Jan. 19, 1954 R. A. FINDLAY 2,666,734

APPARATUS FOR CONVERSION OF RESIDUAL OILS

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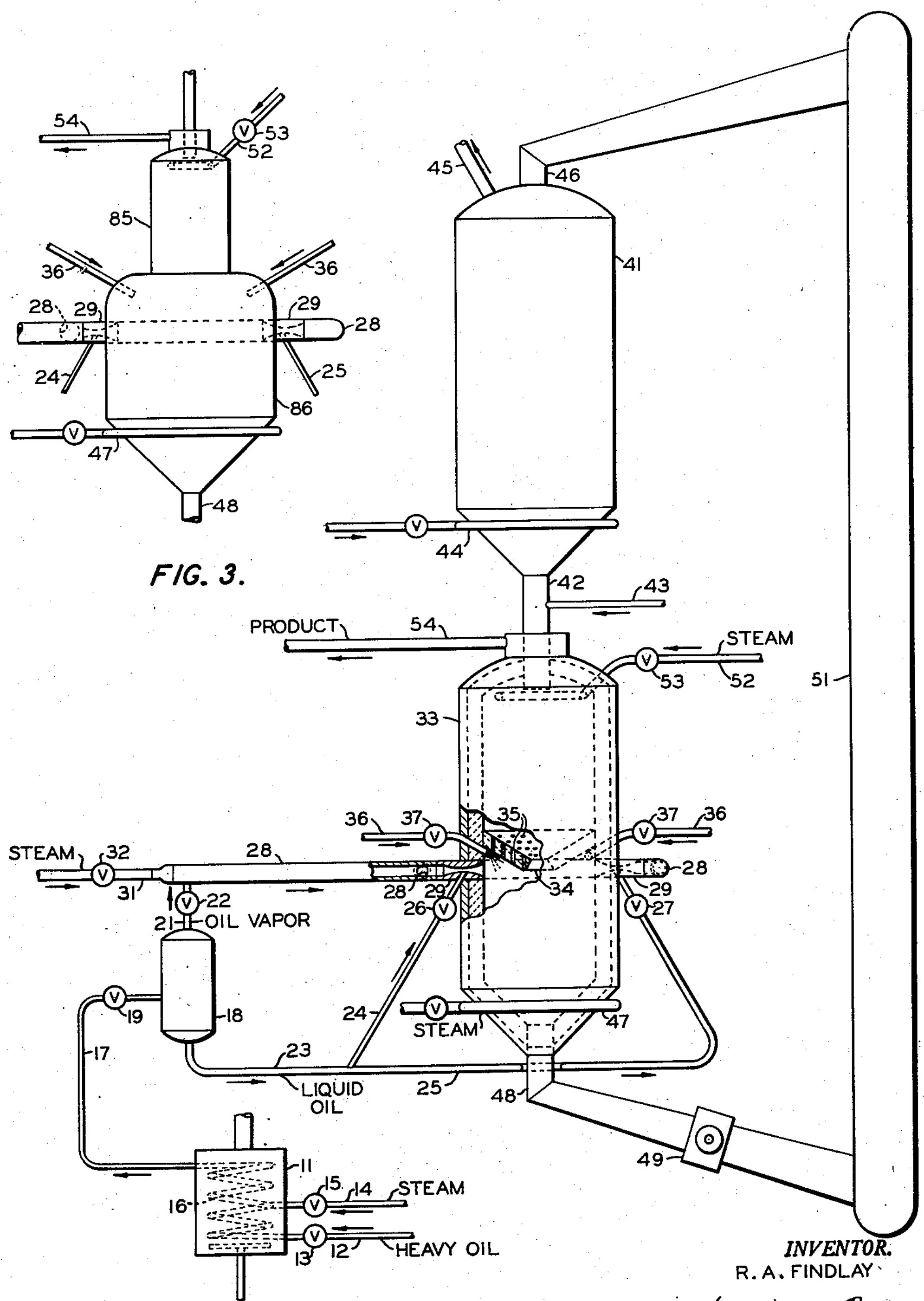

FIG. 3.

FIG. I.

INVENTOR.
R. A. FINDLAY

BY Hudson and Young

ATTORNEYS

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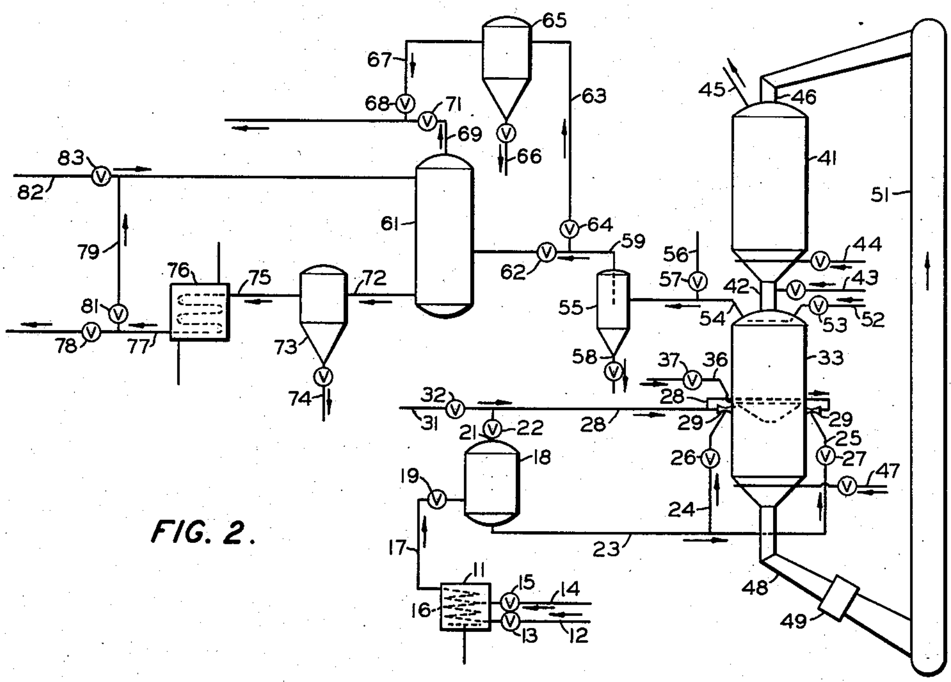

FIG. 2.

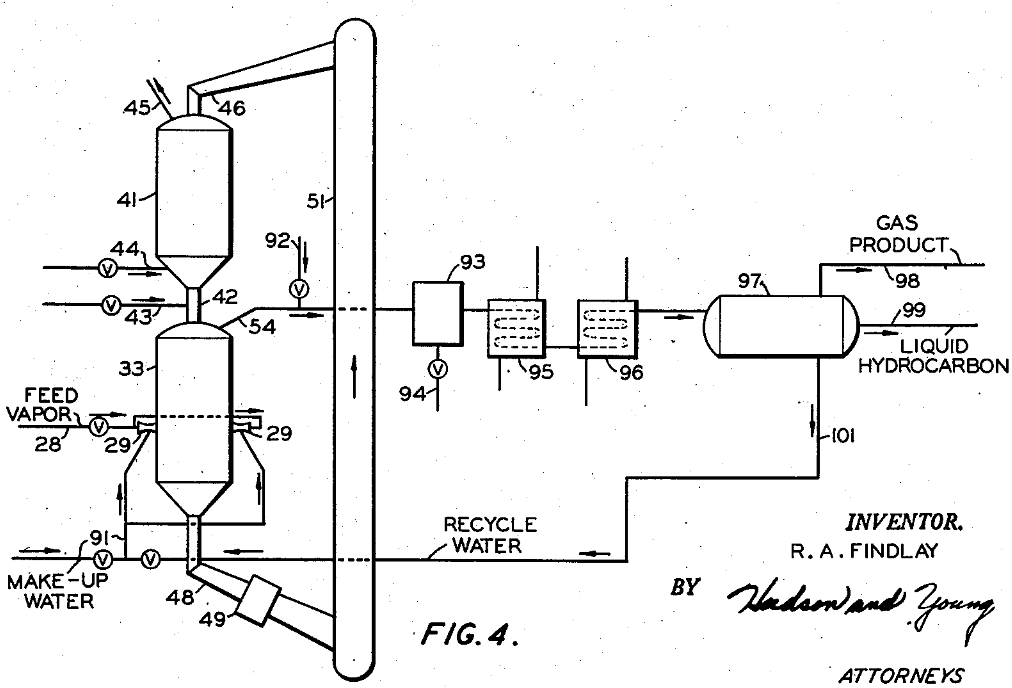

FIG. 4.

INVENTOR.
R. A. FINDLAY

BY Hudson and Young

ATTORNEYS

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APPARATUS FOR CONVERSION OF RESIDUAL OILS

Robert A. Findlay, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

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5 Claims. (Cl. 196—120)

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This invention relates to the conversion of heavy residual oils. In one of its more specific aspects it relates to a method for cracking heavy residual oils at high temperatures. In another of its more specific aspects it relates to an improved system for cracking heavy residual oils at high temperatures.

Heavy residual oils have long posed a considerable problem in the petroleum industry. Although the refining technique of the petroleum industry has improved greatly during the past several years, heavy residual oils have been of little or no value because of the very great tendency of such materials to form and deposit coke, tar, or other carbonaceous deposits in refining equipment. As the demand for petroleum products has increased, that demand has placed a greater burden upon the natural resources of the world and has focused attention more directly upon what heretofore has been deemed waste materials. Heavy residual oils are very closely akin to waste materials and it is believed therefore that any process which aids in the utilization of such materials is of very great importance.

Many processes have been set forth in the petroleum art by which it has been proposed to crack heavy residual oils to provide normally lighter materials, such as hydrogen and hydrocarbons and gasoline stocks. As pointed out above, however, the tendency for such materials to form carbonaceous deposits has made such processes relatively uneconomical. I have devised a process and a system whereby the tendency of such heavy residual oils to form tarry and carbonaceous materials may be considerably overlooked because such materials are handled in this process with minimum detrimental effects.

Broadly speaking, this invention comprises heating a heavy residual hydrocarbon oil to a temperature above its initial boiling point, flashing the oil so as to separate a vaporous phase and a liquid phase, passing the liquid residual oil through an atomizing fog nozzle so as to atomize the unvaporizable material into an exceedingly finely dispersed fog by the flow of the oil vapors. The oil fog is then injected into the conversion chamber of pebble heater apparatus in which conversion chamber the pebbles are maintained at a temperature at least as high as the conversion temperature of the oil. The oil fog passes upwardly through the downflowing heated pebble mass and is converted to form the desired reaction products.

An object of this invention is to provide an improved method for converting heavy residual

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oils. Another object of the invention is to provide an improved system for cracking heavy residual oils. Another object of the invention is to provide a method for cracking heavy residual oil fog by heat treatment in pebble heater apparatus. Another object of the invention is to provide a method for producing substantially tar-free carbon black from heavy residual oil fog. Another object of the invention is to provide a method for producing water gas from heavy residual oil fog. Another object of the invention is to overcome the problem of coking in a process for converting heavy residual oils to carbon black and/or coke, aromatic distillates, and normally gaseous material, such as ethylene. Other and further objects and advantages will be apparent to those skilled in the art upon study of the accompanying disclosure and the drawings.

Solid heat exchange material which may be utilized in the pebble heater system of this invention is generaly termed "pebbles." The term "pebbles" as used herein denotes any substantially solid material of flowable size and form which has sufficient strength to withstand mechanical pressures and the temperatures encountered within the pebble heater system. These pebbles must be of such structure that they can carry large amounts of heat from one chamber to another without rapid deterioration or substantial breakage. Pebbles which may be satisfactorily used in this gasification system may be substantially spherical in shape and range from about one-eighth inch to about one inch in diameter. The pebbles are preferably of a size within the range of from one-eighth inch to five-eighths inch in diameter. Materials which may be used singly or in combination in the formation of such pebbles include among others alumina, silicon carbide, periclase, beryllia, mullite, nickel, cobalt, copper, iron, magnesia, and silica.

More complete understanding of the invention will be obtained upon reference to the schematic drawings in which Figure 1 is a diagrammatic elevation, partly in section, of the conversion system of this invention. Figure 2 is a flow diagram showing the flow of materials in the conversion of heavy residual oils to carbon black and/or coke, aromatic distillates, and normally gaseous products. Figure 3 is a schematic elevation of a preferred modification of the conversion chamber of this invention. Figure 4 is a flow diagram showing a modification of this invention.

Referring particularly to the device shown as Figure 1 of the drawings, furnace 11 is provided with an oil inlet conduit 12 having a flow control valve 13 provided therein. Steam inlet conduit 14, having a flow control valve 15 provided therein, extends into furnace 11 and is connected to heating coils 16 within the furnace. Heated oil conduit 17 extends between coil 16 and flash chamber 18. Flow control valve 19 is provided in conduit 17 to regulate the flow of fluid therethrough. Flash chamber 18 is provided in its upper end portion with vapor outlet conduit 21 which has flow control valve 22 provided therein. Residual oil outlet conduit 23 extends from the lower end portion of flash chamber 18 and is divided into a plurality of residual oil conduits schematically shown as conduits 24 and 25, which conduits have positioned therein flow control valves 26 and 27, respectively. Vapor outlet conduit 21 is connected to vapor conduit 28 which has positioned in its outlet end portions atomizing fog nozzles 29. Diluent fluid conduit 31 is connected to vapor conduit 28 and has flow control valve 32 positioned therein. Residual oil conduits 24 and 25 are connected at their outlet ends to fog nozzles 29. Fog nozzles 29 have their outlet ends extending into conversion chamber 33 of pebble heater apparatus.

A pebble support member 34 extends inwardly from the wall of conversion chamber 33 to a point spaced a substantial distance from the wall of that chamber. Pebble support 34 may be a frusto conical member or a member of any other shape which will provide a sufficient amount of void space around a portion of the pebbles to allow the oil fog to be properly distributed. The support member is provided with a large number of perforations 35 which are of such size as to allow the passage of oil fog and any diluent vapors therethrough but which will prevent the passage of pebbles therethrough. A relatively large pebble throat is formed in the central part of pebble support member 34 and permits the passage of pebbles therethrough. Flushing gas inlet conduits 36, which have flow control valves 37 provided therein, extend into conversion chamber 33 at points adjacent the lower side of pebble support member 34.

Pebble heating chamber 41, positioned above conversion chamber 33, is connected to chamber 33 by a throat member 42, which throat member is adapted to allow pebbles to pass therethrough by gravitation. Sealing gas inlet conduit 43 is connected to throat 42 intermediate its ends. Heating material inlet conduit 44 is connected to the lower end portion of pebble heater chamber 41 and provides means for introducing fuel or hot gaseous heat exchange material into chamber 41. Chamber 41 is provided with an effluent outlet conduit 45 and pebble inlet conduit 46 in its upper end portion. Diluent inlet conduit 47 is provided in the lower portion of conversion chamber 33 and pebble outlet conduit 48 extends downwardly from the lower end of conversion chamber 33. A positive pebble flow control means, such as pebble feeder 49, is provided intermediate the ends of pebble outlet conduit 48. Elevator 51 extends between the outlet end of pebble conduit 48 and the inlet end of pebble conduit 46. A flushing gas inlet conduit 52 having a flow control valve 53 provided therein extends into the upper end of conversion chamber 33 and is preferably in the form of a perforate header disposed adjacent the upper end of chamber 33 and about the effluent outlet. Gaseous effluent outlet conduit 54 extends from the upper end of conversion chamber 33 and provides means of escape for reaction products from reaction chamber 33.

Referring particularly to Figure 2 of the drawings, like numerals are utilized to designate like parts which are shown in Figure 1 of the drawings. Effluent outlet conduit 54 is connected at its outlet end to a centrifugal type separator 55 and is connected, intermediate its ends, with a quench material inlet conduit 56 provided with a flow control valve 57 therein. Outlet conduit 58 is provided in the lower portion of separator 55 to allow the removal of heavy materials therefrom. Gaseous material outlet conduit 59 extends from a point intermediate the ends of separator 55, through the upper portion of separator 55 and is connected at its outlet end to scrubber 61. Conduit 59 is provided with a flow control valve 62 intermediate its ends. A by-pass conduit 63, having flow control valve 64 provided therein, extends from conduit 59 at a point upstream of flow control valve 62 to separator 65 which is preferably an electrostatic separator. Separator 65 is provided with an outlet conduit 66 in its lower end portion, which outlet conduit allows the removal of heavy material, such as carbon black, from separator 65. Gaseous material outlet conduit 67, having flow control valve 68 provided therein, extends from separator 65 at a point intermediate its ends. Gaseous material outlet conduit 69, having flow control valve 71 provided therein, extends from the upper end of scrubber 61 and is connected to conduit 67 at a point downstream of flow control valve 71. Liquid outlet conduit 72 extends from the lower portion of scrubber 61 to a settler chamber 73. Outlet conduit 74 is provided in the lower end portion of settler chamber 73 to allow the removal of heavy materials from that chamber. Conduit 75 extends between the upper portion of settler chamber 73 and cooler 76. Conduit 77 extends from cooler 76 to convey the cooled products therefrom and is provided with flow control valve 78 therein. Conduit 79, having flow control valve 81 provided therein, extends from conduit 77 upstream of flow control valve 78 to the upper portion of scrubber 61. Conduit 82, for make-up washing liquid and having flow control valve 83 provided therein, is connected to conduit 79 downstream of flow control valve 81.

Operation by means of the preferred process or method of this invention, permits the economical conversion of heavy residual oil to normally lighter materials which include highly aromatic gasolines. A readily combustible fuel, together with air or a hot heat exchange gas is introduced into the lower portion of pebble heater chamber 41 through inlet conduit 44. If a fuel and air are introduced into the lower portion of chamber 41, that fuel is burned in the presence of a contiguous mass of pebbles which are gravitated downwardly therethrough, thus raising the temperature of the pebbles to the desired reaction temperature. If a hot heat exchange gas is utilized, it is introduced into pebble heater chamber 41 through conduit 44 and the hot heat exchange gas is passed upwardly through that chamber countercurrent to the flow of pebbles therein. When heavy residual oils are converted to normally gaseous materials or highly aromatic gasoline constituents, reaction temperatures between 1000° F. and 1500° F. are ordinarily utilized. The pebbles are thus heated in pebble heater chamber 41 to a temperature between about 1200° F. and 1700° F., depending upon the amount of diluent utilized in the conversion chamber, and are gravitated into the upper portion of conversion chamber 33 in which they form a hot fluent contiguous mass.

Heavy residual oil is introduced by means of conduit 12 into furnace 11 and is heated therein to a temperature above its initial boiling point. The heated oil is passed to flash chamber 18 in which the vaporous materials are flashed from the unvaporized materials and are removed from the upper portion of flash chamber 18 through outlet conduit 21. The heated oil is flashed in chamber 18 at such a pressure that the vaporized portion is passed to nozzles 29 under sufficient pressure to atomize the unvaporized material. The unvaporized oil is removed from the lower portion of flash chamber 18 through conduit 23 and is passed to fog atomizing nozzles 29 by means of conduits 24 and 25. The vaporous oil materials are passed to the fog nozzles 29 through conduits 21 and 28 and atomize the unvaporized oil so as to form a finely dispersed oil fog which is immediately introduced into the void space in conversion chamber 33 immediately below pebble support member 34.

As stated above, pebble support member 34 prevents the pebbles from filling conversion chamber 33 to the outlet end of fog nozzles 29, thus providing the void space into which the oil fog is introduced. The oil fog is evenly distributed throughout the void space and passes upwardly through the perforations 35 and through the pebble opening in the central portion of support member 34 into the upper portion of conversion chamber 33 countercurrent to the flow of pebbles therethrough. Since the descending pebbles are hotter than the oil fog, the pebbles tend to repel the tiny fog particles because of normal expansion of gas away from the pebbles. The fog particles and gaseous reactants pass upwardly through the pervious pebble mass, being heated to the cracking temperature with concomitant conversion thereof. Such fog particles as strike the pebbles simply form coke thereon, which coke is thereafter removed from the pebbles in the pebble heating chamber by oxidation with an excess of oxygen in that chamber. Reaction products are removed from conversion chamber 33 through effluent outlet conduit 54.

I have found that it is quite advantageous in this process to utilize a diluent material which aids in maintaining a high dispersion of the oil fog. The steps which have been described above are usually modified by the introduction of a diluent such as steam, through conduit 14 into heating coils 16 in furnace 11. The steam is flashed in flash chamber 18, together with vaporized oil material, and is passed through conduits 21 and 28 into fog nozzles 29. Additional steam is added through conduit 31 to aid in atomizing and dispersing the unvaporized oil material removed from the lower portion of flash chamber 18. Deposit of carbon upon pebble support member 34 is greatly reduced by introducing streams of steam along the lower surface of support member 34 through steam conduits 36. Deposit of carbonaceous materials in the upper end of conversion chamber 33 about the effluent outlet conduit is also substantially reduced by maintaining a blanket of steam thereupon, which steam is introduced through conduit 52. Additional diluent material is normally added at the lower portion of conversion chamber 33, which diluent material passes upwardly through the pebble mass and through pebble support member 34. Diluent is advantageously introduced into the conversion chamber in a ratio of between 0.5:1 to 4:1 in relation to the oil.

Pebbles which have been cooled in the heat exchange within chamber 33 are positively fed from the lower portion of conversion chamber 33 to elevator 51 by which means the pebbles are elevated to the upper portion of pebble heater chamber 41.

Although steam has been specifically described as being the diluent material utilized in the oil fog conversion process of this invention, other gaseous diluent materials such as methane, hydrogen, and the like, which are inert to the conversion process may also be utilized with excellent results.

The conversion of heavy residual oil in the manner above described results in the production of between about 25 and 50 per cent by weight of normally gaseous materials in relation to the feed. The resulting product gas stream from the conversion is very rich in olefinic and aromatic materials, such as ethylene, propylene, and highly aromatic gasoline constituents.

Referring again particularly to the flow diagram shown as Figure 2 of the drawings, the conversion products are passed by means of conduit 54 to separator 55. A quench material such as a gas oil or the like is introduced into conduit 54 through conduit 56 and the temperature of the reaction products is lowered to a temperature within the range of about 300° F. to 800° F., preferably 400° F. to 500° F. The quenched products, together with the quench liquid, are introduced tangentially into separator 55 and the gaseous materials are separated from tarry and carbonaceous materials which are condensed as a result of the quench step. The heavier materials are removed from separator 55 through outlet conduit 58 and the gaseous materials are passed by means of conduit 59 into the lower portion of scrubber 61 through which a circulating oil wash is gravitated. The gaseous materials flow upwardly through the scrubber and any further tarry materials, carbonaceous materials, or liquid hydrocarbons which are condensed therein are washed from the gaseous products. The gaseous materials are removed from the upper portion of the scrubber and are passed to product separation means, not shown. The wash liquid, together with condensed liquid and solids, are passed to a settler from which solid materials, such as coke and tar, and water are settled out and are removed through conduit 74. The wash liquid containing condensed hydrocarbons is purified thereby and is then passed to a cooler so as to lower its temperature. A portion of the cooled wash liquid is then returned to the upper portion of the wash chamber and a portion of the liquid is removed as additional liquid prodduct of the reaction.

Referring particularly to Figure 3 of the drawings, like numerals are utilized to designate parts similar to those described in connection with Figure 1 of the drawings. Conversion chamber 85 is formed with lower portion 86 which is expanded or of greater diameter than the upper chamber portion. Fog nozzles 29 extend into the upper end of conversion chamber portion 86. The expanded chamber portion provides a space in its upper end which is void of pebbles during pebble flow through the chamber. In this type of chamber, therefore, it is not necessary to utilize a pebble support member such as is disclosed in the device of Figures 1 and 2. Flushing gas inlet conduits **36** extend into chamber portion **86** above the level of nozzles **29**.

The method of operating chamber **85** is the same as that utilized in connection with chamber **33** except that the oil fog is introduced into the lower conversion chamber portion at a point adjacent the lower end of the upper conversion chamber portion. Further description of the method of operation is therefore deemed to be unnecessary.

A specific embodiment of this invention is set forth in the example below but it is not intended to limit the scope of this invention thereby.

EXAMPLE

Pebbles are heated to 1300° F. in a pebble heating zone and are gravitated into the upper portion of a conversion zone at a rate of 70 pounds per pound of oil feed and the pebbles form a fluent contiguous mass within the conversion zone. A 14° API residuum having a Saybolt Furol viscosity at 122° F. of 820, having an initial boiling point of 820° F., and a 5 per cent distillation point at 912° F., is heated and flashed at a temperature between 850° F. and 950° F. The vaporous material obtained upon flashing of the heated oil and the heated liquid oil are removed from the flash chamber as separate streams. The vaporous stream is passed through a Venturi-type fog nozzle positioned in the reaction chamber intermediate its ends. The heated liquid oil is injected into the fog nozzle and is atomized by the stream of vapors passing therethrough. The oil fog produced by atomizing the liquid oil is introduced into the reaction chamber and is passed upwardly through the hot pebble mass. A conversion to between 30 and 36 weight per cent of normally gaseous material, based upon the feed, is obtained with a coke deposition on the pebbles of between 5 and 20 weight per cent. Steam is introduced into the lower portion of the conversion zone at a rate of between 2 and 5 pounds of steam per pound of oil. Gaseous effluent is removed from the conversion chamber at about 1160° F. and pebbles are removed from the conversion chamber at about 735° F. The product gas has a composition in mol per cent as set forth in the table.

Table

Gas composition:	Mol per cent
Hydrogen	14
C_1	22
Ethylene	38
Ethane	3
Propylene	14
Propane	0.7
Butenes	8
Butane	0.3

Liquid condensed from the effluent has the following composition:

Liquid product composition:	Volume per cent
Gasoline	22.5
Light gas oil, 750 E. P.	12.9
Heavy gas oil, 900 E. P.	17.7
Residuum (tars, etc.)	46.9

The resulting gasoline product has an API gravity of 49.2 and an aniline point of 31.2° F. The process of this invention is particularly adapted to the production of olefins. This is especially apparent upon study of the data set forth in the table above. Each of the C_2, C_3, and C_4 cuts is very highly olefinic. By use of this system and method of operation it is possible to produce cuts which are as much as 96% olefinic.

Heavy residual oils can also be converted to other types of reaction products by changing the reaction conditions within conversion chamber **33**. In some cases it is desirable to utilize low cost materials such as the heavy residual oils to produce water gas which is used commercially as fuel gas.

The process which has been described above is modified by raising the temperature within the conversion chamber to between 2000° F. and 2400° F. At a temperature within this range the oil fog is uniformly spread over the area of the conversion chamber but the temperature is so high that the hydrocarbon oil is cracked to form carbon and light gaseous hydrocarbons. Steam which is injected into the conversion chamber **33** through inlet conduits **47**, **36**, **28**, and **52** reacts with the carbonaceous material to form CO, H_2, and CO_2 by the well known water gas reaction. The following reactions take place upon passing steam over carbon at a temperature within the above specified temperature range.

(1) $C+H_2O \rightarrow CO+H_2$

(2) $C+2H_2O \rightarrow CO_2+2H_2$

(3) $CO+H_2O \rightarrow CO_2+H_2$

(4) $CO_2+C \rightarrow 2CO$

When steam is present during the thermal cracking of the oil fog the above reactions are important along with reactions of hydrocarbons and steam. The reactions of methane and steam may be repreesented as follows:

(5) $CH_4+H_2O \rightarrow CO+3H_2$

(6) $CH_4+2H_2O \rightarrow CO_2+4H_2$

A still further modification of this invention is made when it is desired to convert the heavy residual oils to form carbon black. Once again it is necessary in the modification of the process to change the reaction conditons by raising the temperature of the pebbles within conversion chamber **33**. In this case it is necessary to maintain the temperature within the range of between 2300° F. and 2800° F. When producing carbon black it is desirable to utilize a diluent material other than steam for aiding the dispersion of oil fog within the conversion chamber. For that reason a diluent material, such as hydrogen or methane, is introduced into conversion chamber **33** through inlet conduit **47**. The product effluent is removed from the upper portion of conversion chamber **33** through effluent conduit **54** and a quench material, such as water or methane, is utilized to lower the temperature of the effluent stream to a temperature between about 900° F. and 1100° F. The reaction product stream, together with the quench material, is introduced tangentially into separator **55** and heavy materials which are separated from the gas stream are removed therefrom through outlet conduit **58**. Flow control valve **62** is closed and flow control valve **64** is opened so that the gaseous material which is removed from separator **55** through conduit **59** passes by way of conduit **63** to electrostatic separator **65**. The carbon black is electrostatically precipitated from the gas stream within separator **65** and is removed therefrom by means of conduit **66**. The remaining gaseous products and quench material are removed from separator **65** through conduit **67** and are passed to separation means, not shown, by means of conduit 69.

Many of the hydrocarbon conversion processes carried on in pebble heater apparatus require that pebbles be raised to a high temperature ranging above 1600° F., such as in the production of acetylene from light hydrocarbons and in the manufacture of water gas as well as others heretofore set forth. Pebbles which are at such a high temperature are very difficult to recycle from a conversion chamber to a pebble heating chamber. The amount of fluid material which is introduced into the lower portion of the conversion chamber as a diluent can be varied so as to control the temperature of the recycled pebbles.

The process of this invention may be varied advantageously by utilizing only the flashed vapors as reactant materials and using those vapors to atomize a water stream so as to distribute the water particles through the lower portion of the conversion chamber. Referring particularly to the system shown as Figure 4 of the drawings, pebbles are heated in chamber 41 as heretofore described and are gravitated into conversion chamber 33. The pebbles are separated from the walls of a lower portion of the conversion chamber so as to form a void space therein. Hydrocarbon vapors are introduced into fog nozzles 29 as described above. Water is introduced into fog nozzles 29 through conduit 91. The water is atomized by the vapor stream and the water particles, together with the hydrocarbon vapors, are introduced into the void space formed in the lower portion of conversion chamber 33. The water particles are converted to steam within the lower portion of conversion chamber 33 and the steam, together with the hydrocarbon vapors, pass upwardly through the hot pebble bed within the conversion chamber, the steam acting as a diluent for the hydrocarbon vapors. The hydrocarbon vapors are converted to the desired products within conversion chamber 33 and the gaseous products, together with the steam effluent, are removed from the upper portion of conversion chamber 33 through gaseous effluent outlet conduit 54. A quench material, such as water, is introduced into gaseous effluent outlet conduit 54 through conduit 92 and the resulting mixture of fluids is introduced into separation chamber 93 where coke and tar are removed from the stream. The coke and tar are removed through outlet conduit 94 in the lower portion thereof. The fluid stream is removed from chamber 93 and passed by a continuation of conduit 54 into cooler chamber 95 in which the stream is passed in heat exchange relation with a coolant fluid. The cooled stream is passed by further continuation of conduit 54 through condenser chamber 96 in which the effluent stream is further cooled so as to condense the gaseous materials. The necessity for this condenser chamber will depend upon the amount of cooling obtained in cooler chamber 95. The effluent fluid stream is introduced into separator 97 in which the non-condensible gaseous materials are separated from the liquid materials and are removed from that chamber through conduit 98. Condensed liquid hydrocarbon materials are removed from chamber 97 through conduit 99 and the condensed water is removed from the lower portion of chamber 97 through conduit 101 and is recycled to water inlet conduit 91.

Pebbles which are cooled by the conversion of water to steam in conversion chamber 33 are removed from the lower portion of chamber 33 at a relatively low temperature and are returned to the upper portion of pebble heater chamber 41 through conduit 48, elevator 51, and conduit 46.

This type of operation has many advantages over the operation of a system in which live steam is used as the diluent material. A considerably greater amount of heat is removed from the pebbles by the conversion of water to steam within the conversion chamber than would be obtained by the introduction of a similar amount of steam into that chamber. It is thus possible to utilize very high temperatures within the conversion chamber and yet lower the temperature of those pebbles before it is necessary to handle them in the recycle system to the pebble heater chamber. Very high thermal efficiency of the pebble heater system is therefore obtained by this method of operation. Steam boilers which are normally necessary in order to provide a sufficient quantity of steam as diluent are not necessary in this type of operation. The water which is used as the coolant and diluent in the conversion chamber is condensed and circulated over and over again which makes it possible in areas in which water is scarce or is quite corrosive to treat a small amount of water and utilize that small amount of water continuously. The atomization of water with the flashed oil vapors makes possible a good distribution of the water through the conversion zone before it is transformed to steam.

Various other modifications and advantages of the process of this invention will be apparent to those skilled in the art upon study of the accompanying disclosure and the drawings. It is believed that such modifications are within the spirit and scope of this disclosure and the claims.

I claim:

1. An improved residuum conversion system comprising an upright pebble heater chamber having pebble inlet means and effluent outlet means in its upper end portion; heating material inlet means in the lower portion of said pebble heater chamber; an upright conversion chamber disposed below said pebble heater chamber; a pebble conduit extending between the lower end portion of said pebble heater chamber and the upper end portion of said conversion chamber; a perforate pebble support member extending inwardly from the wall of said conversion chamber at a level intermediate its ends, said pebble support member providing a pebble passage centrally therethrough; pebble outlet means in the lower portion of said conversion chamber; an elevator extending from said pebble outlet means in said conversion chamber to said pebble inlet means in said pebble heater chamber; at least one fog nozzle extending through the wall of said conversion chamber and adjacent the lower side of said pebble support member; an oil residuum heating chamber having residuum conduit means extending therethrough; a flash chamber; a conduit extending from said residuum conduit means in said residuum heating chamber to a point intermediate the ends of said flash chamber; a gaseous material conduit extending between the upper end of said flash chamber and the inlet end of said fog nozzle; a liquid material conduit extending from the bottom of said flash chamber to said fog nozzle; and a gaseous effluent outlet in the upper portion of said conversion chamber.

2. The system of claim 1, wherein a gaseous diluent inlet conduit is connected to said residu-

um conduit means in said residuum heating chamber.

3. The system of claim 2, wherein a gaseous diluent inlet conduit is connected to said gaseous material conduit extending between said flash chamber and said fog nozzle.

4. The system of claim 1, wherein diluent inlet means are connected to the bottom portion of said conversion chamber.

5. The system of claim 1, wherein steam inlet conduit means are provided adjacent the lower side of said pebble support member; and steam inlet conduit means extend through and are ad-

jacent the upper end of said conversion chamber.

ROBERT A. FINDLAY.

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