

TORU SOGAWA ETAL
FURNACE FOR CRACKING HYDROCARBONS HAVING
A FLAME-ADJUSTABLE BURNER

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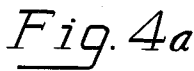
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Fig. 4^l

Fig. 2

Fig. 4c

Fig. 3

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2 Sheets-Sheet 2

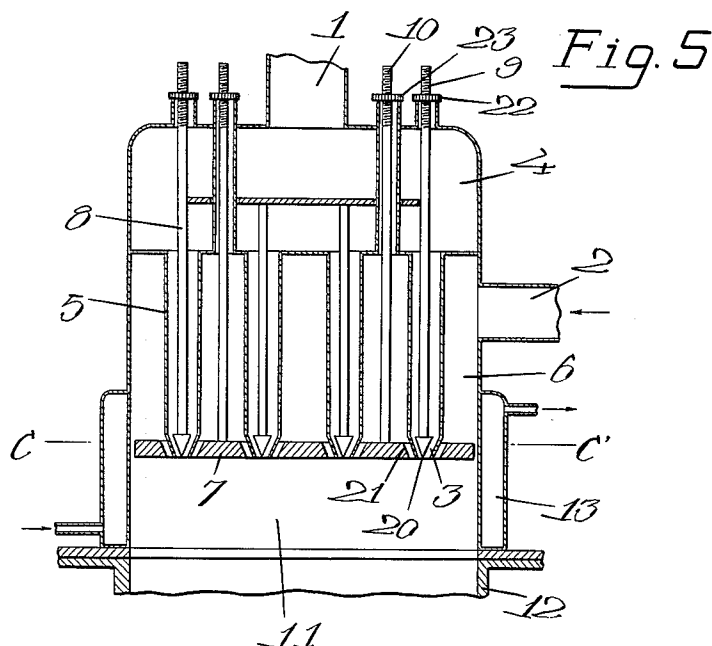
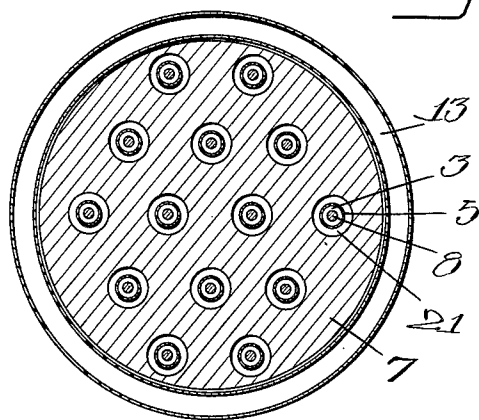


Fig. 6



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**FURNACE FOR CRACKING HYDROCARBONS
HAVING A FLAME-ADJUSTABLE BURNER**

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9 Claims. (Cl. 23-277)

This invention relates to an internal combustion type furnace for the thermal cracking of hydrocarbons and to a burner suitable for use in the same furnace.

With such an internal combustion type furnace for the thermal cracking of hydrocarbons, it is known that one end of the usual combustion chamber is constricted in its cross-section area. In general, it is further known that the combustion of fuel can be substantially completed within the combustion chamber when the lower part of this chamber is constricted making a throat in its cross-section area. In this case, however, there is a defect in that the lower part of the constricted cross-section area of the combustion chamber is directly exposed to the flame and subject to higher temperatures. With this usual type of the thermal cracking furnace, it is conventional that the gaseous reactant to be cracked has been introduced into a central or upper zone of the combustion chamber and the gas of the reactant has been in direct contact with the flame for a long period of time, so that when such a drawback occurs there is local over-heating and over-cracking of the reactant gas. When the reactant to be cracked has been introduced into a zone which exists in or after the part of the constrictor cross-section area or of the smallest cross-section area or throat of the combustion chamber, the inclined portion of the furnace wall which exists before the part of the smallest cross-section area of the combustion chamber is naturally exposed to the hot flame, so that special and expensive high grade refractories have to be used for the construction of the inclined wall portion.

An object of this invention is to provide a thermal cracking furnace which does not suffer from the above-mentioned drawbacks, allowing the thermal cracking of hydrocarbons to be carried out much more efficiently. Another object of this invention is to provide a burner which is suitable for use in such a thermal cracking furnace and which allows the condition of the flame to be easily controlled within the combustion chamber. Further objects of this invention will be made clear in the later description.

We have now found that in cases when the gaseous reactant to be cracked is injected into the combustion chamber of the internal combustion type of the thermal cracking furnace through a plurality of injection orifices which are positioned in the inner wall of the combustion chamber just above or upstream the lower part of the constricted cross-section area of the combustion chamber, the gaseous reactant forms a laminar film on the wall surface of the aforesaid part of the constricted cross-section area and protects said wall surface from the hot flame, and that the reactant being injected can be completely and instantaneously mixed with the hot combustion gases in the part of the smallest cross-section area of the combustion chamber and then cracked in the reaction chamber.

According to a feature of the present invention, a furnace for the thermal cracking of hydrocarbons comprises a combustion chamber which is provided with a lower

part of a constricted cross-section area, a burner for fuel which is arranged at the top of the combustion chamber and which is provided with an inlet for the supply of fuel and with an inlet for the supply of oxidant such as air or oxygen, a plurality of injection orifices for the introduction of the reactant to be cracked which are positioned in a portion of the wall of the combustion chamber just above said lower part of the constricted cross-section area of said chamber, a reaction chamber which communicates to said lower part of the combustion chamber, and an outlet for withdrawing the cracked gases from the reaction chamber.

With the cracking furnace according to the invention, the reactant to be cracked is fed into the combustion chamber at such a zone thereof which is just above or upstream the lower part of the constricted cross-section area of said chamber, and thus the furnace wall can be protected from high temperatures and the reactant can immediately enter into the lower chamber part of the constricted cross-section area. Therefore, the reactant being injected not only may be in contact with the flame in a shorter period of time and be prevented from the local over-heating and over-cracking but also the reactant entering in the combustion chamber part of the constricted cross-section area may be completely and instantaneously mixed with the hot combustion gases in the combustion chamber part of the smallest cross-section area or throat, so that it is possible to carry out the thermal cracking of the reactant efficiently. Consequently, the cracking furnace of the invention may lead to remarkably excellent effects, as compared to the known type of the cracking furnace.

In case the reactant to be cracked is introduced into the combustion chamber in the above-stated manner according to the invention, the temperature in the combustion chamber and particularly in the parts of the combustion chamber which would be brought to higher temperatures may be kept at a relatively low one, so that the protection of the furnace wall is comparatively easier and the loss of heat is less. In this connection, therefore, it is also possible to reduce consumptions of fuel, oxidant and steam etc., for constant yields of the cracking products such as olefines and acetylenes. It is further possible to obtain the aimed cracking products in relatively higher yields.

The fuel may be a gas or mixed gases which contain two or more components, such as hydrocarbons or petroleum cracking gases or main gas which contains hydrocarbons, hydrogen, carbon monoxide and non-combustible gases, e.g. carbon dioxide, nitrogen, etc. The oxidant may be air or mixtures thereof with steam.

We have further found that the thermal cracking of hydrocarbons may be much facilitated if the length of the combustion flame of the fuel extending within the combustion chamber of the above-mentioned cracking furnace can be controlled optionally. According to a further feature of the invention, the burner for the fuel may advantageously comprise a movable, multi-perforated plate which has a flat, cylindrical or spherical face and a plurality of perforations therein for blowing out the gases, a plurality of tubes for the injection of a gas therethrough each of which terminates in a nozzle orifice opening in said perforations of the perforated plate, and a plurality of adjusting valve means each of which extends movably within each of the injection tubes in the axial direction of the tube and is able to adjust the cross-section area of the nozzle orifice through which the gas to be injected out passes. A burner of such a construction is also included within the scope of the present invention. With this type of a burner, the conditions of the combustion of fuel and the flame may be controlled, if necessary, by

selecting the shapes, sizes and numbers of the tubes and/or perforations for the injection of the gaseous fuel and oxidant and thereby adjusting the flow rates and flowing velocities of the fuel and oxidant as well as the state of mixing of them.

In general, it is known that the length of the flame depends on the sorts of the fuel and oxidant used, state of mixing of them, temperature and pressure thereof as well as the diameter of the nozzle orifice, etc., and also on the ratio of the flowing velocity of fuel to that of oxidant. It has been known that in case a stoichiometric quantity of oxidant is used for the combustion of fuel, the length of the flame is shorter as they have been previously mixed with each other much completely prior to the combustion and that there increases then a danger of back-firing into the pre-mixing zone.

In the burner according to the invention, the fuel and oxidant may be quickly mixed with each other as near as possible to the nozzle orifices for the injection of the gases without requiring any pre-mixing zone, whereby the combustion of the fuel can be conducted stably without any danger of back-firing. Arrangement and adjustment of the movable multi-perforated plate and adjustment of the cross-section area of the tube for the injection of the gas make it possible to bring the ratio between the flow rates of the fuel and oxidant to an optimum value, to change the ratio between the flow velocities of them and to optionally adjust the width and length of the flame without large pressure drop. With a single burner, the flow rate of fuel gas depends to some extent on the diameter of the nozzle orifice for the injection of the fuel gas, so that the length of the flame is also decided by said diameter of the orifice. With the burner provided with the multi-perforated plate according to the present invention, however, the flow rates of fuel and oxidant as well as the state of combustion of the fuel may be optionally controlled without large loss of pressure by properly selecting the diameters and numbers of the injection tubes as well as of the perforations in the multi-perforated plate and by changing the ratio of the gas-flowing cross-section area in the injection tubes to that of the perforations with aid of the valve means. The ratio of the flowing velocity of the fuel to that of the oxidant may be adjusted within a range of about 0.03-40.

The burner of the present invention does not require the provision of a pre-mixing zone in particular and is able to perform a stable combustion of the fuel with increased speed of combustion but without danger of the back-firing, even when the fuel and oxidant have been pre-heated to a temperature of up to about 700° C.

In accordance with the invention, the length of the flame extending in the combustion chamber may be adjusted in the above-mentioned way so that a short length of the flame is formed, whereby it is possible to increase the heat input of the combustion chamber to some extent, to reduce the length of said chamber and the surface area of the inner wall of the furnace and to reduce the heat loss of the burner with increased efficiency of the cracking furnace. If it is desired, to pre-mix the fuel with the oxidant before the combustion the pre-mixing zones may be formed by a great displacement of the multi-perforated plate and/or by formation of many holes in the side wall of the injection tubes.

One embodiment of the thermal cracking furnace according to the invention is now illustrated with reference to the accompanying drawings.

Referring to the drawings:

FIG. 1 shows a vertical cross-section view of one embodiment of the cracking furnace according to the invention.

FIG. 2 shows a horizontal cross-sectional view of the furnace along the line A—A' of FIG. 1.

FIG. 3 shows a horizontal cross-sectional view of the furnace along the line B—B' of FIG. 1.

FIG. 4, a, b and c diagrammatically show several ar-

rangements of the injection orifices for the introduction of the gaseous reactant to be cracked into the combustion chamber of the furnace.

FIG. 5 shows a vertical cross-section of one embodiment of a burner provided with the multi-perforated plate according to the invention.

FIG. 6 shows a horizontal cross-sectional view of the burner along the line C—C' of FIG. 5.

In FIGS. 1 and 2, the burner for the fuel gas comprises an inlet for supply of fuel 1, a distribution chamber 4 for distributing the fuel which communicates to the inlet 1, a plurality of tubes 5 for the injection of the fuel gas each of which communicates to said distribution chamber 4, and terminates in the nozzle orifices 20 (FIGS. 5 and 6), a plurality of adjusting valves 8 each of which extends movably into each of the injection tubes 5, an inlet 2 for supply of the oxidant, a distribution chamber 6 for distributing the oxidant and a multi-perforated plate 7; the nozzle orifice 20 of each of the injection tubes 5 being open into each of the perforations 21 in the perforated plate 7, and the gap between the nozzle tip of the injection tube 5 and the perforation 21 of the perforated plate 7 forming an opening 3 for blowing out the oxidant. Referring to FIGS. 1, 2 and 3, the fuel is fed through the supply inlet 1, distributed in the distribution chamber 4 into the injection tubes 5 and then blown out through the nozzle orifices 20 of said tubes into the combustion chamber 11. On other hand, the oxidant is fed through the supply tube 2, distributed via the distribution chamber 6 and then blown through the openings 3 in the perforation 21 of the perforated plate 7 into the combustion chamber 11. The flowing velocities of the fuel and oxidant gases may be set by adjusting relative positions of the injection tubes 5, the adjusting valves 8 and the perforated plate 7 and thereby adjusting the dimensions of the gap 3 and of the gap which is formed between the valve and the injection tube. The adjustment of the positions of the valve 8 and the perforated plate 7 may be conducted with aid of threaded rods 9 and 10 which are fixed to the valve and the plate, respectively. By properly selecting the number and diameter of the nozzle orifices of the injection tubes and modifying the state of mixing of the fuel and oxidant, it is possible to control the length of the flame and the conditions of the combustion of the fuel within the combustion chamber. Fuel may be burnt partially or completely in the combustion chamber 11 and the resulting hot combustion gases are blown into with the reactant to be cracked which is thus subjected to the thermal cracking. The reactant to be cracked mainly consists of a hydrocarbon or mixture of the hydrocarbons of petroleum oil series. After the reactant to be cracked has been pre-heated to 300° C.—700° C., it is supplied through supply inlets 18, via an annular distribution channel 19 and then blown through the injection orifices 14 into the combustion chamber 11. The injection orifices 14 are positioned just above the lower part of the constricted cross-section area 15 of the combustion chamber 11. In this case, the walls of the lower part of the constricted cross-section area 15 and of the part of the smallest cross-section area or the throat 16 of the combustion chamber which usually would be considered to directly expose to the hot flame, may be maintained at comparatively lower temperatures because of the fact that the blown gaseous reactant to be cracked forms a laminar film on said walls and some of the cracking reactions are endothermic. The position of the injection orifices 14 for the introduction of the reactant to be cracked relative to the flame may be further varied to a great extent by modifying the length of the combustion chamber 11. In general, however, it is preferable that the injection orifices 14 should be positioned at a distance from the tip of the flame and the distance should be 0.02-5 times as long as the length of the

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flame which would extend when the burner used would be placed in open atmosphere. Said distance should vary also dependently on what cracking products are desired. Furthermore, the direction of the injection orifices 14 may be inclined at an angle of $+45^\circ$ to a transverse cross-section of the combustion chamber as shown in FIG. 4c or may be inclined at an angle of $0-90^\circ$ to a plane tangential to the peripheral wall of the combustion chamber as shown in FIG. 4b. Each of the injection orifices 14 may be increased in its width at an angle of $5-20^\circ$ towards the combustion chamber to reduce the pressure drop of the reactant gas which is being blown into the chamber 11. The cross-sectional configuration of each of the injection orifices 14 is usually circular but may be elliptical, polygonal or slit-like. As shown in FIG. 4a, each of the injection orifices 14 may be a slit or a row of parallel small holes extending in such a plane which is inclined at an angle of $\pm 90^\circ$ to a longitudinal cross-section which contains the central axis of the combustion chamber. These small holes also may be circular, elliptical or polygonal in their cross-sectional configuration. The combustion chamber wall may be provided with a refractory lining 12 and a water-cooled jacket 13 made of a metal. Alternatively, the combustion chamber wall may be provided only with a water-cooled jacket. The combustion chamber part of the constricted cross-section area 15 may be provided with a water-cooled jacket. The jacket may be utilized also as a preheater for the reactant to be cracked by passing said reactant through the jacket to heat-exchange between the reactant and the jacket. The blown reactant to be cracked is completely mixed with the hot combustion gases in the combustion chamber part of the smallest cross-section area or the throat 16 and then substantially cracked in the reaction chamber 17.

The thermal cracking is carried out in the reaction chamber 17 at a temperature of $800-1500^\circ\text{C}$. and under a pressure of 100 mm. Hg-30 kg./cm.² (absolute). The retention time of the reactant in the reaction chamber is adjusted within a range of $0.1-5 \times 10^{-4}$ seconds. The gaseous cracking products are withdrawn through the outlet and then quenched with water to suppress by-reactions of the products.

The manner in which the reactant to be cracked and the hot combustion gases are mixed with each other and diffused in the above-mentioned thermal cracking of hydrocarbons has great influences on composition of the gaseous cracking products and on yields of the cracking products. In the thermal cracking furnace according to the present invention, optimum conditions for the thermal cracking of hydrocarbons may be easily determined by adjusting the ratio of the linear flowing velocity of the combustion gases to that of the reactant gas within a range of $3 \times 10^{-3}-3 \times 10^2$ and modifying the flow rates of the combustion gases and of the reactant gas according to the required compositions and yields of the gaseous cracking products.

The burner provided with the multi-perforated plate according to the invention is now illustrated in more detail with reference to FIGS. 5 and 6.

The fuel is fed through the supply inlet 1 and distributed in the distribution chamber 4 into the tubes for the injection of gas 5. In this case, the fuel gas may have been preheated to a temperature of up to 700°C . The fuel gas then passes through the injection tubes 5 and the nozzle orifices 20 into the combustion chamber 11 but the flowing rate of the fuel gas is controlled by means of the adjusting valves 8. The adjusting valves 8 are connected to the threaded adjustment rods 9 and seals 22 in such a way that the valve 8 may be moved within the injection tube 5 so as to adjust the gas-flowing cross-section area of the nozzle orifice 20. The perforated plate 7 is also connected to the threaded adjustment rods 10 and seals 23 in such a way that the plate 7 may be moved vertically so as to adjust the cross-section

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area of the gap 3 formed between the nozzle tip of the injection tube 5 and the wall of the perforation 21 of the plate 7 and so as to prevent the nozzle orifice 20 of the injection tube 5 from positioning eccentrically in the perforation 21.

On other hand, the oxidant is fed through the supply inlet 2 and distributed in the distribution chamber 6 to the multi-perforated plate 7 and then injected through the gaps 3 into the combustion chamber 11 to burn the fuel. Since the perforated plate 7 can be moved in a vertical direction with aid of the adjustment mechanism or threaded rods 10 as stated in the above, the cross-section area of the injection gap 3 may be also controlled to adjust the flow rate of the oxidant which passes there-through. A great displacement of the perforated plate may form the zones for pre-mixing the fuel and oxidant together in front of the nozzle tips of the injection tubes 5, if necessary. Capacity of the pre-mixing zones may be adjusted by a proper displacement of the perforated plate. The state of mixing of the fuel and oxidant may be controlled to a great extent by modifying the aforesaid ratio of the flow rate of the fuel to that of the oxidant as well as the capacity of the pre-mixing zones. The fuel and oxidant may be completely pre-mixed before the combustion if the perforated plate 7 has been lowered to an extreme. The numbers of the injection tubes and of the perforations in the perforated plate may be determined properly according to the required conditions of the combustion of fuel.

The perforated plate 7 may be formed from a refractory metal or refractory bricks. Particularly when the perforated plate can be brought to higher temperatures due to the heat which is radiated and transmitted from the flame, the plate may be protected by cooling with water in such a way that the threaded adjustment rods 10 and the plate 7 are made hollow and the cooling water is circulated therethrough. The combustion chamber 11 is also subjected to very high temperatures and may be provided with a water-cooled jacket 13 around the peripheral wall of the combustion chamber in case the latter is formed from a metal.

In general, the numbers of the injection tubes and of the perforations in the perforated plate are preferably the same, but the number of the perforations in the perforated plate may be more than that of the injection tubes, if necessary. The perforations in the perforated plate and the injection tubes may be arranged at the corners of a triangle or a quadrangle or arranged on the circumferences concentric circles. The face of the perforated plate opposite to the combustion chamber is usually flat but may be cylindrical or spherical so as to constrict the flame within the combustion chamber.

The inclined angle α at the nozzle tip of the injection tube 5, the perforation 21 in the perforated plate 7, the nozzle orifice 20 and the adjusting valve 8 is usually an acute. The valve body 8 extending in the nozzle orifice 20 may be an ordinary type of valve such as needle- or ball-type valve etc. The gaps 3 formed between the injection tubes and the perforated plate as well as the gaps formed between the injection tubes and the valve bodies may be provided with guide fan or guide groove so as to impart a whirling movement to the gases which are passing therethrough.

The above description states that the fuel is fed through the inlet 1 and the oxidant through the inlet 2. Contrary to this, however, the oxidant may possibly be fed through the inlet 1 and the fuel through the inlet 2, if necessary.

The employment of the burner provided with the multi-perforated plate according to the invention permits the thermally cracking furnace to be readily enlarged from a pilot plant to a commercial one. The furnace shown in FIG. 1 is vertical but the furnace may be arranged horizontally when it is large-sized in order to perform the thermal cracking of hydrocarbons in a commercial scale.

The following examples show the results of the tests in which the thermal cracking of hydrocarbons was conducted using the apparatus of the invention.

Example 1

A thermal cracking furnace as shown in FIGS. 1, 2 and 3 is operated in such a way that 104 Nm.³/hour of a fuel gas (petroleum cracking gas) are burnt with 105 Nm.³/hour of oxygen and steam of 180 kg./hour. 107 l./hour of naphtha which has been pre-heated to 300° C. are thermally cracked by introduction thereof into the front of the tip of the flame together with 20 kg./hour of steam. At the outlet from the reaction chamber, the temperature is at about 1100° C. and the pressure is at a normal pressure. The gaseous products so obtained amount to 216 Nm.³/hour and show the following composition.

Components:	Percent by volume
N ₂ -----	3.2
CO -----	15.0
CH ₄ -----	6.8
CO ₂ -----	25.8
C ₂ H ₂ -----	7.6
C ₂ H ₄ -----	7.4
C ₃ H ₆ -----	0.4
H ₂ -----	33.5

It is seen from this table that total yield of acetylene and ethylene is 55% by weight based on the starting naphtha.

Example 2

64 Nm.³/hour of a fuel (petroleum cracking gas) are burnt with 76 Nm.³/hour of oxygen and 20 kg./hour of steam. 102 l./hour of naphtha which has been pre-heated to 300° C. is thermally cracked by introduction thereof into a middle zone in the length of the flame together with 10 kg./hour of steam. The gaseous cracking products obtained amount to 177 Nm.³/hour. At the outlet from the reaction chamber, the temperature is at 1000° C. and the pressure is at a normal pressure. The gaseous products show the following composition.

Components:	Percent by volume
N ₂ -----	3.0
CO -----	23.3
CH ₄ -----	7.3
CO ₂ -----	14.0
C ₂ H ₂ -----	6.6
C ₂ H ₄ -----	8.0
C ₃ H ₆ -----	0.8
C ₈ -----	1.2
H ₂ -----	35.7

Total yield of acetylene and ethylene is 46.3% by weight. In this example, the quantities of fuel, oxygen and steam consumed is less than in Example 1, so that the unit of each of the materials consumed for the production of acetylene and ethylene is reduced.

In Examples 1 and 2, the reaction chamber is 140 mm. in diameter and the injection orifices for the introduction of the reactant to be cracked are 12 in their number and 3.2 mm. in their diameter.

Example 3

A burner provided with the multi-perforated plate as shown in FIGS. 5 and 6 is used to combust the petroleum cracking gas as the fuel. The combustion of the fuel is carried out in an open atmosphere under the below-mentioned conditions. The flame formed is about 300 mm. in length and 150 mm. in width.

The fuel gas is fed at a flow rate of 96 Nm.³/hour and at a linear flowing velocity of 291 m./second. The oxygen gas is fed at a flow rate of 100 Nm.³/hour and at a flowing velocity of 88.2 m./second. 180 kg./hour of steam is fed in admixture with the oxygen gas at a flowing velocity of 88.2 m./second. The fuel gas is injected

through 13 injection tubes the nozzle orifices of which are 3 mm. in their diameter. The mixture of oxygen and steam is blown out through 13 perforations in the perforated plate which are 10 mm. in their diameter.

Under the above-mentioned conditions, the ratio of the flowing velocity of the fuel gas to that of the mixture of oxygen and steam is 3.3. The flame length is then about 260 mm. when said ratio is brought to 6 by changing the positions of the valves and the multi-perforated plate.

What we claim is:

1. A furnace for the thermal cracking of hydrocarbons which comprises a combustion chamber which is provided with a lower part of a constricted cross-section area, a burner for fuel which is arranged at the top of the combustion chamber and which is provided with an inlet for the supply of fuel and with an inlet for the supply of oxidant, means in conjunction with said burner for supplying said fuel and said oxidant to said combustion chamber in a direction parallel to the longitudinal axis of said combustion chamber, a plurality of injection orifices for the introduction of the reactant to be cracked into the combustion chamber which are positioned in a portion of the wall of the combustion chamber just above said lower part of the constricted cross-section area of said chamber which communicates to said lower part of the combustion chamber, an outlet for withdrawing the cracked gases from the reaction chamber, the burner comprising a movable multi-perforated plate which has a flat face and a plurality of perforations therein for blowing out the gases, a plurality of tubes for the injection of a gas each of which terminates in a nozzle orifice opening in said perforations of the perforated plate, and a plurality of adjusting valve means each of which movably extends within each of said injection tubes in the axial direction of the tube wherein each is adjustable to vary the cross-section area of the nozzle orifice through which the gas to be injected passes.

2. A furnace for the thermal cracking of hydrocarbons which comprises a combustion chamber which is provided with a lower part of a constricted cross-section area, a burner for fuel which is arranged at the top of the combustion chamber and which is provided with an inlet for the supply of fuel and with an inlet for the supply of oxidant, means in conjunction with said burner for supplying said fuel and said oxidant to said combustion chamber in a direction parallel to the longitudinal axis of said combustion chamber, a plurality of injection orifices for the introduction of the reactant to be cracked into the combustion chamber which are positioned in a portion of the wall of the combustion chamber just above said lower part of the constricted cross-section area of said chamber which communicates to said lower part of the combustion chamber, an outlet for withdrawing the cracked gases from the reaction chamber, the injection orifices for introduction of the reactant are arranged at equal intervals in the peripheral wall of the combustion chamber and extend in a horizontal plane radially outwardly from the chamber.

3. A furnace for the thermal cracking of hydrocarbons which comprises a combustion chamber which is provided with a lower part of a constricted cross-section area, a burner for fuel which is arranged at the top of the combustion chamber and which is provided with an inlet for the supply of fuel and with an inlet for the supply of oxidant, means in conjunction with said burner for supplying said fuel and said oxidant to said combustion chamber in a direction parallel to the longitudinal axis of said combustion chamber, a plurality of injection orifices for the introduction of the reactant to be cracked into the combustion chamber which are positioned in a portion of the wall of the combustion chamber just above said lower part of the constricted cross-section area of said chamber which communicates to said lower part of the combustion chamber, an outlet for withdrawing the cracked gases from the reaction chamber, the burner com-

prising a movable multi-perforated plate which has a flat face and a plurality of perforations therein for blowing out the gases, a plurality of tubes for the injection of a gas each of which terminates in a nozzle orifice opening in said perforations of the perforated plate, valve means movably positioned within each of said injection tubes in the axial direction of the tube, said valve means being adjustable to vary the effective cross-sectional area of the nozzle orifice through which the gas to be injected out passes.

4. A furnace for the thermal cracking of hydrocarbons which comprises a combustion chamber which is provided with a lower part of a constricted cross-section, a burner for fuel which is arranged at the top of the combustion chamber and which is provided with an inlet for the supply of fuel and with an inlet for the supply of oxidant, means in conjunction with said burner for supplying said fuel and said oxidant to said combustion chamber in a direction parallel to the longitudinal axis of said combustion chamber, a plurality of injection orifices for the introduction of the reactant to be cracked into the combustion chamber which are positioned in a portion of the wall of the combustion chamber just above said lower part of the constricted cross-section area of said chamber which communicates to said lower part of the combustion chamber, an outlet for withdrawing the cracked gases from the reaction chamber, the burner comprising a movable multi-perforated plate, the surface of said plate opposite said combustion chamber having a spherical surface, said plate further having a plurality of tubes for the injection of a gas each of which terminates in a nozzle orifice opening in said perforations of the perforated plate, valve adjusting means movable positioned within each of said injection tubes in the axial direction of each tube, said valve means being adjustable to vary

the cross-section area of the nozzle orifice through which the gas to be injected passes.

5. A furnace as claimed in claim 1 in which the injection orifices for the introduction of the reactant are directed at an angle of $0-\pm 45^\circ$ to a horizontal, transverse plane of the combustion chamber.

6. A furnace as claimed in claim 1 in which the injection orifices for the introduction of the reactant are directed at an angle of $0-90^\circ$ to a plane tangential to the peripheral wall of the combustion chamber.

7. A furnace as claimed in claim 1 in which the injection orifices for the reactant are slit-like in their cross-sectional configuration and the slit extends along a plane which is inclined at an angle of $0-\pm 90^\circ$ to such a longitudinal cross-section of the combustion chamber which contains the central axis of this chamber.

8. A furnace as claimed in claim 1 in which the injection orifices consists of a row of parallel small holes extending along a plane which is inclined at an angle of $0-\pm 90^\circ$ to such a longitudinal cross-section of the combustion chamber which contains the central axis of this chamber.

9. A furnace as claimed in claim 1 in which the combustion chamber is circular in its transverse cross-section.

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