March 14, 1944. W. B. HINCKE 2,343,866

PROCESS FOR THE PYROLYSIS OF HYDROCARBONS

Filed Oct. 7, 1938

FIG. 1.

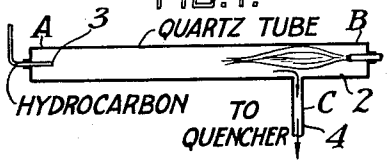


FIG. 2.

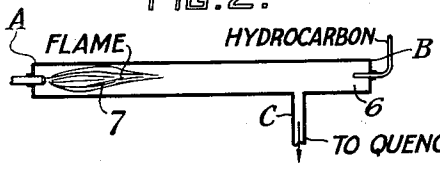


FIG. 3.

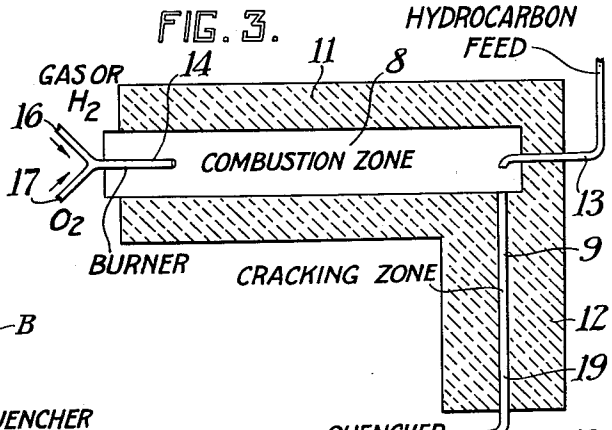


FIG. 4.

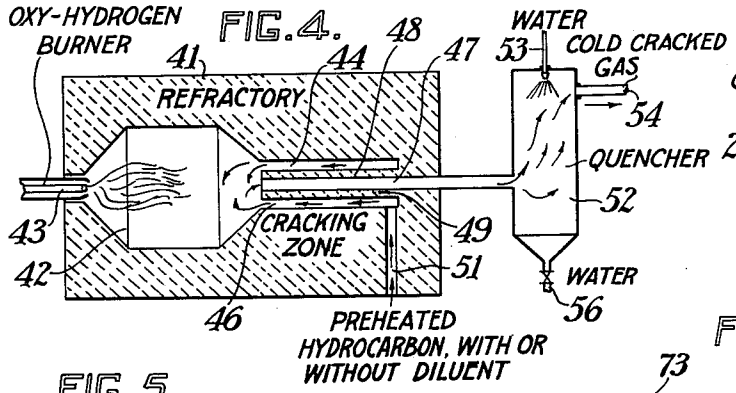


FIG. 5.

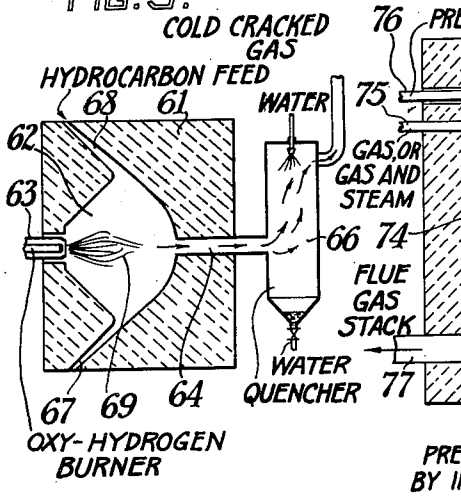
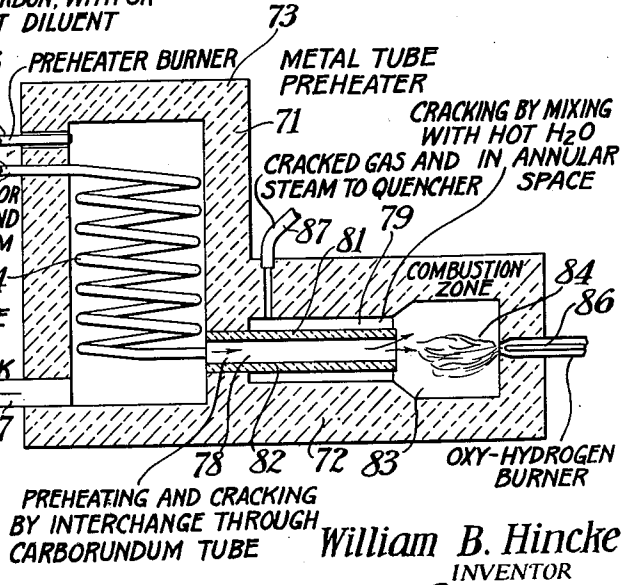


FIG. 6.



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Patented Mar. 14, 1944 2,343,866

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2,343,866

PROCESS FOR THE PYROLYSIS OF HYDROCARBONS

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Application October 7, 1938, Serial No. 233,809

2 Claims. (Cl. 260—679)

This invention relates to the pyrolysis of hydrocarbon materials and more particularly to a thermal process for the manufacture of acetylene wherein at least a part of the heating is obtained by mixing products of complete combustion with the hydrocarbon to be pyrolyzed.

Unsaturated hydrocarbons and in particular acetylene, have many industrial uses. Acetylene is used directly or indirectly in the manufacture of aldehydes, acids, polymerization products and various other compounds. Acetylene has been manufactured from calcium carbide. This is rather an expensive source of acetylene and has other limitations. Various electrical processes, such as employing the heat of an electric arc, have been suggested but, likewise, many of these processes are not economical. It has also been proposed to produce acetylene by pyrolysis of hydrocarbons wherein the heating takes place indirectly through furnace walls or other barriers. In view of the high temperatures employed, deterioration of equipment is rapid in many instances or special equipment may be required.

It has also been proposed to produce acetylene by the partial combustion of hydrocarbons. In such incomplete combustion processes, a part of the hydrocarbon is burned to generate heat within the remainder, which exerts the pyrolysis or cracking effect producing the acetylene. It is apparent that such incomplete combustion processes subjects all of the cracking stock to partial combustion and produces relatively low yields of acetylene, mixed with a variety of combustion products. Various miscellaneous processes have also been suggested for the manufacture of acetylene.

In general, it may be stated that the manufacture of acetylene requires large quantities of thermal energy at high temperatures, for example, greater than 1000° C. The transference of thermal energy at high temperatures presents various problems, inasmuch as the use of ceramics may be required. Transfer of heat through ceramics may reduce the efficiency of the process to some extent as well as induce thermal distortion and deterioration of the apparatus. The use of metals at high temperatures, while more efficient, is limited because at temperatures above 1000° C. for example, it presents a range wherein commercially available metal equipment is not particularly serviceable.

I have devised a process and apparatus for the manufacture of unsaturated hydrocarbons and particularly acetylene, wherein the efficiency of the various heating steps has been improved and the various disadvantages relative to heat transfer have been minimized to a large extent. I have developed a simplified and improved process and apparatus particularly adapted for the manufacture of acetylene.

This invention has for one object to provide a process for the manufacture of unsaturated hydrocarbons and in particular acetylene. Still another object is to provide a pyrolysis process for the decomposition of saturated hydrocarbon wherein at least a part of the heat is directly supplied to the hydrocarbon. Still another object is to provide a pyrolysis process wherein heat losses because of transference through furnace walls or other barriers, is reduced to a minimum. Still another object is to provide a pyrolysis process wherein there is a particular type of combustion. Still another object is to provide a pyrolysis process wherein a substantial proportion of the heat may be supplied in a preheating step employing more or less conventional heating at relatively high mass velocities. A still further object is to provide a pyrolysis process for the thermal decomposition of non-acetylenic hydrocarbons wherein undesirable catalytic effects are minimized. A still further object is to provide a pyrolysis process which is relatively simple and efficient.

Still another object is to provide a pyrolysis apparatus adapted for the direct heat transfer to the hydrocarbon to be heated. A still further object is to provide a pyrolysis apparatus wherein both preheating and final heating may be carried out. Still another object is to provide a pyrolysis apparatus wherein thorough mixing may be caused to take place between at least a part of the heating medium and the hydrocarbon treated. Still another object is to provide a pyrolysis apparatus wherein an undesired catalytic effect may be minimized. A still further object is to provide a pyrolysis apparatus which is relatively simple in construction and operation.

A still further object is to provide novel construction materials which may be employed at least in part for the construction of pyrolysis apparatus. A still further object is to provide construction employing both novel alloy parts and ceramics. A still further object is to provide particular composition alloys adapted for the use in pyrolysis apparatus. Other objects will appear hereinafter.

I have found a method for cracking hydrocarbons wherein an oxy-hydrogen or oxy-gas mixture is burned in such manner that the hot products of combustion either partially or entirely

heat and crack the hydrocarbons by mixing with them. In my process, the flame is preferably so placed that only the hot water vapor (hydrogen oxide) formed mixes with the stream of hydrocarbon to be cracked.

The combustion of the oxy-hydrogen or similar or equivalent) flame, should be complete so that very little hydrocarbon is subsequently reacted with the oxygen. The stream of hydrocarbon gas to be pyrolyzed may be so arranged that it prevents impingement of the flame on any refractory surface.

After mixing the flame vapors with the hydrocarbon gas so that the sensible heat in the flame vapor heats up the mixture rapidly the mixed gas and steam are passed through a cracking zone where they become rapidly cracked to the desired degree at temperatures, for example 1000°–1400° C. The reaction mixture may be then rapidly cooled in a quencher, the water condensed, the cracked gas separated and/or other procedure applied.

For a more complete understanding of my invention, reference is made to the attached drawing forming a part of the present application.

Fig. 1 is a semi-diagrammatic side elevation view in the nature of a flow sheet showing the general arrangement of an apparatus for carrying out my process.

Fig. 2 is another view similar to Fig. 1, showing a slightly modified arrangement.

Fig. 3 is also a semi-diagrammatic side elevation view showing in greater detail an apparatus arrangement which might be employed for carrying out my process.

Figs. 4 and 5 are other semi-diagrammatic side elevation views of various different type apparatus constructions which might be employed for carrying out my process.

Fig. 6 is a side elevation view of a preferred type apparatus which might be employed for carrying out my process. In this view as well as in certain of the other views some of the parts have been shown on section and other parts in exaggerated scale for clarity.

The functioning of the various parts of the apparatus and the operation of my process may be understood to some extent from the legends appearing on the various figures. In Fig. 1, A—B represents a quartz tube having a side tube C joined thereto. A portion of this quartz tube as at 2, functions as the combustion chamber, whereas another portion of the tube 3 functions as the hydrocarbon inlet. The side tube as at 4, may be connected to a quencher or other type device (not shown) employed in the art.

Fig. 2 is substantially similar to Fig. 1 in that it comprises the quartz tube A—B with the side tube C. However, in this arrangement the hydrocarbon inlet 6 in differently located than the hydrocarbon inlet 3. Likewise, the combustion chamber 7 is differently located than the combustion chamber 2.

The apparatus of Fig. 3 is to some extent similar to that already described, inasmuch as it comprises the elongated tube 8 and the side tube 9. These various parts are substantially insulated as at 11 and 12 to prevent heat losses. A hydrocarbon feed inlet may be provided at 13. Substantially opposite the hydrocarbon inlet and positioned at a proper distance therefrom is the burner construction 14. Preferably, the burner should be so disposed that the hydrocarbon gas is mixed with the hot products of combustion from the flame only after substantially complete combustion to hot hydrogen oxide has taken place.

The apparatus is equipped with various parts such as feed lines 16, 17 for conveying materials to the burner. The cooling device 18 may be provided to connect the cracking zone 19 with a trap as at 21. Suitable draw-off conduits may be provided at 22 and 23. The apparatus of Fig. 3, for example, may be constructed of silicon carbide, zirconium silicate or various ceramics which will withstand the temperature.

In the apparatus of Fig. 4 the shell of the heating chamber 41 may be constructed of any of the various refractories already mentioned or various fused or sintered aluminum oxides. The shell would be built up in order to provide an enlarged chamber 42. At one end of the chamber a suitable burner structure 43 would be inserted. At the other end of the chamber at 44 means are provided for introducing the hydrocarbon to be cracked.

In the device shown this means comprises the concentric passageways 46, 47. The passageways are separated by the walls 48, 49. By this construction the hydrocarbon introduced at 51 flows on the outside of the walls 48, 49, thereby absorbing some heat and into the chamber 42. After becoming mixed with the products of complete combustion the materials leave the apparatus through passageway 47 which is connected to a quenching device 52.

The quenching device would include inlet 53 for the quenching medium, and an outlet 54 for the treated gas. Suitable drawoff arrangement may be provided at 56 for withdrawing the liquid components.

The modified apparatus of Fig. 5 is likewise constructed of high-grade refractory as at 61. This shell may be built up of refractory bricks or other such units. A suitable chamber is provided at 62. One or more oxy-hydrogen burners may be positioned at one end of the chamber 63. The other end of the chamber may be provided with an outlet passageway 64 leading to a suitable cooling device 66. Inasmuch as this cooling device is substantially similar to device 52, further description at this point is unnecessary.

In the apparatus of Fig. 5 the hydrocarbons to be pyrolyzed may be supplied through the plurality of inlet conduits 67, 68 and 69. By this arrangement large capacity and thorough mixing may be obtained, as well as preventing the direct impinging of the hot products of combustion from the burner on the refractory wall. Sudden and complete mixing of the gas to be cracked is very desirable, otherwise a portion of the process gas may become overcracked or deteriorate by reforming to CO. This may be avoided by reducing the whole of the mixed gas to a suitable cracking temperature by mixing all of the process gas as rapidly as possible with the heating gas. The contact time that the process gas holds the high cracking temperature is determined by the velocities used and the size of the outlet tube 64 going to the quencher.

It is to be understood that the apparatus described may be equipped with various ancillary devices. For example, fuel and/or air preheaters may be connected to the oxy-hydrogen burners. Suitable temperature recording devices and the like may be attached to the various parts of the apparatus.

The apparatus disclosed in Fig. 6 represents one of my preferred arrangements. This arrangement comprises the shell 71 which houses

the preheating device and the adjacent shell 72 which houses the cracking chamber. As already discussed, these parts may be constructed of a suitable refractory, properly insulated. The various fittings would be constructed of suitable heat and corrosion-resistant metals.

Referring to the preheating shell, this portion of the apparatus comprises heating chamber 73. A metal tube preheater 74 is positioned within the chamber. The preferred constructional features of this preheater such as the metal employed, capacity, etc., is of importance and will be considered in detail hereinafter. A suitable burner of conventional type adapted to burn any readily obtainable commercial fuel is positioned at one end of the heating chamber as at 76. A suitable flue for withdrawing the stack gases is positioned at 77.

The preheating coil 74 is connected to one of the concentric passageways 78 of the concentric passageways 78, 79. These passageways are separated by the walls 81, 82. This arrangement functions somewhat similarly to the device already described. The preheated gas is conducted through the passageway 78 into the cracking chamber 83. The gas at this point becomes mixed with the heating medium 84 generated by the oxy-hydrogen burner 86. The hot mixture is then conducted through the passageway 79 to the conduit 87 that leads to a suitable cooling device (not shown).

Although the operation of my apparatus is more or less apparent from the preceding description and the legends attached to the respective figures, further understanding of the operation will be apparent from the following disclosure relative to my novel process.

As already pointed out, the manufacture of acetylene requires high thermal input and high temperatures of, for example, between 1100° C.–1600° C. The transfer of heat at such high temperatures through ceramic walls or other barriers for cracking a hydrocarbon involves thermal strains, distortion, heat losses and the like. While various metals transfer heat more or less readily as compared with ceramics, the metals do not satisfactorily withstand extremely high temperatures.

I have found that by the proper type combustion, extremely high temperatures may be generated and the combustion materials injected directly into the hydrocarbon being thermally treated. By my process employing the injection of the completely burned materials into the hydrocarbon a number of disadvantages relative to heat transfer are minimized. Also, by my particular type combustion, disadvantages relative to polluting the acetylene are largely minimized. Although acetylene, and hydrocarbons in general, are of an explosive nature my process may be carried out without any undue explosure hazards. The furnace would be brought up to temperature using producer gas, natural gas or any other gas burned with air before changing over to oxy-hydrogen fuel. The burner would, of course, be operated to and designed to avoid flash-back.

I have found that the products of combustion from an oxy-hydrogen flame or similar or equivalent flame comprising a substantial amount of hydrogen oxide and the absence of substantial amounts of oxygen, may be introduced and mixed directly with the hydrocarbon to be cracked. Such procedure affects a high temperature rise in the hydrocarbon accompanied by thermal decomposition thereof to produce a reaction mixture containing acetylene. I have found that the steam (hydrogen oxide) resulting from combustion of oxygen and hydrogen or other gas in any oxy-hydrogen burner even at the high temperatures involved, does not materially dissociate. The dissociation of the products of combustion from the oxy-hydrogen flame in my process and apparatus would probably be less than a few percent at the temperature of the gas mixture in the cracking zone, that is, at 1000° C.–1400° C. For example at the temperature of the flame the dissociation of the products of combustion just after complete burning of the oxygen and hydrogen might be as high as 4–5%, at 2500° C., and 1 atmosphere partial pressure of water vapor. This would give a partial pressure of about .02 to .0025 atmosphere of oxygen and from about .04 to .005 atmosphere of hydrogen.

I have found that the effect upon the pyrolysis reaction of any small amount of oxygen which may be present through dissociation or otherwise, is to some extent dependent upon the surface or packing in the preheating and/or combustion chambers. In my novel process where steam or water vapor may be present with the gas treated, the dissociation or reforming of the gas is counteracted to a great extent by the use of proper materials of construction for both the preheater and cracking chamber, as well as the preferred and controlled short times of contact, as will be set forth in further detail hereinafter.

For a further understanding of my invention, reference will now be made to the following examples described in connection with the several figures shown in the attached drawing.

Reference is now made to Fig. 1, representing a simplified process and apparatus. A quartz tube A—B with a quartz side tube C as shown in Fig. 1, was employed. In the process, first carried out, the oxy-hydrogen flame was at B and the hydrocarbon gas passed into the apparatus at A. The gas and flame in this process actually mixed countercurrent-wise before leaving the hot zone through the tube C to be quenched. The quantity of acetylene formed was not as great by this procedure as by the procedure diagrammatically indicated in the apparatus of Fig. 2.

In Fig. 2 the gas was fed to the tube at B and mixed with the hydrogen oxide from the more or less completely burned oxy-hydrogen flame at A. By this procedure the quantity of acetylene in the cracked gas was increased several percent and the carbon monoxide, carbon dioxide and hydrogen were considerably lower. In the aforementioned examples, as in other of the processes, saturated hydrocarbons such as ethane, propane, butane and the like were employed. Sufficient oxygen and hydrogen were burned in the burner to cause the temperature of the hydrocarbon in the cracking zone to be raised to 1400–1600° C. The hydrocarbons were caused to remain under cracking conditions for only a short residence period, for example, generally less than one-hundredth of a second and the resultant cracked products were rapidly cooled.

Similar procedure was carried out in the apparatus of Fig. 3, but on a larger scale with the production of 6% or more acetylene per pass; hence, further description with respect to Fig. 3 is unnecessary.

In carrying out a process in accordance with Fig. 4, the hydrocarbon to be pyrolyzed was preheated (by means of an economical and commer-

cially obtainable fuel) outside of the cracking apparatus. The preheated hydrocarbon was fed into the cracking chamber through passageway 51 and passed in heat transfer relationship with the hot outgoing products through conduit 47.

The preheated hydrocarbon which may, if desired, be diluted with steam, nitrogen, mercury or various other diluents became mixed with hot hydrogen oxide in the chamber 42. This additional heat input induced further thermal decomposition and formation of acetylene. The injection of the hot products of combustion from the oxy-hydrogen burner also caused increased velocity of flow of the reaction mixture through passageway 47 into the quenching device 52 wherein the acetylene gas was rapidly cooled.

By first heating to about 900–1000° in a suitable preheater, the low temperature cracking takes place prior to mixing the gas with the hot products of combustion. By so heating a great saving in fuel for the oxy-hydrogen flame is effected. Moreover, the conditions of temperature and contact time in the high temperature reaction are more easily controlled with a better yield of acetylene in the cracked gas.

In the process as carried out in Fig. 5, procedure similar to that already described was followed. However, it will be noted with respect to Fig. 5, that the tempering of the heat in the combustion zone is accomplished by causing all or part of the hydrocarbon gas being cracked to enter at certain points in the refractory wall, being careful that the gas is not exposed to direct flame impingement.

By my procedure, since hydrogen and oxygen will burn very rapidly, the gases can be mixed in a suitable burner and caused to burn at a high velocity and produce a short brush flame. This flame will be completely surrounded with a zone of hot steam. The apparatus arrangement of Fig. 6 will be described in more detail, inasmuch as it represents one of my preferred apparatus arrangements. As already set forth, in accordance with my process it is desirable that the thermal treatment of the hydrocarbon should be carried out in a refractory apparatus built of a high-grade refractory material having as little surface as possible and such surface having little catalytic effect on the reforming reactions of the steam and hydrocarbon gas. Preferably, the flame from the oxy-hydrogen burners should be so dispersed that the hydrocarbon gas is readily mixed with the hot products of combustion from the flame and after substantially complete combustion to hydrogen oxide.

In order to further render my process more efficient and to economize on the specialized cracking heat required from the oxygen and hydrogen, which is a more expensive fuel than other fuels commercially obtainable, I preferably subject the hydrocarbon gas to a preliminary heating such as shown in Fig. 4 and more fully shown in Fig. 6.

The hydrocarbon gas to be treated or the mixture of hydrocarbon and diluent is fed at 75 into the preheating coil 74. Preferably, this preheating coil is of a particular composition and construction as will be described in detail hereinafter. This coil may be heated by any conventional and economical type fuel supplied to the burner 76. Temperatures between 900° C. and 1100° C. may be applied to the metal tube with relatively efficient heat transfer thereby substantially raising the temperature of the hydrocarbon.

By this procedure the amount of heat to be supplied from combustion of oxygen-hydrogen is reduced to a small amount.

As will be pointed out it is highly desirable that the heating period in this preheater be a relatively short time. The highly preheated hydrocarbon with or without a diluent is then conducted through the passageway 78 into the pyrolysis chamber 83. In a manner similar to that described with respect to Fig. 4, the incoming hydrocarbon is further heated by the outgoing acetylene containing reaction mixture.

The hot preheated hydrocarbon gases to be cracked, at a temperature generally less than 1000° C. and containing various unsaturated hydrocarbons such as ethylene, a small amount of acetylene under 5%, are rapidly heated by the injection of the combustion products from the oxy-hydrogen burner. This raises the temperature of the hydrocarbons to between 1200–1600° C., thereby causing the formation of further acetylene. The reaction mixture containing acetylene is then rapidly withdrawn through the conduit 87 to quenching, purification, acetylene separation or other treatment.

As already indicated, for optimum results it is desirable that the preliminary heating be carried out under the particular conditions to be described. Although it has been known to employ short contact time in pyrolyzing hydrocarbons in a ceramic apparatus, it has not been understood what procedure to apply in a preliminary heating. I have found that it is very important for optimum yields that the temperature, contact time and type of metal alloy tube used for the preheater be carefully adjusted. I have found that for optimum results the preliminary heating should be at a temperature of over 850° C., that the contact time in the alloy tube should be very short, and that the alloy tube should contain little or no metals detrimental to the reaction.

Many metals or alloys exert a tendency which causes the gas being preheated to decompose into carbon and hydrogen. If the hydrocarbon gas being heated also contains some diluent such as steam, the reforming action is rapid and carbon monoxide, carbon dioxide and hydrogen would build up in the gas being subjected to a preliminary heating.

I have found that ordinary black iron catalyzes the decomposition or reforming reaction as little as many alloys. However, the use of iron at high temperatures and under oxidizing conditions presents structural difficulties. I therefore have found that it is possible to use iron alloys containing little or no nickel but containing one or more elements such as chromium, silicon, aluminum, tungsten, molybdenum and manganese.

Besides the selection of an alloy with the least detrimental catalytic effect on the hydrocarbon gas being treated, it is also desirable that the volume and surface of the preliminary heating device be such that the gas is heated rapidly to as high a temperature as possible without appreciable decomposition or reforming with any diluent, steam (or other diluent) which might be introduced with the hydrocarbon. If ethane, propane, butane or other constituents in a hydrocarbon feed gas are heated and cracked to gas high in olefine content, this content increases to a maximum and then decreases rapidly with increasing temperatures. I have found that at higher temperatures the products of decomposition and reforming may become appreciable. The amount of these products will lower the yield

of olefines produced in the preheater which in turn will greatly lower the yields of acetylene from the final cracked gas. I have found that it is possible, using the proper alloy, to subject the gases to a preliminary heating at a higher temperature without reforming and decomposition and thus accomplish a high total of the cracking heat by transfer through a metal component of the apparatus. Aside from the catalytic effect of the alloy preheater on the gas being cracked, I have found that the contact time of the gas in the preheater should be considerably shorter than has heretofore been used. It is not sufficient that the contact time in the final decomposition step be kept short, but the total heating period in both the preliminary heating zone and high temperature zone should be effected in a short time interval.

If the contact time in the preheater is too long, even though the alloy has little catalytic effect on the degrading reactions it is possible to overcrack the gas even at low temperatures. For optimum yields of acetylene and for increasing the output, it is desirable that the alloy tube transfer a substantial part of the heat to the process gas in such a time interval that the gas passed on to the high temperature cracking in ceramic equipment, is heated as high as possible. Under proper conditions the heated process gas will subsequently produce better yields of acetylene.

Therefore, I propose a cracking process and apparatus involving the use of a series combination of a metal preliminary heating apparatus followed by a ceramic high temperature heating arrangement. The heat resistant metal alloy is of such a composition as to have low catalytic effect on the unwanted side reactions. A variety of such alloyed compositions will be set forth hereinafter. The contact time in the preheat is so adjusted that it is less than .020 minute. Contact time is here defined as the volume in cubic feet of the preliminary heating coil and connecting pipes defined by the c. f. m. rate or flow of the gas plus a diluent such as steam, measured at 60° F. and 760 mm. For example, for heating a mixture of 25 c. f. m. of butane and 200 c. f. m. of steam diluent, I propose a maximum allowable preheater volume of 4 c. f. from the point where the gas and steam mix at 90–110° C. to the point of inlet to the final cracking zone. The final temperature of the preheated gas for good final cracking and efficient use would be from about 800° C. to 1000° C. The composition of the hot gas from the preliminary heating before entering the contacting chamber would contain a substantial olefine content, for example, 35% or greater and a few percent acetylene.

For a rate of flow of gas and diluent, as indicated above, an alloy tube preheater of four cubic feet volume should have from 80–100 square feet of surface to produce the desired mass velocity for rapid heat transfer. The flue design should be countercurrent to the gas being heated.

As for suitable alloys for metal tube preheaters the following are suggested:

Carbon	.16	1.6	.07	.25
Manganese	.75	20.8	.18	1.0
Silicon	.70	.63	.22	.60
Chromium	30.0	24.75	38.8	28.0
Tungsten	3.5	----	----	----
Aluminum	6.2	5.28	8.01	----
Nickel	---	----	----	----

It is to be understood that my invention relative to preheating followed by thermal decomposition at a higher temperature is not limited exactly to the constructions shown. For example, my novel preheating procedure, heating in the alloys specified, the short time of contact and other features, also might be employed in conjunction with an indirectly fired final cracking chamber. That is, hydrocarbon gases may be preheated in accordance with my invention prior to cracking in a regenerative furnace, elongated carborundum tube or various other type heating furnace.

Ceramic tubes do not transfer heat nearly as readily as do metals, but to obtain high yields of acetylene, cracking temperatures must be obtained above those which alloys will withstand. Inasmuch as the contact time of the gas, in the high heat zone, must be very short in order to obtain the best yields from high temperature, indirect heat cracking in ceramic tubes, it is desirable to first accomplish heat transfer to the gas above 800° C. in an alloy preheater. The heat-transferring-surfaces and volume of tube relationship cannot be obtained for the conditions of rapid high heat transfer without the use of such small gas passages through the ceramic tube that a small carbon deposit would obstruct the gas flow.

It is apparent from the preceding description that I have developed a novel process and apparatus for the production of acetylene from hydrocarbons. My process and apparatus may be applied to a large variety of hydrocarbons such as enumerated in Wulff Patents 1,800,308 and 1,800,309. The hydrocarbons may be treated either with or without dilution with steam, nitrogen or various other diluents. However, in my process of high heat cracking diluents are not so necessary because the combustion products from the oxyhydrogen burners are injected directly into the hydrocarbon. My process may be operated under normal pressure or reduced pressure or at a slight positive pressure. A small degree of reduced pressure is preferred in many instances for increase in velocity.

As apparent from the preceding description, a high temperature preheat is desirable for optimum yields and efficient use of the ceramic ware in the succeeding higher temperature step. If I wish to transfer heat in the preheating step in such a manner that a large olefinic content is obtained in the gas preheated to 1000° C., I have found that the solution to the problem is practically unique as far as the variables under control are concerned. As pointed out, the heat-transferring surfaces should be adequate to heat the gas without having too high a temperature drop in the inside film. The volume of the preheating equipment should be such that the contact time of the gases in the preheater be as short as specified. Furthermore, the mass velocity (mass of gas flowing per unit time per unit cross section area) should preferably be such that the heat transfer through the inside gas film, with the low temperature difference between the tube wall and gas as described, can be effected with the surface available. After satisfying these conditions, the only variance is in the use of smaller diameter conduits. However, the use of too small tubes, I have found, is more or less impractical because this necessitates the use of excessive power to blow the gas mixture through such apparatus. Therefore, it is seen that I have described a particularly satisfactory preheater arrangement. Larger preheating units may, for example, be ob-

tained by combining in parallel, units such as I have described.

While I have described my process particularly in connection with the apparatus of Figs. 1–6, inclusive, it is to be understood that this is not to be considered a limitation upon my invention as certain aspects thereof embrace broader applications. As already pointed out, my novel preheating procedure may be applied in numerous processes for the pyrolysis of hydrocarbons.

Since it is apparent that my process is susceptible of some modifications, I do not wish to be restricted in my invention excepting insofar as is necessitated by the spirit of the appended claims.

What I claim is:

1. A process for the manufacture of acetylene by the pyrolysis of hydrocarbons, which comprises preheating non-acetylenic hydrocarbons in a ferrous alloy chamber comprising iron containing a combined content greater than 30% of the metals, aluminum and chromium, by externally contacting the chamber with combustion gases obtained by the combustion of hydrocarbons, for a period not greater than .05 minute and at a temperature greater than 800° C., but less than 1000° C., thereafter immediately subjecting the preheated hydrocarbons to thermal decomposition at a temperature between 1000° C.–1600° C. by injecting directly into the preheated hydrocarbon to be decomposed a quantity of combustion products burned out of contact with the hydrocarbon and injected thereinto while said combustion products are still hot, in a direction opposed to the direction of flow of said hydrocarbon, the combustion products containing little free oxygen and a large amount of hydrogen oxide, resulting from the combustion of oxygen and hydrogen.

2. A process for the manufacture of acetylene, including direct heating of non-acetylenic hydrocarbon which comprises injecting into and mixing with the hydrocarbons a combustion mixture burned out of contact with the hydrocarbons and injected thereinto before any substantial cooling of the combustion mixture, in a direction opposed to the direction of flow of said hydrocarbons, the combustion products being injected in sufficient quantity and at sufficiently high temperature to raise the temperature of the non-acetylenic hydrocarbons to be pyrolyzed to between 1000° C. and 1600° C. in less than .10 minute for causing the conversion of at least a part of the hydrocarbon to acetylene, and withdrawing and utilizing the acetylene.

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