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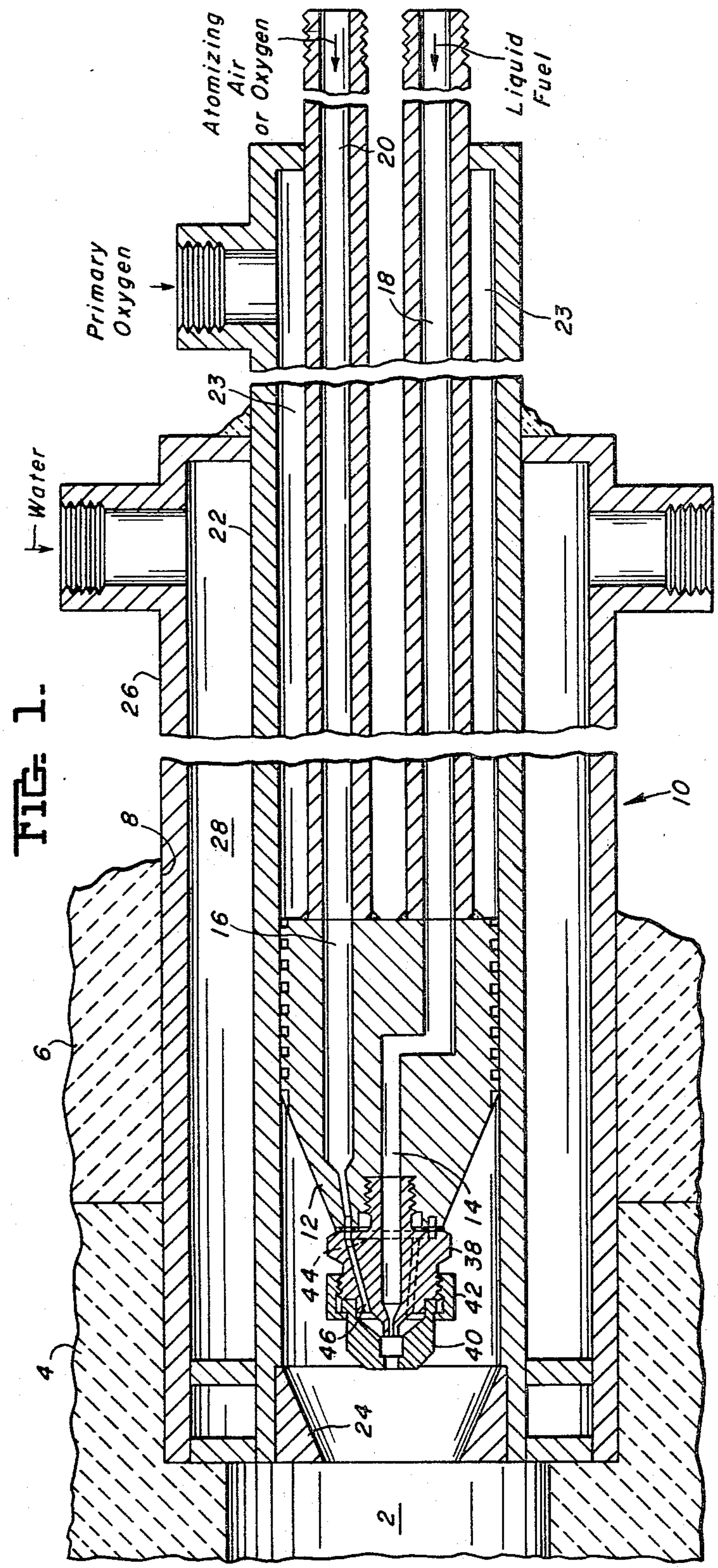
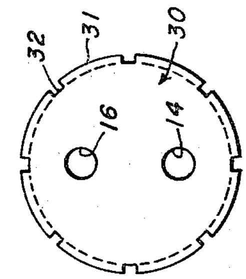
APPARATUS FOR PARTIAL COMBUSTION OF HYDROCARBON FUELS

Filed May 26, 1965 2 Sheets-Sheet 1





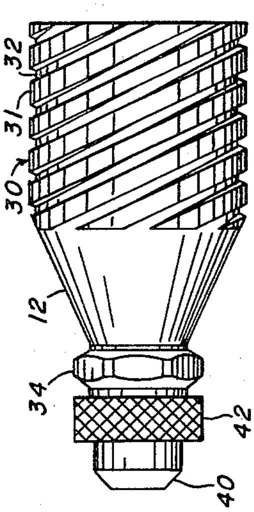


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FIG. 4.

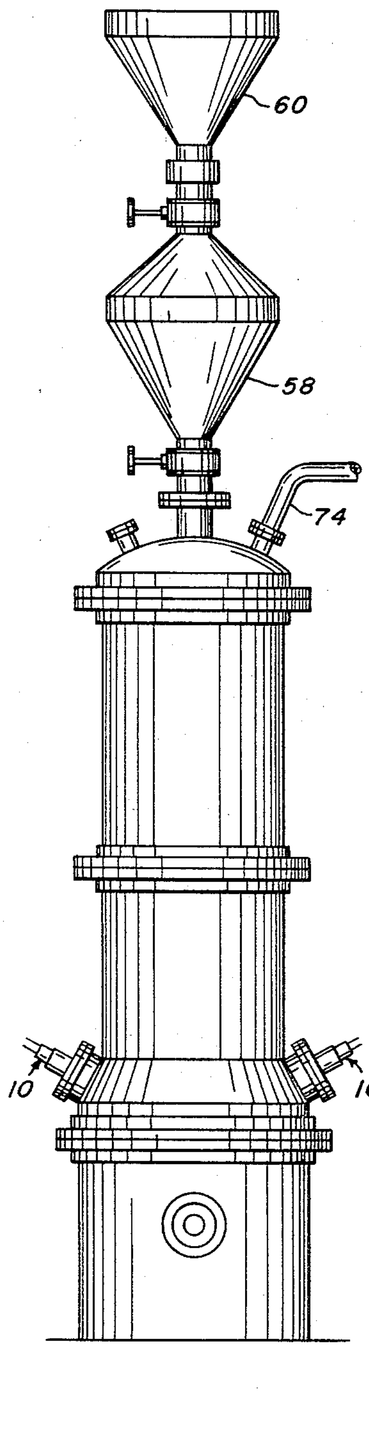
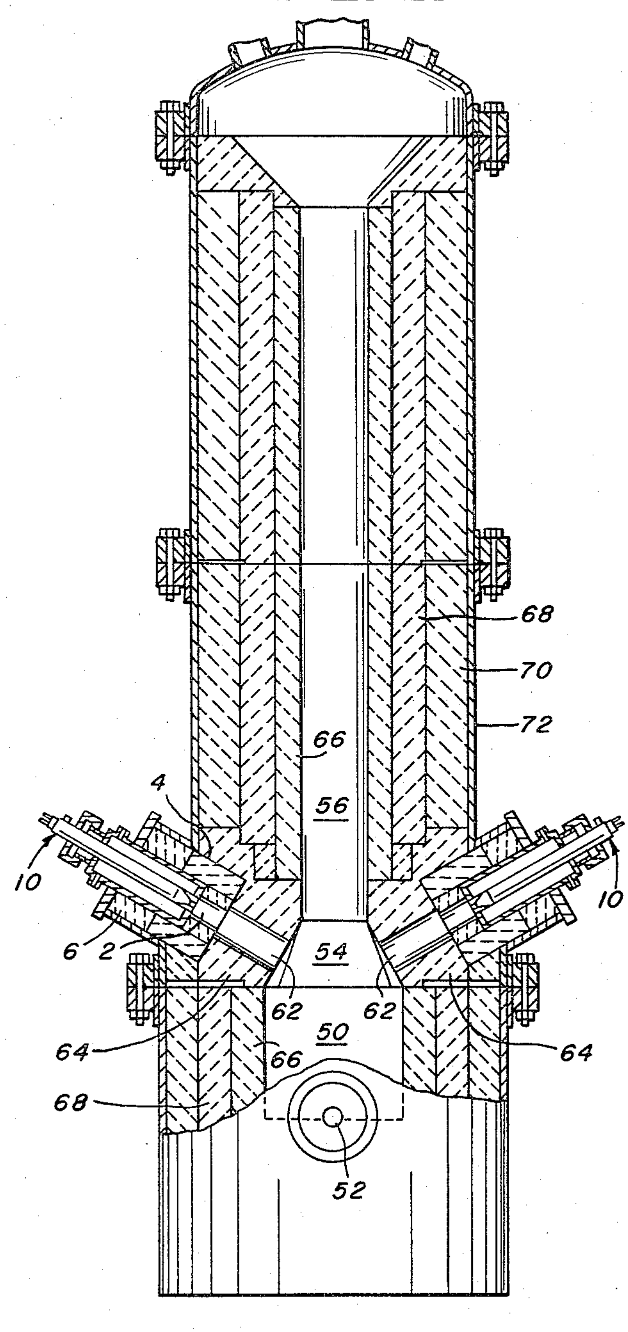


FIG. 5.



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APPARATUS FOR PARTIAL COMBUSTION OF HYDROCARBON FUELS

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3 Claims. (Cl. 158—4)

This invention relates to apparatus for the partial combustion of fuels and more particularly to producing carbon monoxide and hydrogen from carbonaceous liquid fuels such as fuel oil. In certain chemical and metallurgical processes, particularly smelting processes, a stream of hot reducing gases is required. In the conventional iron blast furnace these gases are generated by the combustion of coke and any injected fuel with the preheated air at the bottom of the furnace stack. Because the temperature of the coke reaching the tuyeres is about 3000°, the air must generally be preheated to about 1500° F. to generate the high temperature necessary for the process. The gases leaving the bottom of the furnace will contain about 60% nitrogen which reduces the partial pressure of the reacting gases and imposes through-put limitations because of the increased pressure drop caused by the large volume of gases. In smelting iron ore in a conventional blast furnace it is also necessary to use stoves for heating the air and also to use a large amount of coke. These are expensive items in producing the iron.

It has been proposed to generate synthesis gas by using steam to temper the flame. However, this method has the disadvantage that the temperature of the gas produced is too low for many purposes. Another disadvantage of former processes used in the partial combustion of carbonaceous fuels is the formation of solid carbon deposits in the combustion chamber or down stream therefrom.

It is therefore an object of our invention to provide apparatus for partially combustion liquid hydrocarbons in which the produced product is at a high temperature and contains a relatively small amount of nitrogen and solid carbon.

This and other objects will be more apparent after referring to the following specification and attached drawings, in which:

FIGURE 1 is a sectional view of the burner of our invention;

FIGURE 2 is an elevation of the burner tip;

FIGURE 3 is an end view of FIGURE 2;

FIGURE 4 is an elevation of apparatus for producing iron ore according to our invention; and

FIGURE 5 is a sectional view of the apparatus of FIGURE 4.

Referring more particularly to FIGURES 1 to 3 of the drawings, reference numeral **2** indicates a combustion chamber which is lined with a highly refractory material **4** which is capable of withstanding temperatures in excess of 4000° F. High purity magnesia or zirconia are suitable for this purpose. A low conductivity insulating refractory **6** is provided on the outside of the refractory **4**. An opening **8** is provided through the refractories **4** and **6** into the chamber **2** for receiving burner **10**. Burner **10** includes an atomizing nozzle **12** having a fuel inlet **14** and an atomizing gas inlet **16** which are connected to conduits **18** and **20**, respectively. A tubular shroud **22** having an inside diameter substantially equal to the outside diameter of nozzle **12** surrounds the nozzle **12** and the conduits **18** and **20** and provides a chamber **23** leading to nozzle **12**. The shroud **22** is made of a heat resistant metal such as Inconel or Type 310 stainless steel. A shield **24** of similar material may be attached to the inside of shroud **22** at the outlet end thereof. A conduit **26** surrounds the shroud **22** and provides a cooling water chamber **28**. The nozzle **12** includes a member **30** which has a cylindrical portion **31** with a plurality of spiral grooves **32** therein. While eight grooves are shown the number may be greater or smaller although, for best results, there should be a minimum of one groove per quadrant equally spaced from one another. Primary oxygen passes through the grooves **32** from chamber **23** and the size of the grooves should be such to provide for a total pressure drop therethrough of at least 5 lbs. per sq. in. at the minimum oxygen rate. A nozzle tip **34** is provided at the discharge end of the nozzle **12** and consists of a body portion **38** threaded into member **30** and an outlet member **40** connected to member **38** by means of collar **42**. Axial openings through members **38** and **40** are aligned with fuel inlet **14**. Member **38** has a circular passage **44** which connects with gas inlet **16**. Three equally spaced openings **46** lead from the passage **44** to the discharge end of member **38**. The burner tip **34** may be a conventional tip which includes a standard spray nozzle such as manufactured by Spraying Systems Company of Bellwood, Illinois.

In operation, liquid fuel oil passes through conduit **18** into the nozzle tip **34** and atomizing air or oxygen passes through conduit **20** into tip **34** where the liquid fuel is atomized. At the same time, primary oxygen is introduced through chamber **23** and grooves **32** around the burner tip **34**. The oxygen passing through the grooves **32** is given a vortex or whirling action which, in addition to providing good mixing action, increases the effective residence time of the reactants in the combustion zone and results in more effective fuel conversion so that less ungasified carbon leave the combustion zone. The minimum amount of oxygen provided through conduit **20** and chamber **23** should be the stoichiometric ratio for combustion of the fuel to carbon monoxide and hydrogen, and the maximum amount of total oxygen should not exceed approximately 125% of this amount. Partial combustion of the liquid fuel is completed in the chamber **2** and the gases so produced will pass to the processing chamber where they will be burned to complete the process. In some instances, powdered coal may be substituted for the fuel oil.

We have found that it is essential to maintain at least a minimum atomizing-flow to liquid-flow ratio and to maintain a minimum pressure drop through the nozzle to insure that the liquid droplets are smaller than the maximum required for good performance. In the case of No. 6 fuel oil, the minimum atomizing-flow to liquid-flow ratio is about 4 standard cu. ft. of atomizing gas per lb. of oil, although this ratio might be lower at maximum capacity operation. Ratios higher than the minimum provide better operation. The minimum pressure drop through the nozzle to provide for sufficient dispersion should be about 30 lbs. per sq. in. When operating at low throughputs the minimum pressure drop for effective operation is below 30 lbs. per sq. in. whereas at high through-puts the minimum pressure drop should be above 30 lbs. per sq. in. We have also found that the temperature of the oil and gas streams entering the system should be kept as low as possible so that the oil temperature in nozzle tip will not exceed the minimum temperature for non-coking operation. This prevents formation of coke in the tip and its resultant disadvantages. In general the oil temperature should be less than 175° F. and the gas temperatures less than 100° F. entering the burner.

FIGURES 4 and 5 show an embodiment of our invention where the burner is used to smelt iron ore. As there shown the furnace includes a hearth **50** having a tap hole **52** which is connected by means of a frusto-conical portion **54** to a stack or reactor **56**. A stationary hopper **58** is supported on top of the furnace and a portable hopper **60** is received in the top of the stationary hopper **58**. A plurality of burners **10** discharge into the frusto-conical portion **54** through tunnels **62**. Each tunnel or combustion chamber **62** is lined with a high duty refractory **64** which is preferably zirconia. The hearth **50** and reactor **56** are lined with high alumina brick **66** with a layer of fireclay brick **68** on the outside thereof. A light weight castable refractory **70** surrounds the fireclay bricks **68** to provide insulation. A steel shell **72** forms the outside surface of the furnace and is provided with means for supporting the burners **10**. A gas outlet **74** is provided at the top of the furnace. With the furnace charged with coke, limestone and briquettes containing iron ore and/or iron oxide and the burners are operated in the manner set forth above so as to smelt the iron. The partially combusted gas combines with the oxygen in the ore or other oxide. In a pilot plant operation the furnace was operated with 10% coke and 90% self fluxing iron oxide containing sinter. In approximately 12 hours after the first charge, small amounts of molten iron were tapped and additional burden was added through the hoppers **58** and **60**. Additional operation of the furnace increased the formation of molten iron which reached a steady state after several hours. The combusted gases leave the reactor through conduit **74**. It was found necessary to operate the burners with approximately 20% more oxygen than the stoichiometric amount necessary to form carbon monoxide and hydrogen, because it was necessary to compensate for the high heat losses resulting from the small pilot operation.

While one embodiment of our invention has been shown and described it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

We claim:

1. Apparatus for partially combusting non-gaseous hydrocarbon fuel comprising a tubular member having an

entry and exit end, said tubular member having a substantially constant inside diameter for the majority of its length; a nozzle within said tubular member adjacent its exit end, said nozzle including an outer cylindrical portion closely fitting the inside of said tubular member, said cylindrical portion having at least four spiral grooves therein equally spaced around its periphery and each having an opening at each end into the inside of said tubular member, and a burner tip at its exit end of less diameter than the inside of said tubular member, said nozzle including a central axial passageway for said fuel and means for delivering an oxygen containing gas around said passageway; means within said tubular member for separately delivering fuel and oxygen containing gas to said nozzle, and means for introducing oxygen into said tubular member and into said spiral grooves.

2. Apparatus according to claim **1** including a combustion chamber at the exit end of said nozzle.

3. Apparatus according to claim **1** including a portion on said tubular member extending beyond the exit end of said nozzle, a shield attached to the inside of said last named portion at the end thereof, said shield having a frusto-conical axial opening therethrough with its minimum diameter at the exit end thereof, and a refractory lined combustion chamber at the exit end of said tubular member.

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