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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Flame Cracking of Hydrocarbons

We, SUN OIL COMPANY and THERMAL RESEARCH & ENGINEERING CORPORATION corporations organized under the laws of the State of New Jersey and State of Delaware, respectively, two of the United States of America, with offices respectively at 1608 Walnut Street, City of Philadelphia and Conshohocken, both in the Commonwealth of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for the thermal cracking of a hydrocarbon, or mixture of hydrocarbons, such as a petroleum fraction, by contact with a flame, to produce fuel gas.

It is known to crack hydrocarbons by contacting the hydrocarbon feed stock with a heated refractory surface, such as of checker-brick or ceramic particles. Such surfaces are, however, rapidly cooled by the endothermic cracking reaction, and passage of the feed stock must be discontinued whilst a flame is passed over the surface to reheat it. Such cyclic alternation of heating and cooling results in low efficiency of the process.

Continuous processes are known in which a refractory chamber is continuously heated by an external heat source, whilst the hydrocarbon is passed through the chamber. The refractory material is, however, a poor conductor of heat, and such processes are also inefficient, and the apparatus is costly.

In both the cyclic and continuous processes, there is, furthermore, considerable deposition of carbon deposits on the heated surfaces, which deposits must be periodically removed, and the refractory surfaces rapidly become eroded by the flame and need frequent replacement. Furthermore, the gases produced are of varying quality, and contain considerable

amounts of impurities such as drip oil, tars and smoke, which must be removed by expensive after-treatment. 45

Prior art cracking process and apparatus have heretofore been used primarily in peak shaving operation, for instance during short periods in the winter, and it is hence especially desirable that the capital and operating costs be kept as low as possible for such process and apparatus. 50

It is therefore an object of this invention to provide a process for inexpensively effecting continuous cracking of hydrocarbon, to produce a high yield of combustible gas which can be utilized directly with a minimum of cleaning or after-treatment. 55

The present invention comprises flame-cracking a hydrocarbon or mixture of hydrocarbons by direct contact with a burner flame, a process which may be referred to as "flame-cracking". It is believed that the feed stock injected (which may be at a temperature, for example, of 700°F. (370°C.) cools the surface of the tip of the flame from about 3000°F. (1650°C.) to 800°—1600°F. (425°—870°C.), and this temperature permits the desired degree of cracking with the production of the minimum of by-products. 60 65 70

The feed stock should impinge on the flame at a point where the combustion in the flame is substantially complete, and the flame consists substantially only of the hot combustion products. To ensure this, a burner should be used which produces a steady, elongated flame so that the position of the tip of the flame remains predictably constant; this is suitably achieved by providing a narrow, elongated combustion chamber around the base of the burner, and permitting the tip of the flame to extend into a cracking chamber. 75 80

The process according to the invention thus comprises introducing a hydrocarbon or mixture of hydrocarbons as feed stock in finely 85

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distributed form to impinge on the flame of a burner firing into one end of a cracking zone, in such manner that the impingement zone temperature is 800°—1600°F. (425°—870°C.), thereby to produce a gaseous mixture of combustion products and products of cracking of the feed stock.

The process is preferably carried out in an apparatus which comprises a chamber defining a cracking zone, a burner positioned to direct a flame into the zone, and orifice means for feeding said hydrocarbon as feed stock in finely distributed form into the chamber so as to impinge on the flame.

The feed stock may be injected as a vapor, a gas or an atomized liquid, and the term "finely distributed form" as used in this Specification and the appended claims embraces all these forms.

The feed stock is preferably injected from a plurality of locations, e.g., three nozzles, around the burner. It is advantageous for the feed stock to be directed at an acute angle with the axis of the flame and toward the flame, to increase the contact time of the hydrocarbon with the flame. The cracking chamber is preferably a somewhat elongated tube which provides an elongated flow path for the combustion and cracked product gases away from the burner, and a constricted exit from the cracking chamber may be provided to improve the mixing of the cracking gases.

A heat exchanger is advantageously provided in the path of the hot gases from the cracking zone, so as to preheat and if desired vaporize the feed stock.

It is especially advantageous to utilize the same hydrocarbon as the cracking feed stock and as the burner fuel. A wide variety of hydrocarbon feed stocks, especially petroleum fractions, can be cracked.

The temperature in the impingement zone should preferably not exceed 1450°F. (790°C.), to ensure production of a uniform product relatively free from by-products. The cracking zone must be substantially free of air and free oxygen, to prevent formation of an explosive gas mixture.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a side elevation, partly in section, of a preferred embodiment of a gas preparation apparatus;

Fig. 2 is a vertical section, on an enlarged scale, of the burner end of the cracking tube of the apparatus;

Fig. 3 is a section taken along line 3—3 of Fig. 2, showing the location and disposition of the injection orifices in the cracking tube; and

Fig. 4 is a somewhat schematic sectional view of the burner end of the cracking tube, with a representation of a flow path.

Referring to Fig. 1, the apparatus includes

an elongated cracking tube indicated generally as 1, and consisting of a cracking and mixing chamber 20 into which three injection conduits 6 feed, an intermediate tube portion 3¹ (shown broken away in Fig. 1), and a heat exchange portion 3. At the left-hand end of the tube is a burner 5 communicating with the chamber 20 via a combustion chamber 18, and the right-hand end of the tube communicates with the bottom of a scrubbing tower 2.

A storage tank 7 supplies liquid hydrocarbon via a pump 9, valve 17 and conduit 8 and coupling 14 to the burner 5, and also via a valve 59, and conduit 60 to a heat exchanger 57 within the tube 3¹ and thence via a conduit 61, manifold 29, valves 30 and feedpipes 25 to the injection conduits 6. The conduits 25 are coupled to the manifold 29 by flanges 28.

Referring to Fig. 2, the cracking chamber is shown in more detail. The burner 5 is not shown in detail, since it is not peculiar to the invention. It may for example be a high velocity oil burner in which liquid fuel is vaporized before it is burned, the heat for the vaporization being taken from the combustion chamber of the burner; the burning of the vapor as compared to a liquid gives a high heat release rate, which should preferably be at least 1 to 10 million BThU (British Thermal Units) per hour per cubic foot of combustion space (kilo-cal per cubic meter = 8.92 BThU per cubic foot at atmospheric pressure and 15.5°C.). The burner has an inlet 15 for air under pressure (from a blower, not shown) connected to a coupling 16, and as mentioned, a coupling 14 fuel intake.

A metal pipe 11 (Figs. 2 and 3) provides structural support for the burner end of the cracking tube, and has an annular end plate 10 to which a mounting plate 12 of the burner 5 is attached by bolts 13.

A refractory combustion chamber 18 (Fig. 2) extends outwardly from the end plate 12 and comprises a wider portion 31 adjacent the burner and a narrow portion 33, the two portions being connected by a shoulder 32.

The cracking chamber has a refractory lining 20 and a collar member 21 which forms a constriction at its downstream end. Three apertures 24 are formed radially through the wall of the cracking tube to receive the conduits 6; these apertures are spaced equidistantly round the tube diameter (see Fig. 3) and debouch at a point near the tip of the flame 19 of the burner (see Fig. 2). Through each conduit 6 passes a coaxial injection pipe 25, which is cut off terminally at a 45° angle so that the cut end faces toward the burner. To each cut end is secured a plate 26 having a small aperture 27 (best seen in Fig. 3) there-through.

An intermediate pipe section 3¹ (Fig. 2) is attached to pipe 11 by bolts 37 passing through flanges 35, 36, and this section 3¹ is in turn joined at flanges 54, 55 (Fig. 1)

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to the heat-exchanger portion 3. The tubes 11, 3¹ and 3 are in line with each other, and provides a straight gas flow path. The tubes are shown as of circular cross section, but other cross sections can be utilized.

Heat insulatory material surrounds this flow path, namely a body of refractory material 22 within the pipe 11 and surrounding the chambers 18 and 20, a double jacket 23 of insulation around the pipe 11, a jacket 4¹ around the pipe 3¹ and a jacket 4 around the pipe 3.

A helical metal heat-exchanger coil 57 (Fig. 1) is supported within the pipe 3. An elongated hollow baffle 58 having its upstream end closed is supported within the coil. Two or more coils 57 could alternatively be used, connected together in series. The coil 57 is connected to the injection manifold 29, as already described.

The following are exemplary principal dimensions of the apparatus described:

		inches	centimetres
pipe 11	outside dia.	24	61
combustion chamber 18:	total length	11	28
larger portion 31	internal dia.	5.25	13.4
smaller portion 33	internal dia.	4	10
cracking chamber 20	inside dia.	14	35.5
	outside dia.	15.5	39.5
	inside dia. at		
	collar 21	10.5	27
	Total length	25	63.5
orifice 27	dia.	0.25	0.6
	distance from burner end of chamber 20	9.5	24
pipe 3 ¹	dia.	14	35.5
	length	ca. 96*	ca. 255
pipe 3	length	ca. 60	ca. 150
baffle 53	dia.	7.5	19.8

* this length may be considerably shorter.

Such apparatus has a capacity of 0.3—1 million cubic feet (8,400—28,000 cubic meters) of product gas per day.

The scrubbing tower 40 is not essential to the invention and its construction and operation are described later. The operation, according to the process of the invention, of the cracking apparatus described is as follows.

The hydrocarbon to be cracked is stored in tank 7, and fed to the burner 5, which is also supplied via conduit 15 with an oxygen-containing gas under pressure. Air is generally used, but oxygen or oxygen-enriched air may

be used and will give a higher calorific value to the product gas which will contain less or no nitrogen. The air hydrocarbon ration is 60 to 100% of stoichiometric. The resultant flame fills the combustion chamber 18, and extends a short distance (usually less than 4 inches (10 cm)) axially into the cracking chamber 18, the flame preferably having a conical shape as shown at 19 in Figs. 2 and 4. The narrow portion 33 of the chamber 18 acts as an orifice for the flame to prevent the feed stock being drawn back into the flame. The chamber 18 stabilizes the flame so that

the combustion is substantially complete within the burner, and no carbon deposit should be formed on the walls of the combustion chamber or cracking tube.

According to the embodiment, about 3—15% of the hydrocarbon is used as the burner fuel, and the remainder as feed stock, which is pumped from the tank 7 through the heat-exchanger coil 57, and is thereby heated by the hot gases passing down the tube 1, which gases are diverted by the baffle 58. If the heat exchanger is not present or is by-passed, the feed can be used directly without preheating, but it will be necessary to use more fuel to obtain the desired cracking temperature, and there will be a higher proportion of burner combustion gases in the mixed gaseous products leaving the cracking tube, and hence the calorific value of the product gas will be lower. In a typical example, the calorific value of the product gas obtained in 600 BThU with preheating of the feed stock to 700°F. (370°C.), but only 470 BThU without preheating. If the feed stock is normally liquid, it will be vaporized by passage through the heat exchanger.

The feed stock is injected (as a liquid, vapor or gas) from the orifices 27 into the cracking chamber 20, in the form of streams preferably directed at an acute angle (about 45°) toward the flame 19, and impinges on the flame; each stream then reverses its direction and is swept down the cracking tube by the combustion gases from the flame; the resultant flow path of a feed stock stream is shown in Fig. 4 at 53. This reversal in direction, due to the angle of impingement, increases the contact time of the feed stock and flame. The flame surface or impingement zone is thereby cooled from about 3000°F. (1650°C.) to about 800°—1600°F. (425°—870°C.), and preferably to below 1450°F. (790°C.). The flame may thereby lose its luminosity and become gray-gas.

The feed stock is quickly and efficiently cracked in the chamber 20; it is believed that the cracking takes place essentially at the boundary of the flame 19, which here consists of the gaseous combustion products formed by the combustion in the chamber 18. There is a short residence time of the feed stock in this cracking zone.

The cracked products and combustion gases pass from the flame down the chamber 20, and are constricted at the collar member 21, which causes the gases to be further mixed together and improves the cracking efficiency. This collar member thus provides a restricted orifice from the cracking chamber. The degree of mixing can be further controlled by alteration of the number of injection conduits and their distance from the flame.

The gases then pass, substantially unchanged in composition, down the intermediate tube 3¹, and have a temperature of about 1250°F.

(675°C.) at the downstream end thereof. The gases pass the heat exchanger 57, where they lose heat to the feed stock and are cooled to about 900°F. (480°C.) when they leave the heat exchanger and enter the scrubbing tower 2.

Referring again to Fig. 1, the scrubbing tower 2 shown there is of a conventional spray type, and comprises a vertical, cylindrical casing 38 having at the top thereof spray heads 40 connected by conduits 41 to a manifold 42 which is connected via a control valve 44 and a conduit 43 to a source of cooling oil or water. An array of vertically-spaced, perforated trays 45 secured horizontally across the casing 38 provides a labyrinth passage for the flow of gases from the cracking tube 1 against the counter flow of condensing oil or water from the spray heads 40.

Spray medium and condensate collect in the bottom of the casing 38 at 46. A drain line 47 controlled by a valve 48 is provided to remove spray medium and condensate collected at 46 at the bottom of the casing. This liquid 46 forms a seal preventing gases from escaping through the drain line 47. To maintain this seal at a level sufficient to cover the drain line 47 but below the entrance 39 of the cracking tube 1 into casing 38, a level control unit 49 is provided. This latter unit is coupled as at 50 to valve 48, and operates this valve in a well-known manner to control the flow of liquid from the casing 38.

An exit duct 51 is connected above the spray heads 40, and includes a demister 52 within the duct 51 to remove from the gases any traces of liquid remaining in mist form.

The gaseous products pass from the cracking tube 1 into the base of the tower 2, wherein the cool water or oil spray, passing through the perforated trays 45 countercurrently to the flow of gases, cools the gases, causing condensation of the condensable ingredients upon the cool surfaces of the trays 45. The gaseous product then passes upwardly through the demister 52 and the duct 51 to suitable storage and distribution facilities. The water or oil spray medium, and the condensate, collect in the bottom of the casing 38, wherein the level control unit 49 maintains a proper fluid level to provide a liquid seal, preventing escape of the gaseous products. The collected fluid is then led off through the drain line 47.

The only clean-up step required is the treatment of the gaseous products in an oil or water scrubber. The gas with the condensates removed is of a quality suitable for direct commercial distribution. The burning quality of gas produced in a particular cracking operation is a function of the composition of the feed stock.

Numerous operating factors can be varied to achieve optimum performance. These include type and capacity of burner, burner fuel and air feed rates, feed stock rate, and type

and capacity of injection orifices. These variables and others can be coordinated in accordance with known engineering practice to obtain efficiency from any size unit. The number of orifices used depends on the size and throughput of the apparatus, but it has been found that three orifices, as described, give best yield.

The apparatus can be modified for pressure operation by conventional techniques, such as back pressure devices. Superatmospheric cracking zone pressures can be used, preferably in the range of .05 to 100 p.s.i.g.

If desired, any number of cracking units can be operated from a single source of feed stock, by proper manifolding. The units can be operated in parallel.

The feed stock employed in the process of the invention is preferably a normally liquid petroleum hydrocarbon fraction, although other materials, such as crude petroleum, petroleum gas, or a pure hydrocarbon, such as hexane, heptane or di-isobutylene, can be used. If a hydrocarbon fraction is used, it will preferably have a final boiling point up to

about 750°F. (400°C.) and a 95% boiling point ranging up to about 700°F. (370°C.); examples are kerosenes, No. 1 fuel oil, No. 2 fuel oil, gasoline, naphthas, and mixtures of these fractions. It is preferred that the feed stock contain a majority, e.g., 70%—100%, of saturated hydrocarbons having from 4 to 10 carbon atoms per molecule. This includes straight and branched chain paraffins and alkyl-substituted naphthenes. It is desirable to use feed stocks having a fairly low content of olefins and aromatics.

Petroleum hydrocarbon fractions having a boiling range of 80°F.—750°F. (27°—400°C.) and containing 70%—100% Vol saturated hydrocarbons, and less than 30% preferably less than 15%, aromatic hydrocarbons and olefins, are the preferred cracking stocks. The fraction can contain small amounts of sulfur compounds, nitrogen compounds, and other contaminants usually found in hydrocarbon fractions.

Hydrocarbon mixtures of the following compositions give good results:

	Vol. %
paraffinic hydrocarbons	75—100
branched chain paraffinic hydrocarbons	25—40
naphthene hydrocarbons	<15, preferably <12
aromatic hydrocarbons	<15, preferably <10
unsaturated hydrocarbons	<25, preferably <10
olefin hydrocarbons	<10, preferably <5

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A preferred paraffinic light petroleum hydrocarbon fraction has the following characteristics:

API gravity	70
initial boiling point	100° F. (37.8° C.)
end point	300° F. (149° C.)
total saturated hydrocarbons	91.4 Vol. %
total aromatic hydrocarbons	5.6 Vol. %
olefins	3.0 Vol. %

A particularly desirable cracking feed for the process is petroleum naphtha, i.e. refined, partly refined, or unrefined petroleum products and gas liquids not less than 95% of which distill below 464°F. (240°C.). A preferred material is that known as "Bajo Grande light naphtha", which is a virgin straight-run gasoline having an API gravity of 71°, a Reid vapor pressure of 12 lbs. and an end point of 300°F. (149°C.).

The content of naphthenes in the feed stock can be as high as 10—40 Vol. %.

The following Example illustrates the process of the invention.

EXAMPLE

An apparatus similar to that shown in the drawings was employed to flame-crack the preferred paraffinic light petroleum hydrocarbon fraction, having the characteristics previously set forth. The fuel-air ratio employed in the

burner was 93% of stoichiometric. The temperature at a point approximately 8 feet (2.44 metres) downstream of vapor injection was steady at about 1299°F. (704°C.). Heating fuel was fed to the burner at a rate of 11.2 gallons (42.3 liters) per hour, while the cracking feed stock rate was 109 gallons (412 liters) per hour. The temperature of the vaporized cracking feed stock, as injected into the cracking tube, was 695°F. (369°C.).

An average sample of the fuel gas produced had a specific gravity of 0.97, and its gross heating value, in BTU per standard cubic foot (measured by a calorimeter), was approximately 600. The BThU conversion efficiency, calculated from the cracking feed stock alone was 89.9%, and from the total feed stock (including the portion used as burner fuel) was 81.9%. The gas composition was as follows:

	hydrocarbons									
gas:	H ₂	C ₁	C ₂ s	C ₃ s	C ₄ s	C ₅ s	C ₆ s	N ₂	CO	CO ₂
Vol. %:	8.5	7.8	13.3	3.9	2.8	0.6	1.0	51.8	3.9	6.4

It was significant that the total drip oil, tar, and carbon deposit remaining in the apparatus was minimal regardless of the duration of operation. It was also significant that the hydrogen content of the product gas was relatively low: a low hydrogen content, e.g., less than 30%, is necessary in the product gas so that carbon deposits may be kept minimal. It was very significant that substantially all of the C₂s in the product gas were ethylene; no appreciable amount of the undesirable product acetylene was formed in the cracking reaction, as is the case in prior art cracking processes.

The process of the invention provides a satisfactory fuel gas having a heating value of 200—800 BThU per cubic foot. Many industrial users burn fuel gases in the 300—700 BThU range, and these users can burn directly the gas produced by the process of the invention. Alternatively, the gas can be mixed as a supplement with propane, natural gas, or other gas having a higher heating value. The capacity of a propane-air plant can thus be greatly increased, at low cost, by installation of apparatus according to the invention, the mixed gas having a high heating value, over 1000 BThU per cubic foot.

The gas produced according to the invention is also an excellent source of ethylene, which is present in high concentration and with almost no admixture of acetylene, the ethylene can be separated from the product gas, or

can be reacted immediately to convert it to a desired product such as ethyl chloride, which is then itself separated from the other gases.

The invention thus provides an inexpensive, simple and efficient process for the flame cracking of hydrocarbons, which process is simple to control and provides a good yield of relative pure combustible product gas.

In one embodiment of the invention, a two-step process is carried out in which the flame cracking as previously described is preceded by a partial thermal cracking of the hydrocarbon feed stock in a fired heater that is, a heater in which the feed stock is heated by indirect heat exchange with hot gases such as combustion gases. In this two-step process, the first step is performed by introducing the feed stock into a fired heater which can be separate from the flame-cracking apparatus. In this fired heater, the feed stock is vaporized and partially thermally cracked to convert the less refractory components of the feed stock into cracked products. The temperature of this cracking is usually in the range from 750 to 1250°F., though other temperatures can be used in some cases. The mixture of cracked products and uncracked, more refractory components of the feed stock is then introduced into the second step which consists of flame-cracking in the manner previously described. In the flame-cracking step, further thermal cracking of the hydrocarbon mixture takes place, to convert more refractory components

of the original feed stock to cracked products. The conditions in the partial thermal cracking step are such as to minimize carbon formation.

5 This two-step process is advantageous in some instances in that it enables a gas of higher heating value and lower specific gravity to be obtained than in flame-cracking as previously described, or in flame-cracking with
10 previous vaporization under substantially non-cracking conditions, also as previously described. The properties of the product gas can be varied by varying the amount of cracking which takes place in the first step. A relatively
15 high degree of cracking in the first step makes it possible to reduce the amount of oxygen-containing gas which is used in the flame-cracking step, relative to the amount of hydrocarbon which is cracked, and this results in
20 higher heating value and lower specific gravity in the product gas. In some commercial installations, the latter characteristics may be important. The product gas characteristics may be varied between 0.75 and 1.10 specific gravity for example, and between 350 and 1000 BTU
25 per cubic foot heating value.

In a further embodiment of the invention, a three-step process is carried out in which the feed stock is first vaporized by indirect heat exchange with product gas, in the manner
30 previously described herein, and the vaporized feed stock, at a temperature for example of 700°F., is then introduced into a separate fired heater wherein it is raised to thermal cracking temperature to produce partial thermal cracking, as described just previously in connection
35 with the two-step process. The mixture obtained from the partial cracking step is then introduced into a flame-cracking step as previously described, in order to obtain further cracking. This three-step process differs from
40 the two-step process previously described in that, in the three-step process, the heat for initial vaporization of the feed is provided by heat exchange with the product gas, rather than by heating in the separate fired heater.
45 In both processes, the heat for partial thermal cracking, however, is provided in the separate fired heater.

WHAT WE CLAIM IS:—

50 1. Process for cracking hydrocarbons, which comprises: introducing a hydrocarbon or mixture of hydrocarbons as feed stock in finely

distributed form as defined herein to impinge on the flame of a burner firing into one end of a cracking zone, in such manner that the impingement zone temperature is 800—1600°F. (425—870°C.), thereby to produce a gaseous mixture of combustion products and products of cracking of the feed stock. 55

2. Process according to claim 1, wherein the feed stock is introduced into said zone at a plurality of locations around the periphery thereof. 60

3. Process according to claim 1 or 2, wherein the feed stock upon said introduction is directed at an acute angle with the axis of the flame and toward the flame. 65

4. Process according to claim 1, 2 or 3, wherein the feed stock is a liquid light petroleum hydrocarbon fraction, which is vaporized before its introduction into said region. 70

5. A process according to any of claims 1 to 4, in which the hydrocarbon is a petroleum fraction having a 95% boiling point below about 700°F. 75

6. Process according to any preceding claim, in which the burner flame is provided from a hydrocarbon fuel and a gas containing free oxygen. 80

7. Process according to Claim 6, in which the burner fuel and the hydrocarbon cracking feed are the same hydrocarbon fraction.

8. Process for cracking a hydrocarbon, as hereinbefore described with reference to the accompanying drawings. 85

9. Process for cracking a liquid light petroleum hydrocarbon fraction, as hereinbefore described with reference to the foregoing Example. 90

10. Combustible fuel gas, when produced by cracking a hydrocarbon by a process according to any preceding claim.

11. Combustible gas according to Claim 10, having a calorific value of 200—800 BThU per cubic foot. 95

12. Combustible gas according to Claim 10 or 11, having a hydrogen content below 30 Vol. %.

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distributed form as defined herein to impinge on the flame of a burner firing into one end of a cracking zone, in such manner that the impingement zone temperature is 800—1600°F. (425—870°C.), thereby to produce a gaseous mixture of combustion products and products of cracking of the feed stock.

2. Process according to claim 1, wherein the feed stock is introduced into said zone at a plurality of locations around the periphery thereof.

3. Process according to claim 1 or 2, wherein the feed stock upon said introduction is directed at an acute angle with the axis of the flame and toward the flame.

4. Process according to claim 1, 2 or 3, wherein the feed stock is a liquid light petroleum hydrocarbon fraction, which is vaporized before its introduction into said region.

5. A process according to any of claims 1 to 4, in which the hydrocarbon is a petroleum fraction having a 95% boiling point below about 700°F.

6. Process according to any preceding claim, in which the burner flame is provided from a hydrocarbon fuel and a gas containing free oxygen.

7. Process according to Claim 6, in which the burner fuel and the hydrocarbon cracking feed are the same hydrocarbon fraction.

8. Process for cracking a hydrocarbon, as hereinbefore described with reference to the accompanying drawings.

9. Process for cracking a liquid light petroleum hydrocarbon fraction, as hereinbefore described with reference to the foregoing Example.

10. Combustible fuel gas, when produced by cracking a hydrocarbon by a process according to any preceding claim.

11. Combustible gas according to Claim 10, having a calorific value of 200—800 BThU per cubic foot.

12. Combustible gas according to Claim 10 or 11, having a hydrogen content below 30 Vol. %.

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