Feb. 7, 1939. E. W. REMBERT 2,146,553

VAPOR PHASE CRACKING PROCESS AND THE PRODUCTION OF FOGS

Filed July 22, 1932 2 Sheets-Sheet 1

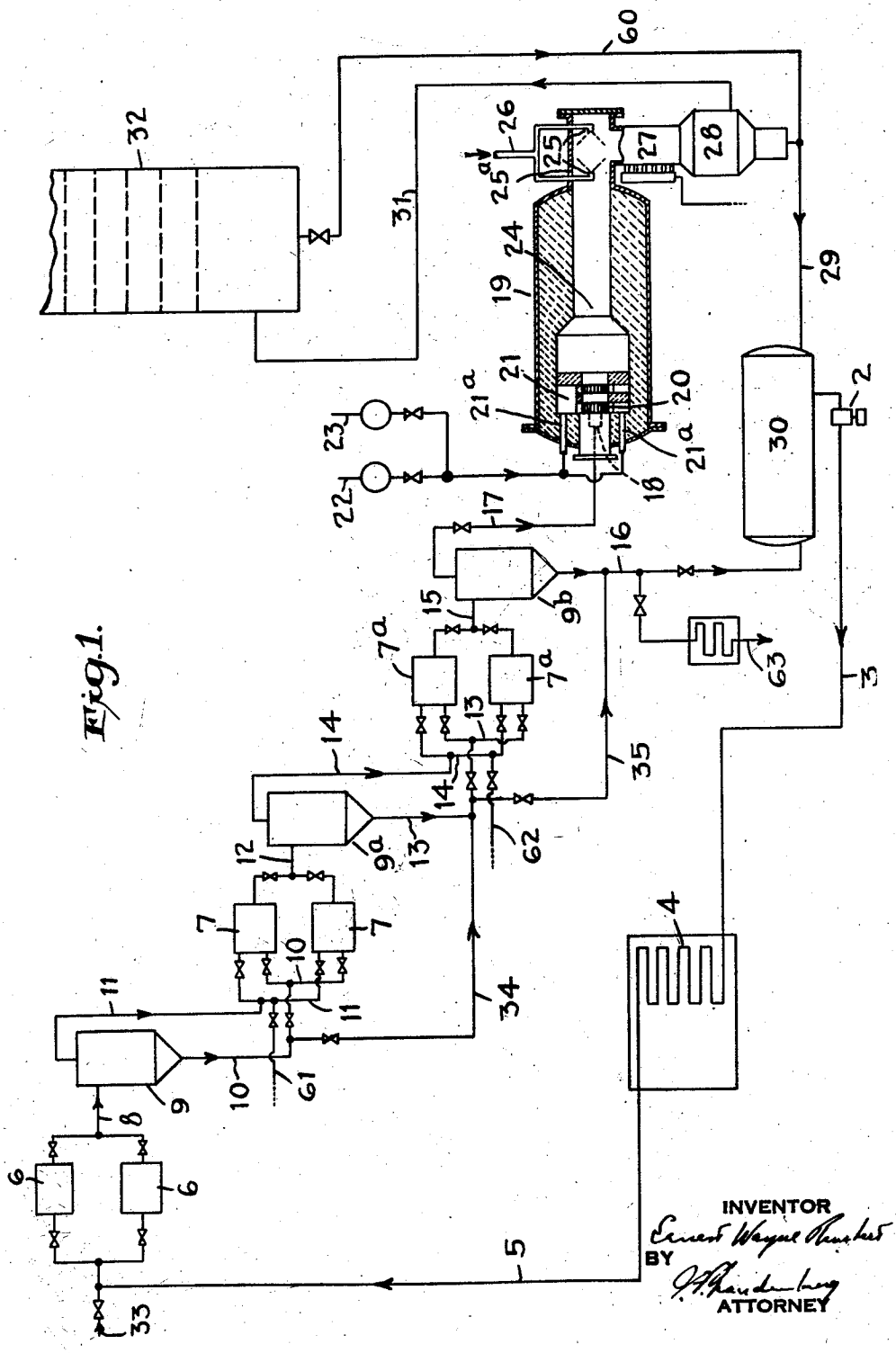


Fig. 1.

INVENTOR
Ernest Wayne Rembert
BY
ATTORNEY

Feb. 7, 1939. E. W. REMBERT 2,146,553

VAPOR PHASE CRACKING PROCESS AND THE PRODUCTION OF FOGS

Filed July 22, 1932 2 Sheets-Sheet 2

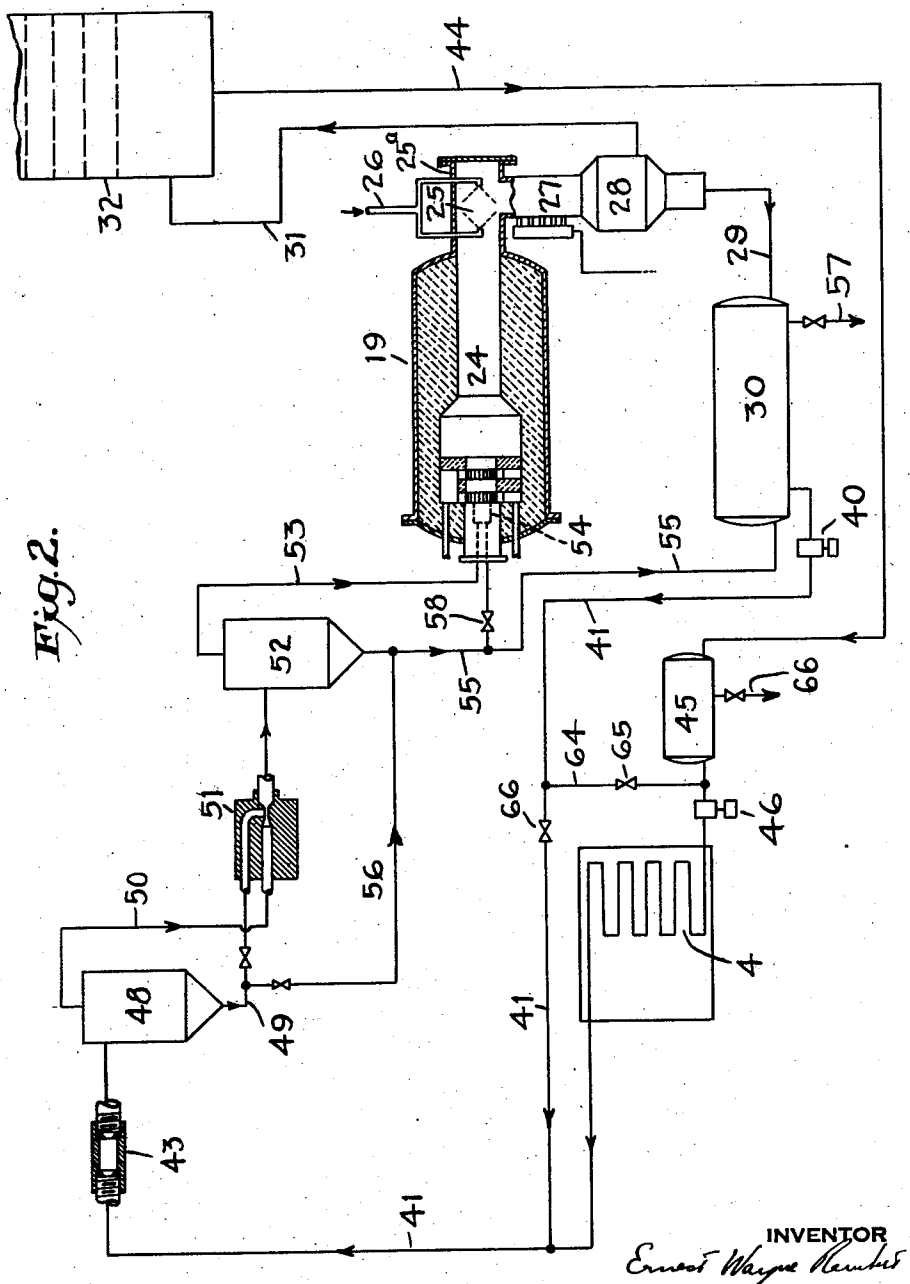


Fig. 2.

INVENTOR
Ernest Wayne Rembert
BY
J. Thomas Hamilton
ATTORNEY

Patented Feb. 7, 1939 2,146,553

UNITED STATES PATENT OFFICE

2,146,553

VAPOR-PHASE CRACKING PROCESS AND THE PRODUCTION OF FOG

Ernest Wayne Rembert, Plainfield, N. J., assignor, by mesne assignments, of three-fourths to Tide Water Associated Oil Company, New York, N. Y., a corporation of Delaware

Application July 22, 1932, Serial No. 623,979

14 Claims. (Cl. 196—61)

This invention relates to the vaporization and the vapor-phase cracking of hydrocarbons, and to the production of fogs and mists containing or constituting the material for conversion by such a process, and for other purposes.

In the field of vapor-phase cracking, the invention relates more particularly to a type of process, such as disclosed in my Patent No. 1,892,534, dated December 27, 1932, in which the material to be converted is intimately mixed with hot gas and is by this direct heating vaporized and/or superheated to conversion temperature. The oil to be converted may be introduced into contact with the hot combustion gases or other heating medium either in the state of vapor or as a liquid spray. In the case of heavy stocks, which are difficult to vaporize satisfactorily outside of the mixing and reaction unit, introduction of the material in the liquid phase is desirable. Existing atomizing or spray nozzles, however, are apt to be unreliable when heavy material is to be fed to a cracking operation of this kind. In the spray formed by such nozzles there is a range in the size of particles, and, if the nozzle becomes dirty, scaled or abraded through use, the spray is likely to become irregular, with the production of excessively large drops. These larger drops, when mixed with the hot, inert gas for cracking in the vapor phase, do not vaporize fast enough to prevent a portion of the liquid actually striking the walls of the mixing chamber. When this occurs, the result is the production of coke, lampblack and gas. Also, when large drops are present, the rate of vaporization is slow compared with the rate of cracking, with the results that a certain amount of coke is formed in the liquid phase, and also excessive amounts of gas and fixed carbon in the form of lampblack are formed in the vapor phase. Such conditions give lower yields of gasoline or other liquid products and make it necessary to interrupt the operation for cleaning more often than is desirable.

An object of this invention is to make it possible to crack heavy material by intermixture with hot gases, without coke formation and without attendant difficulties and losses, when the hydrocarbons to be converted are fed either wholly or partly in the liquid phase to the region of mixing with the hot gas. The process of the invention is also applicable to the treatment of oils, such as distillates, that can be vaporized more readily. In this process, the liquid oil is atomized with or by a gaseous fluid, which may be either a vapor or a gas, before it is brought into contact with the heating gas, by which the liquid particles resulting from atomization are vaporized and the vapors are cracked, and the resulting mixture is subjected also before contact with the heating gas, to a treatment which removes all droplets large enough to suffer local overheating and yield coke in the mixing and heating chamber or the reaction chamber. In this way, a feed stream consisting of a satisfactorily fine suspension of the liquid in the carrying gas or vapor is obtained, and it is this stream which is mixed with the heating agent.

In general, the temperature of the mist or fog so fed should be in the neighborhood of 750°–850° F., the temperature being determined, however, by the refractoriness of the material; that is, if the material can be cracked easily the temperature at which it is permissible to feed the material is relatively low.

The entire supply of hot gas for instantly vaporizing the liquid particles and for superheating the vapor to conversion temperature may be mixed with the feed stream at one point, or this mixing and heating may be effected in stages as disclosed in my copending application Serial No. 623,978, filed July 22, 1932, without altering the invention.

The invention contemplates the elimination of all liquid particles above a given or troublesome size and the production of a feed material which is in the nature of a mist or stable fog, but even though the separation may be conducted in a less effective manner or the atomization be less drastic the evils of coking and excessive production of lampblack and fixed gas can be greatly mitigated. Therefore, I do not necessarily limit myself to the production and utilization for vapor-phase cracking purposes of a suspension consisting altogether of particles so small as to be regarded technically as the liquid phase of a fog or mist, and these terms are, therefore, to be understood in a somewhat general sense. Indeed, as will be disclosed, after a fog-like or mist-like stream, carrying a large part of the liquid material to be vaporized and cracked, has been formed, some additional liquid may be atomized in contact with this stream, and the issue may then be mixed with the heating gas without a further separation of such larger droplets as may result from the final atomization.

The gaseous fluid employed in the atomization and to serve as the carrier for the liquid particles may be a true gas, such as fixed hydrocarbon gases, for example, or it may be a vapor, such as steam. Preferably, however, this fluid consists of

hydrocarbon vapor, which is itself to be cracked. More especially, the invention includes the heating and partial vaporization of oil to be subjected to the cracking reaction, and the automization of the unvaporized portion in the vapor thus produced. The atomization of oil in its own vapor, to create a feed for the steps of mixing with hot gas, vaporization of the liquid particles and cracking by direct heating, constitutes an important feature of the invention.

If the oil is of such character that it can not be easily made to yield sufficient vapor by convenient heating and vaporizing methods, as, for example, by passing it through a pipe still, with or without release into a separating zone at relatively reduced pressure, the vapor which is evolved from the oil may be supplemented by steam or by other medium. Again, a heavy oil can be heated with comparatively little or no vaporization, and this hot oil can be mixed and atomized with the vapors obtained by substantially completely vaporizing a lighter oil or distillate, such as gas oil.

A single separation of large droplets following atomization of the oil in contact with the gaseous fluid, and before mixing the feed stream with the hot gas, can be made to suffice, but in the preferred and most effective mode of execution of the invention liquid is atomized in successive stages, with corresponding successive separations of larger liquid particles, until a definite limit of size of particle has been obtained in the fog or mist, or until a definite quantity of liquid has been suspended in the gaseous carrying fluid.

A further feature of the invention consists in the maintenance of back pressure in the atomizing and separating system, and the abrupt release of the mixture of gaseous fluid and suspended liquid particles from this back pressure, with consequent production of a finer mist or fog, since on the release of pressure a portion of each individual droplet will vaporize automatically and thus the droplet will shrink. The release of pressure is preferably made to take place at the nozzle through which the fog is delivered into contact with the hot gas, though this may be varied.

Other objects and features of the invention will become apparent as the specification proceeds.

In the accompanying drawings forming part hereof:

Fig. 1 is a schematic view of a system of apparatus for carrying out the invention, one part of the apparatus being shown in section; and

Fig. 2 is a schematic view illustrating a simplified system, portions of which are shown in section. Numerous other forms and embodiments of the invention will suggest themselves to those skilled in the art.

In Fig. 1, the oil to be treated is forced under substantial pressure by a pump 2 through a line 3 to and through the tubes of a pipe still or heater 4. A considerable part of the oil is vaporized, and the vapor and unvaporized oil pass through a line 5 to one of a pair of mixers and preliminary atomizers 6. For practical reasons, it is desirable to duplicate the mixers 6 and the atomizers 7 and 7a, and to provide valves as indicated for shutting off their connections, so that one device of a pair can be cleaned while the other is in service. The mixers 6 may be of any suitable construction, as, for example, one employing a series of orifice plates through which the mixture of vapor and liquid is made to pass. From the mixer, the material is delivered through a pipe 8 to a separator 9, where the large drops of liquid are caused to separate from the vapor and from the majority of small drops which remain in suspension in the vapor.

Liquid is conducted from the separator through piping 10 to one of a pair of atomizers 7. The vapor laden with small drops passes from the separator to these atomizers through piping 11. The liquid and vapor are again mixed and more liquid is atomized. The mixture proceeds through a pipe 12 to another separator 9a, where all large droplets of the spray are removed. Liquid collecting in this separator flows through piping 13 to one of the atomizers 7a, to which the vapor-carried spray or mist is conducted through piping 14. Liquid is again broken up in passing through this atomizer, enriching the fog, which is then delivered through a pipe 15 to a separator 9b, where a final removal of oversize particles is effected. The liquid leaving this separator through valved line 16 may be withdrawn from the system or may be delivered to hot oil storage for re-cycling.

The fog or mist of very fine particles in suspension in the vapor leaves the last separator through a valved pipe 17 and passes to the feed nozzle 18 of the mixing, heating and cracking unit 19. There it enters a suitable mixing chamber or tube 20, where it is intimately mixed with hot and inert combustion gases from a combustion chamber 21, this combustion chamber having burners 21a which are supplied with air and liquid or gaseous fuel by blowers through valved lines 22, 23. The liquid material in the issue from the nozzle 18, because of the fine state of division in which it exists, and because all or practically all large drops have been excluded, is vaporized at once. For the same reasons, coking on the walls is avoided or reduced to a minimum, and the mixing, heating and cracking operation proceeds continuously for an indefinitely long time and in an economic manner. The mixture of the heating gas and vapor proceeds through a heat-insulated and refractory-walled reaction chamber 24, where it is kept at the conversion temperature, preferably above 900° F., for a predetermined brief reaction time, at the conclusion of which it is quenched to a temperature sufficiently low (750° F. or less) to arrest the reactions. In respect to these matters, the operation is preferably carried out in accordance with the process disclosed in my Patent No. 1,892,534.

The quenching liquid delivered through spray nozzles 25 in quencher 25a into contact with the mixture issuing from the reaction chamber is preferably the charging stock supplied through a charging line 26, and the oil thus preheated, or the unvaporized part thereof, is preferably the material which is circulated through the pipe still 4. The materials proceeding from the quencher may be passed through a scrubber 27 and a separator 28, as disclosed in my copending application Serial No. 623,977, filed July 22, 1932, the liquid being conducted thence through line 29 to a hot oil receiver 30, from which the pump 2 derives its supply, while the gases and vapors pass through a line 31 to a fractionating column 32 and the usual cooling and condensing equipment connected therewith.

Reflux condensate from the column 32 may be conducted through a line 60 and be added to the preheated oil from the quencher 25a, which is passed through the heater 4. Such admixture

may be effected in the pipe 29 leading to the hot oil receiver 30.

The invention is not limited to the specific forms of the apparatus employed in the atomizing and separating system in which the fog is prepared for feeding the mixing, heating and reaction unit. The atomizers are preferably of the conventional type utilizing separate streams of liquid and expansive fluid, in which the liquid is directed across the stream of expansive fluid, so that the liquid is atomized as the result both of pressure drop and of the action of the expansive fluid. However, a variety of atomizing devices may be employed. The number of atomizers used in series will depend upon the concentration of liquid desired in the vapor at the end of the system, and, also, the more efficient the atomizers the smaller will be the number of units required in series to accomplish a given result.

The design of a separator for use at 9, 9^a or 9^b must be such as to throw out most or substantially all of the drops formed in atomizing that are larger than the desired size. The type that is most advantageous is one in which the stream from the atomizer is delivered tangentially into a circular chamber of considerable volume, the resulting whirling motion of the mixture in the chamber causing the larger drops to be thrown by centrifugal force against the walls, down which they flow to the bottom of the chamber. Instead of such separators, it is evident that large drums, in which the velocity of the stream is slowed down to a point where settling of the larger drops occurs, may be employed. Still other types of separator can be used.

If the oil passed through the pipe still 4 is of a kind that yields insufficient vapor, it may be supplemented with steam or with other vapor or gas. Thus, a valved steam line 33 is is shown joining the still outlet pipe 5 in advance of the preliminary atomizers 6, and in like manner steam or other additional expansive fluid may be introduced at or before any of the atomizers. Valved lines 61 and 62 are shown connecting with the piping 11 and 14, for this purpose.

The amount of liquid fed from a separator to a succeeding atomizer is regulated so that the proportion of liquid to vapor passed through the atomizer is that which will give the most efficient operation. A valved line 34 is shown by which a portion of this liquid can be by-passed past the atomizers 7 to the atomizers 7^a, or through a further by-pass 35 to the line 16 which conducts liquid from the last separator 9^b to the hot oil storage 30 and/or to a draw-off 63 from the system. Similarly, a portion of the liquid from the separator 9^a can be diverted from the atomizers 7^a.

Back pressure is held in the atomizing and separating system, and the egress for the fog at the feed nozzle 18 of the cracking unit, or at an anterior point, is restricted in order to effect a sharp eventual reduction in pressure. This results in a decided diminution in the size of the liquid particles in suspension in the fog, through partial vaporization, regardless of extraneous heating.

The pressure drop across the atomizing and separating system will be determined by the number, size and design of the atomizers and separators, and the requirements of the particular case. The advantage of maintaining as high a back pressure as is economical is not to be overlooked. A pressure drop of 150 pounds per square inch across the atomizing and separating system and the point of release is economically feasible, but naturally may be less. The pressure drop through a single atomizer and separator in series with others may be as low as 30 pounds per square inch, for example, and may range upwards of about 50 to 60 pounds. An atomizer unit giving 40 to 50 pounds per square inch pressure drop across it may be considered as a typical example of a series system.

Fig. 2 illustrates both a simplification of the atomizing and separating process and the atomization of a heavy oil with the vapor of a light oil. Operation on a heavy crude, a large portion of which is flashed off in the quencher at temperatures of the order of 700° F., will be more particularly considered. In this case, operation of a pipe still to provide sufficient vapor for atomization would prove difficult.

The crude oil is charged through the line 26 to the quenching spray 25. The hot reduced crude passes to the hot oil receiver 30, from which it is pumped by pump 40 through line 41 to mixer 43. Reflux distillate from the fractionating column 32 is taken through line 44 to reflux receiver 45, whence it is pumped by pump 46 to and through pipe still 4, where it is practically completely vaporized. Part of this oil may be removed from the system at 63. The vapor, and liquid if any, from the still 4 joins the hot oil stream in the piping 41, and the liquid and vapor are churned in the mixer 43 and are delivered into the separator 48, from which liquid, and vapor carrying a proportion of droplets, are taken off through pipes 49 and 50, respectively, leading to atomizer 51. The fog or mist produced in the atomizer is delivered into a separator 52, wherein large drops are thoroughly removed. The fog then proceeds through pipe 53 to the feed nozzle 54 of the mixing, heating, vaporizing and reaction unit 19. The liquid separated in the separator 52 is returned through line 55 to the hot oil receiver 30.

A portion of the liquid oil from the separator 48 may be by-passed through line 56, past the atomizer 51, and be returned to hot oil storage. Part of the heavy material may be withdrawn from the system, as it may be necessary or desirable to do so, through a draw-off 57 connected with the reservoir 30, or elsewhere.

The valved line 58 indicates the possibility of supplying a certain proportion of liquid oil to the feed nozzle, which in that event would be an atomizing nozzle. If the proportion of oil thus atomized directly into contact with the hot gas is not large in proportion to the volume of preformed stable fog, little or no difficulty in achieving vaporization without coking or excessive gas and carbon formation need be encountered.

A system such as illustrated in Fig. 2 is made more flexible by providing for interconnections in advance of the heater 4, between the reflux from the fractionating column 32 and the heavy or residual-containing stock that is accumulated in the reservoir 30. Operations or processes differing specifically from the one just described can be carried out with the same apparatus, or the system may be definitely designed for one or another of these modified operations.

In the particular organization of apparatus illustrated in Fig. 2 a pipe 64 is shown cross-connecting the heavy-oil line 41 with the connection between the reflux receiver 45 and the pump 46 that forces oil through the still or heater 4. In the operation that has been described, the valve 65 in the pipe 64 would be closed. By opening this

valve more or less and by properly adjusting the valve 66 in the line 41, any desired part of the heavy oil stream on its way to the mixer 43 can be diverted and can be passed together with the light oil or reflux through the still 4 when the temperature of the heavy oil stream needs to be raised. If the hot oil from the quencher 25a be of such character that a sufficient portion of it can be vaporized readily, the valve 66 may be closed, in which event all of the material would be pumped through the still, to be partially vaporized therein. Finally, all of the tower reflux might be removed from the system, as at 63, and only the hot oil from the quencher be passed through the still.

Numerous other modifications and applications of the invention will suggest themselves to those skilled in the arts to which it relates.

I claim:

1. A method of treating hydrocarbons, which comprises atomizing hot oil in hydrocarbon vapor, both of which are to be cracked, separating the larger droplets of liquid from the resulting mixture to obtain a feed stream consisting of the hydrocarbon vapor and much liquid material consisting of suspended fine liquid particles, and vaporizing the particles and subjecting the vapors to a cracking reaction, the heat for vaporization, superheat and cracking being supplied by hot gas with which said feed stream is contacted and intermixed after the feed stream has been formed.

2. A method of treating hydrocarbons, which comprises heating oil material and vaporizing a part thereof, atomizing the unvaporized liquid in the vapor obtained from the original liquid, and thereafter bringing the resulting mixture of vapor and much atomized liquid into intimate contact with gaseous heating fluid sufficient in temperature and amount to vaporize the atomized liquid and crack the vapors.

3. A method of treating hydrocarbons, which comprises heating oil material under pressure and vaporizing a part thereof, atomizing the unvaporized liquid in the vapor obtained from the original liquid, separating larger droplets of liquid from the resulting suspension of fine particles in the hydrocarbon vapor, thereby obtaining a fog or mist, maintaining back pressure on the atomizing and separating steps, abruptly reducing the pressure on the fog or mist to effect reduction in particle size by partial vaporization, and then mixing the fog or mist with hot combustion gases to obtain a vaporizing and cracking reaction.

4. A method of treating hydrocarbons, which comprises heating oil material under pressure and vaporizing a part thereof, atomizing the unvaporized material in the vapor obtained from the original liquid, separating larger droplets of liquid from the resulting suspension of fine particles in the hydrocarbon vapor, separately withdrawing liquid and a suspension of fine particles in the hydrocarbon vapor from the separation step, atomizing this withdrawn liquid in contact with the withdrawn suspension, separating larger droplets from the enriched suspension, maintaining back pressure on the atomizing and separating steps and introducing the fog or mist so obtained, with a simultaneous reduction in pressure to effect reduction in particle size by partial vaporization, into hot combustion gases to obtain a vaporizing and cracking reaction.

5. A method of treating hydrocarbons, which comprises continuously supplying two kinds of oil, one of which is readily vaporizable and the other of which is not, vaporizing the first of these oils, mixing the vapor thus obtained with the other hot oil and atomizing the latter, separating the larger droplets of liquid from the resulting mixture to obtain a feed stream consisting of the vapor and much liquid material consisting of suspended fine liquid particles, thereafter mixing the feed stream with hot gas and thereby instantaneously vaporizing the liquid particles, and subjecting the hydrocarbons to a vapor-phase cracking reaction.

6. A method of treating hydrocarbons, which comprises continuously supplying two kinds of oil, one of which is readily vaporizable and the other of which is not, vaporizing the first of these oils, mixing the vapor thus obtained with the other hot oil and atomizing the latter, thereafter subjecting the resulting mixture of vapor and much liquid material consisting of suspended liquid particles to direct heating by intermixing hot gas therewith, to vaporize the liquid particles, and subjecting the vapors to a cracking reaction.

7. A method of treating hydrocarbons, which comprises atomizing oil in a gaseous fluid, separating larger droplets of liquid from the resulting mixture, collecting said larger droplets and withdrawing this liquid, taking off separately the gaseous fluid laden with fine liquid particles, re-atomizing the withdrawn liquid in the mixture of gaseous fluid and suspended liquid particles previously obtained, and again separating larger droplets, thereby obtaining an enriched, stable fog, and supplying this fog to a vaporizing and vapor-phase cracking operation in which vaporization of the liquid particles is effected by intermixing the fog with hot gas.

8. A method of treating hydrocarbons, which comprises atomizing oil in a gaseous fluid, separating larger droplets of liquid from the resulting mixture, separately withdrawing liquid and a mixture of gaseous fluid and suspended liquid particles from the separation step, atomizing this withdrawn liquid in the withdrawn mixture, separating larger droplets from the enriched suspension of fine particles in the gaseous fluid, mixing a fog or mist thus obtained with hot combustion gases, thereby instantaneously vaporizing the fine liquid particles, and subjecting the hydrocarbons to a vapor phase cracking reaction.

9. A method of treating hydrocarbons, which comprises atomizing oil in a gaseous fluid, separating larger droplets of liquid from the resulting mixture, separately withdrawing liquid and a mixture of gaseous fluid and suspended liquid particles from this separation step, atomizing this withdrawn liquid in the withdrawn mixture, separating larger droplets from the enriched suspension of fine particles in the gaseous fluid, regulating the amount of liquid supplied to an atomizing step and by-passing the remainder to a subsequent atomizing step, and supplying the fog or mist thus obtained to a vaporizing and cracking operation, in which the material is heated by direct contact with hot combustion gases.

10. A method of treating hydrocarbons, which comprises atomizing hot oil in a hot gaseous fluid, both of which are supplied under pressure, separating larger droplets of liquid from a suspension of fine particles in the gaseous fluid, thereby obtaining a fog or mist, maintaining back pressure on the separating and atomizing steps, abruptly releasing the fog or mist from the pressure, mixing it with hot combustion gases at least sufficient in temperature and amount to vaporize

the liquid particles, and subjecting the vapor to a cracking reaction.

11. A method of treating hydrocarbons, which comprises atomizing oil in a gaseous fluid, separating larger particles of liquid from the resulting mixture, enriching the stream of gaseous fluid and suspended particles thus obtained by mixing it with a regulated amount of hot oil and atomizing the latter, and by such steps obtaining a feed containing a large amount of finely dispersed liquid, which feed is then mixed with hot gas to increase the temperature sufficiently to vaporize the liquid particles and crack the hydrocarbons in the vapor phase.

12. A method of treating oil, which comprises heating the oil and vaporizing a part of it, separating the vapor and the unvaporized liquid, withdrawing a stream of the unvaporized liquid and atomizing this stream in the vapor so that the vapor becomes charged with droplets, delivering the carrying vapor and carried droplets to a separating zone, there removing larger droplets, and by such steps producing a feed stream in the nature of a fine mist, which is eventually mixed with enough heating gas of sufficient temperature to vaporize the liquid particles and crack the vapors.

13. A method of treating oil by atomizing oil in contact with a gaseous carrying medium, thereby charging the carrying medium with droplets, eliminating the larger doplets from the mixture and by such steps producing a stream of very fine particles suspended in the medium, which is then mixed with enough high temperature gas to vaporize the liquid particles and crack the vapors.

14. A method for the conversion of hydrocarbon oils, which comprises atomizing liquid oil in and by its own vapor, to produce a fog or suspension of fine liquid particles in the vapor, removing insufficiently atomized oil from this suspension, thereafter mixing the fog-like suspension with hot gas, the heat of which vaporizes the liquid particles, and subjecting the vapors to a cracking reaction.

ERNEST WAYNE REMBERT.