# United States Patent [19]

**Schwedersky**

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[54] **BURNER AND METHOD OF OPERATING IT TO CONTROL THE PRODUCTION OF NITROGEN OXIDES**


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[52] **U.S. Cl.** ....................... **431/8,** 431/351, 431/284

[51] **Int. Cl.** ............................................. **F23c 7/00**

[58] **Field of Search** .................... 431/2, 10, 187, 174, 431/284, 285, 351; 239/423, 424.5



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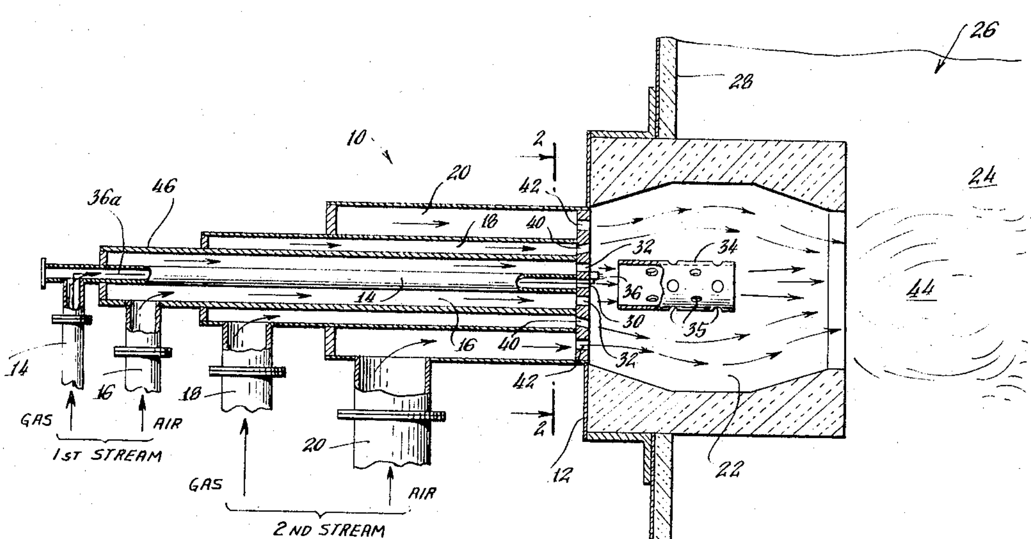
[57] **ABSTRACT**

In the operation of a burner using gaseous fuel the production of nitrogen oxides is limited and controlled by providing successive stages of combustion and by holding down the temperature of combustion. This is accomplished by introducing the fuel in two streams of unequal volume and comprising respectively more and less than the stoichiometric percentage of air, igniting the streams in sequence, thus effecting first and second stages of combustion, and mixing and consuming the excess fuel and air of said streams respectively, thus effecting a third stage of combustion.

**5 Claims, 2 Drawing Figures**

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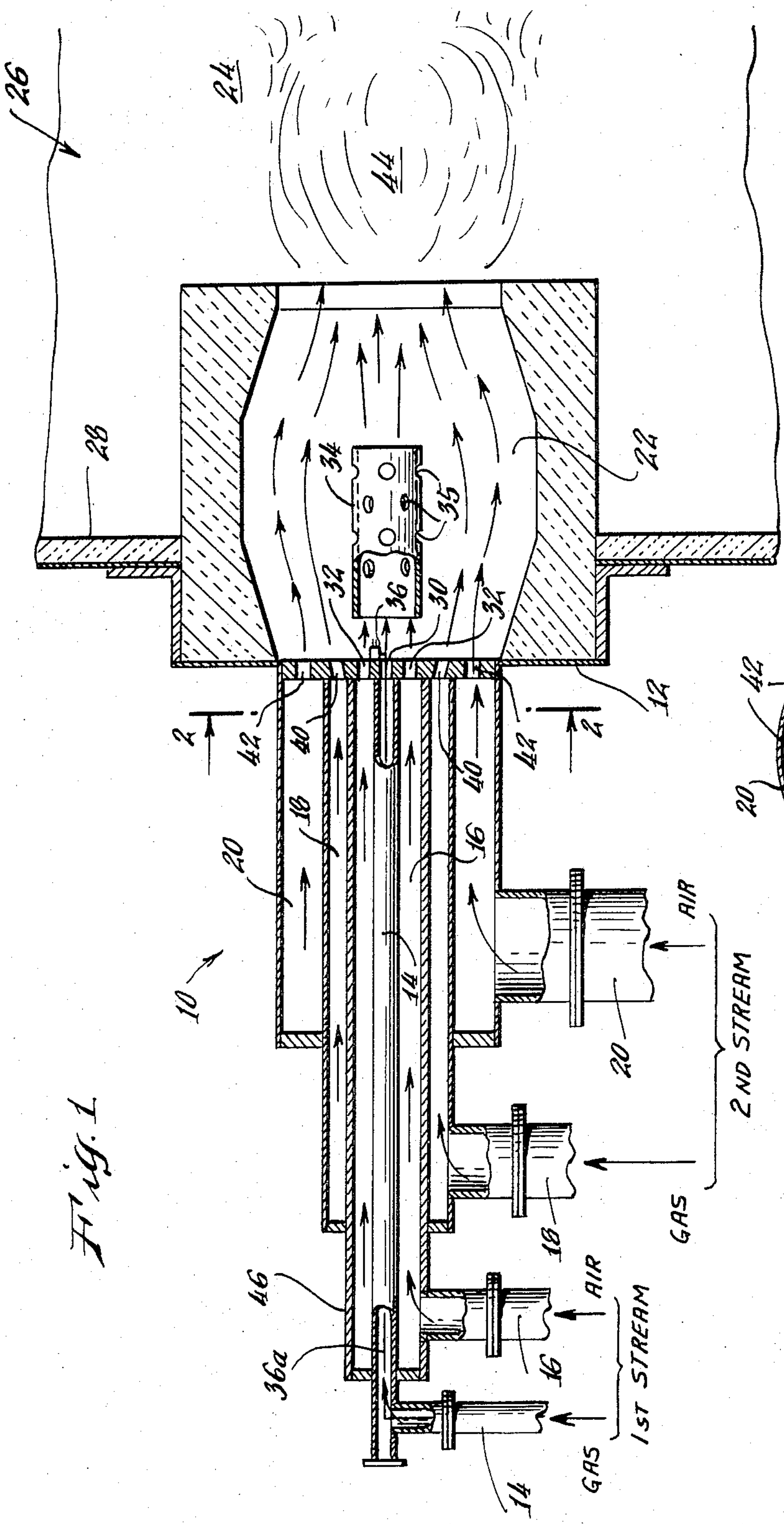


Fig. 1

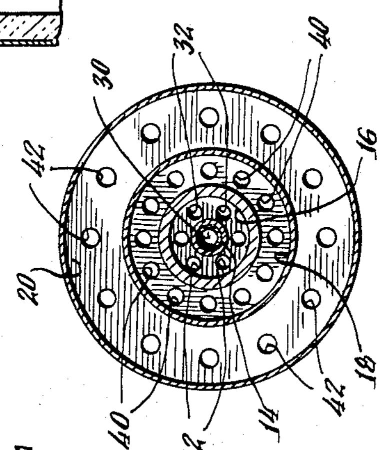

Fig. 2

# BURNER AND METHOD OF OPERATING IT TO CONTROL THE PRODUCTION OF NITROGEN OXIDES

## FIELD OF THE INVENTION

This invention relates to a burner of the kind in which propane gas or other gaseous fuel is combined with air and burned to provide heat, as for example to provide steam in an electric power generating plant. The invention is particularly directed to the method of operating such a burner to limit and control the amount of nitrogen oxides which are produced while obtaining substantially complete and therefor efficient combustion.

## SUMMARY OF THE DISCLOSURE

In accordance with this invention the production of nitrogen oxides is kept at a low level by providing successive stages of combustion, each occurring at a temperature substantially less than would be obtained in a single stage of combustion using the same volume and proportion of gaseous fuel/air. Instead of injecting gaseous fuel and air into the burner to mix and provide a single stream in which for efficient heating the percentage of air would be the optimum for obtaining complete combustion of the gaseous fuel, the gaseous fuel and air are introduced so as to form two separate streams of different volume and each comprising different ratios of gaseous fuel to air. One of the streams comprises an excess of air and the other stream comprises an excess of gaseous fuel. One of the streams is first ignited effecting a first stage of combustion. It then ignites the second stream effecting a second stage of combustion, and a third stage of combustion is provided by the mixing and burning of the excess gaseous fuel in one of the streams with the excess air in the other of the streams. The temperature created in each stage is less than would have been created if the same volumes of gas and air had been mixed and consumed in a single stage, but the total of heat produced is substantially the same as would have been produced in a single combustion stage.

The invention will be best understood if the following description is read in connection with the drawing in which:

FIG. 1 is a side elevation showing a burner having two sets of gas and air inlets disposed to provide two separate gaseous fuel/air mixture streams and means for igniting them, and the excess air from one stream and the excess gaseous fuel from the other stream, in sequence providing a cascading three stage combustion, and

FIG. 2 is a vertical section taken on the line 2—2 of FIG. 1.

## DESCRIPTION

Great difficulty has been experienced in attempting to reduce the amount of nitrogen oxide produced in air-gas burners. It is well established by experiments that the production of nitrogen oxides is highest when the mixture of gaseous fuel and air employed is close to the optimum mixture for combustion, or, in other words close to the point where the temperature of combustion is the highest. Reference to the *Proceedings*, Conference on Natural Gas Research and Technology, sponsored by American Gas Association, Inc. and Institute of Gas Technology, held at Chicago, Ill., Feb. 28–Mar. 3, 1971, and particularly to Session IV, Paper 2, and the curve which is shown on page 20 of that Paper and is identified as FIG. 7., Variation of Nitrogen Oxides Concentration with Stoichiometry for a Premixed Natural Gas/Air Flame consuming 200 Standard Cubic Feet Per Hour of Gas, indicates that the maximum production of nitrogen oxide occurs when a percent of air slightly in excess of the optimum amount of air for combustion, about 107 percent of stoichiometric air, is mixed with the gaseous fuel, and that the production of nitrogen oxides falls off rapidly when the percentage of stoichiometric air by volume is further increased, or is decreased. The curve indicates that when the gas/air mixture burned comprises approximately 107 percent of stoichiometric air by volume the accompanying production of nitrogen oxides, is 120 parts per million by volume, dry basis, whereas when 140 percent of stoichiometric air is employed the nitrogen oxides concentration falls to approximately 80 parts per million by volume. Similarly the curve indicates that if only 90 percent of stoichiometric air by volume is present in the gas/air mixture production of nitrogen oxides falls to approximately 70 parts per million by volume.

In order to reduce the temperature at the time of ignition and thereby substantially reduce the production of nitrogen oxides I have employed the information indicated by the said curve to limit and control the production of nitrogen oxides and at the same time obtain an efficient and substantially complete combustion. In order to accomplish this, instead of introducing into the burner a single mixture of gas and air, in accordance with my method two mixtures of gaseous fuel and air are introduced separately into the burner and ignited in sequence. One of the gaseous fuel-air mixtures comprises substantially more than 100 percent of stoichiometric air and the other gaseous fuel-air mixture comprises substantially less than 100 percent of stoichiometric air. The first mentioned mixture therefor comprises a substantial excess of air and the second gaseous fuel-air mixture comprises a substantial excess of gaseous fuel. When the two streams are ignited the temperature produced by each will be substantially less than the temperature produced by igniting a single gaseous fuel-air stream having the volume of the combined two streams, and comprising 100 percent of stoichiometric air. The temperature close to the burner face is therefor greatly reduced, the exact amount of reduction varying to some extent depending upon the gaseous fuel employed.

With a single stream of gaseous fuel/air, if the ratio is the optimum for obtaining complete combustion, the high flame temperature realized at the burner will fall off gradually as the gases travel to the flue. In the case of the two streams which are ignited in succession and comprise the same total volume of gaseous fuel/air as a single stream, the flame temperature initially adjacent the burner face is lower because of the excess air and excess fuel in the two streams, but the temperature of the gases is sustained by the combustion in the second and third stages, and that temperature will be substantially the same as that of the single stream when the gases of the two streams reach the furnace flue and therefor the total transfer of heat is essentially the same.

By properly proportioning the volume of the two gaseous fuel/air mixtures and the ratio of gaseous fuel to air in each mixture the excess of air in one of the mixtures can be proportioned to the amount of excess fuel in the other of the mixtures so that during the three stages of combustion complete or substantially complete combustion will be realized and a total production of heat obtained equal to, or substantially equal to the amount of heat which can be obtained from a single stream of gaseous fuel equal in volume to the gaseous fuel in the two streams and mixed with 100 percent of stoichiometric air, the essential difference being that by the single flame a flash temperature approximating 2,800° F. – 3,200° F. would be obtained whereas by employing three stages of combustion as described above a much lower temperature near the burner face is obtained, a temperature which in the case of natural gas would be in the neighborhood of 2,100° F. – 2,400° F. Reference to FIG. **8** on page **21** of Paper **2**, Session IV of the aforesaid *Proceedings* of the Conference on Natural Gas Research and Technology shows that close to the burner face a higher temperature results in a proportionately greater concentration of nitrogen oxides measured in parts per million by volume on a dry basis.

In the embodiment illustrated in the drawings a burner **10** comprises a burner face **12** disposed between air and gaseous fuel supply conduits **14, 16** and **18, 20** and a burner tile chamber **22** which at its far end opens into the combustion chamber **24** of a furnace or the like indicated generally by the numeral **26**. As shown the burner tile chamber **22** projects into the furnace combustion chamber **24** and a wall **28** of the furnace extends around the burner tile chamber.

Gaseous fuel conduit **14** and the surrounding air conduit **16** communicate with the interior of the burner tile chamber **22** through orifices **30** and **32** respectively in the burner face **12**. Gas and air is supplied under pressure through said conduits to mix adjacent the burner face and provide a first gaseous fuel/air stream. This stream is ignited by a suitable ignition means **36**, preferably disposed at the burner face, and it may have the ignition wire **36a** extending to it through conduit **14**, and the flame is directed into the tubular and perforate choke collar **34**.

Gaseous fuel conduit **18** and the air conduit **20** communicate with the interior of the burner tile chamber through the orifices **40** and **42**. Gas and air is supplied through conduits **18** and **20** respectively to mix and form a second gaseous fuel/air stream which is concentric with, and spaced radially outwardly of, the first stream. The second stream is not directed into the choke collar **34** but flows around it, and is ignited after the first stream by the flame of the first stream issuing through the perforations **35** in the choke collar **34**. The excess of fuel in one stream mixes with the excess air in the other stream and is ignited within the merged flame **44** resulting from the sequential ignition of the two streams thus providing a third stage of ignition.

It will be noted that wall **46** separates the two sets of conduits which supply the two streams, and that orifices **40** are inclined to direct the gaseous fuel from conduit **18** to mix with air from conduit **20** and not to be injected into the choke collar **34**. The burner tile is shaped so as to bring the excess fuel into the center stream thus mixing it with the excess air causing them to burn and thus release all of the heat from the fuel supplied in the two streams.

It will be understood that if desired the two streams of gaseous fuel/air may be premixed before entering the burner.

The conduits **14** and **16** may be employed to provide a constant minimum supply of gaseous fuel and the conduits **18** and **20** may be controlled to increase the fuel supply as may be desired.

To illustrate my method more specifically I prefer to use two mixed streams of gaseous fuel/air which differ in volume by the ratio of one to three, with a 1 to 1.75 proportion of gas to stoichiometric air in the smaller stream, and a 1 to 0.75 proportion of gas to stoichiometric air in the larger stream. This means that in the smaller stream there will be 75 percent excess air, and in the larger stream there will be a 25 percent deficiency of air, or stated oppositely a 25 percent excess of gas. When these two streams are ignited in sequence all of the gas in the smaller stream will be ignited and burned close to the burner leaving approximately 75 percent unconsumed air which will flow outwardly within the burner tile chamber and the combustion chamber. All of the air in the second stream will combine with gas in the second stream and will be ignited and burned a little further from the burner face, leaving an excess of 25 percent of gas which will flow outwardly within the burner tile chamber and the combustion chamber and become mixed with the excess air from the first stream. Since the volume of the larger stream is three times as great as that of the first stream there will be relative volumes of gaseous fuel and air which are the optimum for complete combustion and this mixture will burn in a third stage of combustion which is a continuation of the first and second stages, the three stages occurring at progressively greater distances from the burner face. Thus in successive stages complete or substantially complete combustion of the total amount of gaseous fuel and air will be achieved, but the temperature of each stage will be very substantially less than in the case of a single stage of combustion employing 100 percent stoichiometric air and the same total volume of gaseous fuel, and the total amount of heat produced will be the same or approximately the same as would have been obtained from a single stage of combustion at a much higher initial temperature.

## LIST OF PARTS

| | |
|---|---|
| **10** | burner |
| **12** | burner face |
| **14** | gaseous fuel conduit |
| **16** | air conduit |
| **18** | gaseous fuel conduit |
| **20** | air conduit |
| **22** | burner tile chamber |
| **24** | combustion chamber |
| **26** | furnace |
| **28** | wall of **26** |
| **30** | orifice for conduit **14** |
| **32** | orifices for conduit **16** |
| **34** | choke collar |
| **35** | perforations in **34** |

**36** ignition means
**36*a*** ignition wire
**40** orifices for conduit **18**
**42** orifices for conduit **20**
**44** merged flame
**46** wall of burner

What I claim is:

1. In the operation of a burner the steps of,
introducing into the burner two streams of mixed air and fuel in gaseous phase,
controlling the air to fuel ratio of the streams so that one comprises an excess of stoichiometric air and the other comprises an excess of fuel and,
igniting said streams in sequence, and thereafter mixing the excess air from one stream with the excess fuel from the other stream and burning the resulting mixture.

2. The method claimed in claim **1** in which one of said streams is of greater volume than the other, and the sum of the percentages of air in the two streams approximates the optimum or stoichiometric air percentage.

3. A burner adapted to provide combustion of gaseous fuel and air in successive stages which comprises:
gaseous fuel and air conduits,
a burner tile chamber,
a perforate choke collar within the burner tile chamber,
an ignition means disposed at the burner face,
conduit and orifice meanS for injecting a first stream of mixed gaseous fuel and air into the choke collar within the burner tile chamber, and
other conduit and orifice means for injecting a second stream of mixed gaseous fuel and air into the burner tile chamber to pass over and around the choke collar.

4. The burner claimed in claim **3** in which the said conduits are concentric and the choke collar is axially aligned with the center conduit means.

5. In the operation of a burner using a gaseous fuel/air mixture which when burned forms nitrogen oxides, the concentration of the nitrogen oxides being greatest when the volume of air employed is substantially the optimum for combustion and therefor when burned has a high temperature, the step of minimizing the temperature of combustion and the formation of the nitrogen oxides by providing multistage combustion at successive distances from the burner face said multistage combustion being achieved by dividing the gaseous fuel/air supply into two streams, one of the streams comprising excess air and the other stream comprising excess gaseous fuel, igniting the said two streams in successive stages and thereafter mixing and burning the remaining excess air and excess fuel from said streams respectively providing a third stage of combustion.

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