

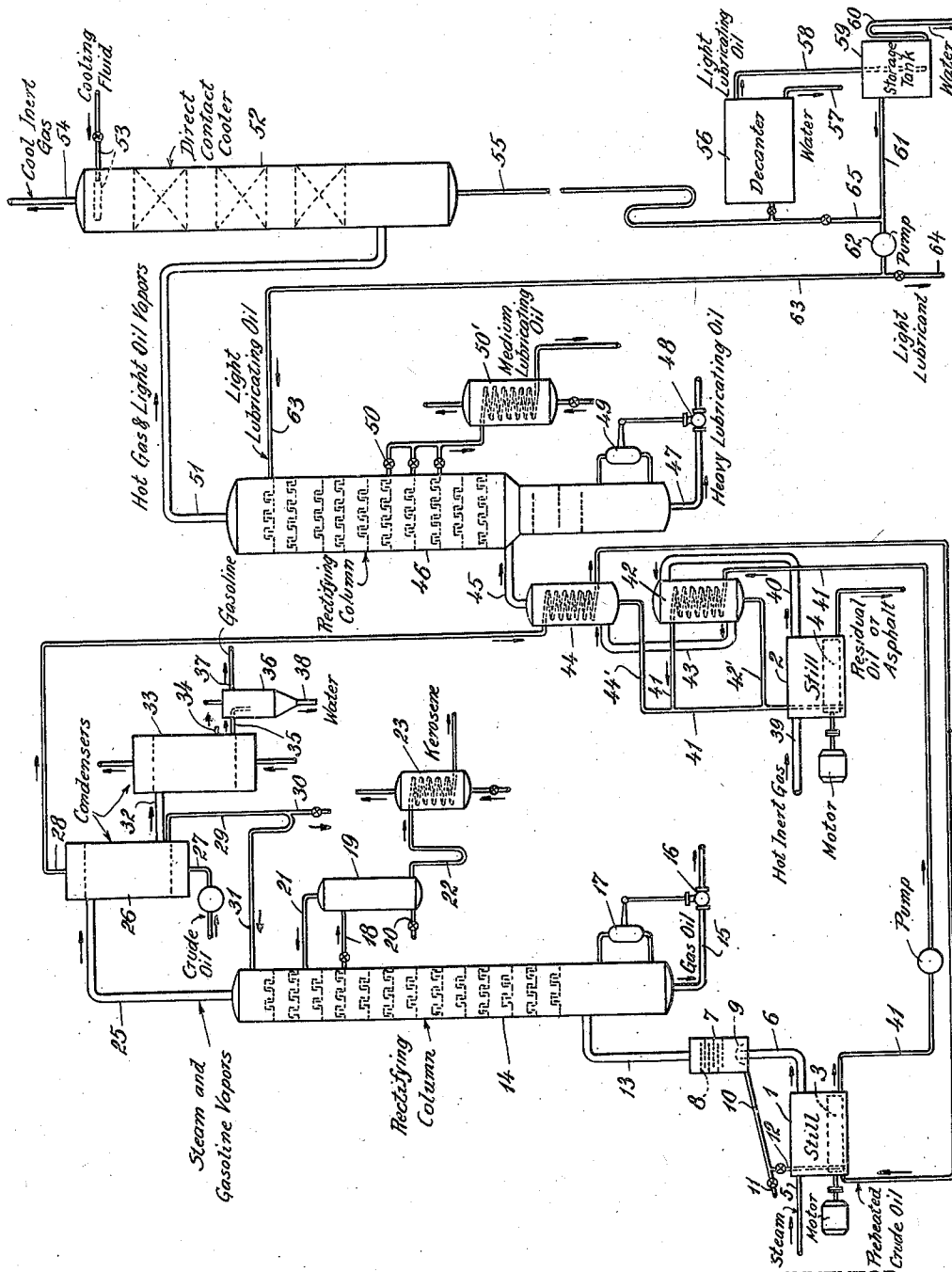
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METHOD OF PETROLEUM DISTILLATION

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METHOD OF PETROLEUM DISTILLATION

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2 Claims. (Cl. 196—73)

This application relates to the fractional distillation of crude petroleum and similar oils subject to decomposition or polymerization under normal conditions of distillation.

Crude petroleum generally contains constituents ranging in volatility from the highly volatile gasoline fractions to the substantially non-volatile paraffinic or asphaltic residue. Between these extremes are the oils of the kerosene and fuel oil type and oils of the light, medium, and heavy lubricating oil type. The most valuable oils lie in the lubricating oil range. Under the severe conditions frequently encountered in the distillation of petroleum, the valuable lubricating oils are subjected to decomposition and perhaps to polymerization conditions so that a portion of these materials is lost by conversion to less valuable products.

By the present invention the fractional distillation of petroleum and similar compositions is effected without substantial decomposition so that a maximum yield of the valuable lubricating oil fractions is obtained. The conditions of distillation are such that little or no unsaturated compounds are formed and consequently the presence of these relatively unstable materials in the product is avoided. The proportions of polymerization products and gum forming constituents in the product are thus reduced to a minimum.

According to my invention the crude petroleum or similar oil is subjected to a primary distillation or topping treatment for removal of the relatively volatile constituents under mild distillation conditions. The petroleum oil freed from these constituents is then passed into a second distillation vessel wherein the oil is sprayed from a body thereof into a stream of hot inert gases passing over the body of oil. In this manner volatile oils are distilled off with a minimum of decomposition. The gases and vapors resulting from the distillation step may be passed to a rectifying column or fractionating column for recovery of separate fractions of distillate.

In its preferred form the process of this invention embodies a preliminary distillation of crude petroleum by spraying it into a stream of steam. This steam effects removal from the petroleum of gasoline and kerosene and possibly other constituents of volatility in the neighborhood of these distillates.

The distillation residue from the first distillation step, substantially free from any constituents lower in boiling point than the oils of the

light lubricating fraction is removed from contact with the steam and brought into a stream of hot inert gas such as flue gas at a temperature around 370° C. to 400° C. (700° to 750° F.) in the form of a fine spray whereby lubricating oil fractions are vaporized by the hot gas; this leaves the relatively non-volatile constituents such as residual oil or asphalt as a distillation residue. Vapors from each distillation step may be passed through fractionating columns or rectifying columns to effect a sharp fractionation of the desired distillates.

In its preferred aspects both the initial distillation with steam and the principal distillation with inert gas are effected in a spray roll type of still. In this type of still a body of the liquid moves slowly through the still. The gas or steam passes through the still over the surface of the body of liquid therein. A rotating roll, either perforate or imperforate, smooth or rough, or series of discs or a similar device capable of picking particles of oil from the body thereof dips slightly into the liquid. This device is rotated at high speed, for example a speed on the order of 900 to 1200 revolutions per minute for a roll having a diameter of around 10 inches. The still is preferably of a generally cylindrical contour with the axis of the rotating roll substantially parallel to the axis of the cylinder. The still itself should have a sufficiently small diameter so that spray from the rotating roll will impinge upon the walls of the still. Such a device produces an intense spray of oil substantially filling the interior of the still and applies to the walls of the still such a copious volume of liquid that the walls are flushed with a rapidly moving, continuous liquid layer. In this manner a uniform and rapid distillation of the oil is effected without overheating any portion thereof. The fineness of the spray may be controlled not only by the design of the agitating device but by the extent to which it dips into the liquid. If the liquid level in the still is substantially parallel to the lower surface of the roll and just contacts therewith, an exceedingly fine and voluminous spray is formed that substantially fills the still with oil particles moving at high velocity through the gas in a direction which traverses the path of the gas stream. By placing the roll close to a side wall and rotating it so that the side adjacent the wall moves upward, it may be caused to pump a layer of oil over the wall producing a rapidly rotating liquid conduit through which the gas passes. The amount of spray within the conduit thus formed

may be large or small depending upon the speed of rotation of the roll and the other variable factors governing conditions in the still.

In the distillation of petroleum in accordance with the present invention, especially in the second distillation step involving distillation with a hot inert gas, it is particularly desirable to employ an exceedingly fine spray of the oil. For this purpose the liquid level in the still should be regulated so as just to contact with the periphery of the rotating cylinder or discs within the still. The body of liquid in each still flows slowly through the still in a direction substantially perpendicular to the plane of spray particles. The flow of the body of liquid may be either concurrent with or countercurrent to the flow of gas through the still. Since particles of liquid are continuously sprayed into the gas, the actual course of the liquid through the still will be on the order of an irregular spiral through which and in contact with which the gas passes.

Some of the fine spray of liquid may be entrained with the gas or steam passing from the still. Accordingly, it is desirable to pass exit gas and vapors through a device for removing the entrained spray. It has been found that a small settling chamber serves this purpose. Chambers containing a small amount of packing such as several layers of iron grating have been found especially suitable. The grating is wet by the spray particles and the wet surface thus produced is an effective means of washing the gases. The spray thus removed from the vapor may be returned to the still for redistillation or it may be withdrawn as a separate product. Since the spray normally will not consist of any one sharp fraction, it is preferred to return it to the still for redistillation.

The preliminary distillation of crude petroleum as outlined above, serves to eliminate those constituents of the petroleum having a high vapor pressure. If such constituents were present in the inert gas distillation step, considerable quantities would remain in the gases even after they were cooled and unless some special means for their recovery were provided, such as scrubbing or recirculation of the gases, would represent a loss of valuable products. Recirculation requires an indirect reheating of the gases and scrubbing will not effect complete recovery of the most volatile materials. By eliminating them in a preliminary steam distillation step, the vapors and steam both may be condensed. Since no substantial quantities of fixed gas are present, no substantial loss of the more volatile constituents results. The oil condensate may be separated from the water by simple decantation, and higher boiling oils being absent, no emulsion difficulties are encountered.

The preliminary distillation step may be regulated to eliminate gasoline, kerosene, and gas oil or only the lighter of these constituents. It is preferred to eliminate all three so that the oil passing to the second distillation step will be free of oils more volatile than the light lubricating fraction. The rate of flow of steam through the still will depend upon a number of factors. Thus, when the initial temperature of the oil entering the still is above the temperature at which it leaves, a part of the heat of vaporization may be supplied by sensible heat of the oil. Accordingly a smaller volume of steam is required to give a definite exit temperature to the vapors than if the oil incurred a temperature rise. If the distillate is only a small frac-

tion of the crude, as with oils low in gasoline and kerosene, less latent heat of vaporization is required for a definite quantity of crude than if the distillate is a large part thereof and the relatively large amount of sensible heat from the oil may supplant a part of that which otherwise would be supplied by the steam. The minimum quantity of steam is, on the other hand, further limited by the amount of oils that it will hold at any one temperature. Thus, if the relatively heavy oils are present in large proportions, a large amount of steam is required to carry them. The temperature and degree of superheat of entering steam of course have a definite effect on the volume required. It is preferred to operate the steam distillation step at around atmospheric pressure and steam entering the still at a temperature of 160° to 200° C. (at about atmospheric pressure) will serve to advantage for vaporization of the lighter than lubricant fractions.

In the distillation of residual oil resulting from the first step by means of a hot inert gas, any suitable inert gas, such as combustion gases, carbon dioxide, nitrogen, methane, natural or manufactured fuel gas, or other non-oxidizing gas, may be employed. Preferably flue gas is introduced into the still at around 370° to 400° C. (700°-750° F.). While somewhat higher or lower gas temperatures may be employed, substantially lower temperatures result in the use of an undesirably large quantity of the gas in comparison with the quantity of the oil distilled and temperatures substantially higher tend to cause some decomposition of the petroleum constituents. As with the steam in the first step, the volume of inert gas to be used will depend upon the temperature of ingoing oil, the proportion of vaporizable oils it contains, the volatility and heat of vaporization of the oil distillate constituents, and the proportions in which they are present, as well as the temperature of the ingoing gas and the specific heat of both the gas and oil constituents. The volume of flue gas at 370° C. thus may be between 4000 and 5000 cc. gas per 1 cc. of liquid oil distillate although larger or smaller volumes may be employed in some instances.

Where carbon, soot, cinders, etc. are not undesirable in the final residual product of distillation, a cleaning of the flue gas to eliminate such constituents prior to introduction of the gas into the still is unnecessary. The spray of oil within the still serves to eliminate such particles from the gas and vapor and prevents their being carried off with the distillate. In general, where asphaltic residue results from the distillation, the small proportion of free carbon introduced in this manner will not be objectionable. When paraffin base crudes are distilled and further treatment of the distillation residue, as by filtration through fuller's earth, is contemplated, it may be desirable to eliminate carbon particles from the gases prior to their use for distillation. Even in this case, however, such treatment is not essential since any solid matter introduced into the residue will be eliminated in the subsequent filtration step.

In the carrying out of the present process, it is preferred that the crude oil be introduced into the first still in a preheated condition. The preheating of this oil may be effected by heat exchange with vapors from the first still, for example after they have passed through a rectifying column to eliminate relatively high-boiling constituents. In some cases the oil may be

still further preheated by heat exchange with the gas and vapor mixture from the main distillation step. If crude petroleum is preheated by this gas-vapor mixture, the heat exchange should be indirect to avoid contamination of the gas-vapor mixture by the light constituents which the crude contains. The degree of preheating is not critical and if desired may be limited to the amount of heat readily extractable from the gases and vapors leaving the stills.

The residue from the first distillation step may be further heated before introducing it into the second still. Such heating also may be effected by gases and vapors leaving this still.

Complete equilibrium between gas and liquid generally is not obtained in the second still and the gas leaving the still therefore is not completely saturated with oil constituents. The preheating of oil by these gases serves usefully to employ the superheat of the gases. The heat exchange should not be such as to condense substantial quantities of oil from the gases although small quantities ordinarily will condense because of the temperature difference between the oil and the gas-vapor mixture. This small amount of oil may be returned to the still together with fresh oil. The heat exchange between oil fed to the second still and gases and vapors therefrom may be either by direct contact or by indirect heat exchange.

With particular reference to the drawing which shows somewhat diagrammatically apparatus for carrying out the process of this invention, the numerals 1 and 2 designate a pair of spray roll stills having spray rolls 3 and 4. These spray rolls may be perforated metal cylinders. Such rolls are relatively light in weight and thus reduce vibration to a minimum, and their rotation may be controlled to produce an exceedingly fine spray of oil at high velocity. The still 1 has a steam inlet 5 and a vapor outlet 6 leading to a separator 7. The separator 7 is a small chamber having a series of grids 8 through which the vapors pass. A cap 9 prevents liquid from returning through the vapor conduit 6 to the still. A pipe 10, having a valved branch 11, and a return connection 12 to the still, are provided for withdrawing liquid from the separator 7. A vapor conduit 13 leads from the top of separator 7 into a rectifying column 14 near the bottom thereof. The rectifying column 14 may be of the well-known bubble tray type in which gases pass upwardly through bubble caps countercurrent to condensate flowing downwardly therein. At the bottom of the column a liquid outlet 15 is shown. Withdrawal of liquid from this outlet may be regulated by valve 16 governed by suitable automatic regulating means 17 actuated by variation in the level of liquid in the bottom of tower 14. If desired, the column may be provided with heating means (not shown) at the bottom to assist elimination of lighter fractions from the gas oil product and in this case it may be desirable to place inlet 13 somewhat farther up in the column. The desirability of such modifications depends on the types of products sought and this or other modifications may, of course, be embodied as will be obvious to those skilled in the art.

One or more liquid draw-offs 18 for the recovery of distillate fractions may be provided on the column depending upon the number of distillate fractions it is desired to recover. Draw-off 18 may pass to a stripping column 19 for further rectification of the distillate fraction. This column may have heating means, for example means 20,

for introducing steam at the bottom thereof and a vapor conduit 21 for returning stripped vapors to the rectifying column. A liquid draw-off 22 and cooler 23 are provided for removal and cooling of the condensate fraction.

Vapor outlet 25 leads from the top of column 14 to condenser 26. The condenser 26 has pipe means 27 and 28 for introducing and withdrawing a cooling fluid so that the cooling fluid passes through the condenser countercurrent to the vapor stream, and a liquid outlet pipe 29 for withdrawal of condensate. A valved outlet 30 is provided for withdrawing a portion of the liquid as a separate product. Pipe 31 leads from outlet pipe 29 back to the top of rectifying column 14 to supply reflux liquid thereto.

A vapor conduit 32 leads from condenser 26 to a second condenser 33 for the final condensation of vapors. The condenser 33 is shown as an indirect heat exchange type which may be cooled by any suitable cooling medium, advantageously water. It has an outlet 34 for exhausting fixed gases introduced into or formed in the system. A liquid outlet 35 near the bottom of the condenser leads to decanter 36 for separation of light oil distillate from water. The decanter has outlets 37 and 38 for separate withdrawal of the light oil fraction and the water resulting from the condensation of steam. Any water originally present with the oil, of course, will also be withdrawn through outlet 38.

The second spray roll still 2 has a gas inlet 39 and a gas and vapor outlet 40. A liquid outlet 41 from still 1 leads through a heat exchanger 42 to the bottom of still 2. Vapor outlet 40 also leads from the still to this heat exchanger so that incoming oil may be preheated by hot gases and distillate vapors from the still. A vapor conduit 43 connects the heat exchanger 42 with a second heat exchanger 44 for preheating crude oil passing to spray roll still 1. The heat exchangers 42 and 44 are provided with liquid return lines 42' and 44' for returning liquid separated from the gases and vapors to still 2.

From the heat exchanger 44 a vapor conduit 45 leads to a rectifying column 46 near the bottom thereof. In the drawing several plates are shown below the gas and vapor inlet. These serve to permit removal of any entrained gases from the liquid. The plates in this section may to advantage be merely baffle trays without bubble caps. The rectifying column has an oil outlet 47 at the bottom thereof controlled by a valve 48 which may be regulated automatically by a device 49 in a manner similar to valve 16 of rectifying column 14. Liquid withdrawal outlets 50 may be provided for recovery of condensate fractions from the rectifying column through a suitable cooler 50'. The location of outlets depends to a considerable extent upon the types of products desired. Hence it is desirable to provide a number of alternative outlets from which the liquid may be withdrawn at any of a number of points.

From the top of the rectifying column 46 a vapor conduit 51 leads to a direct cooler 52 for condensing light oil from the gases. The cooler may be a packed tower or any other type of chamber providing intimate contact of cooling liquid and gas. This cooler may be supplied with water or other cooling liquid through a spray head 53. At its top the cooling tower has a gas outlet 54, at its bottom a liquid withdrawal pipe 55. Pipe 55 leads to a decanter 56 for separation of oil from water. Outlets 57 and 58 are provided

for withdrawal of water and lubricating oil. The oil outlet 58 leads to a storage tank 59 having a pipe 60 for withdrawing any additional water which may settle out in this tank. A pipe 61, having thereon pump 62, is arranged to withdraw oil from the storage tank 59 and to return it by pipe 63 to the top of the rectifying column or to discharge it through pipe 64.

Units of the above apparatus, particularly the stills and rectifying columns, may be provided with heat insulation for avoiding heat loss and improving fractionation.

The process of the present invention may be carried out in the above apparatus in the following manner. Crude petroleum oil is pumped through pipe 27 to heat exchanger 26 where it is heated by indirect heat exchange with vapors from rectifying column 14. The preheated crude petroleum passes from heat exchanger 26 through pipe 28 to heat exchanger 44 where its temperature is further elevated by indirect heat exchange with vapors from still 2.

The heating of the crude petroleum in the heat exchangers 26 and 44 raises its temperature to around 175° to 190° C. (350° to 375° F.) At this temperature it enters still 1. Steam at a temperature of about 175° C. to 200° C. and a pressure of about 1½ atmospheres absolute is introduced through pipe 5 to still 1 and spray roll 3 is rotated at around 1000 R. P. M. to spray the liquid, which is disposed as a body thereof, into the steam. The pressure within still 1 preferably is only sufficient to cause flow of vapors through the system, just slightly above atmospheric pressure. The introduction of oil is controlled so as to maintain the upper level of the liquid body in the still in contact with the surface of the spray roll. The rate of flow of steam may be such that the weight of steam passing through the still is about 2½ to 4 times that of the vapors distilled off so that the temperature of vapors leaving the still will be around 175° C. or above. In this manner gasoline, kerosene, and gas oil distillate are rapidly vaporized from the petroleum and carried from the still through pipe 6 by the steam. These vapors contain entrained liquid introduced by the oil spray in the still. Accordingly they are passed through separating chamber 7 into contact with the grids therein to separate out the entrained liquid. This liquid is returned by means of pipe 10 and branch pipe 12 to the still 1.

Steam and oil vapors pass out of the separating chamber through conduit 13 to the lower end of rectifying column 14 through which they pass in countercurrent contact with condensate from condenser 26. In this manner the vapors and condensate are rectified so that a gas oil fraction is recovered and withdrawn at the bottom of the rectifying column. Automatic valve regulator 17 maintains a sufficient level of gas oil in the bottom of the column to prevent escape of vapor through the gas outlet pipe 15. In case it is desired to secure a sharper line of fractionation between vapor from still 1 and liquid residue, liquid may be returned from the bottom of column 14 to the still, and gas oil may be taken off at a point farther up in the column.

A portion of the liquid collecting in an upper tray of the column is withdrawn gradually through outlet pipe 18 to the stripping column 19. Stripping column 19 may be a simple baffle column or may be a bubble tray column similar to column 14 only on a somewhat smaller scale. Steam may be injected into the bottom of this

column for the purpose of heating the liquid contents thereof or the contents may be heated by an indirect heater in the bottom of the column. The heat applied to the bottom of the column vaporizes a portion of the liquid collected and causes it to pass upwardly through the column in contact with downflowing liquid. This process strips the more volatile fractions from the condensate and delivers them to the outlet 21 by which they are returned to column 14. If sharper fractionation is desired, the vapors at the top of the stripping column may be fractionally condensed by any suitable cooler (not shown) to provide an increased amount of reflux liquid. Liquid collecting in the bottom of the stripping column is withdrawn through pipe 22, and cooler 23. This withdrawal may be regulated so as to recover a kerosene fraction meeting definite specifications as to flash point, distillation end point, burning test, etc.

Vapors reaching the top of column 14 pass out through conduit 25 to condenser 26 where they are partly cooled by heat exchange with ingoing crude petroleum with consequent condensation of a part of their gasoline content. Preferably most of the oil condensate collected in condenser 26 is returned as reflux to column 14. In some cases considerably more than sufficient gasoline may be condensed in condenser 26 than required for satisfactory rectification in column 14. In this case the excess may be withdrawn through outlet 30. It is desirable to avoid introducing water into the top of column 14. Hence the condensation in condenser 26 should be regulated to avoid condensation of water therein or else the condensate should be decanted to remove aqueous condensate prior to introducing it into the rectifying column. Uncondensed vapors passing from condenser 26 enter condenser 33 and are there cooled by heat exchange (either direct or indirect) with a suitable cooling medium such as water to condense remaining gasoline vapors. The steam also will be condensed in condenser 33 and this condensate passes together with the gasoline to a decanter 36. Any fixed gases present in the system are exhausted through pipe 34. In the decanter 36 the water and gasoline separate out. Water is withdrawn through pipe 38 and gasoline is withdrawn through pipe 37. Gasoline recovered at outlet 39 may be added to this product.

The residue from the distillation taking place in still 1 flows out through pipe 41 and is pumped through heat exchanger 42 to still 2. In heat exchanger 42 its temperature may be raised to around 230° to 260° C. (450° to 500° F.). At this temperature it is passed into still 2. Hot flue gases at a temperature of about 400° C. are introduced into the still and the spray roll 4 is rotated at around 1000 R. P. M. to distribute the oil as an exceedingly fine spray through the gases and simultaneously flush the walls of the still. The amount of gases required depends upon various factors as previously indicated and may be around 4000 to 5000 cc./cc. of liquid distillate taken off from the oil.

Residue from the distillation may be withdrawn from the still through a suitable outlet at the end of the still remote from the oil inlet. The nature of this residue will depend upon the character of the crude petroleum treated. Thus it may be either an asphalt or a paraffinic residue or a mixed residue. It may be suitably cooled say to around 60° to 70° C. and pumped to storage.

Hot gases and vapors carrying some entrained liquid oil or asphalt particles pass off from still 75

2 through conduit 40 to heat exchanger 42 and thence through conduit 43 to heat exchanger 44. Heat exchangers 43 and 44 serve the three-fold purpose of preheating ingoing oil, removing superheat from the gas-vapor mixture, and separating out entrained liquid from the gases. The separated liquid, which may also contain a small amount of condensate, collects in the bottom of the heat exchangers and is returned to the still.

10 Gases and vapors freed from entrained liquid particles leave heat exchanger 44 at a temperature around 250° C. and at this temperature enter rectifying column 46, through which they pass upwardly countercurrent to descending liquid condensate, and they are thus rectified. The least volatile fraction or heavy lubricating oil fraction collects at the bottom of the tower. This oil fraction is withdrawn through outlet 47, its withdrawal being controlled by valve 48 and automatic regulator 49, which operates in the same manner as regulator 17 of column 14. A portion of the liquid condensate that collects on a tray about midway of the column is withdrawn and passed through cooler 50'. The withdrawal of this condensate fraction may be made at a particular point on the column depending upon the specifications which the oil is to meet, and depending further upon the constitution of the petroleum distilled. Normally, however, the condensate

30 withdrawn at this point may be classed as a medium lubricating oil. The temperature at the top of column 46 is maintained approximately constant at say 210° C. by controlled introduction of oil condensate through pipe 63.

35 Vapors reaching the top of rectifying column 46, pass off at 51 to a direct cooler 52. This cooler may be a packed tower or any other device suitable for bringing gases into intimate contact with a cooling liquid. Normally water is employed as this cooling liquid and is introduced as a spray at the top of the tower, the quantity of water being regulated so as to maintain a low exit gas temperature at outlet 54, say a temperature around 35° C. Water together with oil condensed from the gases collects in the bottom of the cooler and is withdrawn through outlet 55 to decanter 56. In this decanter light lubricating oil and water separate, water being withdrawn at 57 and lubricating oil at 58. This lubricating oil may be passed to the storage tank 59. Any additional water that settles out from the oil in this tank is removed through pipe 60. The oil freed from water passes off through pipe 61. A regulated portion of this is recirculated by means of pump 62 and pipe 63 to the top of rectifying column 46 where it supplies the necessary cooling effect for the condensation in this column. The remainder of the light lubricating oil is withdrawn through outlet 64.

60 It will be understood that the above example is merely illustrative and that the conditions will vary considerably depending upon the type of oil treated.

Some crude petroleum may contain relatively large proportions of light lubricating oil constituents but such a small proportion of heavy lubricating constituents that their separate recovery is not warranted.

Some crude oils may contain abnormally high percentages of gas oil or cracking stock. In this event it may be desirable to distill off the light gas oil in still 1 and the heavy gas oil in still 2. The different conditions thus encountered may be met merely by adjustment of steam and gas to distill off the desired fractions and adjustment of re-

flux condensates to maintain satisfactory temperatures in the rectifying columns.

Some crude oils have a distillation residue amounting to 30% to 40% by weight of the crude oil. In distilling such oils it may be advantageous to recover heat from the distillation residue. In this event ingoing oil may be passed into heat exchange relation with the distillation residue from still 2. Such heat exchange is preferably effected after the crude oil has been heated by the vapors from the first rectifier and either before or after it has been heated by vapors from still 2. Oils containing only a small percentage of residual constituents will not under most conditions justify the added cost of heat exchange equipment for recovery of heat from the distillation residue.

Vapors from some crude petroleum are highly corrosive under conditions of condensation. This is especially true of the vapors which are condensed simultaneously with water, for example the gasoline vapors mixed with steam. For such oils the apparatus should be especially constructed to avoid corrosion losses. For instance cast iron, which is resistant to the corrosive action of such mixtures, may be used for construction of condenser coils. Under these circumstances it may be advantageous to employ a cooling medium other than the ingoing crude oil in the reflux condenser of rectifying column 14, especially when water is condensed in this condenser. In this event water or some other cooling medium may be used and may then conduct the heat thus abstracted to the crude oil in a second more efficient heat exchanger, or separate heating means may be provided for preliminarily heating the oil.

The final condenser has been illustrated as a direct contact type of cooler. The packing in this unit serves to assist in removing entrained oil by contacting it with oil condensate distributed on the packing. An indirect type of cooler may be substituted for the direct type. In this case the decanter for separation of oil from water is unnecessary if the gas and vapor mixture is not cooled below its dew-point for water vapor, and the recovered oil may be by-passed through pipe line 65. A separator like separator 7 may be employed to remove entrained oil. Oil condensate may be circulated over the packing to thoroughly scrub the gases. Instead of water, oil may be circulated in the final direct condenser. In this case also the decanters may be eliminated and the oil may be circulated serially through a cooler and the condenser so that heat may be removed from the system.

As will be obvious to those skilled in the art, various other changes may be made in the process without deviating from the essentials of the invention defined by the appended claims.

I claim:

1. The method of distilling petroleum, which comprises spraying the petroleum into superheated steam at a temperature around 160° to 200° C. and regulating the respective quantities of steam and petroleum so as to distill off light oil constituents therefrom and to produce a hot petroleum residue containing high-boiling oils, introducing combustion gas at a temperature of about 370° to 400° C. into a still, introducing the petroleum residue without substantial loss of heat into the still into direct contact with the hot gases therein, regulating the volume of the residue and the contact thereof with the gas so that the residue is distilled and the gas is only

partly cooled and is enriched in oil vapors to an oil vapor content of at least 1 cc. oil measured as liquid per 4000 cc. gas measured at operating temperature and pressure and simultaneously flushing the entire surfaces in the still exposed to the gases at said temperature so as to maintain thereon a continuously moving liquid film, withdrawing from the still the hot gas enriched in oil vapor, and cooling the mixture to condense oil constituents.

2. The method of distilling petroleum, which comprises spraying the petroleum into superheated steam at a temperature around 160° to 200° C. and regulating the respective quantities of steam and petroleum so as to distill off light oil constituents therefrom and to produce a petroleum residue containing high-boiling oils, introducing flue gas at a temperature of about 370° to 400° C. in a still, introducing the petroleum residue into the still into direct contact with the hot gases therein, regulating the volume of the residue and the contact thereof with the gas so

that the residue is distilled and the gas is only partly cooled and is enriched in oil vapors to an oil vapor content of at least 1 cc. oil measured as liquid per 4000 cc. gas measured at operating temperature and pressure, and simultaneously flushing the entire surfaces in the still exposed to the gases at said high temperature so as to maintain thereon a continuously moving liquid film, regulating the distillation so as to maintain the gas leaving the still unsaturated with oil vapors, bringing the gas into heat exchange relation with petroleum residue from the steam distillation step and free from light oil constituents while the residue is yet at a temperature of about 175° C. to reduce the temperature of the gas sufficiently so that it will be substantially saturated with oil vapors and to preheat the residue, withdrawing the gas substantially saturated with vapors and cooling it to condense oil constituents, and passing the preheated petroleum residue into the still.

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