June 21, 1966 C. C. MARTINI 3,257,313

MINERAL OIL DISTILLATION AND HYDRODESULFURIZING PROCESS

Filed Aug. 28, 1962 2 Sheets-Sheet 1

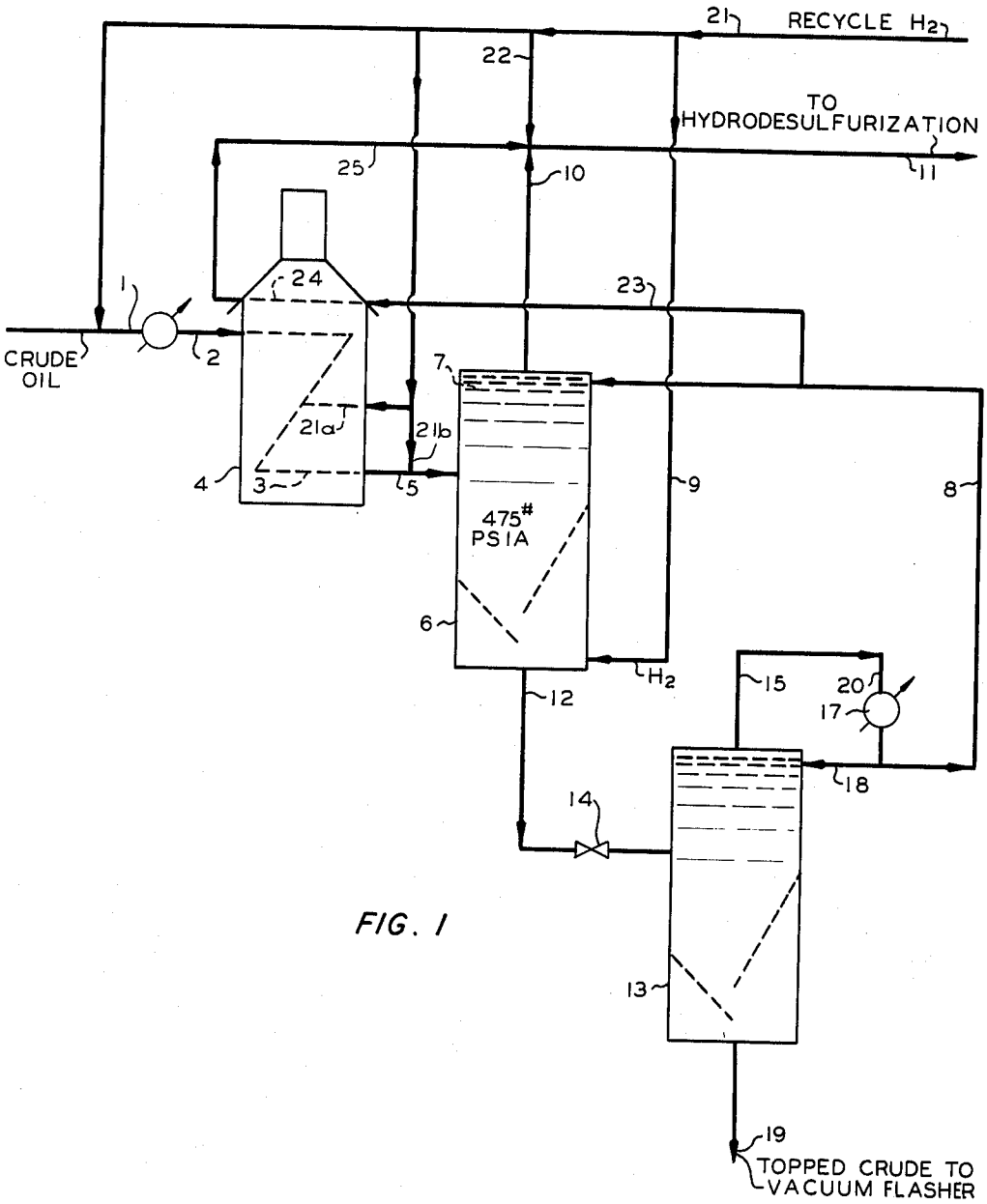


FIG. 1

INVENTOR.
C.C. MARTINI

BY Young & Quigg

ATTORNEYS

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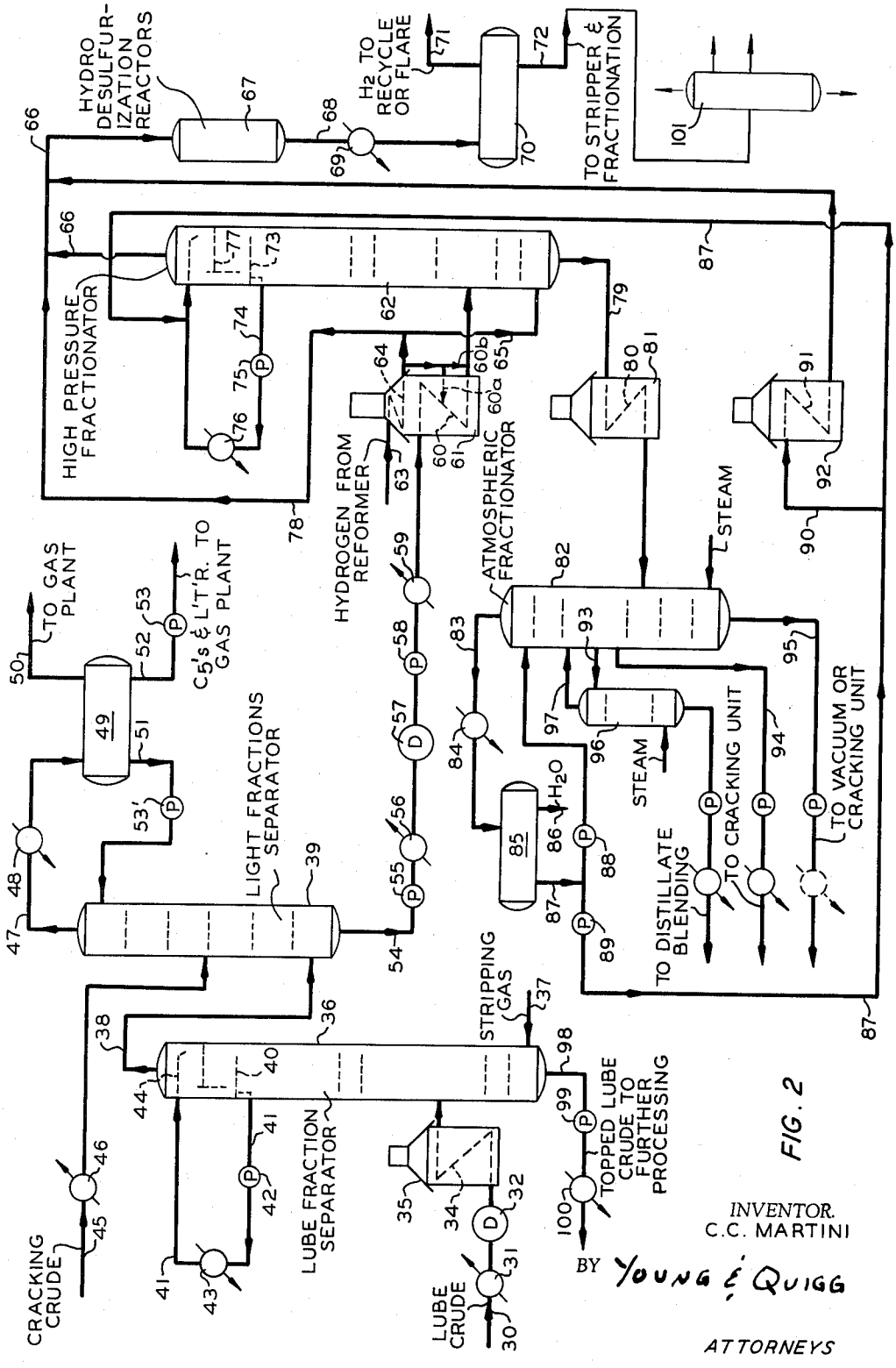


FIG. 2

INVENTOR.
C.C. MARTINI

BY Young & Quigg

ATTORNEYS

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3,257,313

MINERAL OIL DISTILLATION AND HYDRO-DESULFURIZING PROCESS

Charles C. Martini, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

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6 Claims. (Cl. 208—211)

This invention relates to crude oil refining. More particularly, it relates to the fractionation and refining of at least one crude oil or fraction thereof.

In one of its aspects, the invention provides a plural stage distillation of a heated crude oil wherein a reflux stream produced in a lower and later stage fractionation is used as reflux for an earlier higher pressure stage fractionation. In another of its aspects, the invention relates to a method wherein a lube crude and a cracking crude topping operation are combined to effectuate heat savings, with minimum of equipment, by topping said lube fraction and then combining the distillate vapors thus obtained with a cracking crude also requiring topping in a light fractions separation zone from which there is obtained a nonvaporized residual oil stream which can then be fractionated according to at least one embodiment of this invention. Further, in another of its aspects, the invention relates to a combined-high pressure and low pressure fractionation wherein distillate from a low pressure fractionation is employed as reflux for the high pressure fractionation and wherein distillate from both fractionations is combined for further refining, as by hydrodesulfurization, while a nonvaporized residual fraction is obtained which is suitable for distillate blending, cracking, as by catalytic cracking, or vacuum distillation with consequent cracking of the distillate obtained from said vacuum distillation.

The invention also relates to apparatus, as set forth herein, for effectuating the various steps in the various combinations in which these are presented.

In view of the present state of the economy and the continued need for reducing costs of processing in order to better enable this country to compete in foreign markets, it is highly desirable to seek ways and means for more cheaply producing better products. There have been proposed and are presently known and used a number of various operations or combinations of steps for processing an oil stream or various oil streams in the modern oil refinery.

I have conceived process and apparatus for fractionating at least one crude oil in the various distillate streams and a residual stream using first a high pressure separation of the crude oil and then a low pressure separation of the residual oil obtained from the high pressure zone, thus recovering a reduced residual material for further processing as desired; combining the lighter components from the high and low pressure separations for further processing such as desulfurization; and using a common source for reflux for both the high pressure and low pressure separation, the reflux being taken from the low pressure separation, this being a particularly advantageous reflux stream for use in the high pressure separation, as will appear below.

Further, I have conceived that apparatus component parts can be more economically provided and certain streams more economically treated by following the procedures herein disclosed in apparatus particularly suited thereto.

It is an object of this invention to provide a method for the processing of oils. It is a further object of this invention to provide an apparatus for the processing of oils. Still further, it is an object of this invention to provide a method for a plural pressures stage distillation of a crude oil permitting good recovery of desirable distillate

streams and economy of operation. Still further, it is an object of this invention to provide apparatus wherein the component parts required and the arrangement thereof are such that economy of construction and operation can be obtained. A further object of the invention is to provide method and apparatus for obtaining distillate streams which can be hydrodesulfurized or further treated, these streams retaining their heat once it has been applied to them, avoiding repeated vaporization and condensation of these streams with concomitant resultant high utility costs. Still further, the invention provides method and apparatus wherein two different crudes can be treated by combining at a suitable time, according to the invention, to permit conservation of their respective heats and to enable ready handling of a cracking crude obtained because of a decrease in viscosity which ensues due to practice of the invention.

Other aspects, objects and the several advantages of this invention are apparent from a consideration of this disclosure, the drawings and the appended claims.

According to the present invention there is provided in a method for the progressive distillation and refining of a heavy oil to obtain lighter products therefrom, a combination of steps comprising heating the oil in a heating zone under an elevated pressure, passing the heated oil into a first fractionation zone maintained at an elevated pressure, in said fractionation zone, fractionating said oil into a distillate and a nonvaporized residue, passing said residue into a second fractionation zone, in the latter zone reducing the pressure on said residue and vaporizing therefrom additional distillate vapor, cooling and condensing said distillate vapor, passing a portion of the condensed distillate vapor to said second fractionation zone as reflux therefor and also passing a portion of the condensed distillate by increasing the pressure thereon to the first fractionation zone as reflux therefor. Vapors from the two fractionation zones can be combined and passed to further treatment, such as hydrodesulfurization, as will be explained more fully below.

FIGURE 1 is a schematic diagram of an operation in which a crude oil is heated and subjected to two fractionations, the first fractionation being conducted at an elevated pressure, for example at about 475 pounds per square inch absolute, and the second distillation being conducted at substantially atmospheric pressure.

FIGURE 2 shows schematically a diagramming of an operation wherein a lube crude is stripped of lighter components and wherein a cracking crude, also stripped of lighter components, are combined and a residual oil thus obtained, further treated according to the high pressure and low pressure fractionations of the invention, with possible ensuing further refining treatment, such as hydrodesulfurization, etc.

Referring now to FIGURE 1, crude oil passes by **1** and preheater **2** through coil **3** in furnace **4** and then by **5** into fractionator **6**. This fractionator contains trays **7** which are refluxed according to the invention by reflux entering by **8**, as later described. Hydrogen obtained, as later described or as desired, is passed by **9** into the lower portion of fractionator **6** in which vapor separation takes place yielding an overhead vapor stream **10** which, in this embodiment, passes by **11** to hydrodesulfurization, which can be conducted according to methods and with conditions as now known in the art. The nonvaporized residual oil removed from vessel **6** passes by **12** to a midportion of vessel **13**, maintained at substantially atmospheric pressure. The pressure is reduced on stream **12** when it passes through valve **14** which, as one skilled in the art will understand, is located close to or at column **13** to effectuate separation flashing taking place in transfer pipe **12**. The temperatures at the tops of vessels **6** and **13** are, respectively, 625° F. and 675° F. and at their

bottoms 750° F. and 725° F. Vaporous overhead taken off from vesesl **13** is passed by **15**.

One skilled in the art will understand that in the simplified flow diagram pumps, valves, heat exchangers and other routinely supplied equipment, or steps, which are supplied by the design engineer, have been omitted for sake of simplicity. Thus, where pressures are not permitting flow through pipe **12**, a pump can be supplied. Also, a partial condenser and means for recovering hot condensate therefrom, not shown, can be used in pipe **15**, if desired.

The overhead in **15** passes by way of **20**, condenser **17** and conduit **18** as reflux into vessel **13**. Another portion of condensate passes by **8** as reflux to vessel **6**, as the earlier mentioned reflux for this vessel. A residual oil obtained at **19** from the foot of vessel **13** is topped or reduced crude which can be further treated as desired, for example by way of vacuum flashing, to obtain additional heavy stock or gas oil for cracking and a heavier fraction. Hydrogen, which can be recycled from the hydrodesulfurization operation or obtained from another operation in the refinery, is cycled by **21** to **9** for use in vessel **6**, by **22** and **11** for reuse in the hydrodesulfurization and, as and if desired, by **21** and **1** into admixture with the crude oil passing through coil **3** from **4**, and/or passed by way of lines **21***a* and/or **21** *b* as shown. As a modification, all or a part of the feed from overhead **15**, from vessel **13** to the hydrodesulfurization operation, can be accomplished by **23**, heating pipe **24**, in furnace **4**, and **25** and **11** to hydrodesulfurization.

Referring now to FIGURE 2, a lube crude enters at **30**, is heated at **31**, desalted at **32**, and further heated to a temperature in the range of 670° F. to 710° F. in coil **34**, located in heater **35**, and then passed into lube fractionation separator **36**. With the aid of stripping gas introduced by **37** the lube fractionation is topped to remove light fractions therefrom which are not desired in the lube crude as it is further processed to prepare lube oils. These fractions are taken overhead by **38** to light fractions separator **39**. A portion of light fractions condensing on plate or plates **40** is taken off by **41**, pump **42**, passed through cooler **43** into an upper plate of the column **36**, the said upper plate being represented at **44** and being above plate or plates **40**, represented by **40**. It will be seen that the reflux for the lube fraction separator is not an overhead condensate and is not returned overhead condensate, but is a liquid taken from a locus in the column **36**, which is specifically below the locus at which it is reintroduced. Thus, in this feature, the invention being described differs from the operation wherein an overhead vapor is condensed and the condensate is returned to a top tray or trays in the column. Cracking crude is passed by **45** and heater **46** into light fractions separator **39**. The vapors from the lube crude, separated therefrom in separator **36**, intermingle as they flow upward with downwardly flowing portions of the cracking crude and direct heat exchange takes place in separator **39** between them. Overhead is taken by **47** and cooler in condenser **48** to accumulator **49** from which noncondensibles are passed from **50** to gas plant or other disposal. Condensate from **49** is passed by **51** and pump **53** to the top of separator **39**. The remainder of the condensate is passed by **52** and pump **53** for treatment in a gas plant or to other utilization, as may be desired, and contains light hydrocarbons, including in this embodiment some pentanes as heaviest component.

Nonvaporized residue is taken from the foot of column **39**, passed by **54**, pump **55**, heater **56**, desalter **57**, pump **58** and heater **59** to coil **60** in heater **61** and then, when heated, it is charged into high pressure fractionator column **62**. Hydrogen, in this embodiment, from a reforming separation is passed by **63**, heating coil **64** and **65** into the foot of column **62** as an aid to high pressure fractionation of stream **54** after it has been desalted and heated, as described, and/or by branch lines **60***a* and/or

60*b*, as shown in FIGURE 2. Overhead is taken by **66** and passed as vapor to hydrodesulfurization reactors **67**, removed from the reactors **67** by **68**, cooled in cooler **69** and passed to gas separator **70**, from which hydrogen is recovered and recycled to the system as desired and fed to other utilization or to a flare by **71**. Bottoms from **70** are passed by **72** to stripping and fractionation in column **101**. The overhead under now preferred conditions of operation will contain fractions boiling up to a temperature in the approximate range 500° F.–650° F., and will contain diesel fuel components.

Means are provided, as explained earlier in connection with the refluxing of separator **36**, for refluxing the top of column **62**. Briefly, liquid from a tray or trays **73** passes by **74**, pump **75** and cooler **76** to a tray or trays **77**, the tray or trays **77** being above tray or trays **73**. Some hydrogen is passed to hydrodesulfurization reactors **67**, as desired, by **78**.

Bottoms or nonvaporized oil are withdrawn from **62** by **79**, passed through coil **80** and heater **81** into atmospheric fractionator **82**. From fractionator **82** overhead **83** is passed by cooler condenser **84** to accumulator **85** from which water which condenses is removed at **86** and hydrocarbon condensate by **87**, pump **88** as reflux to the tower of fractionator **82**. Also, according to the invention, condensate is passed by **87** and pump **89** to the top of tower **62** as reflux therefor. A portion of the condensate is passed by **87** and **90** through coil **91** and heater **92** and admixed with vapors in **66** and hydrodesulfurized in reactors **67**. Finally, several streams, **93**, **94** and **95**, which, in this embodiment, constitute distillation for blending purposes, a catalytic cracking unit charge stock and a vacuum distillation or catalytic charge stock, respectively, are obtained from fractionator **82**. As indicated, at **96** one or all of the side streams can be steam stripped. The steam and vapors stripped from the side streams being returned, as by **97**, to column **82**.

The topped lube crude from column **36** is passed by **98**, pump **99** and cooler **100** to topped lube crude storage or directly to further processing.

The following tabulation shows conditions of operation which obtain in FIGURE 1 and FIGURE 2 embodiments of the concepts of the invention, by way of specific example.

Example (FIGURE 1)

Crude oil charge (1):	
Volume, B/D	35,000
API @ 60/60° F. (Iranian light)	34.1
Hydrogen (21):	
MCF/Day	7,630
Vessel (6):	
Top temperature, ° F.	625
Bottom temperature, ° F.	750
Pressure, p.s.i.a.	475
Vessel (13):	
Top temperature, ° F.	675
Bottom temperature, ° F.	725
Pressure, p.s.i.a.	20
Topped crude (19):	
Volume, B/D	11,750
API @ 60/60 ° F.	12.5
Product (11)=less H_2 charged (ultimate breakdown):	
Diesel base, B/D	6,960
Kerosene, B/D	8,200
Reforming stock, B/D	7,280
C_4 and lighter, B/D	813
Hydrogen make, MCF/D	2,430

Example (FIGURE 2)

Tower Number	(36)	(39)	(62)	(82)
Top Temp., ° F	650	150	625	675
Btm. Temp., ° F	690	220	750	750
Pressure, p.s.i.a	30	20	475	20

Lube crude charge (30):
Volume, B/D ---------- 29,256
API @ 60/60° F. (Burbank lube crude) -- 36.5
Topped lube crude (98):
Volume, B/D ---------- 8,328
API @ 60/60° F. ---------- 22.5
Lube distillate (38) as vapor:
Volume, as liquid, B/D ---------- 20,928
Cracking crude charge (45):
Volume, B/D ---------- 81,600
API @ 60/60° F. (Western Texas) ------ 32.0
Charge (54) to desalter and Tower (62):
Volume, B/D ---------- 83,659
Hydrogen, MCF/D ---------- 32,600
Distillate (72) volume, B/D (ultimate breakdown):
Reforming stock, B/D ---------- 23,250
Kerosene, B/D ---------- 32,000
Diesel base, B/D ---------- 15,680

The above example (FIGURE 2) shows Burbank lube crude as the lube crude charged. Other so-called lube crudes can be used, or admixtures can be charged to the operation. Such other lube crudes include Oklahoma City crude, Ellenberger crude, Okmulgee crude, West Edmond crude, and the like.

The above examples show cracking crudes: Iranian light, and Western Texas. Of course, any of the known cracking crudes can be used, such as Western Kansas, East Kansas (composite), Denver, Julesburg, East Poplar, etc.

As is well known to those skilled in the refining art, a "cracking crude" is one which contains naphthenic, aromatic, and asphaltic components with some paraffins. These crudes are generally charged to catalytic cracking operations to provide more usable products. Also well known to those skilled in the refining art, a "lube crude" is one which contains a high percentage of paraffins and small quantities of naphthenic, aromatic, and asphaltic components, which crudes are used with a minimum of processing to make lubricating oils.

The specific temperatures, pressures, volumes, etc., in the above examples are for those specific charge materials shown. Of course, the temperatures, pressures, and flow rates can be different than those shown, as is understood by those skilled in the art. Also different crudes yield different quantities of the various cuts, as is understood by those versed in crude fractionation.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, drawings and appended claims to the invention, the essence of which is that there have been provided method and apparatus for a two stage distillation of a crude oil stock, or a lube stock, or both, by distilling under an elevated pressure, in one embodiment, in the presence of a stripping gas or medium, now preferably hydrogen, and further distilling nonvaporized residual oil, from the said distillation, at a relatively low pressure, of the now preferred order of about atmospheric pressure, and refluxing the high pressure distillation zone with reflux obtained from overhead from the low pressure zone and also used in said low pressure zone, passing in as a reflux to the outlet of a distillation zone, a fluid obtained from a locus therein substantially ahead of said outlet (and not obtained from overhead vapors) in an embodiment treating two oils, a lube fraction and a crude fraction not containing a lube portion by topping heated lube fraction, combining with vapors thus obtained a heated crude fraction, as herein described, causing direct heat exchange therebetween by commingling at least a portion of one fraction with the other fraction, and then to said combined fractions a light material separation step obtaining a combined non-vaporized portion to which a two stage distillation of the invention is applied; further, in a modification, combining overhead from each of the distillations of the invention and further treating, as by hydrodesulfurization, the stream thus obtained; further, obtaining a topped lube fraction and treating the same to obtain lube oil product; still further, obtaining for further treatment, a fluid non-vaporized residue from such a low pressure second stage distillation and subjecting the same to vacuum flashing and/or to cracking treatment; while also obtaining, as desired or already described, additional streams or hydrocarbon fractions for further treatment, such as reforming, cracking, etc.

I claim:

1. A method for the progressive distillation and refining of a heavy oil to obtain lighter refined products therefrom and an oil for further treatment to produce a final petroleum product which comprises the steps of:
(a) desalting a lube crude fraction,
(b) heating said lube crude fraction to a temperature at which a lighter than a topped crude fraction not desired in the lube fraction will distill therefrom,
(c) subjecting the thus heated lube crude fraction to distillation, in the presence of a stripping gas,
(d) in said last distillation removing from said lube crude fraction a distillate comprising light components not desired in the lube crude in its further processing to obtain lube oil product,
(e) recovering a topped lube crude for further processing,
(f) passing said distillate into a light fractions separation zone,
(g) also passing into said light fractions separation zone a nonlube fraction containing crude oil stock suitable for cracking,
(h) effecting direct heat exchange in said light fractions separation zone between said distillate and said crude oil stock,
(i) removing from said light fractions separation zone a distillate comprising light fractions,
(j) withdrawing from said light fractions separation zone a combined distillation stock,
(k) desalting said combined distillation stock,
(l) heating said combined distillation stock,
(m) passing the heated combined distillation stock to a high pressure fractionation zone,
(n) adding hydrogen to said heated combined distillation stock in said high pressure fractionation zone,
(o) in said high pressure fractionation zone distilling and fractionating from said combined distillate stock a distillate fraction including components as high boiling as oils having a boiling temperature at atmospheric pressure in the range of about 500° F. to about 650° F.,
(p) hydrodesulfurizing said distillate fraction,
(q) fractionating said distillate fraction, which has been hydrodesulfurized, into desirable product such as a gasoline components-containing fraction, kerosene, diesel oil, etc.,
(r) withdrawing from said high pressure fractionation zone a nonvaporized residual stream,
(s) heating said residual stream,
(t) passing the heated residual stream into a low pressure second fractionation zone,
(u) in said second fractionation zone fractionating said residual fraction to obtain at least an overhead vapor stream,
(v) condensing the overhead stream,
(w) returning a portion of the condensed overhead stream as reflux for said second fractionation zone,
(x) passing a portion of the condensed overhead stream to said high pressure fractionation zone as reflux therefor.
(y) combining a portion of the condensed overhead stream with said distillate fraction prior to hydrodesulfurizing the latter,
(z) and withdrawing from said second fractionation zone at least one stream of oil suitable for further treatment to produce the final petroleum product.

2. A method for the progressive distillation and re-

fining of a heavy oil to obtain lighter refined products therefrom and a heavier oil fraction suitable for further treatment to produce at least one final petroleum product which comprises the steps of:

(a) heating a lube crude fraction to a temperature at which a lighter than a topped crude portion not desired in a lube fraction will distill therefrom,
(b) subjecting the heated lube crude fraction to distillation,
(c) in said last distillation removing from said lube crude fraction a distillate comprising light components not desired in the lube crude in its further processing to obtain lube oil product,
(d) recovering a topped lube crude for further processing,
(e) passing said distillate into a light fractions separation zone,
(f) also passing into said light fractions separation zone a nonlube fraction containing crude oil stock suitable for cracking,
(g) effecting direct heat exchange in said light fractions separation zone between said distillate and said crude oil stock,
(h) removing from said light fractions separation zone a distillate comprising light fractions,
(i) withdrawing from said light fractions separation zone combined distillate stock,
(j) heating said combined distillation stock,
(k) passing the heated combined distillation stock to a high pressure fractionation zone,
(l) in said high pressure fractionation zone distilling and fractionating from said combined distillation stock a distillate fraction including components as high boiling as oils having a boiling temperature at atmospheric pressure in the range of about 500° F. to about 650° F.,
(m) withdrawing from said high pressure fractionation zone a nonvaporized residual stream,
(n) heating said residual stream,
(o) passing the heated residual stream into a low pressure second fractionation zone,
(p) in said second fractionation zone fractionating said residual fraction to obtain at least an overhead vapor stream,
(q) condensing the overhead stream, returning a portion of the condensed overhead stream as reflux for said second fractionation zone,
(r) passing a portion of the condensed overhead stream to said high pressure fractionation zone as reflux therefor,
(s) and withdrawing from said second fractionation zone at least one stream of oil suitable for further treatment to produce a final petroleum product.

3. Apparatus for processing a lube crude and a cracking crude to remove a light fraction therefrom for hydrodesulfurization and a heavier fraction suitable for further treatment comprising in combination:

(a) means for heating and topping a lube crude fraction,
(b) means for removing a topped lube crude fraction from said means for topping a lube crude fraction,
(c) means for removing an overhead from said means for topping a lube crude fraction,
(d) means for separating light fractions,
(e) means for passing said overhead from said means for topping a lube crude fraction into said means for separating light fractions,
(f) means for passing a cracking crude into said means for separating light fractions,
(g) means for removing light fractions from said means for separating light fractions,
(h) means for withdrawing a combined non-vaporized residual oil from said means for separating light fractions,
(i) means for distilling under high pressure said last mentioned oil,
(j) means for recovering an overhead vapor from said means for fractionating under high pressure,
(k) means for withdrawing from said means for fractionation under high pressure a non-vaporized residual oil,
(l) means for distilling at a substantially lower pressure said residual oil,
(m) means for obtaining an overhead distillate fraction from said means for distilling at substantially lower pressure,
(n) means for passing a portion of said distillate into said means for fractionation at substantially lower pressure as reflux therefor,
(o) means for passing another portion of said distillate into said means for fractionation at high pressure as reflux therefor,
(p) and means for recovering at least one non-vaporized residual oil fraction from said means for fractionating at substantially lower pressure for further treatment thereof.

4. A process for hydrodesulfurization of light hydrocarbons obtained from a distilled and refined heavy oil, said process comprising heating said oil in a heating zone under elevated pressure, passing the heated oil into a first fractionation zone maintained at elevated pressure, in said first fractionation zone fractionating said oil at least into an overhead distillate and a non-vaporized residual oil with the aid of hydrogen as a stripping agent, passing said overhead distillate directly to a hydrodesulfurization zone without refluxing of said overhead into said first fractionation zone, passing said residual oil into a second fractionation zone, in said second fractionation zone reducing the pressure on said residual oil and vaporizing therefrom a distillate vapor, cooling and condensing said distillate vapor, passing a portion of the condensed distillate to said second fractionation zone as reflux therefor, and also passing a portion of said condensed distillate by increasing the pressure thereon to the top portion of said first fractionation zone as the sole reflux therefor.

5. A process for hydrodesulfurization of light hydrocarbons obtained from a distilled and refined heavy oil comprising:

(a) heating said oil in a heating zone under an elevated pressure,
(b) passing the heated oil to a first fractionation zone maintained at an elevated pressure,
(c) in said first fractionation zone fractionating said oil at least into an overhead distillate and a non-vaporized residual oil with the aid of hydrogen as a stripping agent,
(d) passing said overhead distillate directly to a hydrodesulfurization zone without refluxing any of said overhead into said first fractionator,
(e) in said hydrodesulfurization zone, hydrodesulfurizing said overhead with an excess of hydrogen,
(f) removing excess hydrogen from the hydrodesulfurization zone and passing said excess to said first fractionation zone to be used as a stripping agent therein,
(g) passing said residual oil into a second fractionation zone, in said second fractionation zone reducing the pressure on said residual oil and vaporizing therefrom a distillate vapor,
(h) cooling and condensing said distillate vapor,
(i) passing a portion of the condensed distillate to said second fractionation zone as reflux therefor, and
(j) also passing a portion of said condensed distillate by increasing the pressure thereon in the top portion of said first fractionation zone as the sole reflux therefor.

6. A process according to claim 5 wherein said first fractionation zone is maintained at a pressure about 475

pounds per square inch and at a temperature between about 625°–750° F., said second fractionation zone is maintained at about atmospheric pressure and at a temperature in the range of about 675° to about 725° F.

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DELBERT E. GANTZ, *Primary Examiner.*

ALPHONSO D. SULLIVAN, *Examiner.*

P. P. GARVIN, H. LEVINE, *Assistant Examiners.*