United States Patent [19]

Takahashi et al.

[11] **3,907,488**

[45] **Sept. 23, 1975**

[54] **METHOD OF BURNING FUELS BY MEANS OF A BURNER**

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[73] Assignee: **Mitsubishi Jukogyo Kabushiki Kaisha,** Tokyo, Japan

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[21] Appl. No.: **442,679**

[30] **Foreign Application Priority Data**

Feb. 24, 1973 Japan 48-22339

[52] **U.S. Cl.** **431/2;** 431/4; 431/115; 431/285

[51] **Int. Cl.**^{2} **F23C 11/00**

[58] **Field of Search** 431/2, 9, 3, 278, 8, 285, 431/10, 12, 4, 11, 115; 60/DIG. 11

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Primary Examiner—Edward G. Favors
Attorney, Agent, or Firm—Toren, McGeady and Stanger

[57] **ABSTRACT**

A method of burning a fuel by means of a burner which comprises premixing the fuel with air in an amount larger than the quantity theoretically required for the combustion of the fuel, allowing the resulting lean premixture to be issued from some of plural nozzles of the burner, while at the same time, premixing the fuel with air in an amount less than the theoretically required quantity, allowing the resulting rich premixture to be issued from the remaining nozzles, and burning the two gaseous premixtures together.

9 Claims, 17 Drawing Figures

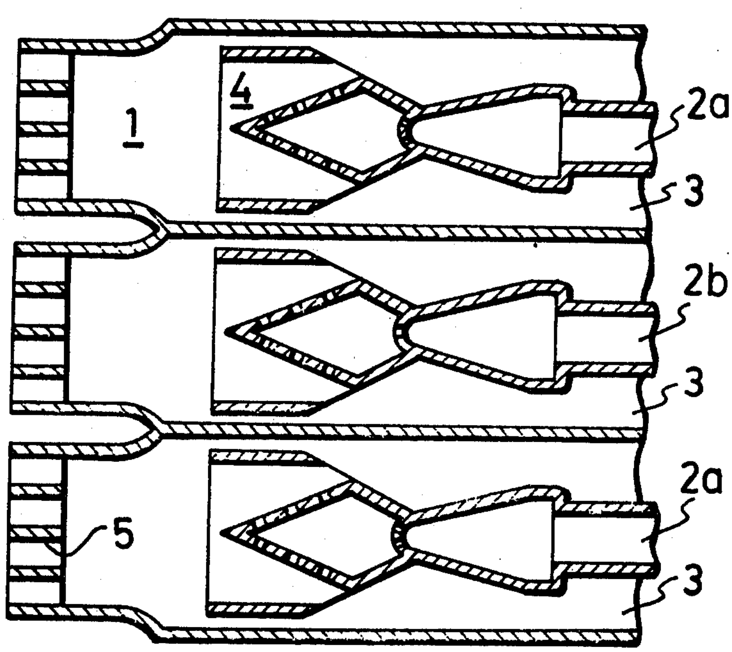
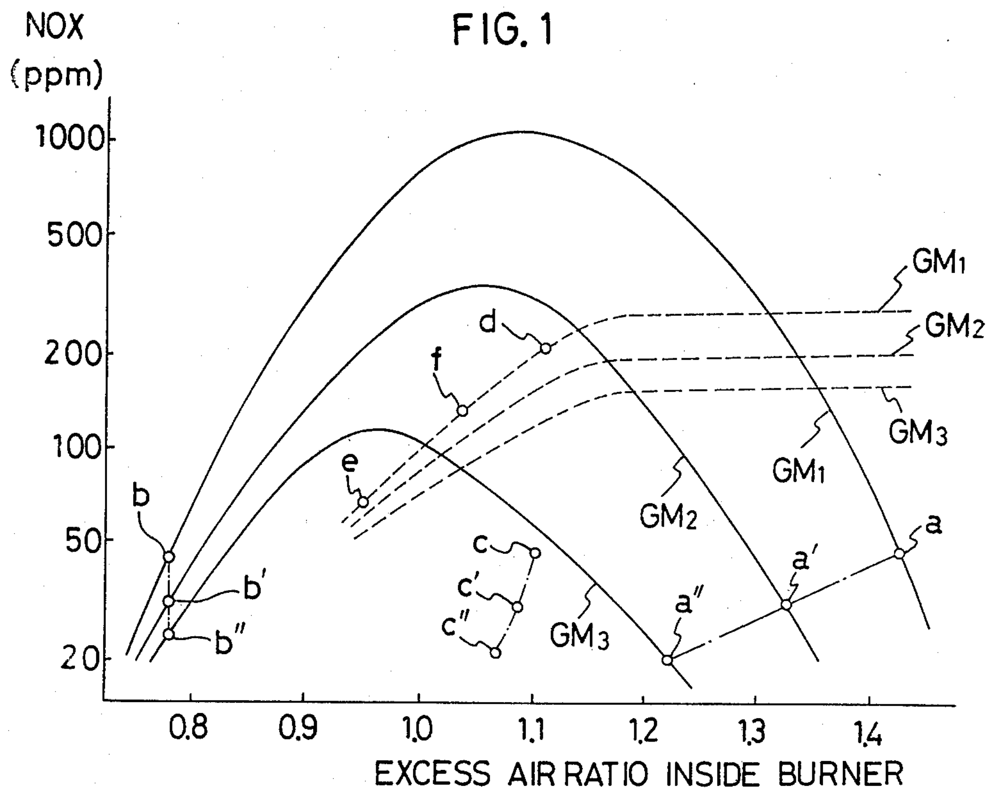


FIG. 1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0.8
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EXCESS AIR RATIO INSIDE BURNER
GM1
GM2
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a
a'
a"
b
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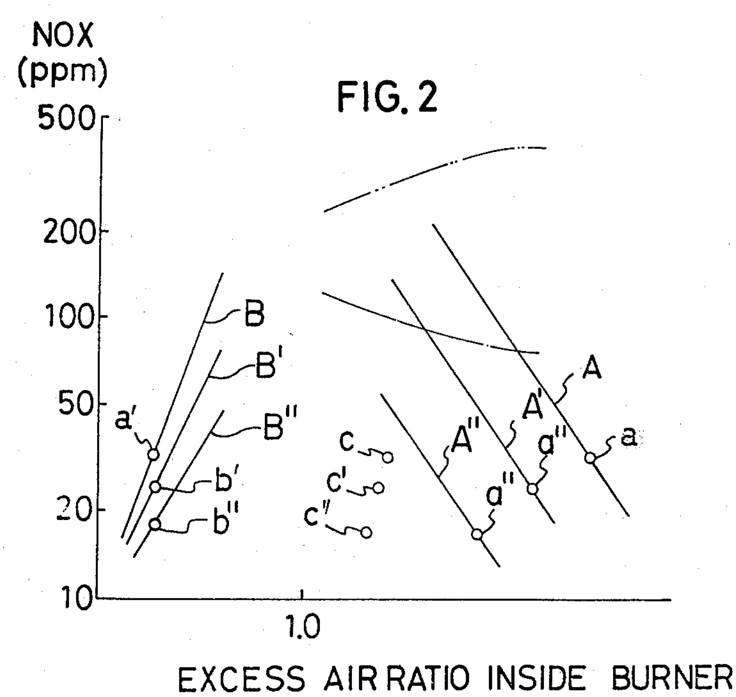
b"
c
c'
c"
d
e
f

FIG. 2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EXCESS AIR RATIO INSIDE BURNER
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c
c'
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FIG. 3

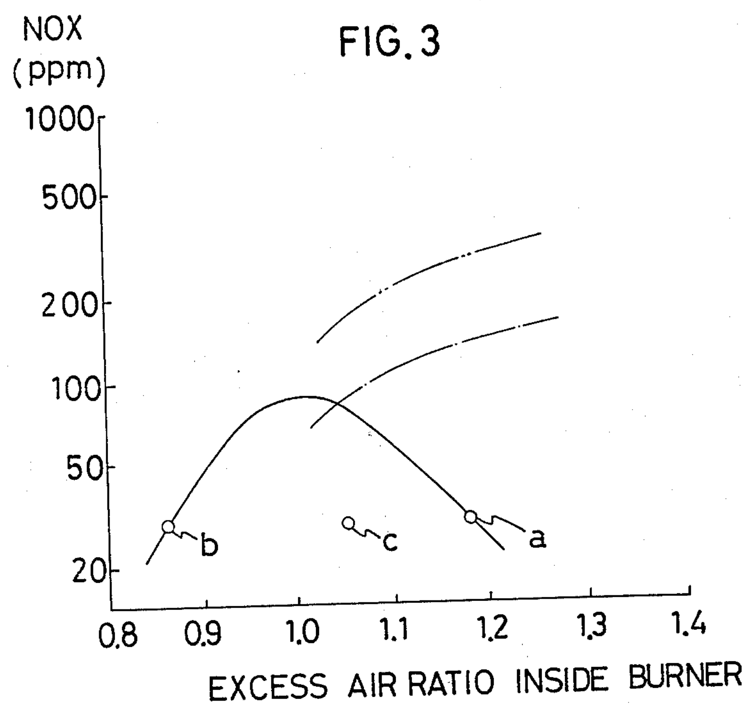


FIG. 4

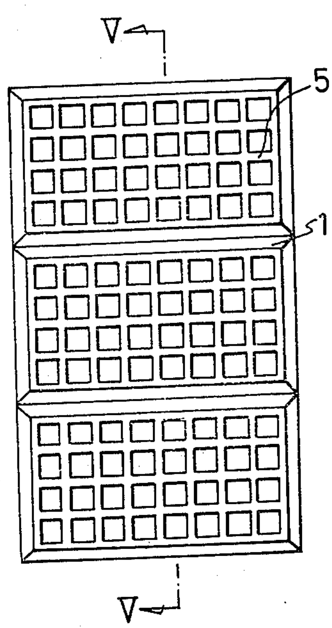


FIG. 5

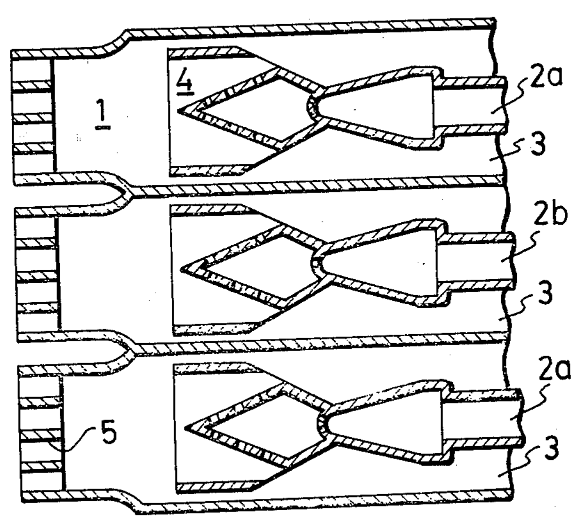


FIG.6

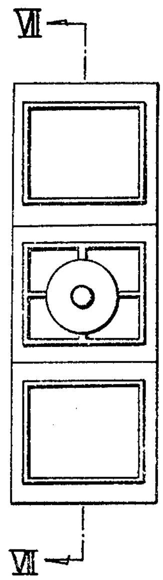


FIG.7

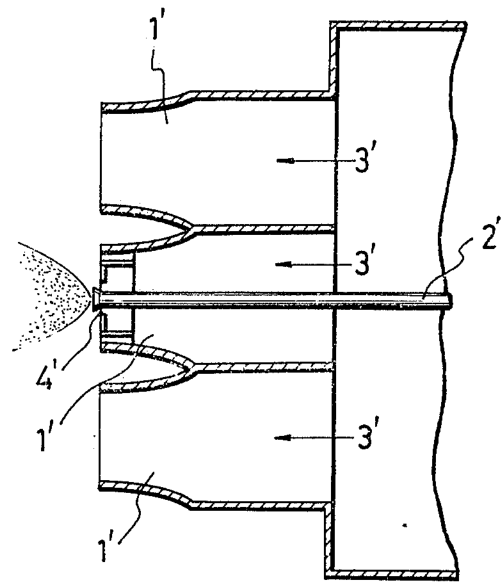


FIG.8

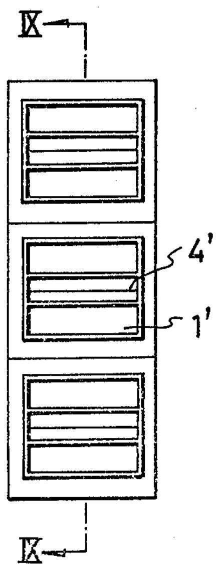


FIG.9

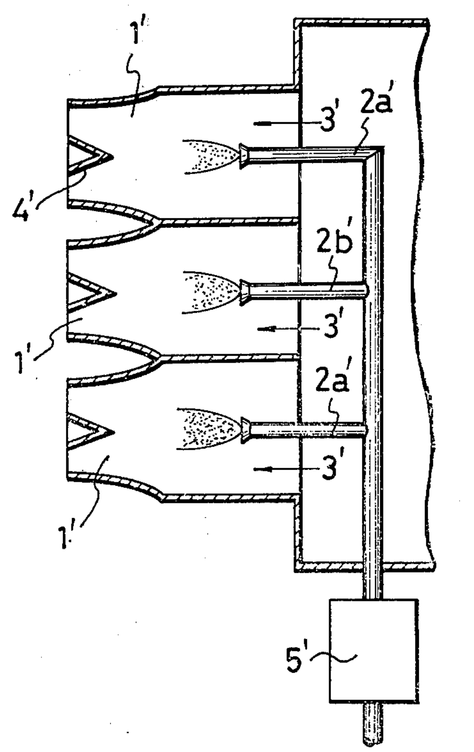


FIG. 10

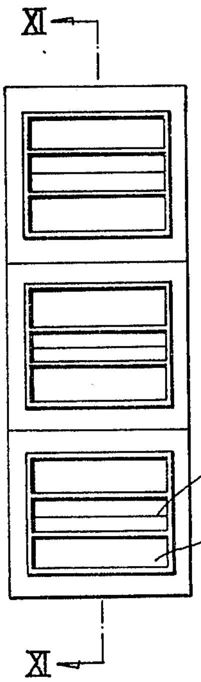


FIG. 11

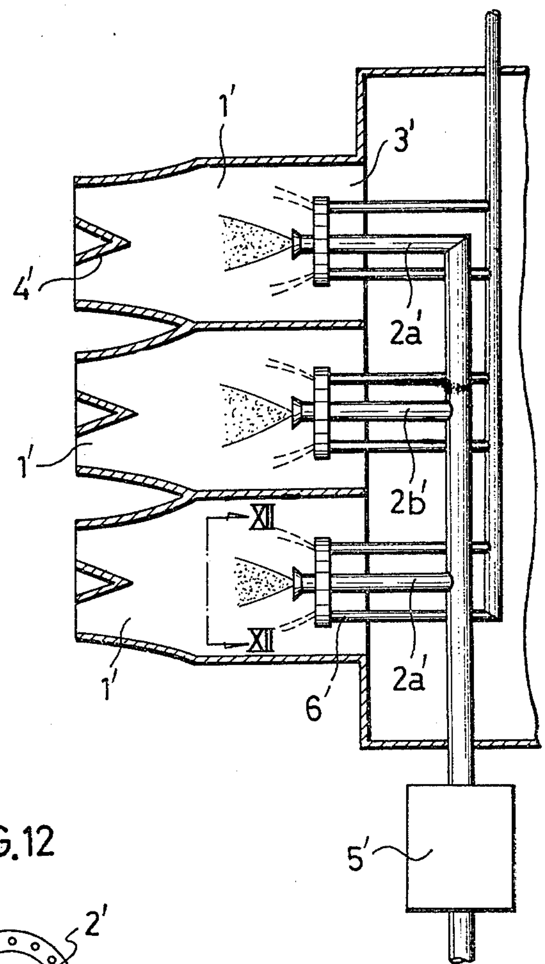


FIG. 12

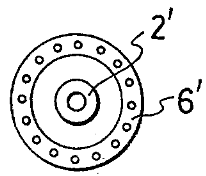


FIG. 13

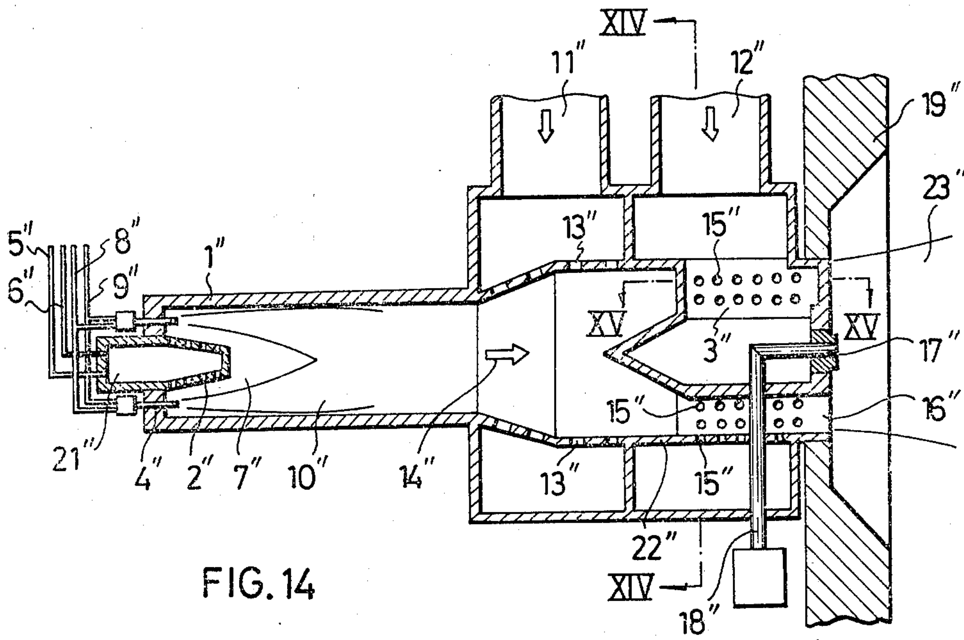


FIG. 14

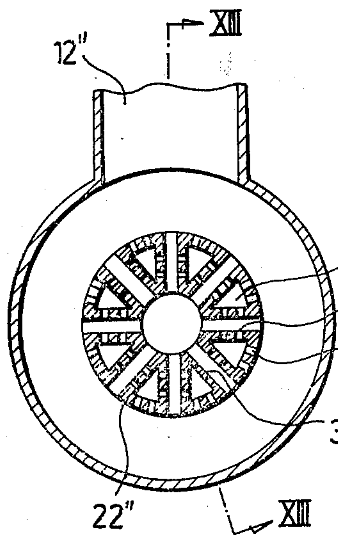


FIG. 15

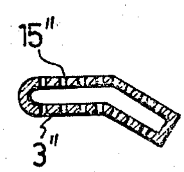


FIG. 16

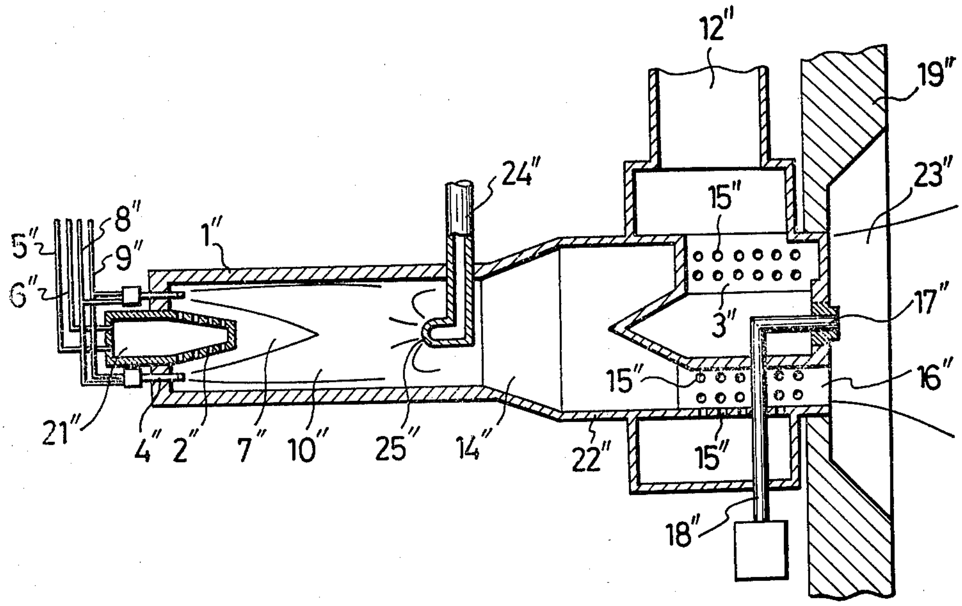
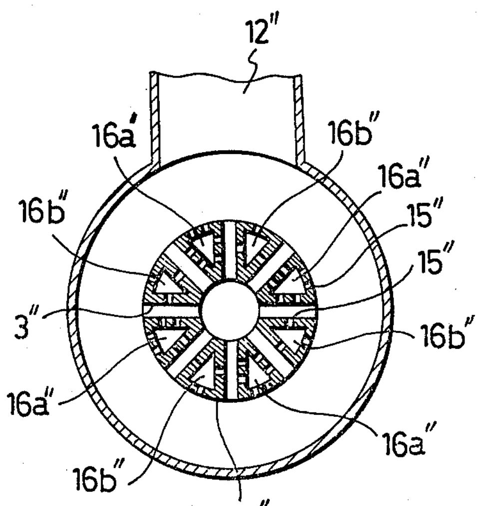

12″
19″
24″
23″
15″
5″
8″
1″
9″
6″
17″
3″
15″
16″
21″
4″
2″
7″
10″
25″
14″
22″
15″
18″

FIG. 17


12″
16a′
16b″
16a″
16b″
15″
15″
3″
16b″
16a″
16a″
16b″
22″

METHOD OF BURNING FUELS BY MEANS OF A BURNER

This invention relates to a method of burning fuels by means of a burner, which can reduce the nitrogen oxide concentrations in the combustion gases.

More particularly, the invention concerns a method of burning gaseous fuels and light and heavy liquid fuels which comprises premixing, upstream of the burner, a fuel gas or vapor with air, with or without the addition of an inert gas or liquid in two different amounts, over and below the amount theoretically required for the combustion of the fuel, and burning the two premixtures to produce a so-called premix flame, thereby effecting combustion while remarkably reducing the concentrations of nitrogen oxides in the emissions and achieving a good thermal efficiency.

In a combustion flame the oxides of nitrogen (hereinafter called NOx) are produced by the combination of oxygen and nitrogen molecules in the combustion air. The velocity of NOx production depends in large measure upon the flame temperature, or the higher the flame temperature, the faster NOx develop. It is therefore effective to decrease the flame temperature in order to reduce the NOx production as a result of combustion. This is well known in the art.

Conventional burners are generally of so-called diffused flame type whereby fuel gas and air for combustion are injected in a furnace by way of separate passages.

In order to reduce the NOx contents of the combustion gases from such burners, the following methods have been adopted:

1. Two-step combustion, so called because part of air supply for combustion is issued from the burner to decrease the excess air rate in the burner and the remaining air is released from a port independent of the burner.

2. Inert-gas mixing, whereby an inert gas (e.g., combustion gas) is added to the air for combustion.

3. Ununiform excess-air combustion, for which a plurality of burners are used with air supply at a uniform flow rate but with ununiform fuel supply settings.

These and other methods hitherto proposed and practiced were examined by us for their NOx-reducing effects. Typical results are presented in FIGS. **1** to **3.**

FIG. **1** shows the relation between the excess air rate inside a burner (on the abscissa) and the NOx concentration in the combustion gas (on the ordinate) produced by the combustion of a gaseous fuel.

FIGS. **2** and **3** show the results of experiments, respectively, with a light liquid fuel (kerosene) and a heavy liquid fuel (heavy oil).

In connection with these figures, the term "excess air rate inside a burner" is used to mean the ratio of the amount of air that passes the throat of the burner (in the two-step combustion, such an amount minus the quantity of air blown in the latter period of combustion) to the amount of air theoretically required for the combustion.

The broken-line curves in FIG. **1** represent the results of experiments conducted by using ordinary burners, with the ratio (hereinafter called GM) of the amount of an inert gas (combustion gas) introduced into air to the amount of the air for combustion increased from GM_1 to GM_3. It will be seen from the graph that the NOx concentration of the combustion gas continues to

increase gradually until the excess air rate inside the burner reaches about **1.2** but remains substantially constant beyond the value of the excess air rate.

It can be seen from the experimental results given in FIG. **1** that the two-step combustion method limits the air supply to the burner and thereby reduces the excess air rate in the burner and to some extent decreases the NOx concentration in combustion gas.

Also it is obvious that the addition of an insert gas, say combustion gas, is fairly effective in that the NOx concentration in the exhaust gas drops with an increase in the percentage of the inert gas (i.e., with the decrease of the excess air rate inside the burner).

In the uniform excess-air combustion method, a plurality of burners are so set as to have irregular excess air rates and combustion is caused in some burner with a large excess of air (e.g., at *d* in FIG. **1**) and in the other with a small excess of air (e.g., at *e* in the same figure). The method is not appreciably useful because the effects of large and small excesses of air counteract and, as a whole, the resulting NOx concentration is such as arising from the combustion with a mean excess of air, e.g., at *f* in the figure.

The present invention has for its object the provision of a method of burning fuels and a burner therefor which can eliminate the drawbacks of the aforedescribed methods.

To achieve the end the invention resides, firstly, in a method of burning fuels, and a burner therefor, which comprises effecting the combustion by discharging from some of plural nozzles of a burner a lean premixture consisting of air in an amount more than that theoretically required for the combustion and a fuel (i.e., a gaseous, liquid, or evaporated or atomized liquid fuel) and by issuing from the remainder of the nozzles a rich premixture consisting of air in an amount less than the theoretically required quantity and the same fuel.

Secondly, the invention pertains to a method of burning fuels as defined above, wherein the gaseous fuel to be used is a gasified fuel obtained by thermally decomposing a heavy liquid fuel, mixing the decomposition product with an inert gas or liquid, and then cooling the mixture.

The method of the present invention will be better understood from the following detailed description.

1. When a gaseous fuel is used, the method of the invention is reduced to practice in the following way: The gaseous fuel and air in an amount more than that theoretically required for combustion are premixed upstream of a burner, and the premixed gas is jetted out from some of plural nozzles of the burner, while, at the same time, the gaseous fuel and air in an amount less than the theoretically required quantity are premixed, and the premixture is issued from the remainder of the burner nozzles to effect combustion. It is also possible to add an inert gas or inert liquid to either or both of the gaseous premixtures before they are delivered from the burner nozzles for combustion.

2. When a light liquid fuel is employed, the method is practiced as follows: At least a part of the light liquid fuel is evaporated to a combustible gas or vapor, premixed with air in an amount more than the theoretically required quantity, with or without the addition of an inert gas or liquid, and the resulting gaseous premixture is issued from some of plural nozzles of a burner for combustion. At the same time, at least a part of the light liquid fuel is evaporated to a combustible gas or vapor, premixed with air in an amount less than the theoretically required quantity, with or without the addition of an inert gas or liquid, and the resulting gaseous premixture is burnt as it is discharged from the remainder of the burner nozzles.

3. With a heavy liquid fuel, the method is further modified as follows: The fuel is thermally decomposed to a combustible gas or vapor, which is then diluted and cooled by the addition of an inert gas or liquid (e.g., water vapor), and a part of the resulting gas is premixed with air in an amount more than the theoretically required quantity, and then the premixture is issued for combustion out of some of plural nozzles of a burner. Simultaneously, the remainder of the diluted and cooled combustible gas or vapor is premixed with air in an amount less than the theoretically required quantity, and then the premixture is spouted from the remainder of burner nozzles for combustion.

For the purpose of the invention, the amount of air more than the quantity theoretically required for combustion is, in terms of the excess air rate (the amount of air actually consumed for combustion divided by the amount theoretically required for complete combustion), preferably between **1.3** and **1.6**, and the amount of air less than the theoretically required quantity is an excess air rate preferably between **0.5** and **0.8.** Although, the amount of air issued from all of the nozzles (i.e., the sum of air introduced to support the combustion) is one to **1.2** times the amount of air theoretically required for the complete combustion of the fuel discharged from all of the nozzles.

The advantageous effects of the present invention will be described in detail hereunder.

1. The results of combustion experiments conducted with a gaseous fuel, using a burner adapted for practicing the method of the invention are represented by continuous-line curves ($GM_1 - GM_3$) in FIG. **1.**

As can be seen from the graph, the use of the burner in conformity with the invention produces curves entirely different from those (represented by broken lines) conventionally obtained with an ordinary burner. The curves according to the invention are mountain-shaped with very sharp gradients, the peaks corresponding to excess air rates of approximately **1.0** to **1.1.**

If no inert gas is admitted and the excess air rate inside the burner is close to **1.0**, the NOx concentration in the combustion gas will be rather high as compared with the values attained with conventional methods. However, as the excess air rate inside the burner increases, and also as the inert gas addition to air assumes a larger percentage, the NOx concentration will markedly decrease and, from a certain boundary point onward, drop below the values with the prior art methods; eventually the NOx concentration will be reduced to a minimum that is never attained conventionally.

This is explained by the fact that, whereas the ordinary methods are directed to so-called diffused flames, the method of the invention produces a so-called premix flame, and that the dissimilarity in flame structure brings about different mechanisms for NOx formation.

As noted above, in the present invention, gaseous mixtures with varied fuel concentrations are supplied to different nozzles of a multi-nozzle burner, thus attaining ununiform excess air rates in the plural nozzles. The beneficial effects thereby achieved will now be described.

Referring to FIG. **1**, the point *a* is the actuating point of a nozzle set for an excess air rate of more than **1.0**, and the point *b* is that actuating point of a nozzle set for an excess air rate of less than **1.0.**

The both actuating points *a* and *b* give lower NOx concentrations than by the corresponding points in the conventional methods. Combining the points *a* and *b* brings an overall excess air rate inside the burner as at the point *c*. Thus, compared with an ordinary arrangement in which all burners are set to the point *a*, combustion with less excess air is made possible. It follows that a heat exchanger equipped with the burner incorporating the method of the invention can achieve a very high thermal efficiency.

The nozzle actuated at the point *b* would produce a flame with insufficient air supply, or in a state of incomplete combustion. The condition can be improved, for example, by sandwiching a nozzle actuatable with an excess air rate at the point *b* with nozzles actuatable at the point *a*, or vice versa. In this manner the combustion incomplete at the point *b* will be made complete by the excess air at the point *a*.

As an alternative, the air inside the burner may be mixed with an inert gas (e.g., the combustion gas) to shift the actuating point from *a* to *a'* or *a''* and, likewise, shift the actuating point from *b* to *b'* or *b''*. Accordingly, the average excess air rate throughout the burner will be shifted to the point *c'* or *c''*. This will make possible combustion with a smaller excess of air and with a higher thermal efficiency than when the combustion is conventionally carried out with all burners set to the point *a'* or *a''*. Moreover, the NOx concentration in the combustion gas will be practically reduced to naught.

2. The results of combustion experiments of a light liquid fuel (kerosene) with a burner adapted for practicing the method of the invention are represented by continuous lines in FIG. **2.** An alternate dash and dot line represents the result of an experiment with kerosene and an alternate dash and two dots line represents with result with heavy oil, both conducted in a conventional way. In the graph the continuous line A summarizes the result of an experiment in which kerosene was completely evaporated, premixed with the total amount of air supplied for the combustion purpose, and the premixture was burnt by a gase burner of the premix type.

It will be manifest from the graph that, when a light oil is evaporated and premixed for combustion in some way as will be described later, the NOx production will be reduced to such a low level that is never attained by the ordinary spray combustion method.

In FIG. **2** the continuous lines B and C indicate the effects of an inert gas (combustion gas) introduced into air upon combustion of kerosene in accordance with the present invention. As compared with the air free of combustion gas (A), the air containing a small quantity (B) or a large quantity (C) of such inert gas is helpful in reducing the NOx concentration in the combustion gas discharged; the greater the addition of such inert gas to air, the lower the NOx concentration will be.

In the combustion method of the invention, it is also possible to decrease the NOx concentration to extremely low levels as represented by straight lines B, B' and B'' by effecting combustion with the addition of the same proportions of combustion gas as in A, A', and A'', respectively, but with very small excess air rates, or in the state of insufficient air supply.

For this reason, if a burner having a plurality of nozzles is employed and some of the nozzles are actuated at points *a*, *a'*, and *a''* and the remainder at points *b*, *b'*, and *b''*, then the mean excess air rates at *c*, *c'*, and *c''* will permit small excess-air combustion with a high thermal efficiency while maintaining the NOx production at a low level.

While the instance in which combustion gas is mixed in air for combustion has been described above, substantially the same effect is achieved by adding some other inert gas or liquid by spraying to air.

3. The relationship between the total quantity of NOx in combustion gas and the excess air rate in combustion of a heavy liquid fuel (e.g., heavy oil) according to various burning methods is graphically shown in FIG. **3.** The amount of an inert gas added was the same throughout the experiments.

In the graph the curve of an alternate dash and two dots line represents the result of a combustion experiment performed by use of a customary spray gun.

The curve of an alternate dash and dot line shows the result of an experiment about so-called diffused-flame combustion effected by gasifying heavy oil and issuing the gaseous fuel and air separately from nozzles of a common burner.

It will be clear from the graph that the combustion with gasification involves conversion of less nitrogen content of the fuel into NOx and hence produces less NOx concentration in the exhaust gas than by the combustion with spraying.

The continuous line gives the result of combustion with a burner according to Example **1** of the invention to be discussed later. It can be seen that NOx are formed in a manner quite different from the two cases referred to above. In addition, the absolute level of NOx concentration is by far the lowest, the peak being at the excess air rate of approximately **1.0.**

Thus, if the excess air rate in some of adjoining gas passages, for example in the gas passages **16''***a* in FIG. **17** to be considered later, is large, for example at the point *a* in FIG. **3,** while the rate in the other gas passages **16''***b* is small, for example at the point *b*, then the overall excess air rate inside the burner and the NOx concentration in the combustion gas can be at the point *c*, for example.

In other words, the excess air rate is smaller and the thermal efficiency is higher than when all the gas passages are set to the point *a*. Although incomplete combustion takes place in the gas passages **16''***b* due to shortages of air, the combustion is made completely by the excess air in the adjacent gas passages **16''***a*.

The method and apparatus according to this invention are applicable to burners of boilers and other industrial furnaces as well as of gas turbines.

Other objects, advantages and features of the invention will become apparent from the following description taken in connection with the accompanying drawings, wherein:

FIGS. **1** to **3** are graphs showing the relations between excess air rates in burners and NOx concentrations in the combustion gases when gaseous, light liquid, and heavy liquid fuels are burnt, respectively;

FIG. **4** is a front view of a burner for burning gaseous fuel to be used in the method of the invention;

FIG. **5** is a sectional view taken on the line V—V of FIG. **4**;

FIG. **6** is a front view of a conventional burner for burning light liquid fuel;

FIG. **7** is a sectional view taken on the line VII—VII of FIG. **6**;

FIG. **8** is a front view of a burner for burning light liquid fuel to be used in the method of the invention;

FIG. **9** is a sectional view taken on the line IX—IX of FIG. **8**;

FIG. **10** is a front view of a modified burner for burning light liquid fuel to be used in the method of the invention;

FIG. **11** is a sectional view taken on the line XI—XI of FIG. **10**;

FIG. **12** is a sectional view taken on the line XII—XII of FIG. **11**;

FIG. **13** is a longitudinal sectional view of a burner for burning heavy liquid fuel to be used in the method of the invention;

FIG. **14** is a sectional view taken on the line XIV—XIV of FIG. **13**;

FIG. **15** is a sectional view taken on the line XV—XV of FIG. **13**;

FIG. **16** is a longitudinal sectional view of a modified burner for burning heavy liquid fuel to be used in the method of the invention; and

FIG. **17** is a cross sectional view of a further modified burner for burning heavy liquid fuel to be used in the method of the invention.

The constructions and operating mechanisms of the burners adapted for practicing the method of the invention will now be described with reference to these drawings, as follows:

1. The burner suited for the combustion of gaseous fuel in accordance with this invention is illustrated in FIGS. **4** and **5.**

As shown, the burner is made up of a plurality of nozzles **1,** each of which consists of a fuel gas feed pipe **2***a* or **2***b*, an air feed pipe **3** for supplying air with or without the addition of an inert gas (combustion gas), a premixing chamber **4** where air alone or air plus the inert gas is mixed with fuel gas, and a flame-stabilizing baffle **5.**

The fuel gas feed pipes **2***a*, **2***b* permit the flow of fuel at ununiform flow rates so that dissimilar excess air rates may be attained.

2. The burner suited for the combustion of light liquid fuel, and its modified form, are shown in FIGS. **8** through **12.**

The burner is shown as comprising a plurality of nozzles **1'**, each of which consists of a fuel injection gun **2'***a* or **2'***b*, an air feed pipe **3'** through which air for combustion or a mixture of air and an inert gas is admitted, and a flame-stabilizing baffle **4'**, and is communicated with a common fuel heater **5'**. In addition, where an inert liquid, e.g., water, is to be used, a cold-water spray nozzle **6'** is provided.

The fuel injection guns **2'***a*, **2'***b* are so built as to discharge the fuel at different flow rates.

For the comparison purpose, FIGS. **6** and **7** show a typical combustor of a conventional design for burning light liquid fuel.

3. The burner suited for the combustion of heavy liquid fuel, and its modified forms, are shown in FIGS. **13** through **17.**

Here, the burner comprises a group of units, i.e., a premixer 21'' for auxiliary fuel, a screen burner 2'', and heavy oil burners 4'' for spraying heavy oil through the agency of water vapor, a group of units, i.e., a burner cylinder 22'' formed with a multiplicity of holes 13'' through which the resulting hot gas is cooled by the combustion gas (recycled gas) and is premixed with excess air for combustion, a plurality of air intake plates 3'', and gas passages 16'' defined thereby, and a starting oil burner 17''.

In the following Examples 1 to 3 will be explained the method of the invention wherein heavy oil is sprayed over and mixed with hot combustion gas arising from the combustion of a gaseous fuel, thus gasifying the heavy oil through contact, and the gas is cooled by recycled gas to form a combustible gas, and then is burnt in the form of two gaseous premixtures of different excess air rates in accordance with the invention.

EXAMPLE 1

With an apparatus in FIGS. **13** to **15**, as gaseous fuel (e.g., LPG) **5** under pressure is premixed with air **6''** for combustion, by means of a premixer **21''**, and the premixture is completely burnt by a screen burner **2''** to form a hot gas **7''** at about **2,000°C**. A number of heavy oil burners **4''** for spraying heavy oil **9''** with the aid of water vapor **8''** are disposed around the hot gas **7''**, and by means of the burners **4''** the hot gas **7''** and the fine droplets of heavy oil **10''** (in a mist form) are rapidly mixed up. The mist of fine droplets **10''** thus spraying by the oil burners **4''** quickly evaporated and undergoes thermal decomposition upon mixing and contact with the hot combustion gas **7''** and, through an aqueous gas reaction with the water vapor present, forms a combustible gas containing some fine droplets.

The combustible gas thus produced in the gasifying cylinder **1''**, which is still as hot as about **1,400°C**, is cooled by blowing and mixing therein the combustion gas (recycled gas) **11''** from a furnace outlet not shown, through a multiplicity of holes **13''** formed in a burner cylinder **22''**. In this manner a combustible gas **14''** at a relatively low temperature of about **500°C** is obtained.

The recycled gas **11''** so added lowers the temperature of the resulting gaseous mixture and thereby serves to prevent unintended ignition and fire hazard in the burner in the next stage of the combustible's premixing with air, while controlling the flame temperature inside the burner at a low level. At the outlet of the burner cylinder **22''**, in conformity with the present invention, either excess or insufficient air **12''** is blown into gas passages **16''** through a multiplicity of air orifices **15''** formed in the burner cylinder **22''**, so that the gasified fuel **14''** and air **12''** are thoroughly premixed. The gaseous premixture of the gasified fuel, recycled gas, and air, rapidly burns and forms a short premix flame **23''**.

The air intake plates **3''** deflect the stream of the gaseous premixture downward and impart a swirl to the gas stream, thus effecting complete premixing of the gasified fuel and air and stabilizing the flame from the starting oil burner **17''** at the time of starting. The oil burner **17''** has an oil line **18** which is secured to a furnace wall **19''**.

The experiment indicated that the effect of the flame temperature upon the production of NOx by the premix flame is greater than when the NOx are produced by a diffused flame.

Combustion in accordance with the present method of a thorough gaseous premixture of the gasified fuel, air, and recycled gas by a burner according to the invention, forms a low-temperature premix flame with remarkably reduced NOx production.

Example 2

An apparatus as illustrated in FIG. **16** is employed. Here, the combustible gas formed in the gasifying cylinder **1''** is not cooled by an inert gas such as recycled gas but by water vapor produced by spraying water from a feed water pipe **24''** through its spraying holes **25''**.

The advantageous effect achieved in this manner using the burner according to the invention is similar to that attained in Example **1**.

EXAMPLE 3

The apparatus employed is the same as used in Example **1** excepting that the orifices **15''** open in the gas passages **16''*a*** differ in number or size of the both from those open in the adjacent passages **16''*b*** so that the burner can produce gaseous premixtures with large and small excess air rates. Accordingly, the excess air rate in the gas passages **16''*a*** is high, and the rate in the adjacent passages **16''*b*** is small.

It has been found by our investigations that the NOx production in a premix flame is small when the excess air rate is extremely low (less than **1.0**) or extremely high and the production is large with an excess air rate in the medial region. Therefore, the afore-described construction in which certain gas passages are supplied with a large excess of air whereas the remaining passages have a small excess of air, renders it possible to suppress the formation of NOx in the combustion gas and, with an overall excess air rate of greater than **1.0**, limit the NOx concentration to a low level.

This is exemplified by an experiment conducted wherein propane gas was used as the fuel, and **53** percent of the fuel was mixed with air at an excess rate of **1.5** to obtain a lean gaseous premixture and the remaining fuel was mixed at an excess air rate of **0.64** to obtain a rich premixture, the overall excess air rate of the premixtures being **1.1**. An inert gas in the form of recycled gas amounting to **15** percent of the total air quantity was divided into two equal portions and added to the two premixtures, thus forming two different premixtures both at **270°C**. These premixtures were issued from the respective nozzles and burnt together. The NOx content of the exhaust gas could be reduced to **33** ppm (as measured on the dry gas basis).

We claim:

1. A method of burning a fuel by means of a burner which comprises premixing the fuel with air in an amount larger than the quantity theoretically required for the combustion of the fuel, allowing the resulting lean premixture to be issued from some of plural nozzles of the burner, while at the same time, premixing the fuel with air in an amount less than the theoretically required quantity, allowing the resulting rich premixture to be issued from the remaining nozzles, and burning the two gaseous premixtures together wherein the two gaseous premixtures are separately mixed with an inert liquid by spraying before they are issued from the respective burner nozzles for combustion.

2. A method of burning a fuel by means of a burner which comprises premixing the fuel with air in an amount larger than the quantity theoretically required for the combustion of the fuel, allowing the resulting lean premixture to be issued from some of plural nozzles of the burner, while at the same time premixing the fuel with air in an amount less than the theoretically required quantity, allowing the resulting rich premixture to be issued from the remaining nozzles, and burning the two gaseous premixtures together wherein the two gaseous premixtures are separately mixed with a recycled combustion gas before they are issued from the respective burner nozzles for combustion.

3. A method of burning a fuel by means of a burner as defined in claim **2** wherein the lean premixture is formed to have an excess air rate from **1.3** to **1.6** and the rich premixture from **0.5** to **0.8** before they are issued from the respective burner nozzles for combustion.

4. A method of burning a fuel by means of a burner which comprises premixing the fuel with air in an amount larger than the quantity theoretically required for the combustion of the fuel, allowing the resulting lean premixture to be issued from some of plural nozzles of the burner, while at the same time, premixing the fuel with air in an amount less than the theoretically required quantity, allowing the resulting rich premixture to be issued from the remaining nozzles, and burning the two gaseous premixtures together wherein the fuel is a gasified fuel prepared by thermally decomposing a heavy liquid fuel, adding an inert gas or liquid to the decomposed fuel, and cooling the mixture.

5. A burner comprising gaseous or gasified fuel and air conduits, first premixing chambers for forming a fuel lean premixture consisting of the fuel and air in an amount larger than the quantity theoretically required for the combustion of the fuel, second premixing chambers for forming a fuel-rich premixture consisting of the fuel and air in an amount smaller than the theoretically required quantity, first nozzles for injecting the lean premixture, second nozzles for injecting the rich premixture, and conduits for an inert fluid means for discharging an inert fluid for mixing with the air to be used for the combustion.

6. A burner as defined in claim **5** further comprising heating means for gasifying a light liquid fuel.

7. A burner as defined in claim **5**, further comprising a gasifying cylinder for converting heavy liquid fuel to a mixture of combustible gases, a premixer for auxiliary fuel, a screen burner for burning the auxiliary fuel, burners for spraying the heavy liquid fuel through the aid of steam, a burner cylinder formed with holes for supplying air to be mixed with a hot gas generated in the gasifying cylinder, means for cooling the hot gas formed in the gasifying cylinder by supplying and mixing therewith an inert fluid, air intake plates, gas passages defined by the air intake plates, and a starting oil burner.

8. A burner as defined in claim **7** wherein said means for cooling the resulting hot gas consists of a plurality of holes formed on the burner cylinder and conduit connected thereto through which the combustion gas is recycled.

9. A burner as defined in claim **7** wherein said means for cooling the resulting hot gas consists of a feed water pipe provided with water spraying nozzles inside the gasifying cylinder.

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