June 27, 1939. H. L. DOHERTY 2,164,132

PROCESS AND APPARATUS FOR DISTILLING OIL

Filed Feb. 24, 1920 3 Sheets-Sheet 1

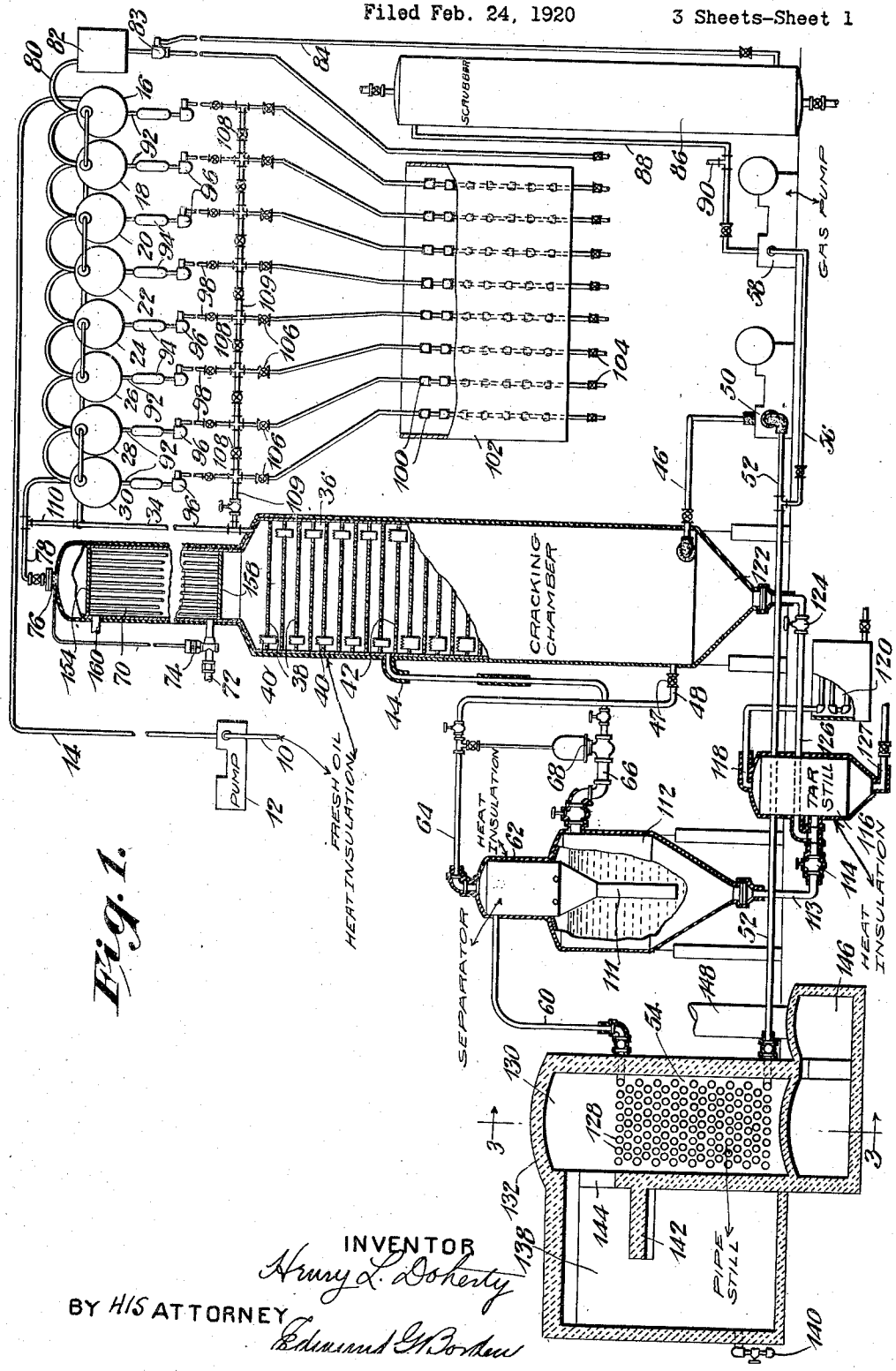


Fig. 1.

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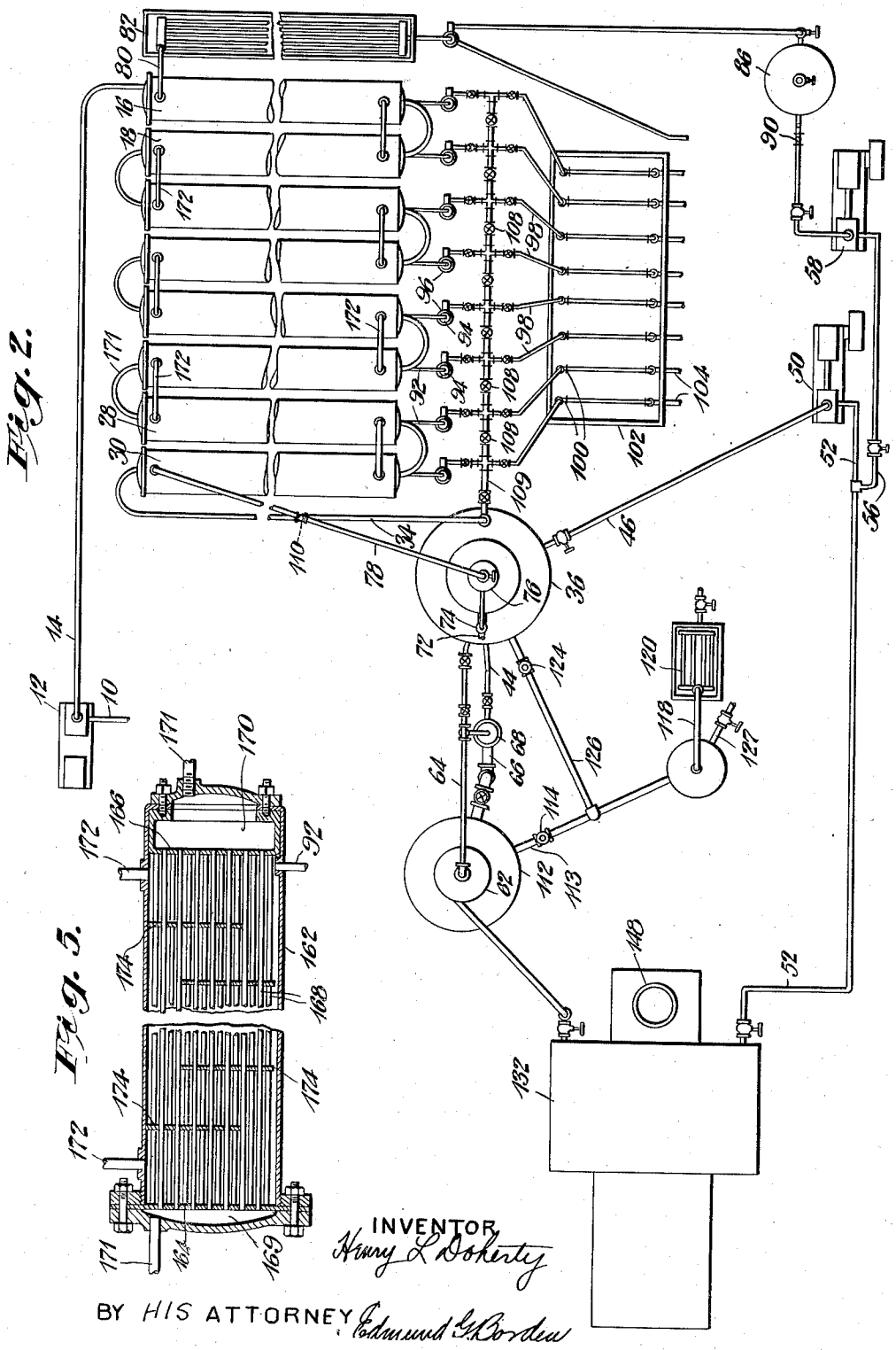


Fig. 2.

Fig. 5.

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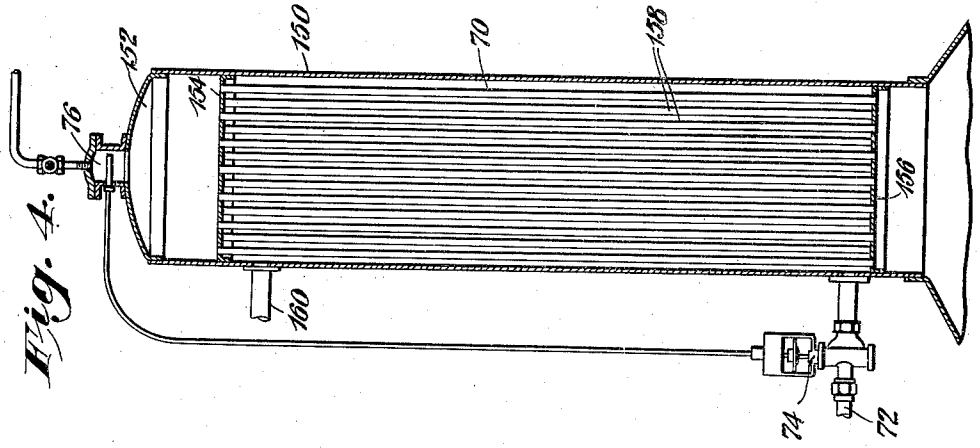


Fig. 4.

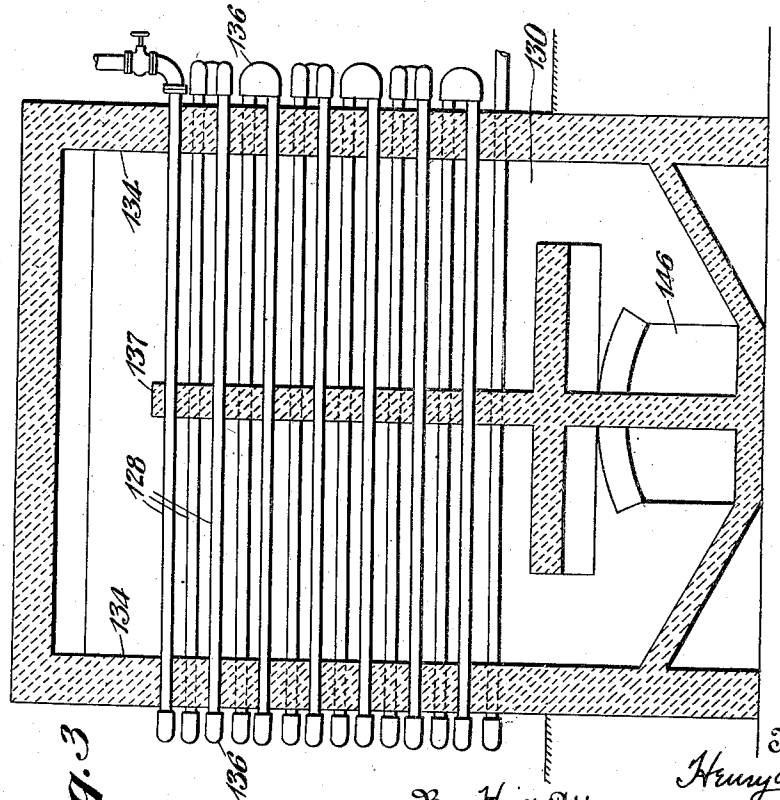


Fig. 3

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Patented June 27, 1939

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UNITED STATES PATENT OFFICE

2,164,132

PROCESS AND APPARATUS FOR DISTILLING OIL

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Application February 24, 1920, Serial No. 361,030

35 Claims. (Cl. 196—58)

This invention relates to a process of distilling oil and more particularly to a process of and apparatus for cracking heavy hydrocarbon oils to form lighter hydrocarbon oils therefrom.

Heretofore the commercial processes for cracking heavy hydrocarbon oils to produce lighter hydrocarbon oils, particularly gasoline, have employed a cylinder still in which the oil is heated in a large body. The inherent nature of the cylinder still presents certain limitations in the process which hold down the character and quantity of gasoline which may be recovered. Among these limitations are the formation of hydrocarbons of higher and lower boiling points than the boiling points of the gasoline desired. Although oil may be cracked through a wide range of temperatures, the most advantageous cracking is obtained in a specific narrow range of temperatures. Experience has shown that at the higher temperatures, the rate of reaction is very rapid with a consequent formation of large amounts of fixed gases and carbon. With lower temperatures, the reaction is slower and consequently the time element is an important factor. Since oil is such a poor conductor of heat, it is not practical to use the lower temperatures when distilling oil in a cylinder still and in fact the outside of the still is subjected to very high temperatures in order to drive the heat into the center of the body of oil. This causes a local overheating and a layer of coke is always formed around the inner surface of the still.

One object of the present invention is to provide a process by which oil may be uniformly heated to any desired temperature.

In accordance with this object, one feature of the invention contemplates rapidly circulating the oil through a heater in a comparatively small stream and carrying a stream of vaporizing and agitating inert gas in contact and parallel with the oil while it is being heated.

Another object of the invention is to provide a process of cracking oil by which the oil may be held under the most advantageous temperatures for cracking for an extended period of time to allow the cracking or decomposing reaction to be completely effected.

In accordance with this object, another feature of the invention contemplates separating vapors from an oil which has been heated to a cracking temperature and passing the vapors and oil through a cracking chamber in countercurrent paths. The oil entering the cracking chamber is uniformly heated throughout and is maintained at a comparatively uniform temperature throughout the body by being agitated with the gas and vapors passing through the oil. The agitation of the oil assists the cracking reaction and while the oil is being agitated by the vapors, the vapors are repeatedly brought into the reaction zone so that they can enter the reaction to form specific hydrocarbons in accordance with the temperature and pressure conditions in the cracking chamber. In this way the more desirable lower cracking temperatures may be maintained for cracking and the oil may be held for any desired period of time under the proper cracking conditions.

Accordingly, another object of the invention is to provide a process of cracking oils by which the cracking reaction may be effectively promoted at the lower temperatures.

A further object of the invention is to provide a process by which the reflux condensation of the higher boiling point vapors may be accurately controlled to bring back into the reaction zone products of any particular range of boiling points.

A further object of the invention is to provide an apparatus by which a hydrocarbon oil may be rapidly and effectively cracked.

With these and other objects in view, the invention consists in the improved process and apparatus of cracking oil hereinafter described and claimed.

The various features of the invention are illustrated in the accompanying drawings, in which:

Figure 1 is a view in side elevation, partly in section, showing a cracking still embodying the preferred form of the invention;

Fig. 2 is a top plan view of the cracking still shown in Fig. 1;

Fig. 3 is a vertical sectional view of the oil heater and furnace therefor taken on the line 3—3 of Fig. 1;

Fig. 4 is a vertical sectional view of the reflux condenser which is mounted on the top of the cracking chamber; and

Fig. 5 is a vertical sectional view of one of the surface condensers used for condensing the oil vapors removed from the cracking chamber.

The process of the present invention provides a treatment of heavy or high boiling hydrocarbon oils to produce light or low boiling point oils. The raw material for treatment may be kerosene, gas oil, fuel oil, or a mixture of two or more of these, and the treatment always produces lower boiling point hydrocarbons therefrom. Under the present commercial conditions the treatment is conducted to produce gasoline. In carrying out the process in the apparatus shown in the

drawings, the raw oil from storage is drawn in through a pipe 10 to a pump 12 and carried by means of a pipe 14 into the first condenser 16 of a series of surface condensers 16, 18, 20, 22, 24, 26, 28 and 30 (Fig. 2). It then advances through the condensers while being passed in heat-transferring relationship with oil vapors, which are formed in the cracking operation and flow through the surface condensers countercurrent to the flow of oil. The oil is preheated by the vapors at 300–450° F., depending upon the temperature of the vapors, and flows from the condenser 30 through a pipe 34 (Fig. 2), and enters the upper portion of a cracking chamber 36. In the cracking chamber, the oil is formed into a series of bodies which are separated by trays or horizontal partitions 38 and the oil overflows by gravity from one tray to the next tray below through overflow pipes 40. When the oil has flowed downwardly in the cracking chamber to a tray 42 (Fig. 1), it meets a body of oil which is introduced through a pipe 44. The oil introduced through the pipe 44 has been previously treated in the cracking operation and has been heated to the most advantageous cracking temperature. By the time the incoming raw oil reaches the tray 42, its temperature is raised to substantially the cracking temperature by the hot vapors and gas passing therethrough. The mixture of preheated raw oil and the heated oil admitted through the pipe 44 is then held at a cracking temperature as it flows downwardly to the bottom of the cracking chamber to an outlet pipe 46.

The incoming raw oil and the mixture of raw oil and cracked oil which flow downwardly through the cracking chamber are constantly agitated by means of gas and oil vapors which are admitted to the bottom of the still through a pipe 48. To accomplish this, the plates 38 which form the bottom of the trays are preferably provided with perforations which have such a size that the gas is permitted to pass upwardly therethrough while the oil is prevented from passing downwardly therethrough. In this way, the gas and vapors entering through the pipe 48 pass upwardly through the bodies of oil on the trays to actively agitate the oils and to transfer to the oil any superheat which they may possess. Further, the oil vapors leaving one tray encounter the oil on the tray above and there is always an intermingling of oil and vapor and an interchange of heat between the vapors and oil. This causes a continual change of state from liquid to the higher boiling point vapors and vice versa, which is inducive of cracking and increases the percentage of low boiling point products in the vapors leaving the cracking chamber.

A portion of the raw oil entering the body of oil in the cracking chamber is cracked in its passage through the cracking chamber from the tray 42 to the bottom of the cracking chamber. The uncracked portion of the oil, together with any uncracked oil which remains from the oil introduced through the pipe 44, after it passes downwardly through the cracking chamber, flow out through the pipe 46 to a pump 50 which forces it through a pipe 52 to a pipe still 54. As the oil flows through the pipe 52, a gas is introduced into the oil through a pipe 56 by means of a pump 58. The gas flows in contact and in parallel current with the oil and serves to actively agitate and accelerate the velocity of the oil passing through the pipe still 54. Further, the oil vapors which are formed in the pipe still are absorbed by the gas flowing in parallel current therewith and at the time the oil and gas have passed through the coil of the pipe still, they are heated to a cracking temperature and the gas is saturated with vapors which are also heated to a cracking temperature. The oil leaving the cracking chamber to pass to the pipe still is heated to substantially a cracking temperature and therefore only a small amount of heat will have to be supplied in the pipe still to vaporize the oil and to provide for any heat of reaction in cracking the oil.

The mixture of gas, oil and vapors leaving the pipe still flows through a pipe 60 into a separator 62 where the oil is separated from the gas and vapors, and the gas and vapors then flow through a pipe 64 to the pipe 48 positioned at the bottom of the cracking chamber. The oil collected in the separator 62 flows out through a pipe 66 to a float valve 68 and then passes into the pipe 44 connected with the upper portion of the cracking chamber. As described above, the oil introduced through the pipe 44 together with incoming oil flowing downwardly through the upper portion of the cracking chamber are heated to the cracking temperature and pass in a countercurrent path through the gas and vapors which are also heated to a cracking temperature. By the countercurrent movement of the oil and vapors, the oil bodies in the cracking chamber are maintained at substantially a uniform temperature, which temperature can be accurately controlled to be the most desirable temperature for cracking oil in order to give a maximum yield of gasoline. The heated gas passing upwardly through the oil, along with the vapors, acts as an absorbent for the gasoline vapors and helps to sweep them out of the reaction zone and carry them out of the cracking chamber.

As the gas and vapors pass upwardly from the tray 42 through the incoming oil, a certain portion of the higher boiling constituents are condensed in the oil and returned to the cracking zone. The sensible heat of these gases and vapors and the heat of vaporization of the vapors condensed serve to preheat the raw incoming oil to a cracking temperature. Those vapors leaving the uppermost tray of the cracking chamber pass through a reflex condenser 70 mounted on and communicating with the upper portion of the cracking chamber. The temperature of the reflux condenser 70 is regulated by means of water which is introduced through a pipe 72. The introduction of water is controlled by a thermostatic valve 74 which in turn is controlled by a thermostat 76 (Fig. 4) mounted in the upper portion of the condenser. With the thermostatic control, vapors of any desired boiling point may be condensed and carried back into the cracking chamber so as to permit only vapors having a predetermined temperature to pass into the condensers 30—16.

The gas and vapors leaving the reflux condenser pass through a pipe 78 and enter the last surface condenser 30. These gases and vapors then pass in series through the condensers 30—16 and finally flow out through a pipe 80 (Figs. 1 and 2) to a water-cooled condenser 82 where the lowest boiling point hydrocarbons are condensed. The fixed gases formed in the process, together with the gases introduced into the circuit through the pipe 56, flow from the condenser through a trap 83 to a pipe 84 by which they are introduced into the lower portion of an oil scrubber 86. In the scrubber 86 the gases

are treated with a mineral oil to remove the uncondensed vapors and the gases leaving the upper portion of the scrubber 86 flow through a pipe 88 to the pump 58. Any excess of gas over that necessary in the process may be removed through the pipe 90. If desired, gas from an external source for starting the process or for any other purpose, may be introduced through the pipe 90.

As the mixture of gas and vapors advances through the condensers 30—16, it is gradually cooled by the incoming raw oil advancing through the condensers 16—30. The gradual interchange of heat between the incoming oil and the gas and vapors permits the condensation of fractions with sharply defined boiling points, which may vary only by a few degrees of temperature. This intensified fractionation of vapors permits the recovery of a number of products of substantially the desired boiling points and thus avoids the necessity of several redistillations in recovering the marketable products. The fractions condensed in the condensers 30—16 are removed through outlet pipes 92 (Fig. 1) to look-boxes 94 and flow into traps 96 from which they are conducted through pipes 98 to their respective cooling coils 100. The coils 100 are supported in a water-cooling tank 102 and each coil has a connection 104 by which the condensates may be conducted to their respective collecting tanks. If desired, any or all of the condensates passing through the traps 96 may be returned to the cracking chamber by closing valves 106 in the pipes 98 and opening valves 108 in a run-back line 109, which connects with the raw oil inlet pipe 34. With the apparatus outlined above, the process may be so conducted that all of the heavy fractions of the oil may be held back by the reflux condenser and the incoming oil in the upper portion of the cracking chamber and only the vapors of the desired oil fractions to be recovered are allowed to pass through the surface condensers 30—16. Also, some of the surface condensers may be used in conjunction with the reflux condenser in carrying back any desired fraction to the cracking chamber. Further, if any of the fractions in the surface condensers do not meet the desired specifications, they may be returned to the cracking chamber through the run-back line 109 for retreatment. To promote the positive circulation of the vapors and gas in the condensers and to maintain the proper pressure conditions throughout the apparatus, a pressure-equalizing pipe 110 (Fig. 1) is connected between the vapor-pipe 78 and the oil-inlet pipe 34.

In all cracking processes a certain amount of carbon and tarry sludge is always formed and if this material is not removed from the still or oil circuit, it will soon interfere with the cracking operation. Due to the high velocity with which the oil and gas go through the coil of the pipe still 54, the carbon deposited therein is reduced to a minimum. The principal portion of the carbon and tar is set free in the separator 62. The carbon and tar set free in the separator 62 pass down with the oil through a tube 111 (Fig. 1) to a settling chamber 112 where the oil slowly rises to the top and the carbon and tar settle to the bottom. This carbon and tar is intermittently drawn off from the chamber 112 through a pipe 113 and passes through a valve 14 to a still 116. Since the oil in the settling chamber 112 is heated to a cracking temperature while under a high pressure, it contains a large amount of potential energy or sufficient sensible heat to vaporize approximately 50% of the oil when it is reduced to atmospheric pressure. Accordingly, the still 116 is maintained at atmospheric pressure and the carbon and tarry sludge is intermittently drawn off from the settling chamber 112 by opening up the valve 114. The still 16 is not heated but the sensible heat in the sludge will vaporize the lighter constituents at atmospheric pressure and these vapors will pass out of the still through a pipe 118 to a condenser 120. The vapors collected in the condenser 120 may then be added through the raw oil entering the pump 12 for retreatment in the cracking still.

Since the cracking operation is completed in the cracking chamber 36, considerable carbon and tar sludge will be formed therein. To remove this carbon and tar from the oil circuit, the lower end of the cracking chamber is provided with a conical collecting chamber 122 (Fig. 1), which is connected through a valve 124 and pipe 126 with the still 116. The oil containing carbon and tar may be drawn from the cracking chamber 36 in the same manner that it is withdrawn from the collecting chamber 112 and passed into the still 116 to recover any light oil vapors therefrom. The heavy tar sludge which does not vaporize in the still 116 is withdrawn through an outlet 127. Although the distillation operation is continuous, it is preferred to operate the valves 114 and 124 for withdrawing sludge from the oil circuit alternately and intermittently since an intermittent pulsating operation tends to clear the heavy sludge from the pipes 113 and 126 due to the rapid rush of the high pressure oil into the low pressure still 116.

Of the high boiling point vapors which are formed in an oil cracking operation, those vapors which condense at temperatures above 400 to 450° F. carry a large amount of carbon and tarry material. If these vapors are condensed in contact with cooling surfaces, this tarry material is deposited and clogs the condensers as well as seriously interfering with the heat transfer of the condenser. With a cracking chamber constructed as described above, this difficulty is overcome since the vapors are cooled to the desired minimum temperature for removing carbon and tarry material by passing them through the incoming oil in the upper portion of the cracking chamber before the heavy vapors come into contact with the cooling surface of the reflux condenser. When the heavy vapors are condensed within the oil, the carbon and tarry material is caught in the oil and carried downwardly to the collecting chamber at the bottom of the cracking chamber.

The cracking chamber 36 described above may consist of any approved form of apparatus in which the oil may be supported in a body to permit the gas to pass countercurrent therethrough. The function of the cracking chamber is to provide a means by which the oil may be held at a cracking temperature for an extended period of time to permit the cracking and conversion reaction to take place. By means of the apparatus shown in the drawings, the oil is supported in comparatively thin bodies and the gas and vapors passing through the oil act to thoroughly agitate the oil so as to maintain a uniform temperature and to repeatedly bring the vapors into contact with the heated oil to assist in the heat reactions.

To effect the countercurrent treatment of the oil and vapors in the cracking chamber with the apparatus illustrated in the drawings, it is necessary to maintain a lower pressure in the cracking chamber from that in the separator in order that the oil may flow in a continuous circuit throughout the still. The oil entering the separator 62 preferably has a pressure of from 80 to 125 pounds per square inch and this pressure is reduced from 10 to 15 pounds in the cracking chamber. The amount by which the pressure is reduced, however, depends upon the difference in vertical head between the pipes 44 and 48 and is controlled to allow the oil to be admitted into the upper portion of the cracking chamber while the gas is being introduced at the bottom of the chamber. A ten to fifteen pound pressure differential will ordinarily produce an active circulation of the gases and vapors up through the body of the oil in the cracking chamber. To obtain this pressure differential, the oil flows through a float valve and is introduced into the cracking chamber under the pressure prevailing in the separator with only frictional losses. While the pressure of the gas and vapors is reduced by means of a valve 47 in the pipe 48 (Fig. 1) the float valve 68 acts merely to maintain a predetermined level in the separator and only causes slight frictional losses in the pressure of the oil passing therethrough.

The pipe still 54 is shown more particularly in Figs. 1 and 3. The still consists of a series of pipes 128 which are connected to form a long continuous coil in which the oil is heated. The pipes are mounted in a horizontal position in a heating chamber 130 of a furnace 132 and the opposite ends of the pipe project through side walls 134 of the furnace. The ends of the pipes 128 are connected by means of return bends 136 (Fig. 3), which are located on the outside of the walls 134 to permit the return bends to be readily removed for cleaning and repairing the pipes. The ordinary tube cleaner which is used for cleaning water tube boilers may be effectively used for cleaning the tubes 128. A division wall 137 (Fig. 3) is placed in the heating chamber 130 to support the central portion of the pipes 128 and prevent them from sagging while being heated. The pipe still is preferably heated by means of an oil or gaseous fuel, which is ignited in a combustion chamber 138 positioned outside of the heating chamber 130. The fuel is introduced into the combustion chamber 138 by means of a burner 140 and the products of combustion are deflected around an ignition arch 142 (Fig. 1) in passing to the upper portion of the heating chamber 130 through a flue 144. The products of combustion pass downwardly through the heating chamber 130 around the pipes 128 to a flue 146 and flow out to the atmosphere through a stack 148. By this arrangement, the heat is supplied to the pipe still coil in a direction countercurrent to the direction of movement of the oil therein, that is, the highest temperature is developed adjacent the outlet end of the heating coil and the lowest temperature developed adjacent the inlet end of the coil. In this way, the oil and gas are gradually heated up to the cracking temperature in passing through the pipe still.

The reflux condenser 70 is shown more particularly in Figs. 1 and 4. This reflux condenser is in the form of a steam boiler and converts all of the heat liberated by the condensing vapors into useful steam energy which may be used to drive the pumps or other apparatus. The temperature of the reflux condenser is controlled by varying the steam pressure to produce the products desired and variations in the operating temperatures are regulated by means of the water which is introduced through the pipe 72. The condenser consists of a cylindrical shell 150, the lower end of which is mounted on the upper end of the cracking chamber and the upper end of which is closed by a vapor-collecting dome 152. Tube sheets 154 and 156 are mounted respectively near the upper and lower ends of the shell 150 and a series of long vapor tubes 158 are connected between the tube sheets. The vapors and gas passing out of the cracking chamber flow through the tubes 158 and are cooled by means of water and steam which is positioned around the tubes. By means of the thermostatic control of the water entering the condenser through the pipe 72, the vapors passing up through the dome 152 may be maintained at any desired temperature. To accomplish this, the steam formed from the water in the condenser by the heated vapors, is permitted to flow out of the condenser through a pipe 160 to maintain a uniform pressure within the condenser. The transfer of heat in the lower portion of the condenser from the vapors to water is very rapid as compared to the transfer of heat from the vapors to superheated steam in the upper portion of the condenser. If the temperature of the vapors passing the thermostat 76 tends to rise, the thermostatic valve will be opened to permit more water to flow into the condenser and this influx of water will continue until the vapors are sufficiently cooled by rapid heat transfer to the water to close or partly close the valve 74. On the contrary, if the vapors fall below the desired temperature, the valve 74 will be closed to stop the influx of water into the condenser, and the longer path of travel of the vapors in contact with steam with the consequent low rate of heat transfer will allow the vapor temperature to be raised to the desired point before the valve will be opened. With this construction, the water level in the condenser 70 will automatically vary to maintain the desired temperature of vapors flowing out of the condenser through the pipe 78. In case there is a very large volume of vapors having a specific boiling point such that it would overtax the cooling capacity of the condenser 70, these vapors may be partially condensed in the surface condensers 30—16 and returned to the cracking chamber without interfering with the collection of the desired end product in the surface condensers. The reflux condenser 70, however, permits of a wide range of operation and can be used with a comparatively small number of fractional condensers to recover any desired end product.

The details of construction of the surface condensers 30—16 are shown more particularly in Fig. 5. These condensers consist of cylindrical drums 162 which have tube sheets 164 and 166 mounted at their opposite ends. Tubes 168 are connected between the sheets 164 and 166 and the oil is caused to pass through the tubes in effecting a heat interchange with the vapors and gas. Oil-collecting chambers 169 and 170 are formed respectively between the ends of the cylinders 162 and the tube sheets 164 and 166. The chambers 169 and 170 of adjacent condensers are connected by pipes 171 which are arranged to connect the condensers in series so that the oil flows therethrough in a continuous stream. The

vapors are introduced into and leave the vapor chambers of the cylinders **162** through pipes **172**, the pipes **172** being arranged to connect the ends of the vapor chambers for series circulation. In passing through the vapor chamber, the vapors flow around baffles **174** which effect a uniform distribution of the heat into the oil passing through the tubes **168**. Any vapors which are condensed in the shell **162** and on the tubes and baffles are collected at the bottom of the shell **162** and withdrawn through the pipes **92** (Figs. 1 and 5).

With the apparatus outlined above, it will be seen that practically any desired combination of pressure and temperature may be maintained in the pipe still **54**, separator **62**, and cracking chamber **36**. Temperatures of from 600–900° F. and pressures of from 60 to 125 pounds per square inch are the usual working temperatures and pressures which are employed in accordance with the end products desired. The form of pipe still shown in the drawings affords a means by which a large amount of heat may be rapidly placed in the oil and the separator and cracking chamber give a means by which a large body of oil may be maintained at a uniform temperature during the cracking operation. The separator and cracking chamber may be insulated as illustrated at **200** to prevent radiation losses and these parts may be heated in the usual manner by means of exhaust flue gases.

While it is preferred to introduce gas under pressure into the oil entering the pipe still, to furnish a carrying medium for the oil vapors and to induce a positive, rapid, circulation of the oil and vapors, this addition of gas is not essential. Some gases are always formed while cracking oil, and this gas, together with the vapors formed in the pipe still **54** and separator **62**, will always produce an active countercurrent circulation of the oil and vapors in the cracking chamber **36**.

In the process outlined above, the gas introduced is still-head gas which is hydrocarbon that may enter into and assist in chemical reaction or cracking in the still. For many purposes, natural gas is preferred to still-head gas because it contains more of the heavy hydrocarbons that may be useful in the formation of gasoline. Also, inert gases such as flue gas, air, etc., may be used as an agitating and vapor-carrying medium, but it is preferred to use a hydrocarbon gas.

Certain subject-matter disclosed in this application and not claimed herein is claimed in Patents No. 1,917,705 and No. 1,984,522, and in divisional application Serial No. 333,650, filed January 19, 1929.

Having thus described the preferred form of the invention, what is claimed as new is:

1. A process of distilling oil, comprising conducting a stream of a heavy hydrocarbon oil and a gas in parallel and in contact with each other, gradually raising the temperature of said gas and oil to a cracking temperature while under a high pressure, separating from the unvaporized oil the gas and oil vapors formed by the heat treatment and passing them in intimate contact with oil heated to a cracking temperature, and conducting the resulting gas and oil vapors following said contact in heat-interchanging relationship counter-current to but out of contact with incoming heavy hydrocarbon oil advancing to said cracking zone.

2. A continuous process of distilling oil, comprising advancing a stream of a heavy hydrocarbon oil and a gas in contact and in parallel, gradually increasing the temperature of the oil and gas while under a high pressure to vaporize said oil, saturating the gas with oil vapors while maintaining the gas at substantially a cracking temperature, passing said saturated gas and oil vapors in intimate contact with oil in a cracking zone, separating the gas and vapors from the oil and passing them through a condenser and withdrawing a heavy residuum from the oil circuit at the cracking zone.

3. A process of distilling oil as defined by claim 1 in which said gas is a hydrocarbon gas adapted to enter into and assist in chemical reaction and cracking in said stream of heavy hydrocarbon oil.

4. A continuous process of distilling oil as defined by claim 2 in which said gas is a hydrocarbon gas adapted to enter into and assist in the cracking reaction in said stream of heavy hydrocarbon oil.

5. A continuous process of distilling oil as defined by claim 2 in which said gas is natural gas containing heavy hydrocarbons that are utilized in the formation of gasoline.

6. A continuous process as defined by claim 2 in which the heated materials of said stream are passed into an insulated unheated chamber provided with an enlarged vapor space prior to the passage of the vapor and gaseous materials through the oil in said cracking zone.

7. A continuous process as defined by claim 2 in which the gas heated with said stream of hydrocarbon oil is air.

8. A continuous process of distilling oil, comprising advancing a stream of a heavy hydrocarbon oil and a gas in contact and in parallel, gradually increasing the temperature of the oil and gas while under a high pressure to vaporize said oil, saturating the gas with oil vapors while maintaining the gas at substantially a cracking temperature, passing said saturated gas through a body of oil in a cracking zone, separating the gas and vapors from the oil, passing said gas and vapors in heat-transferring relationship with incoming oil, fractionally condensing said vapors into a series of cuts and returning all cuts having a predetermined boiling point to the oil circuit advancing toward said cracking zone.

9. An oil distilling apparatus, comprising an oil heater, a separator, a cracking chamber, means for introducing oil into said heater, connections between said heater, separator and chamber arranged to conduct oil from the heater to the separator and then to the chamber, a residuum still connected with said separator and means for reducing the pressure of the oil passing from said separator to said still.

10. An oil distilling apparatus comprising a pipe still, a separator, means for forcing oil through said still to said separator, a cracking chamber, means for conducting oil from said separator to said chamber, means for conducting vapors from said separator to the lower portion of said chamber, a reflux condenser connected with said chamber, pressure controlling means for maintaining said still, separator, chamber and condenser under superatmospheric pressure and means arranged for heating said pipe still only.

11. An oil distilling apparatus comprising an oil heater in which oil is heated to a cracking temperature, an unheated separator providing an enlarged vapor space and a space arranged to hold a body of oil with a low rate of circulation therein, an unheated cracking chamber adapted

to hold a body of oil, means for conducting vapors from the vapor space in the separator into the lower portion of the cracking chamber, means for leading oil from the oil chamber of the separator into the upper portion of the cracking chamber, a reflux condenser connected with the cracking chamber, pressure controlling means for maintaining said heater, separator, chamber and condenser under superatmospheric pressure and a final condenser connected with said reflux condenser.

12. A process of distilling oil comprising continuously circulating oil under pressure through a pipe still heater in a stream to raise it to a cracking temperature, introducing the oil from the heater into an enlarged zone to separate vapors from the unvaporized oil, of said stream maintaining in said zone an enlarged body of separated oil under cracking conditions of pressure and temperature without material agitation for a sufficient period of time to promote cracking reactions, then bringing oil of said body into contact with the separated vapors to be reheated and thoroughly agitated to remove vapors therefrom, subjecting vapors from the agitated body of oil to reflux condensation to hold back high boiling point products and condensing gasoline-like vapors.

13. A process of continuously distilling petroleum oil, which comprises continuously feeding into a system petroleum oil, continuously evolving therein mixed petroleum vapors, continuously passing the mixed vapors therein evolved into a tower wherein thorough contact is had between the evolved mixed vapors and reflux oil and the feed oil introduced into said tower, continuously introducing such feed oil into such tower, introducing water into the tower, and condensing the residual vapors leaving the tower.

14. A continuous process for cracking hydrocarbon oils, which comprises heating the oil in a confined stream of restricted cross-section in a cracking zone, passing cracked oil from said zone through successive vapor releasing chambers of decreasing temperature and pressure, passing vapors released in a chamber of higher temperature through and in intimate contact with liquid oil in the next succeeding chamber of lower temperature, and withdrawing and condensing vapors from the chamber of lowest temperature.

15. The process of cracking hydrocarbon oils which comprises, heating the oil to be cracked to a cracking temperature in a confined stream of restricted cross-section in a heating zone, passing heated oil from said zone through successive vapor releasing zones of decreasing temperature and pressure, passing vapors released in each vapor releasing zone, except the last, into the next succeeding zone of lower temperature in contact with liquid oil constituents therein, subjecting vapors remaining uncondensed in said zones to dephlegmating conditions to produce reflux condensate, passing reflux condensate produced by said dephlegmating conditions to said heating zone for retreatment, and producing a final condensate from the vapors removed from the last vapor releasing zone.

16. A process of distilling oil, comprising heating a stream of oil to a cracking temperature while passing through a coil in a pipe still furnace under a high pressure, separating the heated oil stream into vapors and unvaporized oil in a separating zone, reducing the pressure on said vapors and passing them through and in intimate contact with separated unvaporized oil of said stream in a countercurrent flow operation in a cracking zone maintained at a lower pressure than that maintained in said separating zone, and cracking the separated unvaporized oil brought in contact with said vapors in said cracking zone.

17. A process of distilling oil, comprising circulating oil in a stream through a heater to raise its temperature to a cracking temperature, separating vapors from the heated unvaporized oil of said stream, separately passing heated unvaporized oil of said stream and said separated vapors through a cracking chamber in direct contact in countercurrent paths, condensing vapors leaving said chamber to separate products of any desired boiling point, and returning the resulting condensate to the chamber to be scrubbed by a countercurrent action with said vapors.

18. The process of cracking petroleum oils, which comprises passing oil to be cracked through a heating zone where the oil is heated to a cracking temperature, delivering the heated oil into an unheated vapor separating zone in which an enlarged body of oil is maintained at a cracking temperature and where carbon and tar is separated from oil with which it is mixed, withdrawing the carbon and tar from said zone, passing vapors from said zone in heat exchange with charging oil in a reflux condenser, passing reflux condensate and charging stock from said condenser and clarified tar and carbon free oil from said separating zone into an enlarged chamber, and passing oil from said chamber into said heating zone.

19. A process of distilling oils, comprising passing oil through a heating zone whereby the oil is brought to a distilling temperature, introducing the heated oil into a separating chamber, effecting a separation of residual matter from oil in said separating chamber, withdrawing the residual matter from the system, passing the clarified oil into a second enlarged zone, passing vapors evolved in said chamber and enlarged zone into a reflux condensing zone, introducing the oil to be distilled into the vapors in said refluxing zone, passing the introduced oil and reflux condensate into said second enlarged zone to mix with the oil from said separating chamber, and passing the resulting mixture through said heating zone.

20. The process of cracking petroleum oil, which comprises heating oil to be cracked to a cracking temperature while passing it in a stream through a heating zone, passing the heated oil into a large reaction zone where conversion occurs, separately removing vapors and unvaporized oil from said reaction zone and introducing the same into a zone maintained under a lower pressure, and subjecting the combined vapors from said zones to reflux condensation in heat exchange with charging stock for the process.

21. The process of treating hydrocarbon oils, which comprises passing the oil to be treated in a confined stream through a heating zone wherein the oil is heated to a temperature below 900° F., passing air through said zone in intimate contact and in parallel with the oil passing therethrough, separating unvaporized oil from the vapor products formed in said zone, passing separated vapors and unvaporized oil in countercurrent and in intimate contact with each other in an enlarged zone, returning unvaporized oil to said heating zone, and separating the condensible products of said vapors from normally uncondensible gaseous constitutents.

22. A process of distilling oil, comprising passing oil under pressure in contact with a hydrocarbon gas in a stream of restricted cross-section through a pipe still heater to heat the oil to a cracking temperature and vaporize oil, separating oil vapors and gas from unvaporized oil in an enlarged separating zone, passing the separated vapors and gas through and in contact with separated unvaporized oil from said zone in a counter-current operation, and maintaining said separated oil, vapors and gas at substantially a cracking temperature from the time said products pass through the pipe still heater until they complete the counter-current contact.

23. A process of distilling oil, comprising passing oil in a confined stream of restricted cross-section through a pipe still heater to raise it to a cracking temperature, passing the resulting heated products into an enlarged separating zone in which vapors are separated from unvaporized oil, separately passing the resulting separated vapors and unvaporized oil separated out in said zone into a cracking chamber in which the oil and vapors pass in counter-current contact, maintaining a cracking temperature in said chamber, passing vapors from said chamber through a vapor contact zone in intimate contact with charging oil and then in indirect heat exchange with charging oil to preheat the oil and condense portions of the vapors, passing charging oil first in said indirect heat exchange and then into said vapor contact zone, and condensing a final desired gasoline product from the remaining vapors.

24. A process of distilling oil, comprising heating a hydrocarbon oil to a cracking temperature while it is passing in a stream of restricted cross-section in a pipe still heater, discharging the resulting heated oil constituents into an enlarged chamber while maintaining a pressure therein to separate vapors from unvaporized oil, continuously and separately leading unvaporized oil and the separated vapors from said chamber into a second chamber in which a cracking temperature and pressure is maintained and in which said vapors are brought in intimate contact with oil introduced thereinto, withdrawing an oil residue from the bottom of said second chamber, and leading off vapors therefrom and condensing them.

25. A process of distilling oil, comprising passing oil under pressure in a stream through a pipe still heater and heating it to a cracking temperature therein, passing the resulting heated products into a separating chamber in which vapors are separated from unvaporized oil, separately passing hot unvaporized oil and vapors from said chamber into a cracking chamber and then therethrough in counter-current paths, maintaining a cracking temperature in said cracking chamber, and withdrawing oil residuum from said chambers.

26. A process of distilling and cracking oil, comprising passing oil in contact with a hydrocarbon gas in a stream through a pipe still heater and heating the oil to a cracking temperature therein, discharging the hot oil products from said heater into an enlarged separating zone and separating oil vapors and gas from unvaporized oil, passing separated unvaporized oil and oil vapors and gas from said zone in intimate contact with each other in an enlarged cracking zone maintained at a cracking temperature, fractionating the vapors to recover reflux condensate and gasoline, recovering uncondensed hydrocarbon gases from the distilling and cracking operation and re-circulating the same to said pipe still heater to be brought in contact with the oil heated therein, said gases being adapted to enter into and assist in chemical reaction and cracking of the oil.

27. A process of distilling oil, comprising passing oil under pressure in contact with a hydrocarbon gas through a pipe still heater and heating the oil therein to a cracking temperature, separating the hot products from said heater into unvaporized oil and a mixture of oil vapors and gas, passing said vapors and gas into contact with separated unvaporized oil in counter-current paths, recovering uncondensed gases from the operation, scrubbing the gas with an oil, compressing the scrubbed gas and passing the same into said pipe still heater to be passed therethrough with the oil.

28. A process of distilling and cracking oil, comprising passing oil under pressure through a pipe still heater in a stream of restricted cross-section and heating the oil passing therethrough to a cracking temperature, discharging the resulting heated oil products from said pipe still heater into an enlarged separating chamber in which vapors are separated from unvaporized oil, separately passing hot unvaporized oil and said separated vapors from said chamber in intimate contact with each other in an enlarged cracking chamber maintained at a lower pressure than said enlarged separating chamber, maintaining the oil and vapor products in said chambers at a cracking temperature, and removing vapors from said enlarged cracking chamber and fractionating out therefrom a cracked gasoline product.

29. A process of distilling and cracking oil, comprising passing oil under pressure through a coil in a pipe still heater and heating the oil passing therethrough to a cracking temperature, passing the heated oil products from said heater into an enlarged separating chamber in which vapors are separated from unvaporized oil, passing unvaporized oil from said chamber into a cracking chamber, passing separated vapors from said separating chamber at a reduced pressure from that maintained in said separating chamber into contact with the unvaporized oil introduced into said cracking chamber, maintaining a cracking temperature and pressure in said chambers, and conducting vapors from said cracking chamber for condensation and recovery of cracked gasoline.

30. A process of distilling oil, comprising continuously advancing a stream of heavy hydrocarbon oil through a coil in a pipe still, gradually raising the temperature of said oil under pressure to a cracking temperature to vaporize the same, separating the resulting vapors from unvaporized oil, passing separated unvaporized oil and vapors in separate and countercurrent paths in direct contact in a cracking zone where a cracking temperature is maintained, removing vapors from said cracking zone and condensing them, and returning condensates having a predetermined boiling point to the process for retreatment.

31. A process of distilling oil comprising heating a heavy hydrocarbon oil under pressure to a cracking temperature while it is flowing in a stream in a pipe still heater, discharging the heated oil into an enlarged separating chamber while maintaining pressure therein to separate vapors from unvaporized oil, continuously leading separated vapors and unvaporized oil from

said chamber into a second enlarged chamber in which a cracking temperature and pressure is maintained, bringing the vapors into direct and intimate contact with oil in said second chamber, maintaining a pool of oil in the enlarged separating chamber, withdrawing an oil residue from the bottom of the pool in said separating chamber into a still and distilling said withdrawn residue therein under reduced pressure, and leading off vapors from said second chamber and condensing them.

32. The process of distilling oil comprising heating heavy hydrocarbon oil under pressure to a cracking temperature while it is flowing in a stream in a pipe still heater, discharging the heated oil into an enlarged chamber while maintaining pressure therein to separate vapors from the unvaporized oil of said stream, continuously leading separated vapors and unvaporized oil in separate streams from said enlarged chamber into a second chamber in which a cracking temperature and pressure is maintained, introducing oil to be cracked into said second chamber, bringing the vapors introduced into said second chamber into direct and intimate contact with oil introduced thereinto, making up the oil to be heated in said stream from the oil in said second chamber, and leading off vapors from said second chamber and condensing them.

33. An oil conversion process which comprises passing a restricted stream of oil through a heating coil disposed within a heating furnace, heating said oil by furnace gases during its passage through said coil to a cracking temperature, delivering the stream of heated hydrocarbons into an enlarged zone to separate vapors from unvaporized oil of said stream, passing the separated vapors into an enlarged reaction zone where a cracking temperature is maintained, introducing oil into contact with vapors in said enlarged reaction zone, promoting the cracking reaction of the heated oil in said heating coil while conversion thereof is occurring by introducing hydrocarbon gas adapted to aid in the formation of gasoline into said heating coil to physically commingle with the oil therein, maintaining a superatmospheric pressure on the oil stream and on the oil in said reaction zone, discharging vapors from the reaction zone for reflux condensation, and withdrawing unvaporized residue from the separating zone without again admitting the same to the heating coil.

34. An oil conversion process which comprises passing a restricted stream of oil through a heating coil disposed within a heating furnace, heating such oil by furnace gases during its passage through said coil to a cracking temperature, delivering the stream of heated hydrocarbons to an enlarged zone to separate vapors from unvaporized oil of said stream, passing the separated vapors into an enlarged reaction zone where oil is maintained at a cracking temperature, promoting the cracking of the heated oil in said reaction zone by physically commingling heated hydrocarbon gas with the oil therein, maintaining a superatmospheric pressure on the oil stream and on the oil in said reaction zone, discharging vapors from the reaction zone for reflux condensation, and withdrawing unvaporized residue from the reaction zone without again admitting the same to the heating coil.

35. A process for treating hydrocarbon oils, which comprises subjecting the oil to a cracking temperature in a heating zone by passage through a heating coil disposed therein, directing the oil constituents from said coil into an enlarged zone to separate vapors from unvaporized oil, passing separated unvaporized oil from said enlarged zone into a separate reaction zone located outside of the heating zone, injecting uncondensable gas produced in the system into said heating coil and then passing it with the separated vapors from said enlarged zone into intimate contact with oil in the reaction zone to prevent adherence of free carbon to the walls thereof and to cause such carbon to remain in suspension in the oil residuum, withdrawing the residuum and suspended carbon from the reaction zone, and discharging and condensing the vapors from the reaction zone.

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