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PRODUCTION OF UNSATURATED HYDROCARBONS AND REACTOR THEREFOR

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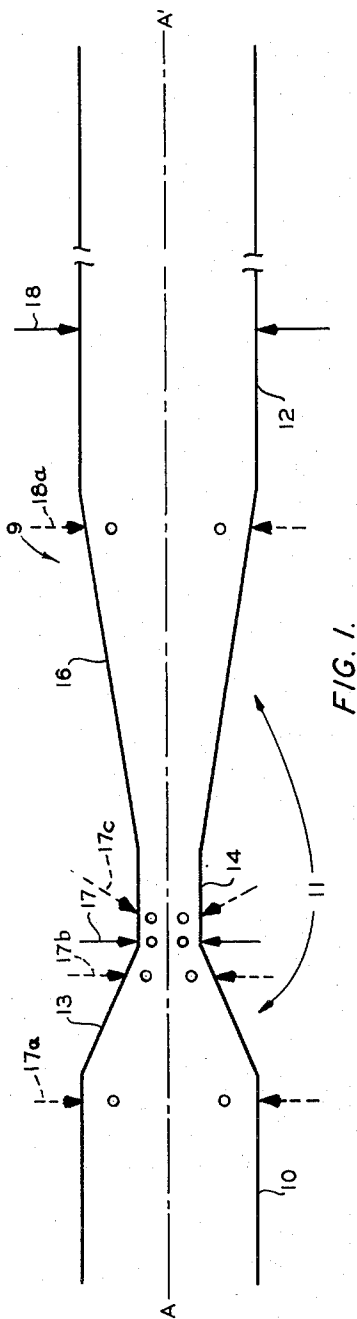


FIG. 1.

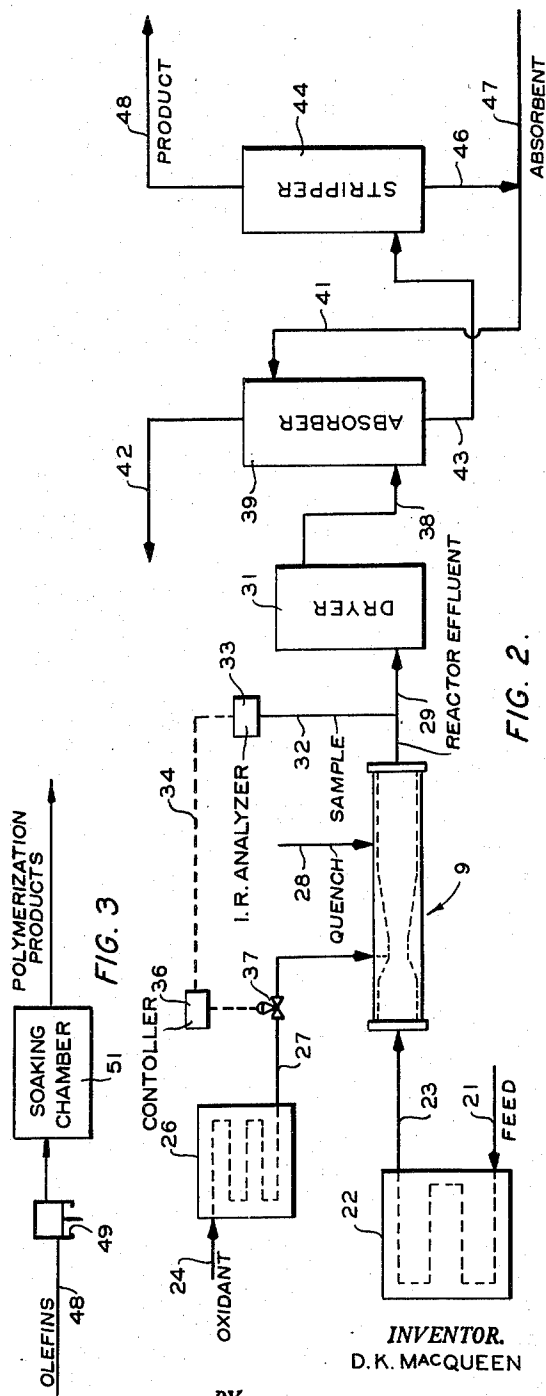


FIG. 2.

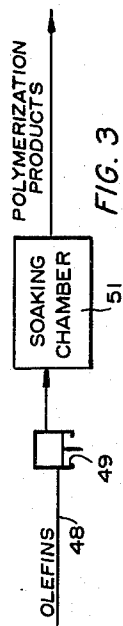


FIG. 3.

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ATTORNEYS

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2,813,138

PRODUCTION OF UNSATURATED HYDROCARBONS AND REACTOR THEREFOR

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Application July 27, 1953, Serial No. 370,296

17 Claims. (Cl. 260—673)

This invention relates to the production of unsaturated hydrocarbons. In one of its more specific aspects, it relates to a novel reactor adapted for use in a partial oxidation process for the production of unsaturated hydrocarbons. In another of its more specific aspects, it relates to a process for the production of unsaturated hydrocarbons such as acetylene, ethylene and benzene.

In the early years of the petroleum industry, the possibilities of producing unsaturated hydrocarbons by the cracking of low boiling hydrocarbons received comparatively little attention. Because of apparatus limitations imposed by the high reaction temperatures involved and the lack of understanding of the best manner of operation, early developments excluded the cracking of low boiling hydrocarbons. Still another deterrent in the development of successful processes was the availability of vast supplies of heavy naphthas which could be cracked by more easily manageable processes to form easily purifiable products in high yield. Recent advancements made in organic chemistry have resulted in an increased demand for petro-chemical starting materials such as acetylene, ethylene and benzene to such a point that it is no longer possible to rely on the old sources of supply for these materials. Thus, the demand for ethylene and benzene has reached such proportions that it cannot be supplied from refinery streams without upsetting the balance in the production of motor and aviation fuels. And furthermore, commercial production of acetylene by reacting calcium carbide with water is too expensive and is limited to amounts far too low to satisfy the demand for acetylene as a chemical synthesis starting material. Accordingly, the development of successful processes for producing unsaturated hydrocarbons by the cracking of low boiling hydrocarbons has in recent years taken on added importance.

Various methods for the pyrolysis of gaseous hydrocarbons have been proposed which involve a variety of heat sources, including externally heated tubes, electric heating resistance elements, and spark or arc electric discharges. The lack of cheap electric power has also drawn attention to other possible methods of heating such as by the combustion of preheated natural gas with preheated compressed air. In such latter processes, the heat may be applied either to the outside of refractory tubes or to a checker-work heat exchanger in which combustion and pyrolysis take place alternately.

It is also well known to the workers in the art that hydrocarbons may be converted into olefins and acetylene by a high temperature heat treatment wherein partial oxidation of the hydrocarbon feed is utilized to supply the endothermic heat of the cracking reaction. It has been found, however, that the partial oxidation processes described in the literature fail to meet expectations in that the claimed theoretical high product yields are impossible of attainment, or if actual product yields are recorded in a reduction of the process to practice, such yields have been consistently low. The shortcomings of these processes can be attributed at least in part to the improper

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mixing of the hydrocarbon feed and oxidant which results in overcracking and undercracking. Improper mixing of the reactant gases also causes a non-uniform heating of the reactant material which results in the development of "hot spots" with consequent failure of the refractory material lining the reaction chamber walls. By employing the reactor of this invention in processes for the production of unsaturated hydrocarbons, it is possible to overcome the aforementioned operational difficulties while still obtaining a high yield of desired product.

The following objects and advantages will be attained by the various aspects of the invention.

It is an object of this invention to provide a novel reactor for use in processes for cracking low boiling hydrocarbons.

Another object is to provide an improved method of mixing preheated hydrocarbon and oxidant gases within the reaction zone of a cracking process so that the resultant partial oxidation of the hydrocarbon in proximity to the cracking reaction supplies the heat of activation as well as the heat of cracking to the remaining hydrocarbon.

Another object is to provide a process for the production of acetylene.

Another object is to provide a process for the production of ethylene.

Another object is to provide a process for the simultaneous production of both acetylene and ethylene.

Another object is to provide a process for the production of benzene and toluene.

Still another object is to provide a universal reactor design for use in partial oxidation processes for the manufacture of acetylene, ethylene, benzene, toluene, mixtures of acetylene and ethylene, and mixtures of benzene and toluene, utilizing low boiling hydrocarbons as feed.

A further object is to provide a dependable method for the control of temperature and reaction time in processes relating to the cracking of low boiling hydrocarbons.

A still further object is to provide a reactor for the production of unsaturated hydrocarbons which is compact, inexpensive to install, and simply and easily constructed.

Still other objects and advantages will be apparent to those skilled in the art from the following descriptions and disclosure.

In accordance with the present invention a reactor is provided which comprises a fluid inlet conduit, a fluid outlet conduit, and a venturi comprising a converging section, a throat section and a diverging section. The venturi is disposed so that the converging section is connected to the downstream end of the fluid inlet conduit while the diverging section is attached to the upstream end of the fluid outlet conduit which has a quenching or cooling means positioned therein. A plurality of pairs of opposed fluid inlet jets, preferably, radially-disposed and diametrically-opposed, are positioned in the reactor between the downstream end of the throat section and a vertical plane intersecting the fluid inlet conduit preferably no farther than one throat section diameter upstream from the beginning of the converging section.

In the employment of the reactor in a partial oxidation process for the production of olefins or acetylene, a hydrocarbon feed is introduced axially through the fluid inlet conduit while an oxidant is injected laterally into the reactor through the fluid inlet jets. It is to be understood, however, that the manner of fluid introduction can be reversed so that the hydrocarbon feed constitutes the lateral gas while the oxidant is the axial gas. The axial gas in passing through the venturi undergoes a pressure drop with a corresponding increase in mass velocity in this part of the reactor. Simultaneously with the passage of the axial gas through the venturi, a lateral gas

is being injected into the reactor through the fluid inlet jets so that the streams of gas impinge in the reactor. A condition of extreme turbulence is thereby created in the venturi, resulting in a rapid and uniform mixing of the axial and lateral gases.

Since the hydrocarbon feed and the oxidant have been preheated prior to introduction into the reactor, a combustible mixture is formed which immediately burns, the hydrocarbon undergoing an incomplete combustion. As this latter reaction is exothermic, the temperature of the remaining hydrocarbon is concomitantly raised to a level suitable for the formation of the desired product. Immediately thereafter the effluent is quenched or cooled to a temperature at which the product is stable.

A wide variety of hydrocarbon feed stocks can be used in the practice of the processes of this invention. Those which are suitable include methane, ethane, propane, butane and mixtures of these hydrocarbons and/or the corresponding olefins. Oxidants which can be utilized include oxygen, air, oxygen-enriched air, oxygen and steam, air and steam, and oxygen-enriched air and steam. In selecting an oxidant and/or diluent, the addition of difficultly separable inert gases should be avoided, and for this reason the additional cost of oxygen may be justified when it is realized that the addition of air involves the separation of nitrogen from the effluent gases. The addition of steam in the process for the production of acetylene results in an increased yield, and in any case has the benefit of removing any carbon formed on the reactor walls.

In the various processes of this invention, the reaction temperatures vary from about 1400° F. to 2700° F. and higher while the reaction times are in the range of about .0005 second to about 2 seconds. Furthermore, it can be stated that, in general, the preheat temperature of the hydrocarbon feed and the reaction temperature will be lowered as the molecular weight of the hydrocarbon feed increases. Accordingly, in the production of acetylene, methane can be preheated to 1700° F. and higher without severe cracking, and best results are obtained near the top of the desired reaction temperature range of about 2400 to 2700° F. With ethane as the feed, a lower preheat temperature range from about 1100 to 1500° F. is utilized with the reaction temperature lying in the range of about 2400 to about 2650° F. In the case of propane as the feed, the preheat temperature can vary from about 1200 to 1500° F. with a reaction temperature from about 2400 to 2600° F. while with butane a preheat temperature from about 1200 to 1400° F. can be employed with a reaction temperature between about 2400 and 2500° F. For the production of ethylene the preheat temperature of the hydrocarbon feed is near the lower end of the range of temperatures used for the production of acetylene as outlined above whereas the reaction temperature is in the approximate range of 1400 to 1700° F. In the process for the production of both acetylene and ethylene, a reaction temperature in the range of about 1700 to about 1900° F. is utilized while the preferred preheat temperatures are approximately 50 to 100° F. higher than those employed in the production of ethylene. For the production of benzene and toluene, the operating conditions for the cracking reaction can be selected from the above processes to produce the desired olefinic stock which is then treated by polymerization processes for the conversion of the olefins to aromatics.

In general, it can be stated that the reaction times vary inversely with the reaction temperatures, i. e., the higher the reaction temperature the shorter the reaction time. In the case of the production of acetylene, it is important that the reaction be allowed to proceed for only a very short period of time, for otherwise decomposition and polymerization of the acetylene will result with a correspondingly small product yield. It will become apparent that the reactor of this invention is well adapted for effecting the control over reaction temperatures and

reaction times necessary to obtain a high yield of the desired product.

While in the practice of the processes of this invention, the reaction temperatures will fall within the ranges as previously discussed, it has been found that the measurement of high temperatures in gaseous reactions of short duration is not at all times accurate nor dependable. Accordingly, the reaction temperatures are not utilized to control the processes, but rather control is based on depth of cracking which is proportional to both reaction temperature and reaction time. In adapting the reactor of this invention to one of the several processes, a given rate of axial flow of preheated hydrocarbon feed places the time of reaction in a limited range for that particular reactor. By varying the amount of oxidant gas, more or less of the partial oxidation reaction is brought about which automatically limits the temperature of the cracking process. By analyzing a portion of the quenched effluent stream so as to determine the concentration of a key component, the amount of oxidant introduced into the reactor can be controlled so as to ensure that a predetermined amount of the key component is at all times present in the stream. In this manner sensitive control over the cracking operation can be maintained without resort to reaction temperature and time measurements.

A more complete understanding of the invention may be obtained by reference to the following description and the accompanying drawing, in which:

Figure 1 is a diagrammatic longitudinal section of the novel reactor of this invention;

Figure 2 is a diagrammatic flow diagram of an arrangement of apparatus in which the processes for the production of acetylene, ethylene, or a mixture of acetylene and ethylene can be practiced and

Figure 3 is a diagrammatic flow diagram of an arrangement of apparatus in which the process for the production of aromatics can be practiced.

Referring to the drawing and in particular to Figure 1, reactor 9 comprises three principal sections, namely fluid inlet conduit 10, venturi 11 and fluid outlet conduit 12. The venturi in turn is made up of three sections as follows: converging section 13 in the form of a truncated cone, a throat or constricted section 14, tubular in shape, and diverging section 16 also in the form of a truncated cone. Venturi 11 is disposed between fluid inlet conduit 10 and fluid outlet conduit 12 so that converging section 13 is connected to the downstream end of the inlet conduit while diverging section 16 is attached to the upstream end of the outlet conduit. A refractory material capable of withstanding the contemplated high temperatures, such as mullite, alumina, zirconia or silicon carbide, is utilized to line the interior of the reactor.

A plurality of opposed fluid inlet jets 17, preferably, radially-disposed and diametrically-opposed, are positioned in the reactor, and, as illustrated, the jets are located at about the beginning of throat 14. It is not intended, however, to so limit the invention, but rather it is within the contemplation of the invention to position the jets in any part of throat 14 or converging section 13, but preferably not more than one throat diameter upstream from the beginning of the converging section. Accordingly, fluid inlet jets 17a are positioned upstream from the beginning of the converging section while jets 17b are placed in the converging section. The fluid inlet jets can be constructed of a refractory material similar to that mentioned above, or they can be made of a metal such as copper or steel since they are not subjected to temperatures higher than the preheat temperatures.

The placement of the fluid inlet jets constitutes an important aspect of the present invention. In order to effect an efficient mixing of the hydrocarbon feed and oxidant, it is imperative that the plurality of streams of fluid injected laterally impinge in the reactor so as to create a state of high turbulence in venturi 11 with concomitant uniform mixing of the lateral and axial gases.

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In a preferred embodiment of the invention utilizing radially-disposed, diametrically opposed fluid inlet jets, the plurality of lateral streams are injected so as to impinge at about the longitudinal axis AA' of the reactor. In order to achieve this desired result, it is necessary to inject the lateral gas at a mass velocity great enough so that the stream of gas are not swept downstream by the axial gas. Otherwise, there will be an axial zone of insufficiently mixed axial gas, part of which will proceed through the reactor unchanged. As shown in Figure 1, the fluid inlet jets are positioned in the upstream end of the throat. For this specific location of the jets, as the mass velocity of the axial gas increases, a point will be reached at which a great enough velocity cannot be imparted to the lateral gas to effect the desired efficient mixing of the gases. Since the velocity of the axial gas decreases in the direction of the upstream end of the venturi, this undesirable condition of inefficient mixing can be corrected by positioning the fluid inlet jets at some point in the converging section. For slower rates of flow of axial gas, however, when it is feasible to inject the streams of lateral gas at a sufficient mass velocity to ensure impingement as described, the positioning of the inlet jets near the upstream end of the throat is preferred, for in this part of the venturi the velocity of the axial gas is greatest.

While the opposed fluid inlet jets are illustrated as being radially-disposed and diametrically-opposed it is within the contemplation of this invention to incline the fluid inlet jets slightly away from the vertical to the longitudinal axis so that the gas flowing therethrough will initially be directed upstream. Fluid inlet jets 17c are so inclined away from the vertical and illustrate this aspect of the invention. The angle of inclination of the jets will vary with the operating conditions, i. e., the mass velocities of the axial and lateral gases entering the venturi, but in general it should be such that the streams of lateral gas will impinge at about the longitudinal axis of the reactor. It is also within the scope of the invention to utilize other arrangements of opposed fluid inlet jets whereby a plurality of fluid streams are injected into the reactor so that at least two of the streams impinge at points other than at the longitudinal axis of the reactor.

A quenching means 18 is positioned in outlet conduit 12 so as to provide for the rapid cooling of the effluent gases. The location of the quenching means in the outlet conduit will for any given rate of flow of axial gas determine the reaction time for the particular cracking operation being performed. While the quenching means is shown as being positioned in the outlet conduit, it is to be understood that it can be placed in diverging section 16 of venturi 11 without departing from the scope of the invention. Thus, quenching means 18a is shown as being positioned in the diverging section of the venturi. And furthermore, while the quenching means as illustrated provides for the radial introduction of the quenching medium, it is within the scope of the invention to position the quenching means within the reactor so that the quenching medium is sprayed toward the upstream end of the reactor. It should be apparent that by varying the length of the outlet conduit and the position of the quenching means therein, any desired reaction time can be obtained for any given rate of flow of axial gas. And furthermore, assuming that the axial gas is the hydrocarbon feed, when it is considered that the reaction temperature can be controlled by varying the amount of oxidant entering the reactor through the fluid inlet jets, it should be evident that the reactor of this invention is well adapted for use in processes for cracking low boiling hydrocarbons.

In the operation of the reactor of this invention in the process for the production of acetylene, referring to Figure 2 of the drawing, a hydrocarbon feed is passed through line 21 into heater 22 where it is heated to above its ignition temperature. The preheat temperature ranges

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for specific hydrocarbons of the paraffin series have been previously discussed. It is to be understood that a mixture of these hydrocarbons can be used, or a cracked hydrocarbon feed such as obtained by the precracking of ethane and/or propane can be utilized. The preheated hydrocarbon feed leaves the heater through line 23 and is thereafter introduced into reactor 9.

Referring to Figure 1 as well as to Figure 2, the preheated hydrocarbon enters reactor 9 through fluid inlet conduit 10 and thereafter passes into venturi 11. In flowing through the venturi, the gas undergoes a pressure drop with the result that it is moving through the venturi at a greatly accelerated velocity. An oxidant is introduced through line 24 into heater 26 where it is heated to a temperature near that of the preheated hydrocarbon. While air may be used as the oxidant, as previously discussed, it is preferred to use commercially pure oxygen in order to decrease the number of diluents present in the system. Furthermore, it is preferred that steam be added to the oxygen in the process for the production of acetylene in order to increase the acetylene yield. And in any case, steam can be advantageously added to the oxidant in order to inhibit carbon deposition in the reactor. The preheated oxidant leaves the heater through line 23 and is thereafter introduced into reactor 9. It is also within the scope of the present invention to pass the oxidant into the reactor without prior heating.

The oxidant is injected into the reactor through a plurality of fluid inlet jets 17. The streams of oxidant entering venturi 11 at about the upstream end of throat 14 impinge in the reactor preferably at about its longitudinal axis AA'. A highly turbulent condition is thereby created in the venturi, resulting in a rapid and uniform mixing of oxidant and hydrocarbon feed. The combustible mixture so formed immediately burns, the hydrocarbon undergoing an incomplete combustion. Since the partial oxidation reaction is exothermic, the temperature of that part of the reactor comprising diverging section 16 and outlet conduit 12, which may be termed the reaction zone, is rapidly raised to an acetylene forming temperature. The remainder of the hydrocarbon, not converted in the partial oxidation reaction, undergoes a cracking reaction in the reaction zone forming acetylene in high yield. The effluent gas is thereafter immediately quenched to a temperature at which acetylene is stable by quenching means 18 positioned in fluid outlet conduit 12 and supplied water or steam through line 28.

The cooled effluent gas leaves reactor 9 through line 29 and is thereafter passed into bauxite dryer 31 where the water is removed from the product-containing gas. A sample of the effluent stream is taken off through line 32 and passed to a means for measuring the concentration of a key component in the stream. As illustrated in Figure 2, a sample of the effluent gas is passed to infra-red analyzer 33 which may be of any desired instantaneous continuous type. Essentially, the type of infra-red analyzer preferred is of the split beam type capable of identifying a key component in the effluent gas by selective infra-red absorption. In this type of analyzer, a Wheatstone bridge circuit is utilized to detect the unbalance between two beams of radiation, in one of which a sample cell, through which a sample is continuously circulated, is placed. The output of analyzer 33 is passed through electrical leads 34 to controller 36 which is operatively connected to valve 37. The signal produced by analyzer 33 is indicative of the concentration of the key component present in the effluent stream, and controller 36 is adapted to respond to changes in this signal so as to control valve 37, thereby varying the amount of oxidant entering the reactor. In this manner the amount of oxidant introduced into the reactor is continuously controlled so as to ensure that a predetermined amount of the key component is present in the effluent stream. By controlling the process on the basis of a key component in the effluent stream as described, the reaction time and tem-

perature required for a high acetylene yield are concomitantly obtained. While an infra-red analyzer is shown as the means for analyzing the effluent stream to determine the concentration of a key component therein, it is to be understood that other gas analysis methods as, for example, ones utilizing a differential refractometer or a gravitometer can be utilized. The product-containing gas is passed from dryer 31 through line 38 to an absorber-stripper system, of the conventional type utilizing as the absorbent a solvent selective for acetylene such as N-alkyl-2 pyrrolidones, ethylene diamine, dialkyl cyanamides, or the like. Material in line 38 is introduced into absorber 39 and passed therein countercurrently in relation to downwardly flowing fresh and/or stripped absorbent introduced through line 41. Hydrogen-rich gas is passed overhead from absorber 39 through line 42, and thereafter can be used in conjunction with heaters 22 and 26 as fuel or recycled to reactor 9 for cracking of the unconverted hydrocarbons contained therein. Enriched absorbent is withdrawn from the bottom of absorber 39 through line 43 and introduced into stripper 44 which is maintained under distillation conditions so that the rich absorbent is distilled. Lean absorbent is passed from stripper 44 through line 46 which is connected to line 41 by which it is recycled to absorber 39. Line 47 provides means for introducing fresh absorbent into the system. The product acetylene is withdrawn overhead through line 48 and thereafter passed to storage facilities.

The processes for the production of ethylene and a mixture of acetylene and ethylene are conducted essentially in the same manner utilizing the same steps as described above in conjunction with the preparation of acetylene. Since the reaction temperatures and reaction times, as discussed hereinbefore, are considerably different from those utilized in the acetylene process, it becomes necessary to adjust the amount of oxidant passed into the reactor so as to control the cracking reaction. In order to obtain longer reaction times, it may be found necessary to further vary the operating conditions of the acetylene process by decreasing the rate of flow of the axial gas or by moving the quenching means downstream from its location in the outlet conduit. In any event, after the reaction has been set up for the particular process, control over the cracking reaction is maintained by varying the amount of oxidant supplied to the reactor in accordance with the measurement of the concentration of a key component in the effluent stream. In recovering ethylene from the effluent gas, the absorber-stripper system utilizes a solvent selective for ethylene such as acetonitrile-n-heptane or nitromethane. When operating the process so as to obtain a mixture of acetylene and ethylene, recovery of the acetylene and ethylene from the effluent gas is effected in an absorber-stripper system using both types of solvents, i. e., a solvent selective for acetylene and a solvent selective for ethylene.

In the process for the production of aromatics, such as benzene and toluene, the reactor is operated so as to obtain an effluent rich in olefins. The olefinic products are thereafter separated from the reaction products utilizing an absorber-stripper system as described in conjunction with Figure 2 in which an absorbent such as mineral oil is utilized. As shown in Figure 3, the gaseous olefins recovered from the stripper through line 48 are then compressed in compressor 49 and introduced into a soaking chamber 51 where they are subjected to high pressure and temperature. The polymerization products formed in the soaking chamber are thereafter quenched, and the tar is removed from the cooled products. The tar-free hydrocarbon is then introduced into a product separation means comprising coolers, separators, distillation equipment, storage tanks and the like which can be used to effect a separation of the various selected product fractions such as benzene, toluene and/or heavier aromatic hydrocarbon fractions.

My invention will be further illustrated and defined by the following example which is not, however, to be construed as unduly limiting the invention.

For this example, propane at the rate of 2000 S. C. F. H. was preheated in a pebble heater having a maximum pebble temperature of 1500° F. Preheat was controlled to obtain 70 percent conversion of the propane to olefins. The effluent gas leaving the bottom of the pebble heater through a 3 inch conduit at about 1275° F. was passed through a 2½ inch converging section of truncated conical conduit in which the conduit diameter was reduced to 1½ inches. The throat section of the reactor was 1½ inch diameter by 1½ inch long and was followed by a diverging section 10 inches long in which the conduit diameter was increased to 4 inches. Oxygen, at 95° F., was fed through four radially-disposed, diametrically-opposed jets (0.18" I. D.) at the rate of 1660 S. C. F. H. The centers of the ports were located at points ⅜" downstream from the beginning of the throat section. The oxygen was under 10 to 15 pounds per square inch gauge pressure and was controlled by means of a needle valve. The reactor terminated in a 4-inch section of 4-inch conduit followed by a 36-inch long by 4-inch diameter quench section. Water for quenching was introduced at a point 3 inches downstream from the beginning of the quench section. Reaction time was estimated to have been about 5 milliseconds while the reaction temperature was estimated at approximately 2600° F. The effluent gas had the following composition on a dry basis:

Component:	Mol percent
H ₂ -----	45.4
CH ₄ -----	10.7
C ₂ H ₂ -----	10.8
C ₂ H ₄ -----	5.9
C ₂ H ₆ -----	0.1
C ₆ H ₆ -----	0.1
C ₃ ≡ and C ₄ ≡ -----	0.4
CO -----	23.1
CO ₂ -----	3.3
O ₂ -----	0.2
	100.0

Yield: .237 pound of acetylene per pound of C₃H₈ feed.

Rate: 55.0 pounds C₂H₂ per hour.

It will be evident that by providing a reactor of the type described it is possible to control the severity of the cracking reaction of the various processes within narrow limits. The importance of effective control is emphasized by the fact that overcracking results in failure of the refractory material and increases the formation of secondary products which form coke and tars. And furthermore, in the case of undercracking a part of the hydrocarbon feed passes off with the cracked gases, resulting in a low product yield. Another advantage of the present invention lies in the variety of feed stocks which can be treated to prepare acetylene or olefins. Because of the design of the reactor of this invention, it is possible to obtain flow rates therethrough which result in reaction times measured in milliseconds. This latter feature of the invention becomes important in the production of acetylene where extremely short reaction times are especially desirable. Moreover, I have provided a reactor which combines the advantages of compactness, simplicity, and ease of construction with the feature of high throughput capacity, all of which results in an inexpensive installation.

As will be evident to those skilled in the art, various modifications of this invention can be made or followed in the light of the foregoing disclosure and discussion without departing from the spirit or scope of the disclosure.

I claim:

1. A reactor adapted for use in a process for the pro-

duction of unsaturated hydrocarbons which comprises, in combination, a fluid inlet conduit; a venturi comprising a converging section, a throat section and a diverging section, said converging section being connected to the downstream end of said inlet conduit and said throat section encompassing the sole constricted passage in said reactor; a fluid outlet conduit having its upstream end connected to said diverging section, said fluid inlet conduit, said venturi, and said fluid outlet conduit forming a continuous, unobstructed passage in said reactor; a fluid introduction means positioned in said reactor between the downstream end of said throat section and the downstream end of said fluid outlet conduit; and fluid inlet jets positioned in said reactor for injecting a plurality of fluid streams into said reactor so that said streams impinge at about the longitudinal axis of said reactor, said fluid inlet jets being inclined toward the upstream end of said fluid inlet conduit.

2. A reactor adapted for use in a process for the production of unsaturated hydrocarbons which comprises, in combination, a substantially cylindrical fluid inlet conduit; a first truncated conical member having its large end attached to the downstream end of said inlet conduit; a throat member attached to the small end of said first conical member, said throat member encompassing the sole constricted passage in said reactor; a second truncated conical member having its small end attached to the downstream end of said throat member; a substantially cylindrical fluid outlet conduit attached to the large end of said second conical member, said inlet conduit, said first conical member, said throat member, said second conical member and said outlet conduit forming a continuous, unobstructed passage in said reactor; a means for quenching gases disposed in said outlet conduit; and a plurality of pairs of radially-disposed, diametrically-opposed fluid inlet jets positioned in said reactor, said fluid inlet jets being inclined toward the upstream end of said fluid inlet conduit and adapted to inject a plurality of fluid streams into said reactor so that said streams impinge at about the longitudinal axis of said reactor.

3. The reactor of claim 2 wherein said fluid inlet jets are positioned in said reactor between the downstream end of said throat member and a vertical plane intersecting said fluid inlet conduit about one throat member diameter upstream from the large end of said first truncated conical member.

4. The reactor of claim 3 wherein said fluid inlet jets are positioned in said throat member.

5. The reactor of claim 3 wherein said fluid inlet jets are positioned in said first truncated conical member.

6. A process for the production of unsaturated hydrocarbons wherein the reactants are preheated gaseous hydrocarbons and preheated oxidant which comprises introducing an axial stream comprising one of said reactants into one end of an elongated conduit; increasing the velocity of said axial stream in a portion of said conduit; injecting a plurality of streams comprising the other of said reactants laterally into the accelerated axial stream so that the plurality of lateral streams impinge; rapidly and uniformly mixing said reactants; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons and form the desired unsaturated hydrocarbon; and cooling the reaction products to a temperature at which the resulting unsaturated hydrocarbon is stable.

7. A process for the production of unsaturated hydrocarbons which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in a portion of said conduit; injecting a plurality of streams of oxidant laterally into the accelerated stream of hydrocarbons so that said streams impinge; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the result-

ing mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons and form the desired unsaturated hydrocarbon; and cooling the reaction products to a temperature at which the resulting unsaturated hydrocarbon is stable.

8. A process for the production of unsaturated hydrocarbons which comprises the steps of continuously introducing a stream of oxidant into one end of an elongated conduit; increasing the velocity of said stream of oxidant in a portion of said conduit; introducing a plurality of streams of preheated hydrocarbons laterally into the accelerated stream of oxidant so that said streams impinge; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons and form the desired unsaturated hydrocarbon; and cooling the reaction products to a temperature at which the resulting unsaturated hydrocarbon is stable.

9. A process for the production of acetylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons; varying the amount of oxidant introduced into said conduit so as to maintain the temperature of said reaction zone at an acetylene forming temperature; and rapidly cooling the reaction products to a temperature at which acetylene is stable.

10. A process for the production of ethylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons; varying the amount of oxidant introduced into said conduit so as to maintain the temperature of said reaction zone at an ethylene forming temperature; and rapidly cooling the reaction products to a temperature at which ethylene is stable.

11. A process for the production of a mixture of acetylene and ethylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons; varying the amount of oxidant introduced into said conduit so as to maintain the temperature of said reaction zone at a temperature suitable for the formation of a mixture of acetylene and ethylene; and cooling the reaction products to a temperature at which said mixture of acetylene and ethylene is stable.

12. A process for the production of aromatics which comprises the steps of continuously introducing a stream

of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction to crack the remainder of the hydrocarbons; varying the amount of oxidant introduced into said conduit so as to maintain the temperature of said reaction zone at a temperature suitable for the formation of olefins; cooling the reaction products to a temperature at which said olefins are stable; separating the olefins from the reaction products; and polymerizing said olefins in order to form aromatics.

13. A process for the production of unsaturated hydrocarbons which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction in order to crack the unreacted hydrocarbons and form the desired unsaturated hydrocarbon; measuring the concentration of a key component contained in the product stream removed from said reaction zone; varying the amount of oxidant introduced into said conduit so as to maintain the concentration of said key component at a predetermined value, thereby obtaining a high yield of the desired unsaturated hydrocarbon; and cooling the reaction products to a temperature at which said unsaturated hydrocarbon is stable.

14. A process for the production of acetylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction in order to crack the unreacted hydrocarbons and form acetylene; measuring the concentration of a key component contained in the product stream removed from said reaction zone; varying the amount of oxidant introduced into said conduit so as to maintain the concentration of said key component at a predetermined value, thereby obtaining a high yield of acetylene; and cooling the reaction products to a temperature at which said acetylene is stable.

15. The process for the production of ethylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the par-

tial oxidation reaction in order to crack the unreacted hydrocarbons and form ethylene; measuring the concentration of a key component contained in the product stream removed from said reaction zone; varying the amount of oxidant introduced into said conduit so as to maintain the concentration of said key component at a predetermined value, thereby obtaining a high yield of ethylene; and cooling the reaction products to a temperature at which said ethylene is stable.

16. A process for the production of a mixture of acetylene and ethylene which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons and said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction in order to crack the unreacted hydrocarbons and form a mixture of acetylene and ethylene; measuring the concentration of a key component contained in the product stream removed from said reaction zone; varying the amount of oxidant introduced into said conduit so as to maintain the concentration of said key component at a predetermined value, thereby obtaining a high yield of acetylene and ethylene; and cooling the reaction products to a temperature at which the mixture of acetylene and ethylene is stable.

17. A process for the production of aromatics which comprises the steps of continuously introducing a stream of preheated gaseous hydrocarbons into one end of an elongated conduit; increasing the velocity of said stream of hydrocarbons in the middle portion of said conduit; injecting a plurality of streams of preheated oxidant into the accelerated stream of hydrocarbons so that said streams impinge at about the longitudinal axis of said conduit; rapidly and uniformly mixing said hydrocarbons in said oxidant; partially burning the resulting mixture in a reaction zone; utilizing the heat given up in the partial oxidation reaction in order to crack the unreacted hydrocarbons and form olefins; measuring the concentration of a key component contained in the effluent stream removed from said reaction zone; varying the amount of oxidant introduced into said conduit so as to maintain the concentration of said key component at a predetermined value, thereby obtaining a high yield of olefins; cooling the reaction products to a temperature at which said olefins are stable; separating the olefins from the reaction products; and polymerizing said olefins in order to form aromatics.

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