Nov. 7, 1939. F. J. METZGER 2,179,379

MANUFACTURE OF ACETYLENE

Filed July 18, 1936 2 Sheets-Sheet 1

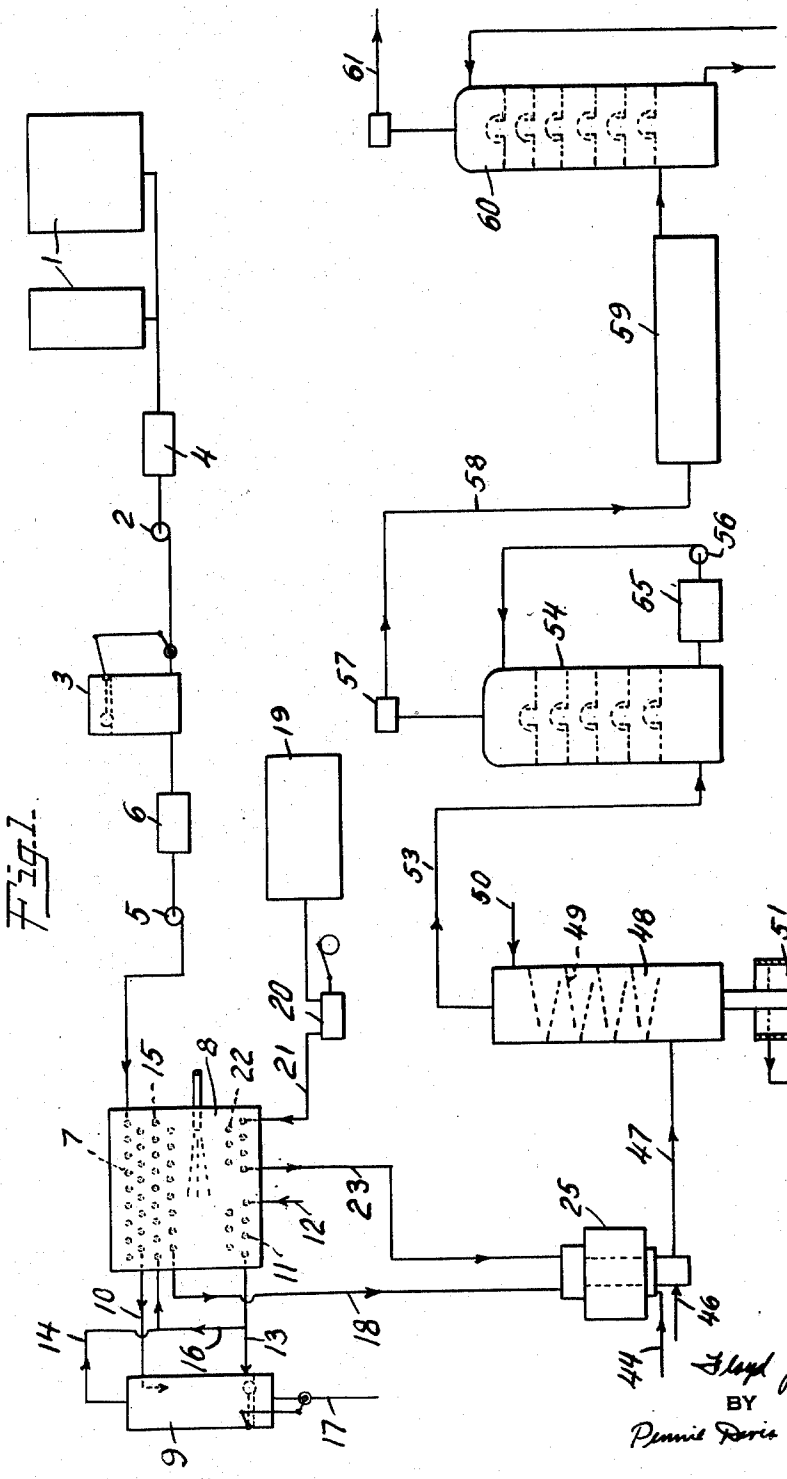


Fig. 1.

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MANUFACTURE OF ACETYLENE

Filed July 18, 1936 2 Sheets-Sheet 2

Fig. 2.

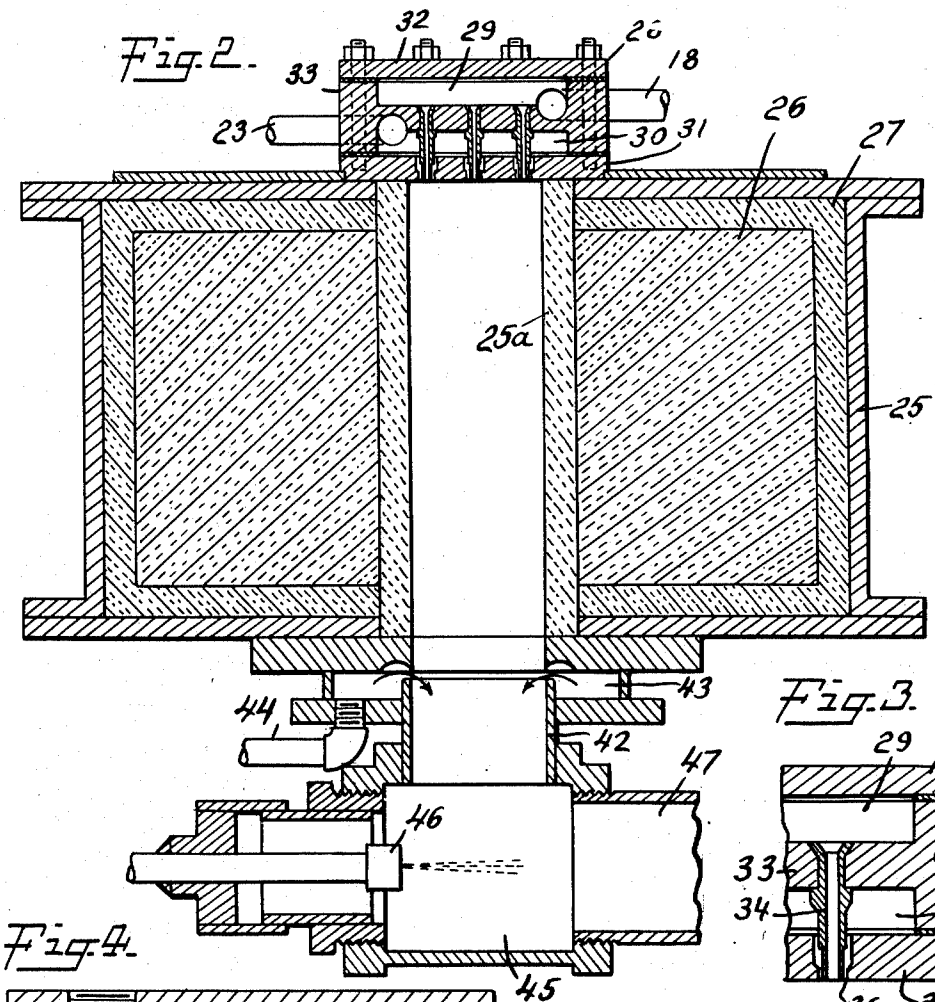


Fig. 3.

Fig. 4.

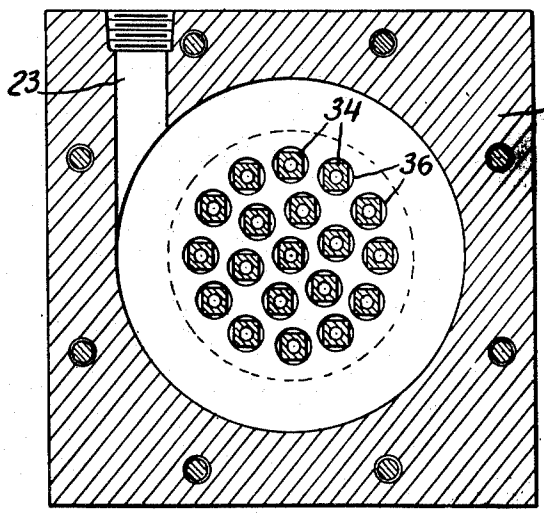
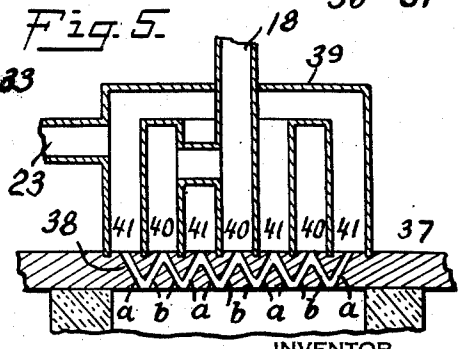


Fig. 5.



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Patented Nov. 7, 1939

2,179,379

UNITED STATES PATENT OFFICE

2,179,379

MANUFACTURE OF ACETYLENE

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Application July 18, 1936, Serial No. 91,408

7 Claims. (Cl. 260—679)

This invention relates to improvements in processes and apparatus for the production of acetylene; and more particularly to improvements in processes and apparatus for the production of acetylene from normally liquid hydrocarbons by a cracking or conversion operation in which the heat required for the cracking or conversion is obtained by the combustion or reaction with oxygen of a portion of the hydrocarbons being cracked or converted.

The processes and apparatus of the invention are intended and adapted for the commercial production of acetylene from normally liquid hydrocarbons in a continuous manner with the use of an apparatus of simple construction and with the practice of a process of economical operation such that the production can be continued for long periods of time without objectionable interruptions due to accumulation of carbon in the apparatus.

In accordance with the present invention, the normally liquid hydrocarbon to be cracked or converted is vaporized, steam is admixed in proper proportion with the vapors, and the mixture is subjected to reaction or combustion with an amount of oxygen insufficient to bring about the complete combustion of the hydrocarbon, but sufficient to cause the cracking or conversion of a substantial part of the hydrocarbon to acetylene.

In its broader aspects, the invention includes the production of acetylene by a cracking or conversion operation, in which vapors of normally liquid hydrocarbons, in admixture with steam, are subjected to combustion or reaction with a regulated amount of oxygen in different types of apparatus, and by different methods of combustion.

In addition, the invention includes specific improvements in the production of acetylene from such a mixture of hydrocarbon vapors and steam in which the combustion or reaction is carried out by accomplishing a regulated localized intense combustion, followed by a further combustion or reaction in a composite combustion zone, by the introduction, into a combustion and cracking chamber which is large in cross-section in relation to the jets, of a large number of individual and separate high velocity jets of hydrocarbon vapor and steam in admixture, and a large number of individual and separate high velocity jets of oxygen in such a way as to bring about simultaneous mixing of the high velocity jets and localized and intense combustion of part of the hydrocarbon at a large number of localized points or zones, followed by further composite combustion or reaction in a composite combustion or flame zone; and with this further composite reaction or combustion followed promptly by cooling or quenching of the resulting gases and subsequent treatment of the resulting gases for the separation of acetylene therefrom.

In the carrying out of the invention in this way the amount of oxygen thus introduced locally in the form of high velocity jets at a large number of points is sufficient to effect combustion of a part only of the hydrocarbons, but the heat resulting from the combustion of the hydrocarbon with the oxygen is sufficient to produce cracking of substantial quantities of the hydrocarbon with the resulting production of substantial yields of acetylene in the resulting gases. Oxygen of varying purity can be used, but it is used advantageously as oxygen of 90%, or higher, which is commercially available.

While I do not wish to limit myself by any theoretical explanation of the precise reaction which takes place in this process, yet I am led to believe that the separate and localized introduction of a large number of separate and individual high velocity jets of hydrocarbon vapor admixed with steam and of oxygen results in localized intense combustion at a large number of individual localized zones where the jets of oxygen come into contact with the jets of hydrocarbon and steam and effect initial intense combustion in such localized zones, followed by further commingling of the individual jets into a composite zone where further combustion or reaction takes place and in which the reactions are completed such that the gases which escape and which are cooled or quenched are free or substantially so from free oxygen and contain substantial quantities of acetylene.

According to the present invention, the liquid hydrocarbon to be cracked or converted is vaporized and the vapors admixed with steam in proper proportion so that a composite admixture of hydrocarbon vapor and steam is subjected to reaction or combination with the oxygen. It is important to admix the steam with the hydrocarbon vapor, and not with the oxygen.

Advantageously, the mixture of hydrocarbon vapor and steam is introduced into the cracking or reaction apparatus in the form of a large number of individual jets. In such cases the large number of individual separate jets of admixed hydrocarbon vapors and steam and the large number of separate individual jets of oxygen are brought together to accomplish the localized combustion of a part of the hydrocarbon vapors in a large number of localized individual zones merg-

ing into a flame zone to accomplish the completion of the conversion or cracking operation.

When heavy liquid hydrocarbons, such as crude oil, topped crude oil, coal tars, etc., are utilized in the present process and apparatus, it is advantageous to utilize the steam for aiding in the vaporization of the liquid hydrocarbon in producing the composite mixture of hydrocarbon vapors and steam which are utilized in the carrying out of the process. The apparatus of the invention includes, when needed, a suitable vaporizer, which, when heavy oils are used, is advantageously a countercurrent vaporizer, in which steam and preheated liquid oil flow countercurrently, and in which the steam aids in the vaporization of the oil and in which substantially more complete vaporization of the oil is obtainable without objectionable cracking or coking than is obtainable with other types of vaporizers, in combination with a suitable superheater and a suitable reaction chamber or vessel.

The introduction of the large number of separate individual jets of a mixture of hydrocarbon vapors and steam and of oxygen, according to the present invention, is effected as directed jets such that effective localized intense combustion is obtained followed by blending of the gases in the composite flame zone which is continuously changing in the sense that the large number of individual high velocity jets and their combustion products are continually merging into the composite flame zone and such that the products of the completed reactions are continuously removed and immediately cooled or quenched and subsequently treated for the recovery of acetylene therefrom.

In order to obtain the large number of directed jets of high velocity of both the hydrocarbon vapors and admixed steam and the oxygen it is important to supply both the hydrocarbon vapors and admixed steam and the oxygen to the individual jets under a sufficiently high pressure to give the directed jets of high velocity. When these directed jets are discharged into the large combustion and reaction chamber, the jets first intermingle with each other locally, with expansion of the jets as they emerge at high velocity into the zone of lower pressure in the combustion and reaction chamber, and with decrease in velocity of the jets, and contact or intermingling of the jets locally followed by intermingling or mixing or blending in the large combustion chamber. Moreover, a large volume of hydrocarbon vapor, steam and oxygen is thus introduced with rapid and intense combustion in a relatively short time, usually a very small fraction of a second, and with a high velocity of the gases and vapors, and of the products of combustion and reaction, through the large chamber.

In this process, the presence of the steam admixed with the vapors of liquid hydrocarbons seems to be important both in its effect on the localized combustion brought about in the zones where the high velocity jets are initially admixed, and in its effect on the subsequent composite combustion or reaction and in reducing or preventing the accumulation of coke or carbon in the large combustion or reaction chamber. This steam may also be advantageously used, as above pointed out, for assisting in vaporizing the liquid hydrocarbon.

The present process is an advantageous one for the cracking or conversion of relatively heavy liquid hydrocarbons; and crude oil or even heavy residuum oil, if suitably vaporized and admixed with steam, can advantageously be utilized according to the present invention for the production of acetylene therefrom. With such heavy hydrocarbons special precautions should be taken to insure complete vaporization of the hydrocarbons or of such portions of the hydrocarbons as are supplied to the cracking or reaction zone in admixture with the steam.

The amount of steam which is used in admixture with the vapors of liquid hydrocarbons, may vary within more or less wide limits, depending somewhat on the particular oil vaporized. It should be sufficient to prevent the accumulation of carbon in the reaction chamber, but not sufficient to cause the production of too much carbon dioxide in the exit gases, or to prevent the temperature attained in the reaction chamber from being sufficiently high to accomplish the desired production of acetylene. With various oils, the amount (i. e., weight) of steam may be less than or about the same as the amount of oil or may be in excess of the amount of oil, e. g., up to about twice as much steam as oil. The amount of steam required increases with heavier oils, and with an East Texas crude oil, for example, of which about 90% is vaporized, about 150 pounds of steam may be used with 87 pounds of the vaporized oil.

The temperatures which are used in the reaction chamber according to the present process are considerably in excess of those used in ordinary cracking operations for the production of gasoline or pressure distillate, and considerably in excess of those used in the various cracking processes which have been proposed for the production of ethylene While the temperatures attained at the zone where the localized combustion of the oxygen and hydrocarbon jets takes place are difficult to measure, the temperature of the walls of the reaction chamber may be as high as 900° C. or 1020° C. or higher on the outside, with the temperature on the inside of the wall somewhat higher.

It is advantageous to preheat the vapors fed to the reaction chamber. The oil should be vaporized and supplied in vapor form admixed with steam, and it is advantageous to preheat the admixed oil vapors and steam to around 400° C. or 500° C. to prevent the condensation of any of the vapors and to avoid feeding to the reaction chamber any of the hydrocarbon in liquid form. It is also desirable to preheat the oxygen, to increase the efficiency of the combustion.

For the production of about 100,000 cubic feet of gas per day containing 7 to 8% or more of acetylene a reaction chamber consisting of a carborundum tube about 4 inches in diameter and about 12 inches long can be advantageously used. This cylinder may be provided at one end with a head of suitable metal having a large number of directed jets arranged in pairs, or as concentric jets, or otherwise. When the jets are arranged in pairs one jet of each pair is used for hydrocarbon vapors and steam, and the other jet is used for the supply of oxygen.

For an operation such as just referred to, and with a cylinder or reaction chamber about 4 inches in diameter, the head may thus be provided with 20 or 30 pairs of impinging or concentric jets; and for larger scale operation, using cylinders or reaction chambers 12 or 18 inches in diameter, the head may be provided with two or three hundred pairs of jets, although a much smaller or larger number of jets may be used, depending on the size of the apparatus,

the size of the jets, etc. Instead of arranging the jets in pairs, there may be provided a plurality of jets of oxygen for each jet of hydrocarbon vapor and steam or vice versa, as long as the arrangement is such as to give the intense localized combustion followed by a further combustion or reaction in a composite combustion or reaction zone which is advantageously used in the process.

At the other end of the cylinder, through which the exit gases flow, there is advantageously provided a water spray which aids in the removal of tar or carbon from the exit gases and quenches and rapidly cools these gases.

The apparatus is provided with suitable means for vaporizing and preheating the liquid hydrocarbon feed, and with means for the regulation and control of the hydrocarbon and oxygen fed to the apparatus, and with means for admixing the hydrocarbon vapors with steam. There are also provided suitable scrubbers for the exit gases, to remove entrained tar and carbon therefrom, and suitable means for recovering the acetylene from the gases, or for converting the acetylene into other useful products, such as acetaldehyde.

The invention will be further illustrated by the accompanying drawings, and the process of the invention will be further described in connection therewith; but it will be understood that the invention is not limited thereto.

In the drawings:

Fig. 1 is a flow sheet or schematic representation of an apparatus suitable for the production of acetylene from normally liquid hydrocarbons;

Fig. 2 illustrates in a somewhat conventional and diagrammatic manner a reaction chamber and head which may be used;

Fig. 3 shows conventionally and in somewhat greater detail the arrangement of one of the pairs of jets used in the head illustrated in Fig. 2;

Fig. 4 is a sectional view of the head shown in Fig. 2; and

Fig. 5 is a somewhat conventional sectional view of a modified head which may be used with advantage.

In the apparatus illustrated in Fig. 1, which is adapted for the production of acetylene from relatively heavy hydrocarbon liquids, such as crude oil or topped crude oil, or other liquid hydrocarbons, the oil is fed from the storage tanks 1 through filter 4 by pump 2 to a constant level tank 3, from which it is drawn through filter 6 by pump 5 and passes to preheater 7, which consists of suitable pipes or tubes within furnace 8. From this preheater, the oil is supplied to a counter-current vaporizer 9 through pipe 10.

In this countercurrent vaporizer, the oil flows downwardly in intimate contact with superheated steam, which is supplied to a preheater 11 through pipe 12, and which after being preheated enters the countercurrent vaporizer 9 at the bottom through pipe 13. The admixed hydrocarbon vapors and steam pass from the top of the vaporizer 9 through pipe 14 to superheater 15. A connection 16 from the superheated steam line 13 to the vapor line 14 is provided for the introduction of more superheated steam to the mixture of hydrocarbon vapor and steam, where the amount of steam required or utilized in the counter-current vaporizer is less than that which is desirable for use in admixture with the oil vapors. The residue from the vaporizer is drawn off through outlet 17 and may be used as fuel. From the superheating coil 15 the admixed hydrocarbon vapors and steam are led to the reaction chamber 25 by pipe 18.

The oxygen used in the process is advantageously supplied from an oxygen plant 19, e. g., a liquefaction plant, in which it is produced from air as required. The oxygen is compressed in compressor 20 and passes through pipe 21 to heating coils 22, in which it is preheated, and from which it passes through pipe 23 to the reaction chamber 25.

In the arrangement shown, the various preheating and superheating coils (which are used for the preheating and superheating of the hydrocarbon, the steam and the oxygen) are advantageously placed within a single furnace 8; but instead of this arrangement, the preheating of the liquid oil and the superheating of the steam to be used in vaporizing it may be carried out in a separate preheater, with the oil vapors and admixed steam, and the oxygen, being suitably superheated in a separate furnace (not shown).

The construction of the reaction chamber, and the attached head and the means for quenching the exit gases from the chamber are illustrated, in a more or less conventional fashion, in Figs. 2 to 5.

In Fig. 2, there is shown a suitable reaction tube 25*a*, which may be advantageously made of carborundum or other refractory material, or may be made of metal, with provision for causing a stream of water to flow down its interior surface to protect the metal and keep it clean, surrounded by suitable insulation 26, in casing 27. At the top of this tube is provided a head 28 into which is introduced the admixed superheated oil and steam vapors through pipe 18, and the oxygen separately through pipe 23. The oil vapors and admixed steam enter the upper chamber 29, while the oxygen enters the lower chamber 30, both provided within the head. This head is advantageously made in three sections, a lower section 31 provided with holes for the nozzles, an upper section 32, and a middle section 33, which is provided with openings for the nozzles and which is formed with central recesses on both sides so that the chambers 29 and 30 are formed when the upper and lower plates are fastened to it.

The head 28 is provided, as shown, with a number of nozzles or jets through which the hydrocarbon vapors and admixed steam and the oxygen separately flow into the tube 25*a*. The construction of these nozzles is illustrated in Fig. 3. Each nozzle includes a tube 34 which extends from the plate 33 through an opening 36 in the plate 31, forming a passageway from chamber 29 to the interior of the tube 25*a*. The openings 36 in the plate 31 through which these tubes pass are somewhat larger than the outer diameter of the tubes 34 as shown, so that there is an annular passageway around each of the tubes from the chamber 30 to the interior of the tube 25*a*.

The openings in the plate 31 are made somewhat smaller at the bottom of the plate than at the top of the plate, and the tubes 34 are square in shape where they fit into the upper part of the openings, so that they are properly centered in the openings, while leaving suitable passageways for the flow of oxygen down past the tubes 34 into the tube 25. This method of centering the tubes 34 is illustrated in Fig. 4, which shows how the square portions of the tubes 34 correctly center the tubes in the openings 36 while leaving spaces for the flow of the jets of oxygen.

The number of such nozzles, each of which provides a jet of hydrocarbon vapor admixed with steam through the central opening with an annular jet of oxygen surrounding it, may vary; but in the apparatus illustrated, with a tube about 4 inches by 12 inches and intended for the production of five to ten thousand cubic feet of acetylene per day, about 19 such nozzles may be used, each, e. g., with the diameter of the openings for the flow of hydrocarbon about three-sixteenths of an inch, and with the area of the annular space through which the oxygen flows about equal to that of the three-sixteenths inch opening.

Where the apparatus is intended for a larger scale operation, and the reaction chamber is made of a tube 12 to 18 inches in diameter, and 3 or 4 feet long, the number of nozzles may be increased about as the cross-sectional area of the tube, so that 200 or more such nozzles may be provided; although with the larger scale apparatus, the size of the nozzles may be somewhat increased, and their number may be somewhat less than the number which would be provided if the apparatus were simply enlarged to scale, so as to reduce the back pressure and the resistance to flow of the vapors and gases. The number may be as low as 50 or less, or as high as 300 or more, depending on the size of the apparatus, the size and shape of the nozzles, etc.

A modified arrangement of the head which may also be used with advantage is illustrated in Fig. 5. In this head, there is provided a plate **37**, which has a number of obliquely cut holes **38**, about one-eighth inch in diameter, arranged in concentric circles. These openings are arranged in pairs so that they produce directed jets of hydrocarbon vapors and admixed steam and oxygen in pairs, the jets of each pair impinging as they come into the reaction tube. Above this plate is a box **39** with separate chambers into which the hydrocarbon vapors and admixed steam are introduced through line **18**, and the oxygen through line **23**. The hydrocarbon and admixed steam thus flow into the chambers **40** while the oxygen flows into the chambers **41**. The oxygen thus passes through the openings *aaa*, while the hydrocarbon and admixed steam flow through the openings *bbb*. With this head, when used with a combustion tube such as shown in Fig. 2, about 32 pairs of openings may be provided; and with a larger scale apparatus, the number of openings provided may be increased in about the same ratio as the cross-sectional area of the reaction tube is increased.

Below the reaction tube **25** there is provided a metal tube **42** through which the exit gases flow. This tube is kept cool by a stream of water which flows down its inner surfaces, the water entering the annular chamber **43** from pipe **44** and flowing over the upper portion of the tube **42** and down the inner surface of the tube. This stream of water not only serves to keep the tube **42** cool, but also serves to prevent the deposition of carbon thereon.

The exit gases flow through this tube **42** into the chamber **45** where they are quenched and cooled by a water spray from nozzle **46**. The amount of water which is sprayed into the gases through nozzle **46** is in excess of the amount of water which can be vaporized by the sensible heat of the gases, and is sufficient to cool the gases to a low temperature of, e. g., about 40° C. more or less. The cooled gases, with admixed water, then pass through the pipe **47** to a suitable countercurrent washer **48**. In this washer, which may be provided with baffle plates **49**, the gases and vapors are brought into contact with water introduced through pipe **50**. This washer, together with the water spray, removes a large part of the tar and carbon from the gases. The water from the washer, and the excess water sprayed into the gases by nozzle **46**, flows into the water seal **51** and then into a settling basin **52** in which oil and tar is separated.

Instead of providing a water washer for the exit gases, the vapors and gases and water from the nozzle **46** may be passed through a separator, in which the greater part of the water is removed, and then led to an oil scrubber. However, it is advantageous to provide a water scrubber, as the gases, even after the separation of entrained water from the nozzle **46**, contain a good deal of water vapor, and if they are cooled to any great degree in an oil scrubber or tar scrubber, tend to condense out water which forms an emulsion.

The gases and vapors, after having been scrubbed with water in the scrubber **48**, are led by pipe **53** to a tar separator **54**. This separator, which may be of the bubble plate type, is shown of usual construction, and is provided with a tank **55** and a circulating pump **56** so that the scrubbing oil used may be circulated through the separator. In this separator, entrained tar and oil which the gases and vapors carry is removed. The vapors and gases then pass through a centrifugal separator **57** and through pipe **58** to the vessel **59**, in which the hydrogen sulfide is removed by iron oxide. After the removal of hydrogen sulfide in this vessel, the gases and vapors pass to a suitable bubble plate column **60** in which the light oils such as benzol are removed by scrubbing with a suitable absorbent, such as straw oil. From this tower, the gases and vapors, which now contain, e. g., about 7 to 8% of acetylene, pass through pipe **61** to be treated for the recovery or use of the acetylene.

These purified gases, which contain, e. g., from 7 to 8% of acetylene, may be treated directly for the production of acetaldehyde from the acetylene, or they may be passed into contact with a suitable solvent for acetylene for the recovery of the acetylene in more concentrated form. For example, the gases may be brought into contact, as in a suitable scrubbing tower, with diethyl carbonate, which preferentially dissolves the acetylene as described in my Patent No. 1,900,655. By bringing the gases while under pressure into contact with diethyl carbonate, and then boiling the acetylene off from the diethyl carbonate, the concentration of acetylene may be increased to as much as 60% or more, and by one or more repetitions of the treatment may be increased to above 90%. The concentrated acetylene-containing gases may be advantageously used for the production of acetaldehyde, or may be used in other ways or for other purposes.

It is one advantage of the process and apparatus of the present invention that high superatmospheric pressures are not required; nor does the process require the use of a vacuum. The invention can advantageously be practiced at pressures around atmospheric, or such that the gases emerge from the purifying apparatus at about atmospheric pressure. That is, the pressure in the various parts of the apparatus subsequent to the combustion or reaction chamber may be only sufficiently above atmospheric to provide

for the flow of the gases and vapors through these subsequent parts of the apparatus.

It is, however, important in those parts of the apparatus which precede the combustion or reaction chamber to have a sufficient pressure to insure introduction of the hydrocarbon vapors and admixed steam and of the oxygen through the jets to give directed jets of both the oxygen and the hydrocarbon vapors and admixed steam; and, where the exit gases from the purifying apparatus are at atmospheric pressure, it is also important that the pressure of the oxygen and the hydrocarbon vapors and admixed steam sufficient to insure flow of the gases through the apparatus from the reaction or combustion chamber to the purifier.

The pressure drop through the jets and the pressure required to force the oxygen and hydrogen through the jets with sufficient velocity will vary somewhat with the size and construction of the jets and may be e. g. around 8 or 10 pounds per square inch for the steam and admixed oil vapors and around 3 pounds per square inch for the oxygen. The pressure drop throughout the subsequent parts of the apparatus will vary with the construction and arrangement of the apparatus but may be, for example, around 2 or 3 pounds or more per square inch. The necessary pressure of the oxygen and of the admixed hydrocarbon vapor and steam is readily obtained by supplying the same under the necessary pressure to the respective large number of jets.

The invention will be further illustrated by the following specific examples, but it is not limited thereto.

Example I. Acetylene from East Texas crude oil.—East Texas crude oil is supplied to the counter-current vaporizer at such a rate that about 87 pounds of oil is vaporized per hour, about 60 pounds of steam being supplied to the vaporizer per hour to assist in the vaporization. About 90 pounds of additional steam are admixed with the oil vapors and steam, and the resulting mixture is superheated, e. g., to about 450° C. These vapors are fed to a 4-inch reaction vessel, provided with a head such as is illustrated in Fig. 2. About 952 cubic feet of oxygen, measured at atmospheric temperature and pressure, are supplied per hour, preheated to about 400° C.

The preheated gases and vapors are supplied at a sufficient pressure to provide the necessary flow and velocity through the jets and the apparatus, the oil vapors and admixed steam being at a gauge pressure of , e. g., about 11 pounds, and the oxygen at a gauge pressure of about 6 pounds.

The oil vapors and admixed steam, and the oxygen, are introduced into the reaction chamber through separate nozzles in such a manner that there are a number of directed jets of oxygen and a number of directed jets of oil vapor and steam, each jet of oxygen coming into contact with, or impinging upon, a jet of admixed oil vapor and steam. As a result, there is an immediate localized combustion of the oxygen with the oil vapors, with the formation of a large number of separate flames and the production of a large number of localized high temperature zones. The gases and vapors as they continue to pass down the reaction tube intermingle and intersperse in a composite flame zone, and the reaction continues or goes to completion.

The gases as they flow from the bottom of the reaction chamber may have a temperature as high as, e. g., around 1200° C. They are immediately quenched by the water spray, and then pass out into the other portions of the apparatus in which the water is removed and the gases are purified and the acetylene recovered or utilized.

In such an operation, more than 10,000 cubic feet of gas and vapor enter the reaction chamber per hour, and, assuming the temperature of the exit gases to be about 1,000° C., over 27,000 cubic feet of gas and vapor leave the reaction chamber per hour. After the removal of water from the gases, and their cooling to room temperature, there may be obtained, e. g., about 3,100 cubic feet of dry gas per hour. In one case the gas so produced had the following composition:

	Percent
C_2H_2	7.8
C_2H_4	5.3
CH_4	6.2
H_2	38.6
CO	31.3
CO_2	11

In this case, about 240 cubic feet of acetylene were produced per hour, or about 1 pound of acetylene for each gallon of oil. The gas after the removal of the acetylene contained about 42% hydrogen, about 34% carbon monoxide, and about 12% of saturated hydrocarbons, and was suitable for use as a fuel gas or for the production of synthetic methanol.

Example II. Acetylene from range oil.—Range oil (approx. kerosene) is vaporized at the rate of about 110 pounds per hour, and with the vapors are admixed about 67 pounds of steam per hour. The mixture is superheated to about 330° C., and fed to a 4-inch carborundum reaction vessel, provided with a head of the type illustrated in Fig. 5. About 1020 cubic feet of oxygen, preheated to about 360° C., are also supplied (through separate jets) to the reaction vessel per hour.

In one case, about 3320 cubic feet of exit gas, measured dry and at room temperatures and pressure, were obtained. The gas had the following composition:

	Per cent
C_2H_2	7.9
CO_2	7.2
C_2H_4	1.3
O_2	0.6
CO	35.2
CH_4+H_2	47.8

Example III. Acetylene from naphtha bottoms.—A mixture containing about 123 pounds of naphtha bottom vapors and 71 pounds of steam, the steam being added to the naphtha bottom vapors, superheated to about 365° C. is supplied per hour to a reaction vessel similar to that of Example I, along with about 1020 cubic feet of oxygen, preheated to about 380° C. In one case, an exit gas containing about 6.0% of acetylene was obtained.

Example IV. Acetylene from Darst Creek crude oil.—Darst Creek crude oil is supplied to the counter-current vaporizer at a rate of about 126 pounds per hour, along with about 77 pounds of steam per hour. About 89.5% of the oil is vaporized, and the mixture of oil vapors and steam is superheated to about 377° C., and supplied to a reaction chamber similar to that of Example II, along with 950 cubic feet of oxygen, preheated to about 373° C. per hour. In one case, about 3000 cubic feet of exit gas (measured dry, at room temperature and pressure) were

obtained per hour. The gas had the following composition:

	Per cent
C_2H_2	8.3
CO_2	7.2
C_2H_4	3.3
O_2	0.2
CO	34.0
H_2	37.8
CH_4 and higher	7.0
N_2 (by difference)	2.2

Example V. Acetylene from Darst Creek crude oil.—Darst Creek crude oil is supplied to the counter-current vaporizer at the rate of about 126 pounds per hour, along with about 58 pounds of steam. About 88.8% of the oil was vaporized and about 93 pounds of steam per hour are admixed with the mixture of oil vapors and steam. The resulting mixture is superheated to about 435° C., and fed to a reaction vessel similar to that of Example II along with about 1060 cubic feet of oxygen, preheated to about 400° C., per hour. In one case, about 3400 cubic feet of exit gas (measured dry, at room temperature and pressure) were obtained per hour. The gas had the following composition:

	Per cent
C_2H_2	7.6
CO_2	11.0
C_2H_4	5.2
O_2	0.0
CO	31.6
H_2	38.8
CH_4 and higher	5.8

Example VI. Acetylene from Darst Creek crude oil.—Darst Creek crude oil is supplied to the counter-current vaporizer at the rate of about 126 pounds per hour, along with about 60 pounds of steam. About 88% of the oil is vaporized, and about 60 pounds of steam are admixed with the vapors per hour. The resulting mixture is superheated to about 425° C., and supplied to a reaction chamber similar to that of Example II, along with about 1120 cubic feet of oxygen, preheated to about 400° C. per hour. In one case, an exit gas containing 8.4% of acetylene was obtained.

In the process as described, using a liquid hydrocarbon such as crude oil, it is important, as previously pointed out, to admix the oil vapors with steam, both for the prevention of objectionable coking and for modification of the reaction. The oxygen should be used without an excess of diluent or it will not produce the localized high temperature combustion required in the process.

It will thus be seen that by the present invention I provide a new and improved process by which acetylene may be produced from normally liquid hydrocarbons in large quantities and with apparatus which can be run for long periods of time without dismantling for cleaning or other purposes. When cleaning is required, the head can be readily removed and replaced.

The acetylene produced by the present process may be used for chemical manufacture or for other purposes, and the other gases which are produced as by-products can be advantageously used for fuel or for the manufacture of such products as synthetic alcohols.

Thus the process of the invention, in its broader aspects, includes the production of acetylene by the combustion or reaction of a mixture of vapors of normally liquid hydrocarbons and steam with insufficient oxygen to cause the complete combustion of the hydrocarbon, but sufficient to bring about a reaction or combustion which releases heat sufficient to produce cracking or conversion of substantial quantities of the hydrocarbon, with the production of substantial amounts of acetylene, and I claim this invention broadly. The carrying out of the combustion or reaction by the burning of a large number of directed jets of oxygen or a gas rich in oxygen, with a large number of jets of hydrocarbon vapor and admixed steam under conditions such that a large number of small, regulated and localized flames are produced, with localized high temperatures, and with subsequent mingling and interspersing of the burning and burned products in a composite flame or reaction zone to permit the completion of the reaction, is particularly advantageous, and I claim this process specifically.

Also, the method in which part or all of the steam used in admixture with the hydrocarbon vapors is used to aid in the vaporization of the hydrocarbon is an advantageous method of operation, particularly for the heavier hydrocarbon liquids, such as crude oil, topped crude oil, etc. and I claim this method of producing the mixture of hydrocarbon vapors and steam used for the production of acetylene by reaction or combustion with oxygen.

The new and improved apparatus of the present invention includes the vaporizer, and particularly the countercurrent vaporizer, adapted for the production of a mixture of oil vapors and steam, in combination with a suitable superheater and reaction chamber, adapted for the cracking or conversion of the hydrocarbon vapors with the production of substantial amounts of acetylene, and for the treatment of large quantities of liquid hydrocarbon, and the production of large quantities of gas, per day. I do not claim this apparatus herein because it is claimed in my divisional application Serial No. 252,640, filed January 24, 1939.

The new and improved combustion or reaction chambers including the new and improved heads for the supply of a large number of directed and separate high velocity jets of oxygen and hydrocarbon vapor and steam so arranged that each directed high velocity jet of oxygen impinges upon or is surrounded or comes into intimate contact with, one or more directed high velocity jets of hydrocarbon vapor and steam, or so that each directed high velocity jet of hydrocarbon vapor and steam impinges upon or is surrounded by or comes into intimate contact with one or more high velocity jets of oxygen, in combination with a suitable reaction chamber, comprising an open, unrestricted tube advantageously made of carborundum or other suitable refractory material; and in combination with means for supplying the hydrocarbons and oxygen to the jets under a sufficiently high pressure, and means for quickly removing and cooling the resulting gases, which are described herein, are not broadly claimed herein, as they are described and claimed in my companion application, Serial No. 91,407, filed of even date.

I claim:

1. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises admixing hydrocarbon vapors with steam and causing regulated combustion of the resulting admixed

hydrocarbon vapors and steam with oxygen in such proportions as to give regulated combustion with resulting production of acetylene, the admixed hydrocarbon vapors and steam, and the oxygen, being separately introduced into the chamber in which the combustion takes place.

2. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises supplying to a relatively large combustion chamber a large number of directed jets of high velocity of admixed hydrocarbon vapor and steam, separately supplying to said chamber a large number of directed jets of oxygen of high velocity, and causing combustion of the hydrocarbon and oxygen so introduced with resulting production of gases containing acetylene.

3. In the method of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises vaporizing the liquid hydrocarbon with the aid of steam and with the resulting production of admixed steam and hydrocarbon vapors, and causing regulated, intense combustion of the admixed hydrocarbon and steam with oxygen to produce acetylene, the admixed hydrocarbon vapors and steam, and the oxygen, being separately introduced into the chamber in which the combustion takes place.

4. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises introducing into a large combustion and reaction chamber a large number of separate high velocity jets of hydrocarbon vapors admixed with steam and of oxygen, the jets being so directed as to cause commingling and combustion in a localized and regulated manner and with blending of the resulting jets and products of combustion in a composite combustion or reaction zone.

5. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises supplying the hydrocarbon vapors admixed with steam in a gaseous or vaporous form under pressure, separately supplying oxygen under pressure, and causing the hydrocarbon vapors and admixed steam and oxygen to discharge separately through a large number of directed jets at high velocity into a large combustion and reaction chamber, with resulting expansion and reduction in velocity of the individual jets and localized combustion followed by further blending or mingling of the jets and products of combustion in a composite combustion or reaction zone.

6. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises introducing, into a relatively large combustion chamber, a large number of separate individual jets of hydrocarbon vapor admixed with steam and oxygen at a high velocity, said jets being arranged in pairs so that each jet of hydrocarbon has a corresponding impinging jet of oxygen, and causing combustion of the gases thus introduced and combining of the same in a composite combustion or reaction zone followed by prompt cooling of the resulting gases and vapors.

7. In the process of producing acetylene from liquid hydrocarbons by combustion with an amount of oxygen insufficient for complete combustion, the improvement which comprises introducing, into a relatively large combustion or reaction chamber, and in a continuous manner, a large number of individual directed jets of hydrocarbon vapor admixed with steam in gaseous or vapor form at high velocity, separately introducing a large and corresponding number of individual directed jets of oxygen at high velocity, directing the respective jets to cause localized initial combustion in a large number of localized combustion zones, followed by blending or intermingling of the products of initial combustion in a further composite combustion zone, and causing the gases to pass through the combustion or reaction chamber at high velocity and promptly cooling the resulting gases.

FLOYD J. METZGER.