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PROCESS OF CRACKING OIL

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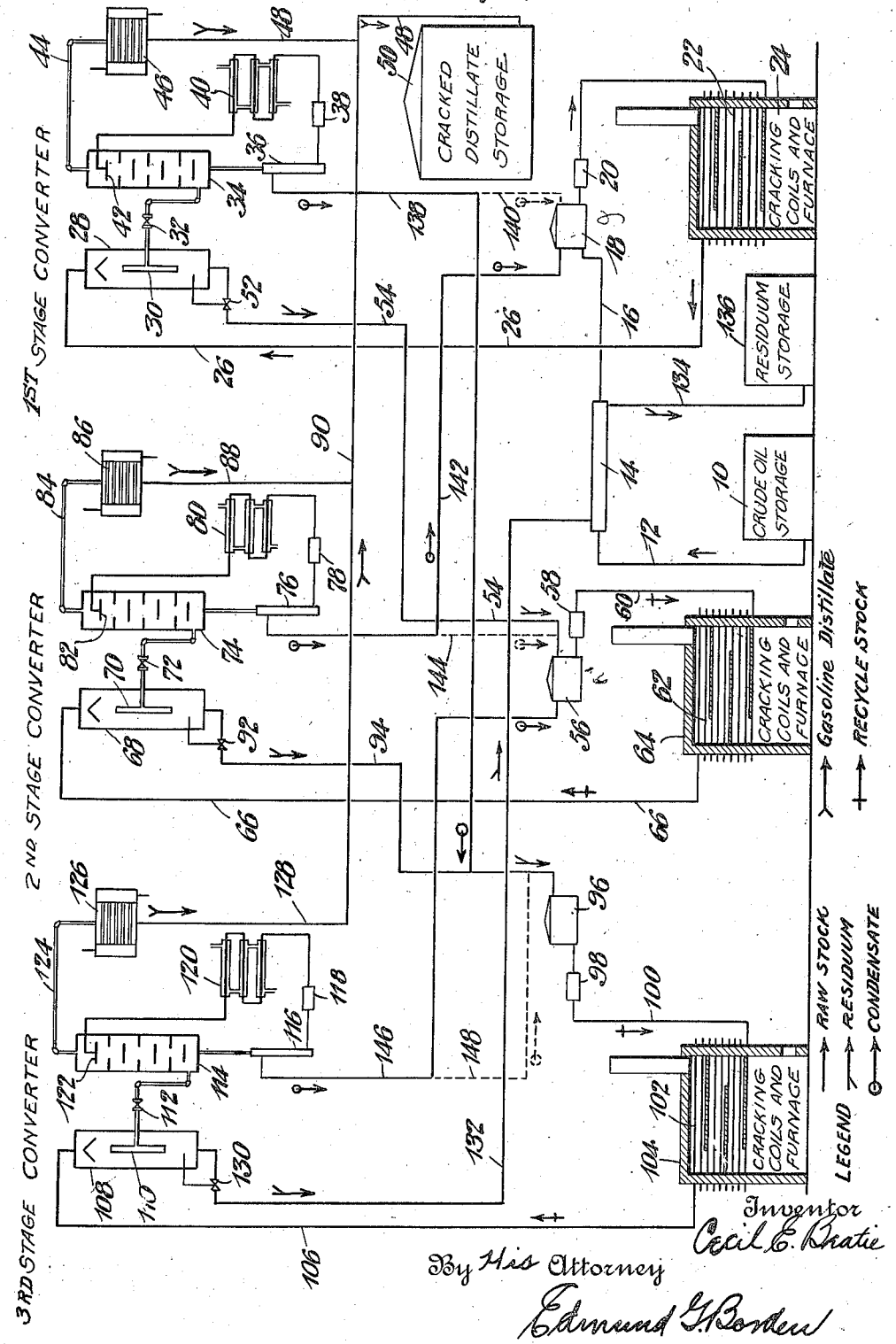

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PROCESS OF CRACKING OIL

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This invention relates to a process of cracking oil and more particularly to a continuous process of cracking oil in stages.

Since the decomposing or cracking temperatures of mineral oils or various distillates thereof are usually higher than their boiling temperatures, it is the common practice in cracking oils to place them under sufficient pressure so that they may be raised to the decomposing temperature before they are vaporized. When cracking oil under pressure, three factors, namely, pressure, temperature and time must be accurately controlled in order to secure the best results. If a high temperature is used for cracking, the oil must be subjected to such a temperature for only a short time. Conversely, if a low temperature is used for cracking, the oil must be held at such temperature for a long time. Either pressure-temperature combination will produce substantially the same results but the higher temperatures are usually preferred because with them oil may be cracked more rapidly. When cracking oil on a commercial scale, there is a critical temperature for each different oil above which it is not practicable to go regardless of the time factor, because at these higher temperatures carbon is deposited so rapidly that the apparatus soon becomes clogged.

For every cracking temperature, each oil appears to have a critical length of time, to which it may be subjected to such temperature before it will be broken down almost instantaneously into carbon and gases. With some oils, the point of "fatigue" or the point where the oil seems to suddenly decompose may occur while the oil has a comparatively low specific gravity. If, however, the temperature and pressure to which the oil is being subjected are changed or if carbon is removed from the oil, the oil may be reduced to a comparatively high specific gravity without danger of reaching the "fatigue" point.

The heavier hydrocarbons decompose more easily, that is, at lower temperatures and pressures, than the lighter hydrocarbons, and therefore it is desirable that oils of different gravities be decomposed separately. When a hydrocarbon is cracked, a plurality of different hydrocarbons are formed whose specific gravities vary in series from the low specific gravity up to the high specific gravity. The hydrocarbons having a specific gravity higher than that of gasoline or the desired hydrocarbons are usually separated from the desired hydrocarbons by condensation and returned to the still for retreatment. Those condensates having a specific gravity higher than gasoline preferably should not be mixed with the oil from which they are formed and returned to the still to be again cracked, because a mixture would be formed for which it would be difficult to find the proper combinations of pressure, temperature and time to obtain the most favorable cracking without reaching the "fatigue" point.

The primary object of the present invention is to provide a process of cracking oil by which the oil may be cracked in stages to allow intermediate decomposition products of the oil to be treated separately.

Another object of the invention is to provide a process of cracking oil in stages in which the residuum oil from one stage advances to a succeeding stage for treatment at a lower temperature and heavier condensates of vapors formed in one stage advance to a preceding stage or in a direction countercurrent to the advance of the residuum.

Another object of the invention is to provide a continuous process of cracking oil by which the various gravities of oil formed successively in the course of the heat decomposition process may be cracked separately under different conditions of pressure and temperature.

Another object of the invention is to provide a process of cracking oil in stages by which the lighter or lower specific gravity constituents are cracked in the stages maintaining the highest temperature and the carbon and heavy residue are removed from the stage maintaining the lowest temperature.

Another object of the invention is to provide a process of cracking oil in stages by which the carbon which is formed in each of the stages is continuously and progressively carried forward through the stages to the point of discharge by a stream of fresh incoming oil advancing successively through the stages.

Another object of the invention is to provide a process of cracking oil in stages by which the heavier condensates are separated from the finished distilled residue and carbon formed in each stage and these condensates are progressively circulated through the various stages for retreatment therein under the proper conditions of pressure and temperature.

Another object of the invention is to provide a process of cracking oil by which the pressure and temperature of the oil and the time the oil is under predetermined pressures and temperatures may be accurately controlled.

A further object of the invention is to provide a process of cracking oil by which the deposition

of carbon in the treating apparatus may be effectively controlled.

With these and other objects in view, the invention consists in the improved process of cracking oil hereinafter described and particularly defined in the claims.

The process embodying the preferred form of the invention is preferably carried out in such a manner as to produce gasoline as a finished distillate. The oil to be treated is preheated and forced continuously under pressure through a series of separate cracking coils arranged in stages. The residuum of oil from one stage passes in succession to the succeeding stages. Immediately after the oil is cracked in the coils, the vapor is separated from the oil residuum, the pressure of the vapors reduced, and the vapors are condensed to separate the heavy condensates from the final distillate. The residuum of each stage passes to a succeeding stage of lower temperature for its next treatment. The residuum which is separated from the vapors in each stage has its pressure reduced and passes to a surge tank where it is mixed with a heavy condensate from a preceding or a succeeding stage in accordance with the specific gravity of such condensate. This mixture is then pumped under pressure through the cracking coil of the next succeeding stage. The temperature and pressure of the oil as it passes through each of the cracking coils is controlled to produce the maximum amount of gasoline, but this temperature varies in the stage in accordance with the gravity of the oil being treated. For the lighter oils, higher temperatures and pressures are used, and for the heavier oils, lower temperatures and pressures are used. In each of the cracking coils, the maximum temperatures and shortest time intervals are used which will give the highest yields with practicable operating conditions.

In the accompanying drawing is diagrammatically illustrated a flow sheet of a process embodying the preferred form of the invention.

A process of cracking an oil such as crude oil, kerosene, gas oil or fuel oil to produce gasoline may be carried out in the apparatus illustrated in the drawing as follows: Crude or gas oil from storage 10 flows through a line 12 to a heat interchanger 14 and passes through a line 16 to a surge tank 18. From the surge tank 18 the oil is circulated for treatment in the apparatus of a first stage converter. The oil leaving the surge tank 18 is placed under pressure by means of a pump 20 and forced through a cracking or heating coil 22 positioned in a furnace 24. The heated and vaporized oil leaves the coil 22 through a line 26 and passes into a separator 28. Vapors separated from the oil in the separator 28 flow through an offtake 30 through a pressure-reducing valve 32 thence into the bottom of a spray condenser 34. In the condenser 34 the vapors are subjected to a spray of heavy condensate which is taken from an overflow tank 36 by means of a pump 38 and passed through a cooling coil 40 to a spray nozzle 42 in the upper portion of the condenser. The heavy condensate removes all of the heavier portions of the oil and the finished vapors flow through a line 44 to a condenser 46 where the vapors are condensed and the resulting condensate passes through a line 48 to a storage tank 50.

The oil residuum collected in the separator 28 passes through a float-controlled valve 52 to a line 54 and thence to a surge tank 56 which serves as storage for the oil treated in the apparatus of a second stage converter. The oil from the surge tank 56 is forced under pressure by means of a pump 58 through a line 60 to a cracking coil 62 mounted in a furnace 64. The oil cracked in the coil 62 passes through a line 66 to a second stage vapor separator 68. The vapors from the separator 68 pass into an offtake 70 and flow through a pressure-reducing valve 72 into a spray condenser 74. In the condenser 74 the vapors are condensed by means of a heavy condensate which is taken from an overflow tank 76 by means of a pump 78 and forced through a cooling coil 80 to a spray nozzle 82 mounted in the upper portion of the condenser 74. The finished distillate vapors pass through a line 84 to a condenser 86 and the distillate passes through a line 88 to a line 90 which connects with the finished distillate line 48.

The oil residuum from the second stage separator 68 flows out through a float-controlled valve 92 through a line 94 to a surge or storage tank 96. The surge tank 96 serves as the storage for oil to be treated in the apparatus of a third stage converter. The oil from the storage tank 96 is forced under pressure by means of a pump 98 through a line 100 into a cracking coil 102 mounted in a furnace 104. The oil cracked in the coil 102 passes through a line 106 to a separator 108 which has substantially the same construction as the separators 68 and 28. The vapors from the separator 108 pass through an offtake 110 through a pressure-reducing valve 112 into a spray condenser 114. The vapors in the condenser 114 are condensed by means of a heavy condensate which is taken from an overflow tank 116 and circulated by means of a pump 118 through a cooling coil 120 to a spray nozzle 122 mounted in the upper portion of the condenser 114. The finished distilled vapors from the condenser 114 pass through a line 124 to a condenser 126 and the distillate passes through a line 128 which is connected with the finished distillate line 90.

The residuum from the separator 108 flows through a float-controlled valve 130 to a line 132 and thence into the heat interchanger 14 from which it passes through a line 134 to a residuum storage tank 136.

The heavy condensate condensed in the condenser 34 of the first stage converter overflows from the tank 36 and passes through a line 138 to the surge tank 96 for the third stage converter. A line 140 may also be connected between the line 138 and the surge tank 18 by which the heavy condensate may pass to the surge tank 18 for retreatment in the first stage converter. The heavy condensate recovered in the condenser 74 of the second stage converter overflows from the tank 76 and passes through a line 142 to the surge tank 18 for the first stage converter. A line 144 may also be connected between the line 142 and the surge tank 56 by which the heavy condensate from the second stage converter may pass to the surge tank 56 for retreatment. The heavy condensate from the condenser 114 of the third stage converter overflows from the tank 116 and passes through a line 146 to the surge tank 56 for the second stage converter. A line 148 may also be connected between the line 146 and the surge tank 96 by which the heavy condensate from the third stage condenser may pass directly to the surge tank 96 for retreatment.

With the apparatus outlined above, the heavy

condensates formed in the different stages of the cracking may be passed to a surge tank in a preceding or the same stage to be mixed with a residuum oil in accordance with the specific gravity of the oil to be treated and in accordance with the specific gravity of the heavy condensate. In the preferred form of the invention, the main body of the oil or the residuum remaining in the separators of the different stages advances from the first to the third stage converters to be subjected to progressively lower temperatures. The heavy condensates formed in the various stages, however, advance from the third to the first stage converters or in a countercurrent direction to the advance of the oil. All of the free carbon formed in the cracking operation is carried forward continuously with the main body of the oil and is discharged with the residuum from the separator of the third stage converter, which converter is maintained at the lowest temperature. By this means the carbon or residue is separated from the oil in the lower temperature stage of the apparatus where the carbon is least liable to cause trouble in the operation.

The cracking of oil in separate stages permits the various decomposition products of the oil to be grouped separately and treated separately under the most favorable conditions of temperature and pressure. The oil may be handled in each stage by a pump to accurately control the time period and therefore the higher temperatures may be used by circulating the oil at high velocities. The high velocity circulation of the oil further assists in carrying residuum and carbon through the apparatus so that it will not become clogged and also serves to carry the vapors out of the heated zone as soon as they are formed so that the vapors will not be supercracked. A sample of the oil being treated in each of the converters may be removed to determine the amount of free carbon in the oil and accordingly the three factors, time, pressure and temperature used in the cracking coil of each stage converter may be accurately regulated to obtain the desired finished distillate and the maximum evaporation or cracking.

In the first stage converter the fresh incoming fuel or gas oil is circulated so rapidly through the cracking coil that the oil is not cracked to any appreciable extent but is merely topped or vaporized so that the vapors may be fractionally condensed. The heavy condensate which is mixed with the fresh incoming oil, however, has resulted from two previous heat treatments of oil and condensates in the third and second stage converters and receives another cracking treatment in the coil of the first stage converter. This mixture of crude oil and condensate has the lowest specific gravity of any of the oil mixtures which is to be treated and is subjected to the highest temperatures.

The oil treated in the second stage converter consists of the residuum of the first stage converter and the heavy condensate from the third stage converter. The residuum is subjected to a lower temperature and pressure in the second stage converter and is therefore further vaporized. The heavy condensate which has previously had a cracking treatment in the third stage converter is given its second cracking treatment.

The oil treated in the third stage converter consists of a mixture of the residuum from the second stage converter and the heavy condensate formed in the first stage converter. The residuum being treated under a lower temperature and pressure than that maintained in the second stage converter is further vaporized. Any of the oil passing through the coil of the third stage converter which has not been vaporized by the third heat treatment in the third stage converter passes out of the apparatus as a residuum which is controlled to be suitable for fuel oil purposes. The heavy condensate of the mixture treated in the third stage converter is given its first cracking treatment in the second stage converter.

Any oil which has not been vaporized in any of the various stages never goes through the same cracking or heating elements twice and therefore the length of the time in which any particular portion of the oil remains under treatment may be accurately controlled to prevent the oil from reaching the "fatigue" stage or a point where it will be broken down with an excess formation of carbon. The treatment of oil in each stage consists of a finishing cracking operation to form a finished distillate, an intermediate cracking operation to form a heavy condensate, a cleaning or topping operation to form vapors for the finished distillate and the heavy condensate, and the removal of carbon from the finished distillate and heavy condensate. In each stage the vapors formed are fractionally condensed to separately collect the finished distillate and the heavy condensate. The carbon separated is deposited in the residue to be advanced to a following stage and the heavy condensate free from carbon advances to a preceding stage. Although the heavy condensate may be mixed with a residue containing carbon, it has a lower specific gravity than the oil mixture of the stage in which it was formed and is mixed with an oil which is subjected to a different temperature and pressure than the temperature and pressure of the stage in which it was formed so that the operation does not tend to bring the oil toward a "fatigue" point. On the other hand, the residue containing the carbon advances to a succeeding stage where it is mixed with a lighter condensate and the mixture is subjected to a lower temperature and pressure than the pressure and temperature maintained in the stage where the carbon was formed. The heavy condensates which are added to the residuum to make up a mixture for circulation through a heating element serve to decrease the viscosity of the oil mixture, and since this condensate has all been vaporized in a prior heat treatment, it will be practically all cracked in its second heat treatment.

Although the process of treating oil has been illustrated and described as being carried out in three stages, it is to be understood that the invention is not limited to a three-stage process. Some oils may be properly treated in less than three stages and other oils may require more than a three-stage treatment. The number of stages to be used and the specific temperatures and pressures in each stage depend entirely upon the character of the oil being treated and the kind of finished product to be obtained.

The method of separating the finished distillates from the vapors removed from the separators in the various converters is particularly advantageous in that a clean separation may be accurately made. The vapors are scrubbed with condensates of vapors of the same general type and any desired amount of condensate may be used for the scrubbing operation. The temperature of the condensate used for scrubbing may be accurately controlled by cooling the coils through

which they are circulated and in this way a large body of condensates of any desired temperature may be circulated through the condenser. This scrubbing operation will prevent any of the higher fractions of oil going over into the finished distillate and will thus do away with the necessity of rerunning the finished distillate to obtain a finished product.

The preferred form of the invention having been thus described, what is claimed as new is:

1. A continuous process of cracking oil comprising circulating oil under pressure once only through each of a series of separate heating zones having progressively lower temperatures in the direction of advancement of the oil, passing the heated oil from each zone to an unheated chamber to complete the cracking reaction therein, separating a reflux condensate from the vapors from each chamber, withdrawing oil from each chamber, except the last, and mixing therewith reflux condensate produced from the vapors from a succeeding chamber, passing the resulting mixture into the next succeeding heating zone, and separating a gasoline distillate from vapors of each chamber.

2. A process of cracking oil comprising circulating oil under pressure once only through each of a series of separate heating zones, maintaining a cracking temperature in each zone, successively reducing the pressure on the oil in the direction of its advancement through the heating zones, passing the heated oil from each zone to an unheated chamber to complete the cracking reaction therein, separating a reflux condensate from the vapors from each chamber, withdrawing oil from each chamber, except the last, and mixing therewith reflux condensate produced from the vapors from a succeeding chamber, passing the resulting mixture into the next succeeding heating zone, and separating a gasoline distillate from the vapors of each chamber.

3. A process of cracking oil, comprising advancing oil in a continuous path through a series of heating zones of successively lower temperature in succession, maintaining a high pressure and cracking temperature in each zone, separating reflux condensates from vapors formed in the heating zones, and supplying reflux condensate from one zone to oil passing through the next preceding zone.

4. A process of cracking oil, comprising advancing oil in a continuous path through a series of heating zones in succession, maintaining said zones at progressively lower temperatures and pressures, separating heavy condensates from vapors formed in the heating zones, mixing a heavy condensate from each zone with the oil advancing through the next preceding zone, the condensate from the first zone being mixed with the oil passing through the last zone.

5. A process of cracking oil comprising advancing oil under pressure in a continuous path through a series of separate cracking heating zones maintained at progressively decreasing temperatures, separating condensates from vapors formed in each heating zone and circulating said condensates through said heating zones in a direction to subject them to progressively increasing temperatures.

6. A process of cracking oil comprising advancing oil in a continuous path through a series of separate cracking heating zones maintained at progressively decreasing temperatures and pressures in the direction of the advance of the oil, separating condensate from the vapors formed in each heating zone and circulating condensates through said heating zones in a direction to subject them to progressively increasing temperatures.

7. A continuous process of cracking oil comprising passing oil through successive heat cracking stages maintained at progressively lower temperatures, passing the oil residuum from one stage to the following stage, maintaining cracking temperatures and pressures on the oil and vapors in each stage, separately removing the vapors formed in each stage, reducing the pressure of the separate vapors, collecting by condensation a heavy condensate and a gasoline distillate from the vapors of each stage, and passing the heavy condensate from each stage for re-treatment in a stage of higher temperature.

8. A continuous process of cracking oil comprising circulating oil under pressure through a series of separate heat cracking stages having progressively lower temperatures and pressures in the direction of advancement of the oil, removing residuum containing carbon from the lowest temperature stage, separately condensing heavy and light distillates from the vapors formed in each stage under pressure lower than the pressures maintained in the respective stages, and supplying heavy distillate from one stage to the oil being treated in another stage and at higher pressure than the pressure in the stage in which the vapor of the heavy condensate is formed.

9. A continuous process of cracking oil comprising passing oil under pressure through successive heat cracking stages of successively decreasing temperatures and pressures, the oil residuum from one stage passing to a following stage, removing heavy condensates from the vapors formed in each stage, introducing the raw oil in the stage having the highest temperature and pressure, and introducing a high boiling point oil residuum to be cracked into the stage having the lowest temperature and pressure, and supplying heavy condensate from one stage to oil passing through the stage of the next higher temperature and pressure.

10. A process of cracking oil in stages comprising circulating oil under pressure through a heating zone, separating by condensation higher boiling point condensates from lower boiling point condensates of the vapors formed in the said zone, separating a residuum oil from the oil heated in said zone, and passing it under pressure into a second heating zone maintained at a lower temperature than said first mentioned heating zone, passing said higher boiling point condensate into oil passing through a third heating zone, separating by condensation higher boiling point condensates from lower boiling point condensates from vapors formed in the said second heating zone, separating a residuum oil under pressure from the oil heated in the said second heating zone and passing it to said third heating zone, passing said second higher boiling point condensate under pressure into oil passing through said first heating zone, condensing the vapor formed in the said third heating zone into higher boiling and lower boiling point condensates, passing the oil residuum from the third zone out of the oil cracking system, and passing the higher boiling point condensate from the third zone under pressure into oil passing through the second heating zone.

11. The process of cracking oil, which com-

prises passing oil to be cracked through a heating zone and then into a vapor separating zone in which vapors are separated from unvaporized oil, passing unvaporized oil from said separating zone through a second heating zone of lower temperature and then into a second vapor-separating zone, cooling and condensing portions of the vapors from said vapor-separating zones in separate refluxing zones, conducting uncondensed vapors from said reflux zones for final condensation and collection, and passing reflux condensate from said reflux zones into said first mentioned heating zone for retreatment.

12. The process of cracking oil which comprises passing oil once only through each of a plurality of heat-cracking zones maintained at successively lower cracking temperatures, separating vapors from the oil heated in each zone, condensing higher boiling constituents as a reflux condensate from the vapors thus separated from the oil heated in each zone, and passing the reflux condensate derived from each zone, except the first, through a heat-cracking zone of higher temperature than that maintained in the zone from which the reflux condensate was derived.

13. A hydrocarbon oil cracking process which comprises passing the oil serially through a plurality of interconnected reaction zones and maintaining the oil under cracking conditions of temperature and pressure in each of said zones, removing vapors from each of said reaction zones and introducing the same to independent dephlegmating zones associated with the respective reaction zones, condensing insufficiently cracked fractions of the vapors as reflux condensate in said dephlegmating zones, passing reflux condensate from a dephlegmating zone associated with one of said reaction zones into a preceding reaction zone in the series, and removing and condensing the vapors uncondensed in said dephlegmating zones.

14. A hydrocarbon oil cracking process which comprises passing the oil serially through a plurality of interconnected reaction zones and maintaining the oil under cracking conditions of temperature and pressure in each of said zones, removing vapors from each of said reaction zones and introducing the same to independent dephlegmating zones associated with the respective reaction zones, condensing insufficiently cracked fractions of the vapors as reflux condensate in said dephlegmating zones, passing reflux condensate from each of said dephlegmating zones except the one associated with the first reaction zone into the preceding reaction zone of the series, and removing and condensing the vapors uncondensed in said dephlegmating zones.

15. The process of cracking mineral oils, which comprises passing the oil to be cracked through a heating zone in which it is subjected to a cracking temperature and then into a vapor separating zone in which vapors are separated from the unvaporized oil, passing unvaporized oil from said separating zone through a second heating and cracking zone of lower pressure than said first-mentioned heating zone and then into a second vapor separating zone, cooling and condensing portions of the vapors from said vapor separating zones to produce reflux condensate and uncondensed vapors, subjecting the uncondensed vapors to final condensation and collection, and passing reflux condensate produced by the reflux condensation of vapors from said separating zones into said first-mentioned heating zone to be subjected to cracking conditions of temperature and pressure.

16. The process of converting heavy mineral oil cracking stock into lower boiling point products of the type of gasoline, which comprises passing an oil stock to be cracked in a confined stream of restricted cross section in a high temperature cracking zone and therein heating and cracking the oil at high temperature, separating the products of said stream into vapors and unvaporized oil constituents in a separating zone, passing the unvaporized oil constituents from said separating zone at a reduced pressure into a separate zone in which they are subjected to a lower cracking temperature than that of the oil in said first-mentioned zone, removing the vapors produced in said lower pressure and temperature zone and fractionating a heavy reflux condensate therefrom, separately fractionating the vapors separated out in said separating zone to produce reflux condensate therefrom, passing reflux condensate from both fractionating operations into said high temperature cracking zone to be cracked therein, and collecting the low boiling point gasoline-like products from the fractionating operations.

17. A hydrocarbon oil cracking process which comprises passing a distillate oil serially through a plurality of interconnected cracking zones and maintaining the oil under cracking conditions of temperature and pressure in each of said zones, maintaining progressively lower pressures through the cracking zones, removing vapors from each of the cracking zones and introducing the same to independent dephlegmating zones associated with the respective cracking zones, condensing insufficiently cracked fractions of the vapors as reflux condensate in said dephlegmating zones, passing reflux condensate from a dephlegmating zone associated with the second of said cracking zones into the first cracking zone of the series to supply at least in part the distillate to be cracked therein, and removing and condensing the vapors uncondensed in said dephlegmating zones.

18. The process of converting higher boiling point hydrocarbon oils into lower boiling point products of the type of gasoline, which comprises passing a distillate oil through a high pressure heating and cracking zone to effect vaporization and cracking of the distillate oil therein, separating vapors from unvaporized oil constituents resulting from the heating and cracking of said distillate oil, fractionating the vapors separated from the cracking of the distillate oil in said high pressure heating and cracking zone to produce a reflux condensate and an overhead vapor containing gasoline constituents, passing the unvaporized oil constituents from the high pressure cracking zone into a second lower pressure cracking zone in which the unvaporized oil constituents are heated and subjected to cracking conditions, separating vapors and unvaporized residue from the cracking of said unvaporized oil constituents and fractionating the resulting vapors to produce a reflux condensate and an overhead vapor containing gasoline constituents, and passing said reflux condensates into said high pressure cracking zone to supply at least in part the distillate to be cracked therein.

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