

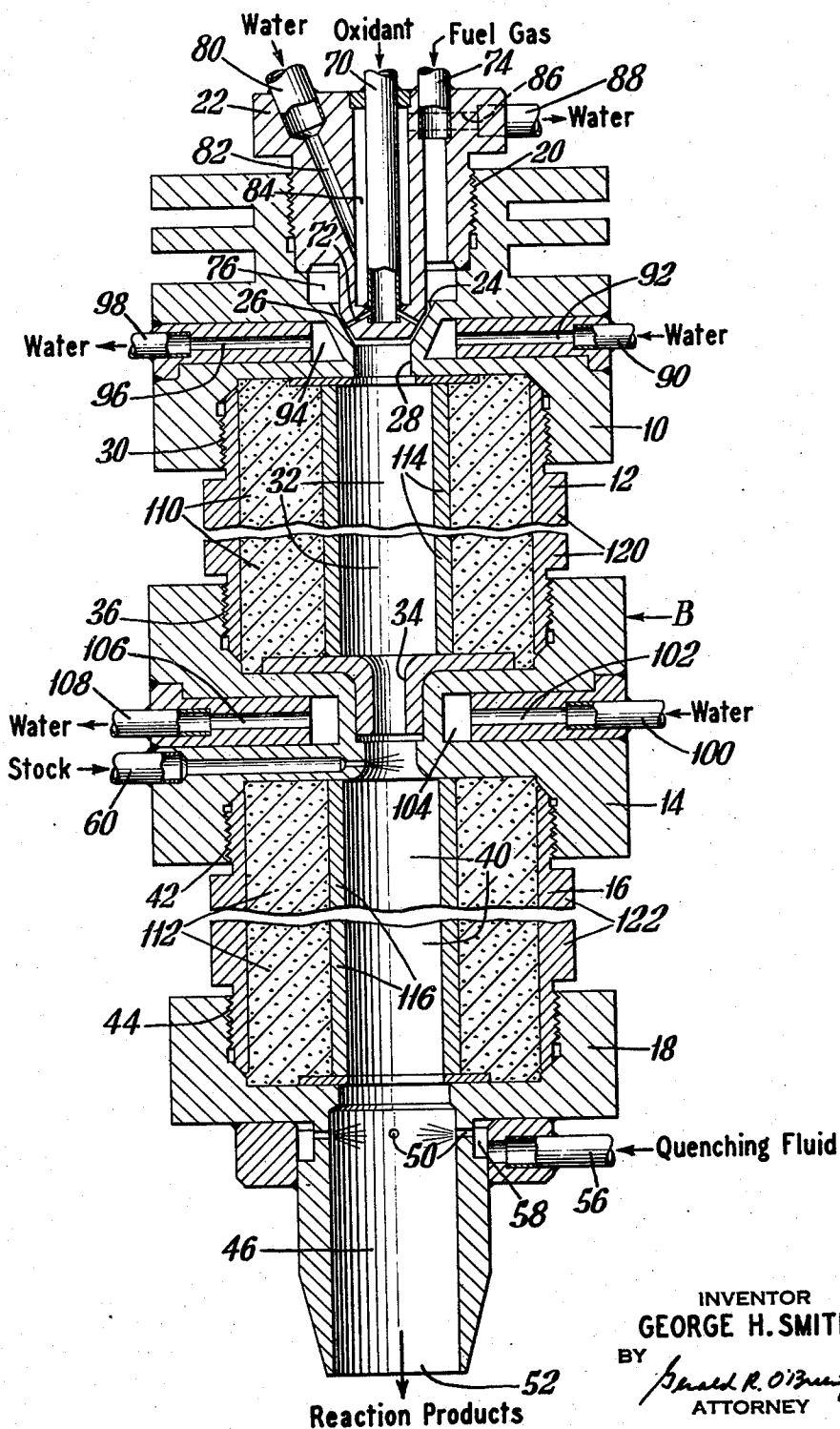
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TWO-STAGE BURNER APPARATUS

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TWO-STAGE BURNER APPARATUS

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7 Claims. (Cl. 23—277)

The present invention relates to a two-stage burner for the mixing, pyrolyzing, or atomizing of fluid fuels.

It is the main object of the present invention to provide apparatus for the rapid treatment of fuels in thermal pyrolysis reactions, such as the pyrolysis of hydrocarbons to produce acetylene. Another object is to provide apparatus for mixing and preheating gases prior to reaction in a chemical process. A still further object is to provide apparatus for preheating and atomizing reactants which are subsequently to be employed in a chemical reaction. Other aims and advantages of the invention will be apparent from the following description and appended claims.

In accordance with the present invention, a two-stage burner is provided having two successive stages separated from each other by a throat section of reduced cross-sectional area. A fluid fuel and oxidant are injected through a mixer into the first stage. The fuel and oxidant mixture is burned in the first stage and the hot products of combustion are discharged through the communicating throat section to the second stage. Concurrently therewith, a fluid or fluidized stock to be treated is introduced into the second stage wherein it is heated and atomized or pyrolyzed by contact with the hot products of combustion from the first stage. Factors determining which of these three effects are produced include the manner in which the fluid stock is introduced into the second stage and the composition of the stock introduced.

The single figure of the drawing is a longitudinal cross-sectional view of a burner embodying the invention and adapted primarily for use in the pyrolysis of hydrocarbons to produce other hydrocarbons, such as acetylene.

Referring specifically to the drawing, burner B is provided having axially aligned members 10, 12, 14, 16 and 18, successively positioned from the rear toward the forward end of the burner.

Member 10 is a water-cooled mixer member having an axially-positioned stepped internal boring passing there-through and provided with threads 20 at the upper end thereof adapted to receive and engage an injector member 22 therein. The internal boring is provided with a frusto-conical portion 24 adapted to cooperate with the outer surfaces of injector 22 to form a conical shaped annular passage 26 therebetween. A throat section 28 in which mixing of the gases takes place is preferably provided downstream of the frusto-conical portion 24. The internal boring of mixer member 10 terminates at the lower end in a threaded circular portion 30 adapted to engage the upper end of member 12.

Member 12 contains the first stage of the two-stage burner, and has an internal chamber 32 of substantially constant diameter discharging through a reduced-diameter throat section 34 positioned at the lower end thereof in member 14. Member 12 is secured to member 14 by threads 36.

Member 16, containing internal chamber 40 of substantially constant cross-sectional area, is substantially

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identical to member 12 and is secured to member 14 by threads 42.

Member 18, secured to the lower end of member 16 by threads 44, contains an internal passage 46 of substantially constant cross-sectional area into which a quenching fluid is introduced in multiple radial sprays through ports 50. The discharge end 52 of passage 46 is connected to a gas collector (not shown) when the two-stage burner is employed for the pyrolysis of saturated hydrocarbons to produce other hydrocarbons, such as acetylene. The quenching fluid is introduced into member 18 through fluid conduit 56, communicating annular passage 58, and discharging through the multiplicity of radially-positioned quenching fluid ports 50 opening into the internal passage 46 of member 18.

It is, of course, to be understood that, when the two-stage burner of the invention is employed in other than a pyrolysis process, member 18 may be removed from the burner, since quenching fluid introduction is no longer necessary.

Conduit 60 is provided in block 14 for the introduction of stock to the second stage of the burner. This stock comprises the fluid to be heated, and pyrolyzed or atomized in the second stage, depending upon the operation to be performed.

Injector member 22 comprises a centrally-positioned oxidant conduit 70 communicating at the lower end thereof with a plurality of radially disposed oxidant metering ports 72 positioned to discharge oxidant at high velocity transversely to the annular metering passage 26 formed between the lower surface of injector 22 and frusto-conical side walls 24 of the internal boring of member 10. A longitudinal fuel gas conduit 74 is eccentrically-positioned in injector 22 and discharges into the annular chamber 76 formed between injector 22 and the internal boring mixer member 10. Chamber 76 communicates with conical annular passage 26 so that a stream of fuel gas is fed therethrough past the discharge ends of oxidant ports 72. The streams of fuel gas and oxidant then pass through throat section 28 of the mixer at very high velocity; and intimate mixing is achieved between these gases, which are then passed to the first stage 32 of the burner. It has been found preferable, regardless of the specific fuel and oxidant employed, to introduce the gas having the large volume through passage 26 of the mixer, while the gas having the smaller volume is passed through metering ports 72.

It has been found that by maintaining the pressures across oxidant ports 72 at a ratio of greater than 2:1 (inlet pressure-to-outlet pressure) an oxidant stream discharge velocity at or near sonic velocity can be attained. In this manner, mixing takes place at or near sonic velocity and intimate mixing is achieved by the time combustion of the mixture is initiated in the first stage 32 of the burner.

Thus, the cross-sectional area of the metering ports and the pressure drops across them are so selected as to provide for impingement of the streams of fluid fuel and oxidant at a velocity greater than Mach number of 0.5 and preferably at about a Mach number of 1.0.

As employed herein the term "Mach number" refers to the ratio of the linear gas velocity of the mixture to the velocity of sound in the same mixture for the given temperature and gas composition.

Upon combustion in the first stage of the burner, hot combustion products are discharged through throat section 34 into the second burner stage 40. The fuel and oxidant are introduced into the first stage in substantially stoichiometric proportions and the fluid stock introduced into the second stage is heated by the hot products of combustion entering the stage through throat 34.

In addition, if a liquid stock is employed, the stock is atomized to a fine spray which passes with the hot combustion products at a very high velocity from the second stage 40. Under these conditions, the burner operates to heat, pyrolyze or atomize (depending on quantity of stock introduced) with the high velocity stream of hot combustion products from the first stage.

When the burner of the invention is employed for the pyrolysis of hydrocarbons, it is imperative that the ports 50 for the introduction of quenching fluid be properly positioned with respect to the pyrolysis zone. This is necessary since the hydrocarbons generated will decompose if exposed to the hot combustion products for too long a period of time, and the hydrocarbon yield will be reduced if the time is too short. For example, in the production of acetylene by the pyrolysis of methane, in order to prevent undue acetylene decomposition it is desirable that the reaction products be quenched within less than four milliseconds after the initiation of the pyrolysis reaction.

The hot products of combustion passing from the first stage 32 pass through throat section 34 and into the second stage 40 at a velocity greater than 0.5 Mach number, and preferably 1.0 Mach number, due to the pressure drop maintained across the throat section. Therefore, the stock introduced into the second stage is introduced into a high-temperature, high-velocity (approximately 3000 f.p.s.) stream, and the treatment of the stock (whether it be preheating, atomizing, or pyrolyzing) is accomplished at high velocity and, consequently, at short intervals of time. This result is very beneficial in all applications of the burner. Where preheating alone is effected, the stock is preheated and discharged from the burner to the point of desired use before any substantial quantity of preheat is lost by conduction through the side walls. Where atomization of a hot stream of stock is effected, this is accomplished and the atomized stream is discharged from the burner to the point of desired use before heat loss or a settling out of the atomized spray can occur. And where pyrolysis of the stock is the application, this result can be accomplished and the reaction products quenched, in short intervals of time, before extensive decomposition of the unsaturated hydrocarbons produced can occur.

Injector member 22 is provided with passages for the circulation of a cooling fluid, such as water. The cooling fluid is introduced through conduit 80 to boring 82 discharging into annular space 84, surrounding oxidant inlet conduit 70, and is discharged therefrom through boring 86 to outlet conduit 88. Mixer member 10 is similarly provided with cooling water through conduit 90 communicating, in turn, with radial boring 92, annular space 94, radial boring 96 and water discharge conduit 98. Member 14 is also provided with cooling water from inlet conduit 100 communicating, in turn, with radial boring 102, annular space 104, radial boring 106 and cooling water discharge conduit 108.

Portions of the burner of the embodiment of the drawing are constructed of refractory material. The two-stage members, 12 and 16 are constructed of refractory sections 110 and 112, respectively, lined with internal sleeves 114 and 116, respectively, suitably composed of metal ceramic materials such as disclosed in U.S. Patent 2,698,990. In addition, constricted throat section 34 is suitably composed of such metal ceramic material. Outer sleeves 120 and 122, respectively, are provided around the outside of the refractory material and serve to secure the stage-members to the adjoining members of the burner.

Larger scale burners have also been made with metallic liners provided with water cooling. Such construction has been found to be satisfactory since as the size is increased the ratio of wall area to volume decreases and thus the percentage heat loss through the walls also decreases.

The apparatus of the invention has been successfully

employed to produce products containing in excess of 7 vol. percent of acetylene in the pyrolysis of methane by the method described and claimed in my application entitled "Hydrocarbon Pyrolysis," Serial No. 516,957, filed June 21, 1955. In addition, apparatus embodying the present invention has been successfully employed to atomize fuel for introduction into furnaces of the open-hearth type, as described and claimed in my application entitled "Method and Apparatus for Heating of Industrial Furnaces," Serial No. 610,553, filed September 18, 1956.

What is claimed is:

1. A burner of the internal combustion type comprising an internal combustion chamber; a processing chamber; a constricted throat section communicating between said internal combustion chamber and said process chamber for introducing the hot products of combustion from said combustion chamber into said processing chamber, said constricted throat section having a cross-sectional area such that the products of combustion from said internal combustion chamber enter said processing chamber at substantially sonic velocity; inlet means for introducing a stream of fluid fuel and oxidant mixture in substantially stoichiometric proportions into said combustion chamber to burn substantially completely therein, said inlet means comprising separate supply conduits for fuel and oxidant terminating in metering passages adjacent the inlet of said internal combustion chamber, said metering passages each having cross-sectional area smaller than the supply conduit therefor to form and impinge streams of fuel and oxidant at high velocity into sudden mixing engagement with each other at a substantial angle of impingement such that the fluid fuel and oxidant mixture is formed and introduced into said internal combustion chamber at a velocity greater than 0.5 Mach number; and means positioned in said processing chamber in the vicinity of the juncture of said constricted throat section and said processing chamber for introducing a stream of fluid stock into said substantially sonic velocity stream of hot combustion products entering said processing chamber from said constricted throat section.

2. A burner in accordance with claim 1, wherein the walls of said internal combustion chamber, said constricted throat section and said processing chamber are composed of a refractory material, and the walls of said internal combustion chamber and said processing chamber are elongated thick walled sections of substantially constant internal diameter.

3. A burner in accordance with claim 1, wherein said inlet means for introducing said stream of fluid fuel and oxidant mixture to said combustion chamber comprises a water-cooled metal mixer having a frusto conical entrance, and an injector having a portion forming with said entrance a mixing passage in which said sudden mixing engagement takes place, and said mixer has a depending flange receiving the top of said refractory lined section of said internal combustion chamber wall.

4. A burner of the internal combustion type comprising an internal combustion chamber; a processing chamber; a constricted throat section communicating between said internal combustion chamber and said process chamber for introducing the hot products of combustion from said combustion chamber into said processing chamber, said constricted throat section having a cross-sectional area such that the products of combustion from said internal combustion chamber enter said processing chamber at a velocity greater than 0.5 Mach number; inlet means having a central oxygen passage and an annular fuel chamber surrounding the same, and a converging inlet to a throat leading to said internal combustion chamber to form a metering passage receiving fuel from said annular chamber, and radiating oxygen passages from said central oxygen passage into said metering passage for introducing a stream of fluid fuel and oxidant mixture in substantially stoichiometric proportions into said com-

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bustion chamber to burn substantially completely therein, said inlet means having cross-sectional area such that the fluid and oxidant mixture is formed and introduced into said internal combustion chamber at a velocity greater than 0.5 Mach number; and means positioned in said processing chamber in the vicinity of the juncture of said constricted throat section and said processing chamber for introducing a stream of fluid stock into said stream of hot combustion products entering said processing chamber from said constricted throat section.

5. A burner in accordance with claim 4, wherein the walls of said internal combustion chamber, said constricted throat section and said processing chamber are composed of a refractory material and the walls of said internal combustion chamber and said processing chamber are substantially identical sections lined with metal ceramic sleeves of substantially constant internal diameter.

6. A burner in accordance with claim 4, wherein said inlet means for introducing said stream of fluid fuel and oxidant mixture to said combustion chamber comprises a water-cooled metal mixer in which said annular fuel chamber, converging inlet and metering passage are formed, and an injector in which said central oxygen passage and radiating oxygen passages are formed.

7. In a burner for hydrocarbon pyrolysis having means for quenching the hot pyrolysis products and means for collecting said quenched pyrolysis products and separating the components thereof, an internal combustion chamber, and a processing chamber; a constricted throat section communicating between said internal combustion chamber and said process chamber for introducing the hot products of combustion from said combustion chamber into said processing chamber, said constricted throat sec-

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tion having a cross-sectional area such that the products of combustion from said internal combustion chamber enter said processing chamber at substantially sonic velocity; inlet means having a central oxygen passage and an annular fuel chamber surrounding the same, and a converging inlet to a throat leading to said internal combustion chamber to form a metering passage receiving fuel from said annular chamber, and radiating oxygen passages from said central oxygen passage into said metering passage for introducing a stream of fluid fuel and oxidant mixture in substantially stoichiometric proportions into said combustion chamber to burn substantially completely therein, said inlet means having cross-sectional area such that the fluid fuel and oxidant mixture is formed and introduced into said internal combustion chamber at a velocity greater than 0.5 Mach number; and means positioned in said processing chamber in the vicinity of the juncture of said constricted throat section and said processing chamber for introducing a stream of fluid stock into said substantially sonic velocity stream of hot combustion products entering said processing chamber from said constricted throat section, said fluid stock being thereby pyrolyzed by means of said stream of hot combustion products.

References Cited in the file of this patent

UNITED STATES PATENTS

1,828,784	Perrin	Oct. 27, 1931
2,419,565	Krejci	Apr. 29, 1947
2,495,665	Spring	Jan. 24, 1950
2,659,662	Heller	Nov. 17, 1953
2,719,184	Kosbahn et al.	Sept. 27, 1955
2,790,838	Schrader	Apr. 30, 1957