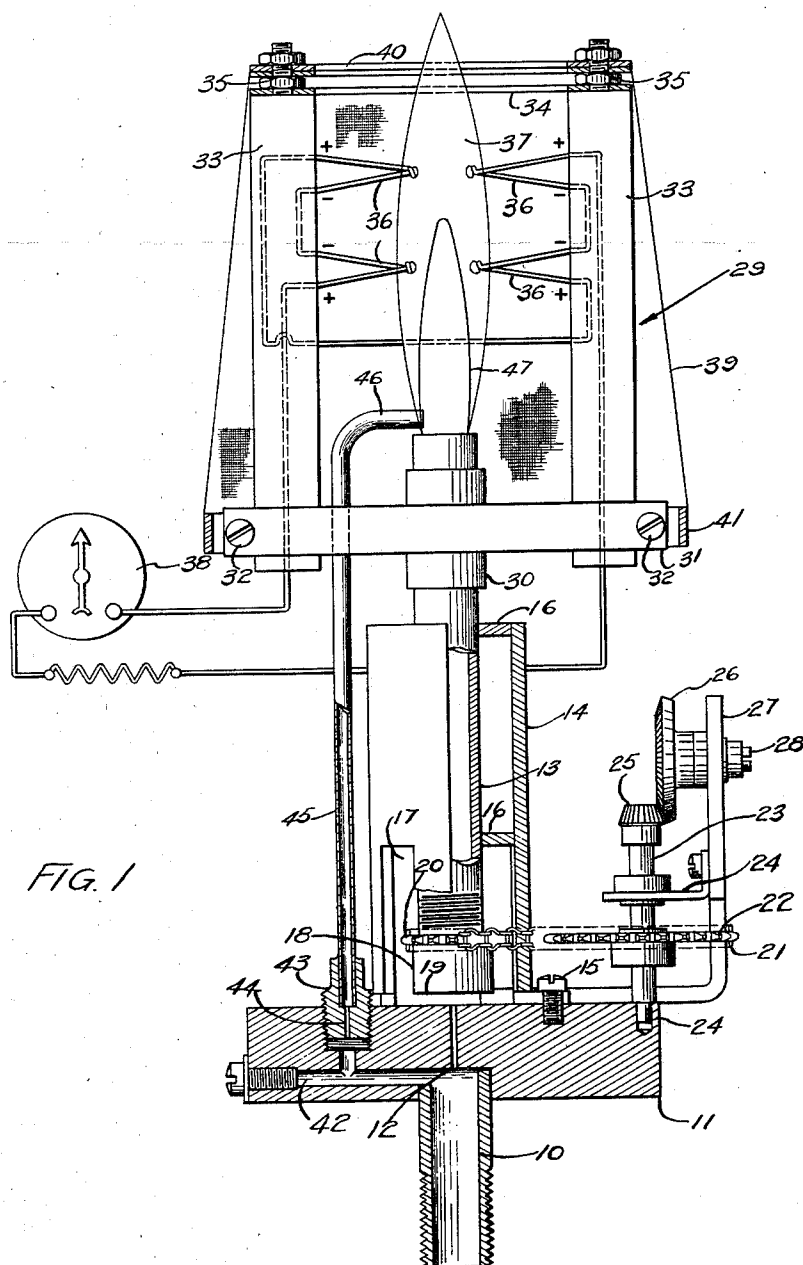


FIG. 1

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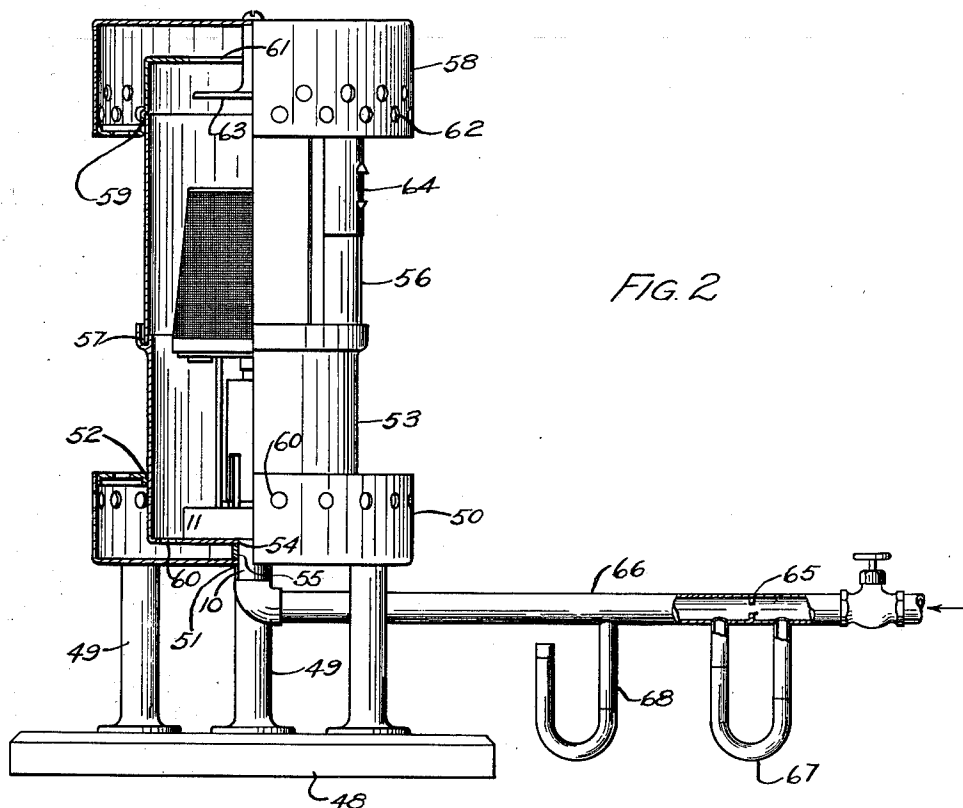
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FLAME PROPAGATION ANALYZER

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5 Claims. (Cl. 73—32)

This invention relates to combustible materials such as fuels and especially fuels of a vaporous or gaseous nature. This invention relates to the determination of the heating effect of fuels and also to the preparation of fuels of a constant heating value.

Heretofore to measure continuously the heating value of a gas it has been customary to measure the effect of the combustion of a given quantity of the heating fluid upon the temperature of another fluid such as air or water. Such procedure is very complicated and is subject to very large errors due to flow changes in the heating or in the heated fluid, etc., as is well known in the art.

Due to these complications operators have frequently been compelled to estimate the heating value of a fuel by observing a flame and its structure. This procedure is very largely affected by sunlight or artificial light and cannot be accomplished within close limits.

It is the object of this invention to provide an improved means for measuring the heating effect of combustible fluids. It is another object of this invention to provide an improved means for measuring the characteristics of a flame and particularly the temperature gradient of a stationary flame.

The features of novelty which characterize the present invention are pointed out with particularity in the claims appended to and forming a part of this specification. For a better understanding of the invention and its advantages, however, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which

Fig. 1 shows, in an elevation and partly in section, the flame analyzing device of this invention.

Fig. 2 shows, in elevation partly broken away and in section, another view of the flame analyzing device of this invention.

According to this invention the heating effect or value of the combustible material is ascertained by burning some of the fuel and determining the characteristics of the flame produced. The stationary type of flame is used as the form in which the flame characteristics may be most practically and accurately determined. Accordingly a burner is provided which will burn the combustible material with a stationary flame of well defined structure and characteristics. Such a burner is shown in Fig. 1.

The combustible material, usually a gas or a vapor, enters through pipe connection 10, fixed in the block 11 of the burner. Block 11 is pro-

vided with a passage or orifice 12 of small size, through which the combustible fluid passes. A tube 13 is arranged to receive the combustible fluid passing through the orifice 12, and the tube 13 is supported relative to the block 11 by the cylinder 14 fixed to the block 11 by any suitable means such as the screw 15. The tube 13 may be conveniently supported in the cylinder 14 by rings 16. The cylinder 14 is provided with openings 17 which permit the passage of air or any other fluid surrounding the burner therethrough. The tube 13 is provided with a sleeve or collar 18 adjustable longitudinally thereof. The longitudinal adjustment of the sleeve or collar 18 relative to the tube 13, may be effected in any of a variety of ways, and preferably is made so adjustable by providing the tube and the collar with screw threads. The sleeve or collar 18 is provided with a substantially flat surface on its bottom face 19. By adjusting the sleeve or collar 18 longitudinally of the tube 13, a gap between the block 11 and the collar 18 may be varied so as to vary the rate at which air is drawn in the tube 13 by the aspirating effect of the combustible material flowing from the orifice 12 into the tube 13.

The collar 18 conveniently carries a sprocket 20 driven by a chain 21 trained over the sprocket 22. The sprocket 22 is fixed on shaft 23, rotatable in bearings 24. The shaft 23 carries a gear 25 meshing with gear 26 rotatably carried by support 27. The shaft 28, upon which the gear 26 is fixed, is provided with a kerf with which a suitable tool may be engaged for adjusting the position of the collar or sleeve 18.

A frame 29 is carried by the burner and is conveniently supported on the tube 13 by a collar 30 fixed on the tube and supporting the bar 31 which is split and provided with an opening fitting around the sleeve 30, the bar 31 being clamped onto the sleeve 30 by screws 32, drawing together its split halves. At either end of the bar 31 and clamped between its split halves are upright standards 33 which are held in fixed spaced relation at their upper ends by the ring 34, bolted to the uprights 33 by bolts 35—35. The ring 34 serves to maintain the vertical standards 33 in accurately spaced relation without interfering with the flame of the combustible gas issuing from the burner. The upright standards 33 carry thermocouples 36 of any suitable material, preferably of platinum and platinum-rhodium. The thermocouples are fixed in the standards 33 in any suitable manner and preferably by clamping them in place. The junction of the thermo-couples extend

into the body 37 of the flame of combustible gases issuing from the burner.

The thermo-couples 36—36 are connected differentially, that is the polarities of some of the thermocouples are opposed to the polarities of the remaining thermocouples as shown in Fig. 1, to an indicating, recording, or controlling instrument 38 of any suitable and well known type.

In order to protect the thermo-couples from mechanical injury, especially when the combustible gases are being lighted, a screen 39 surrounds the support in such a position, as shown in Fig. 1, as to protect the thermo-couple 36. The screen 39 depends from ring 40 to which it is secured by brazing, soldering, welding or clamping, or any suitable manner. The ring 40 is secured to the standards by bolts 35. The screen 39 is provided with a lower band 41 which symmetrically weights the screen so that the screen will hang in a position as shown in Fig. 1 when the instrument is upright. In addition, the band 41 cooperates with bar 31 to support the screen 39 at its lower margin when the burner is not in upright position.

The block 11 has a passage 42 leading from the inlet pipe 10. A plug 43 is threaded into the block 11 and is provided with a passage 44 of restricted size, leading to the passage 42 in the block 11. A tube 45 extends from the plug 43 and is open to the passage 44. The tube 45 is open at its upper end 46 and acts as a pilot light for the burner. The relative size of the orifices 12 and 44 is such that only a small percentage of the combustible fluid entering through pipe connection 10 passes into the pilot tube 45.

In the operation of the device as so far described, the combustible fluid entering through the pipe connection 10, passes through the orifice 12 into the tube 13 and draws, by an aspirating action, a supply of primary air through the gap between sleeve 18 and the block 11. The supply of primary air can be adjusted to any desired quantity by adjusting the gap between the sleeve 18 and the block 11. The mixture of combustible gas and air is lighted as it issues from the tube 13 and burns with a stationary flame composed of the body part 37 and inner cone 47. The size of the flame is determined by the supply of primary air and by the quantity and composition of the combustible fluid. As the quantity or the quality of the combustible fluid varies, the inner cone 47 rises and falls, and the temperature gradient or temperature difference between those parts of the flame in which junctions of the thermo-couples 36 are positioned, varies correspondingly. For optimum operation it is desirable to have the junction of the thermo-couples 36 positioned in the body 37 of the flame and so positioned that none of the thermo-couples will enter into the cone 47 in any position or size of the flame. It has been found by experiment that as the structure of the flame changes so that the height of the inner cone 47 varies, the temperature gradient between those parts of the flame in which the junctions of the thermo-couples are positioned, varies in exact proportion to the height of the inner cone of the flame. It has long been recognized that the height of the inner cone of the flame is a practical working standard for the heating effect of a flame of burning gas having unvarying constituents. Accordingly the variation of the temperature gradient along the flame, in the direction of flame propagation, is a practical measure of the heating effect of the par-

ticular fluid being burned. The instrument 38, which is responsive to the variation in the temperature gradient in the flame, may be employed to indicate or record the heating value or effect of the combustible fluid, or it may be employed to control a system so as to adjust the system in accordance with the variation in the heating effect of a flame of the combustible fluid being used in the system.

In addition to the well known fact that from a practical operating standpoint the height of the inner cone of the flame of the type produced by the burner shown in Fig. 1, is regarded as a satisfactory criterion of the heating value of a fluid containing non-varying constituents, it has been determined experimentally that the height of the inner cone 47 does bear a definite relation to the heating value of a combustible fluid so long as the nature of the constituents of the combustible fluid does not change. Variations in the proportions of the constituents of the combustible fluid produce a change in the flame structure which bears a definite relation to the heating value or effect of the combustible mixture. Accordingly, by using the instrument 38 to control the quantity supply of the combustible mixture or the particular ratio of composition of constituents of the combustible mixture so as to maintain a flame of constant structure or of the constant cone height 47, the heating effect of the combustible mixture may be maintained constant. Since the temperature gradient of the flame measured by the thermo-couples 36 is in exact proportion to the height of cone 47, the temperature gradient in the flame may be used through the instrumentality of the control device 38 to effect automatic control of the composition of a combustible mixture so as to maintain it of a constant heating value or effect.

While it has been found entirely satisfactory to feed the primary air to the burner through a gap such as that between the sleeve 18 and the block 11 in the construction shown in Fig. 1, as an alternative construction it may be desirable and practicable to feed the primary air into the burner tube from a supply of compressed air through suitable pressure controlling device. Where it is desired to use oxygen or to precondition the primary air, a supply of air such as an auxiliary supply connected to the pressure tube by tubing may be used.

In addition, as another alternative way in which the flame analyzer may be used, air or oxygen may be fed through the burner tube and the gas under test may be used as the atmosphere surrounding the burner tube.

As shown in Fig. 1, four thermo-couples are used in two pairs symmetrically arranged about the axis of the flame so that deviations in the flame shape from a symmetrical shape will not effect the operation of the instrument. In the arrangement shown in Fig. 1, each pair of thermo-couples at the same level coact in neutralizing the effect of horizontal deviation or lateral displacement of the flame at that level. If desired, a larger number of thermo-couples may be used to determine the temperature at a series of points in the flame and thereby measure more accurately the temperature gradient throughout the body of the flame.

In order to make the burner and its associated parts an instrument of a high degree of accuracy, it is found convenient to surround the burner with

a shield such as shown in Fig. 2, which is of the following construction:

A base 48 has attached thereto the standards 49, which support a cup shaped sheet metal member 50. The member 50 is provided with an aperture 51 in its base through which the pipe connection 10 passes. At its top, member 50 is provided with an aperture 52 into which the cup shaped member 53 fits. The cup shaped member 53 is provided with an aperture 54 through which pipe connection 10 passes and a bushing 55 is provided for separating the members 50 and 53. The block 11 rests upon the bottom of the cup shaped member 53, which thereby supports the burner. A tubular member 56 rests in a flange 57 of the member 53 and supports at its top the cap 58 provided with the flange 59, which fits on to the upper end of the cylinder 56. The members 50 and 53 are provided with apertures 60 through which air may be drawn into the interior of the casing to provide a steady supply of air for the burner. The products of combustion pass upwardly through the opening 61 and out through openings 62 in cap 58. The cap 58 is provided with a baffle 63 depending therefrom, which serves to prevent the flame from striking the casing. A door 64 is conveniently provided on the cylinder 56 which may be opened to permit lighting the combustible gases. An aperture, (not shown), may be provided in the member 53 through which a tool may be inserted for engaging the kerf of the shaft 28 to adjust the primary air supply.

The casing provides a shield for the burner which prevents changes in atmospheric conditions, drafts, or mechanical disturbance from interfering with the flame of the burner, so that the burner operates practically independently of surrounding conditions. The casing is so constructed and the apertures are such that the flow of air to the burner and of the products of combustion from the burner are not appreciably hindered.

In case the combustible content of the combustible mixture falls so low that the flame of the burner dies out, the pilot 46 will continue to burn for a considerable length of time due to the fact that the combustible gases issuing from it are not mixed with a primary supply of air, and accordingly when the composition of the gas under test again changes to a combustible mixture, it will be lighted by the pilot flame.

Inasmuch as it is desired to employ the flame analyzer to respond to changes in the combustible condition of the combustible mixture or its heating effect, it is desirable that the combustible mixture be fed to the burner at a constant rate and under constant pressure, and it may be desirable to precondition the combustible gas as to moisture content and temperature. Accordingly the flow of gas under test may be controlled by any suitable pressure regulator, either of wet or dry type, and the gas may be brought to and held at an even temperature, and the moisture content may be adjusted by any of the well known and suitable devices available.

An orifice 65 is conveniently provided in the pipe line 65 leading to the burner for creating a pressure differential depending on the rate of flow which is measured by U tube manometer 67. In addition a U tube pressure gauge 63 may be attached to the pipe line 66 to measure the pressure of a combustible mixture flowing to the burner.

In the operation of many systems for supplying

gas for heating and industrial purposes, the available supply of gas changes from time to time and accordingly the combustible mixture may be made up of a mixture of natural gas, producer gas, coal gas, butane, hydrogen, and many other inflammable fluids; the quantities of such gases which are available, varying from time to time in a manner uncontrollable by the user. In maintaining a supply of fuel for home and industrial consumption where the mixture must be made up from such a variable supply of the constituents of the mixture, it is necessary to adjust the composition of the mixture from time to time as the supply of the constituents of the mixture varies, in order to keep the heating effect and the flame produced by burning the gas substantially constant. The flame analyzer herein disclosed lends itself readily to the control of a system for maintaining a mixture of gases at a substantially constant heating effect or flame structure.

In addition, the flame analyzer may be used for other purposes than to adjust the composition of a combustible mixture of gases in a predetermined manner; for example, where a combustible mixture is employed for heating a particular material or product, variations in the heating effect of the combustible mixture as determined by the flame analyzer may be caused to control the rate of flow of the medium being heated, or may be caused to control any of the many furnace conditions such as damper position, draft position, etc., to adjust the resulting effect upon the material being heated in the manner desired.

While a particular embodiment of the flame analyzer has been herein disclosed by way of illustration, it is not intended so to limit the invention, inasmuch as many modifications in the details of construction and operation of the instrument and the control systems in which it may be used, may be made, as will be apparent to one skilled in the art, without departing from the scope and spirit of the invention.

Having disclosed my invention, what I claim is:

1. The combination with means for burning fluid fuel in an elongated stationary flame, of means for measuring a temperature gradient in said flame comprising a plurality of temperature responsive devices distributed longitudinally of the flame and extending into the flame at one side of the latter and another plurality of temperature responsive devices extending into the flame at the opposite side of the latter and also distributed longitudinally of the flame, the devices at the one side producing one effect, and the devices at the other side producing another effect which decreases or increases relatively to said one effect accordingly as the axis of the flame is displaced toward or away from said one side, and means responsive to the sum of said effects.

2. A device for measuring the heating effect of a combustible fluid which consists of means for burning a sample of the fluid as a stationary flame in which the combustion progresses from an initial surface of combustion, first means responsive to the temperature difference between a plurality of parts of the flame distributed along the direction in which combustion progresses, second means spaced apart from the said first means in a direction transversely of the direction in which combustion progresses and responsive to the temperature difference between a plurality of parts of the flame distributed along the direction in which combustion progresses, and measuring means jointly responsive to said first and

second means, whereby on deflection of the flame toward either of said means and away from the other of said means the increased response of one means neutralizes the effect of the decrease in the response of the other means.

3. A device for measuring the heating effect of a combustible fluid which comprises, a burner for burning the fluid as a stationary flame, a support fixed relative to the burner, first temperature responsive means comprising a plurality of temperature responsive elements held in the flame by the support, said elements being arranged along the direction of flame propagation, second temperature responsive means displaced transversely of and producing an effect in the same direction as the first mentioned means and comprising a plurality of temperature responsive elements arranged along the direction of flame propagation and an indicator connected to said elements so as to respond to the sum of the effects of the first and second means.

4. A device comprising a burner for burning a fluid as a stationary flame, a support, a plurality of thermo responsive elements mounted on said support and adapted to project into said flame when burned to produce an effect responsively

to the flame temperature, means responsive to the combined effects of said elements, the said elements being displaced angularly about the axis of said burner, and arranged so that the individual effects of the elements displaced angularly from one another are in the same direction, whereby movement of the flame, in a direction transversely of said axis, will be substantially ineffective upon the means responsive to the combined effect of said elements.

5. The combination with means for burning fluid fuel in an elongated stationary flame, of means for measuring a temperature gradient in said flame comprising a plurality of fixed thermocouple junctions in said flame, distributed longitudinally thereof on opposite sides of the flame and at least one pair of said thermocouples being arranged in the same horizontal plane at opposite sides of the flame, the polarities of the thermocouples being such that the thermocouples disposed on the same side of the flame are differentially connected and the thermocouples in the same horizontal plane are additively connected.

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