

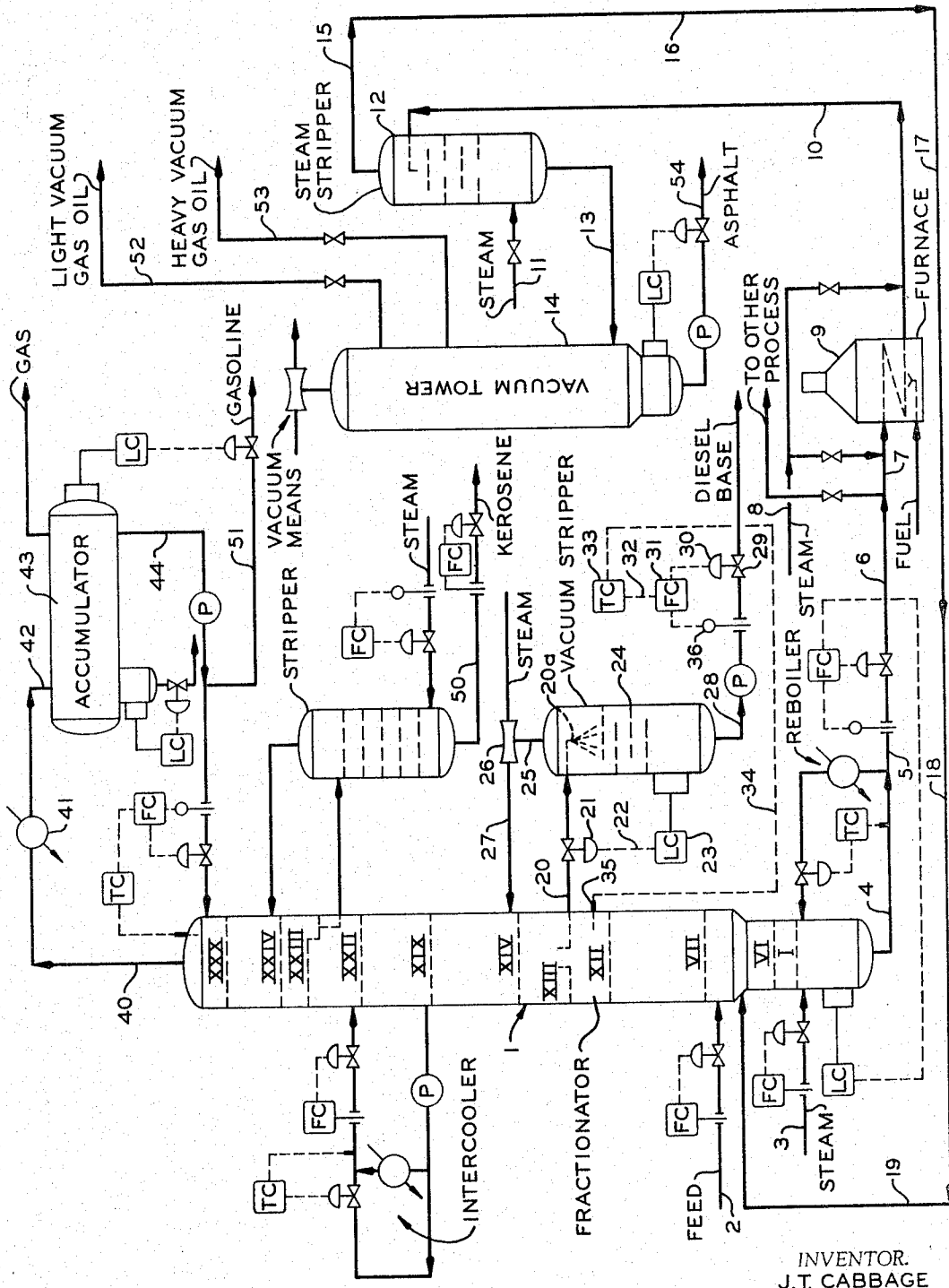
Jan. 31, 1967

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3,301,778

FRACTIONAL DISTILLATION

Filed June 15, 1964



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FRACTIONAL DISTILLATION

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Filed June 15, 1964, Ser. No. 375,183
5 Claims. (Cl. 208—355)

This invention relates to a process and apparatus for fractionation. One aspect of this invention relates to decreasing the amount of topped crude produced in a fractionator from a crude feed by treating the topped crude produced in said fractionator to separate therefrom a lighter fraction and returning said lighter fraction to the fractionator at, above or below, but in the vicinity of the crude feed input. Another aspect of this invention relates to the dilution of a crude oil feed and the increased recovery of intermediate distillate from the fractionation of a crude oil feed by steam stripping the heavy oil residue of the fractionator to produce a lighter hydrocarbon phase and returning said lighter hydrocarbon phase to the bottom of the fractionator below, but in the vicinity of, the input of the crude oil feed and above the input of steam. Another aspect of this invention relates to the fractional distillation of oil by contacting same with steam in a fractionator, removing the bottom flow of the fractionator to a vacuum unit, mixing steam with at least some of the bottom flow material, treating said mixture in a feed stripper column to separate a light overhead, and returning the light overhead and steam mixture from said feed stripper column to the bottom of said fractionator and in the vicinity of the feed input of the fractionator. Another aspect of this invention relates to treatment of an intermediate distillate from a fractionator by treating same with a stripper-dehydrator while automatically controlling the flow of said intermediate distillate to said stripper-dehydrator by means of a level sensing and control device in said stripper-dehydrator and operative on the input line of said stripper-dehydrator. Another aspect of this invention relates to the control of flow from a stripper in which a hydrocarbon feed is injected from a fractionator by means of a flow control which is responsive to the temperature of the plate in the fractionator from which said material is originally trapped out. Another aspect of this invention relates to the control of flow of an intermediate distillate from a fractionator to a side stripper by first control means responsive to the level of fluid in said stripper and second control means responsive to temperatures in the vicinity of the fractionator plate from which intermediate distillate is removed. Yet another aspect of this invention relates to the control of flow of feed to and from a treating apparatus by simultaneously sensing the level of the liquid in said apparatus and controlling the flow of the feed thereby and by sensing the temperature of the source of the feed and controlling the outflow of said apparatus thereby. Still another aspect of this invention relates to fractional distillation of crude oil by use of live steam in which topped crude in the fractionator is sent to a vacuum unit and before entry into said unit is mixed with steam, the mixture is steam stripped to recover a mixture of gas oil and steam which mixture is returned to the fractionator at or below the input of the crude oil to dilute the crude oil and increase the recovery of lighter hydrocarbons from said crude oil, some of which are separated at a point intermediate of the fractionator and passed to a steam side stripper, the overhead of which returns steam and lighter hydrocarbons to the fractionator and the bottom flow of which is controlled by means responsive to temperature in the area from which the feed is taken from the fractionator while the flow of intermediate hydrocarbon from the fractionator to the stripper

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is controlled by means responsive to the level of liquid in said stripper.

Crude petroleum is made up of hundreds of different individual chemicals from natural gas and light gasolines to waxes and asphalts. The refining of petroleum separates these multitudinous constituents into various fractions or phases according to various properties such as boiling range and viscosity. The separation of these various constituents into several general fractions, i.e., light distillates (gasolines, kerosenes), intermediate distillates (heating or diesel base oils, gas oils), heavy distillates (lubricating base oils), and residues (pitch, asphalt), requires many very expensive, and complex treatments. Foremost among these treatments is fractionation, or, specifically, fractional distillation, wherein the above-mentioned fractions and even specific constituents are separated according to their boiling temperatures, heavier materials tending to collect at the bottom of the fractionator and lighter materials tending to collect at the top of the fractionator and an infinite number of variations and blends of the two being available at an infinite number of locations between the top and the bottom of said fractionator. An omnipresent problem of fractional distillation is the separation of a pure and unadulterated fraction or constituent. The common result of most attempts to separate a particular fraction or constituent is the obtention of a material composed substantially of the desired fraction or constituent but also containing, generally in unacceptable amounts, other fractions or constituents which not only are undesirable but also must be removed prior to use and/or sale of the desired fraction or constituent. This invention is concerned with solving, at least in part, the above-mentioned problem and at the same time effecting a more economical, efficient and complete recovery of all fractions and constituents present in the crude oil.

Accordingly, it is an object of this invention to provide a process of separating fractionable material into its various fractions. Another object is to provide fractional distillation of a hydrocarbon oil by use of steam. Another object is to increase the amount of separation of distillable materials recovered from a crude oil with minimum production of topped crude, all of which are contained in virgin crude oil. Another object is to increase the amount of overhead hydrocarbon and intermediate hydrocarbon produced by a fractionator. Another object is to increase the tendency of lighter hydrocarbons to separate from the heavier residuum and thereby produce a cleaner separation of topped crude from intermediate and light distillates.

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

Although the illustrated embodiments of this invention refer to the use of hydrocarbon oil, it is to be understood that this invention is not limited to such oil, but is applicable to the distillation and fractionation of any distillable or fractionable material such as, for example, vegetable, animal, and mineral oils, and distillable organic and inorganic chemical mixtures or solutions. It is also to be understood that the drawings hereinafter described are diagrammatic and may be altered in many respects by those skilled in the art in possession of this disclosure and yet remain within the intended scope of this invention.

In accordance with one of the concepts of this invention, a method and apparatus are provided wherein a crude hydrocarbon oil stock is injected at or near the bottom of a fractional distillator, for example above plate 6 but below plate 7, while live steam via line 3 is injected at the bottom of said fractionator. Due to the contact with the steam, the lighter hydrocarbons included in the initial flash liquid are vaporized and rise toward the top

end of the fractionator while the heavier hydrocarbons, substantially in liquid form, flow to the bottom of the fractionator. These heavier hydrocarbons, hereinafter referred to as topped crude, are withdrawn from the bottom of the fractionator by any suitable means, heated in a heat exchanger, preferably a furnace, and then, after treatment in the heat exchanger, mixed with steam to form a steam-hydrocarbon mixture. This mixture is then passed to a feed stripper column and the overhead from this column, comprising substantially gas oil and steam, is returned to the bottom of the fractionator from whence the topped crude originally came. This mixture of gas oil and steam is injected into the fractionator either at the point of injection of the crude stock, or, preferably, just below the point of injection of the crude stock. This injection of lighter hydrocarbons mixed with steam in the vicinity of the inlet for the fractionator feed not only dilutes the feed with a larger amount of more desirable hydrocarbons, but also tends to force from the incoming crude stock that which ultimately would have constituted topped crude. Furthermore, by treating the topped crude to recover the lighter fractions and returning same to the fractionator the overall recovery of intermediate and higher distillates is increased and a more efficient overall separation is achieved.

In another inventive concept of this invention, method and apparatus are provided wherein an intermediate distillate, e.g., a diesel base fraction, is treated to improve the quality of the product while being responsive to prevailing conditions in the vicinity of the fractionator plate from which the intermediate distillate is removed. In this connection, an intermediate fraction is trapped out from a plate or plates of the fractionator or fractionators and fed into the top of at least one stripper-dehydrator in which is maintained a subatmospheric pressure due to an eductor means operatively connected to the overhead flow from at least one of said stripper-dehydrators. The strippers may or may not utilize external heat. A normal state for the vacuum stripper is not to use external heat. At the lower end of the stripper, the control means which senses the level of liquid in the bottom of said stripper is operatively connected to a valve which controls the amount of flow of intermediate distillates from the fractionator plates to the top of the stripper. This control means is adjusted in such a manner that, for example, when the level within the stripper rises above a desired maximum, the level controller will sense this variation and automatically adjust the valve hereinabove-mentioned, thereby decreasing the amount of feed from the fractionator plate to the top of said stripper. A similar, but opposite, function is obtained when the liquid level in the stripper falls below an arbitrarily determined minimum level.

The above-mentioned stripper-dehydrator may be provided with internal baffles or packing in order to obtain turbulence and/or a large contact surface area, as desired. However, equally as satisfactory results may be achieved by removing and not using any type of internal baffle in said stripper-dehydrator. The removal of baffles not only decreases the cost of the apparatus and process, but also allows the use of a stripper-dehydrator apparatus of significantly smaller overall dimensions.

It should also be noted here, in relation to the above-described stripper-dehydrator, that results are achieved by this single piece of apparatus which heretofore generally required not only a stripper but also a separate flash dehydrator which acted on a bottom flow from the stripper to, primarily, flash away water and some lighter distillate vapors. This combining of the functions of two separate apparatus into a single stripper-dehydrator is accomplished by utilizing a spray feed, such as that shown at 20a in the drawings, in a stripper which is maintained at a subatmospheric pressure by means of a steam eductor or other vacuum means and by controlling the feed of intermediate distillate to the spray, 20a, by mechanical

means which is responsive to the changes of liquid level in that same stripper, elements 21, 22 and 23. When the intermediate distillate feed to the stripper-dehydrator is sprayed into said stripper-dehydrator, for example, in a hollow cone pattern, and the amount of said feed is controlled in response to, for example, increases in liquid level in the bottom of the same stripper-dehydrator, not only is the need for a separate flash dehydrator removed, but also the need of any internal baffles or packing in said stripper-dehydrator is obviated. Therefore, it can be seen that, by utilizing the spray and feed control means responsive to the liquid level of the bottom of the stripper-dehydrator, the amount of apparatus required is combined into one entity and that entity is, itself, less costly and of smaller overall dimensions. Furthermore, even better efficiency is achieved when the stripper-dehydrator bottom flow is controlled by means responsive to the temperature in the fractionator as described hereinabove along with the above-mentioned level sensing stripper feed input control and spray injection of said stripper feed. It should be noted that the above-mentioned combination of spray and feed control not only allows the elimination of expensive baffles and packing and a separate flash dehydrator, but also effects a significant cost saving by the elimination of piping and flow control means necessary to connect a stripper to a separate flash dehydrator and pumping means to move the bottom hydrocarbon fraction from the stripper to the dehydrator. The above-mentioned stripper-dehydrator also has the advantage that it removes water from the distillate substantially completely, thus eliminating problems that evolve when the distillate is subsequently cooled and stored, i.e. water condensing upon cooling and forming small droplets to make the distillate cloudy and, therefore, of a lower quality.

Another inventive concept of this invention provides a method and apparatus whereby an automatic control of treatment of an intermediate fraction from a fractional distillator is achieved. More specifically, an intermediate fraction is taken from an intermediate area of a fractional distillator and passed to the top of a stripper-dehydrator wherein it is maintained at subatmospheric pressures by suitable means, for example, by a steam eductor operatively connected to the overflow from said stripper and which returns said overflow to the fractionator. The stripper may or may not be heated by external means. The bottom flow from the stripper, comprising a purified diesel, kerosene, or other intermediate distillate, is fed through a heat exchanger and then to storage or other suitable disposition. The line through which this intermediate fraction travels to storage contains a valve for restricting and/or completely shutting off the flow of liquid in that line. This valve is operatively connected to control means which are disposed so as to sense the temperature at or near the point in the fractionator from where the intermediate distillate is originally taken. Thus, said valve responds to temperature variations in the fractionator and, accordingly, either allows more bottom flow from the stripper to the storage or other disposition or restricts the amount of flow from said stripper. A preferred, but not exclusive, means of attaining such temperature response comprises a valve which is connected to a flow controller which controls the flow of fluid in the line in which the valve is connected. The flow controller in turn is connected to a temperature controller which adjusts the flow control means when a temperature control means senses a variation in temperature in the fractionator. Thus, for example, the system can be set up so that when the temperature within the fractionator rises, the temperature sensing unit in the fractionator passes the knowledge of this rise to the temperature control means, which, in turn, resets the flow control means, which, in turn, further closes the valve, thus allowing less bottom flow from the stripper, which, in turn, allows the stripper to handle a lesser quantity of intermediate

distillate, thus decreasing the amount of intermediate distillate withdrawn from the fractionator, thereby reducing the temperature in that area of the fractionator. It should be noted that the combination above explained may also be designed to further open the valve upon a decrease in temperature below the draw-off tray in the fractionator. This allows maximum yield of "on-specification" product from this locus at all times.

Another inventive concept of this invention provides a method and apparatus whereby an intermediate distillate is treated in a side vacuum stripper under conditions totally responsive to conditions which obtain not only within the fractionator, but also to conditions extrinsic to the fractionator itself. In this case, the vacuum stripper contains level control means which will control the amount of flow of intermediate distillate from the fractionator to the vacuum stripper. Said stripper also contains a valve in the bottom flow line which is responsive to the temperature within the fractionator, preferably at or near the vicinity where the intermediate distillate is originally taken from the fractionator to the stripper. Thus, the feed to the stripper from the fractionator and the outflow from the bottom of the stripper is responsive not only to the temperature within the fractionator, but also the level of liquid in said stripper. Thus, it can be seen that, when the temperature varies in the locus of the fractionator plate from which the intermediate distillate is withdrawn, a valve in the line which carries the bottom flow from the vacuum stripper is operated, thus either increasing or decreasing the amount of flow in said line. This, in turn, varies the liquid level in the vacuum stripper which is sensed by the level controller and which in turn operates a valve in the line which carries the intermediate distillate from the fractionator to the top or other location in the stripper. In this manner, the rise in temperature in the fractionator could shut the valve or otherwise restrict the flow of hydrocarbon from the bottom of the stripper, thereby increasing the level of liquid in the stripper, thereby actuating the valve which would restrict or stop the flow of intermediate distillate from the fractionator to the stripper. For further clarification of this invention, reference is made to the attached diagrammatic drawing wherein is disclosed a preferred method and apparatus for attaining the above-mentioned objects by treating the topped crude flow from the fractionator and returning thereto a lighter hydrocarbon fraction while treating intermediate fractions in a manner which automatically responds to conditions both within and without the fractionator.

More specifically, the drawing shows a fractionator 1 with feed input 2 and steam addition means 3. The bottom flow from said fractionator, topped crude, passes through lines 4, 5, 6 and 7 to heat exchanger 9. Either prior to or after passing through heat exchanger 9, steam means 8 injects steam into intimate contact with the topped crude. The topped crude-steam mixture then passes through line 10 to stripper 12 to which is added steam 11. The bottom flow from stripper 12 passes through line 13 to vacuum column 14. The bottom flow from vacuum column 14, comprising primarily asphalt and other heavy residua, passes either to storage or to further treatment, while the overhead flow from said vacuum column, comprising primarily vacuum gas oil, passes on to further treatment. The overhead of stripper 12, comprising a mixture of lighter hydrocarbons and steam, passes through lines 15, 16, 17, 18, and 19, into fractionator 1 in the vicinity of feed 2.

At one or more intermediate positions along fractionator 1, varying degrees of lighter hydrocarbons are withdrawn and treated as follows: An intermediate plate in fractionator 1 is tapped by line 20, which carries intermediate fraction through valve 21 to spray 20a in vacuum stripper 24. Spray 20a, as described hereinabove, in combination with level control means 23 and valve 21,

allows the simultaneous omission of baffles or packing in stripper 24, thus reducing the size and cost of said stripper, and a separate vacuum, flash dehydrator, well known in the art, to treat the underflow 28 from stripper 24. Valve 21 is operatively connected via line 22 to level control means 23. Level control means 23 is connected to vacuum stripper 24 in a manner to sense variations of liquid level in said vacuum stripper and respond accordingly. For example, when the liquid level in vacuum stripper 24 exceeds an arbitrarily defined maximum level, controller 23 will actuate valve 21, thus restricting or stopping the flow in line 20. The overhead from vacuum stripper 24 passes via line 25 into steam injection and vacuum means 26 and thence via line 27 to fractionator 1. Steam injection means 26 utilizes live steam flow to create and maintain subatmospheric pressure in vacuum stripper 24. The bottom flow from vacuum stripper 24 passes via line 28 through valve 29 to storage, transportation and/or further treatment. Valve 29, however, is operatively connected via line 30 to flow control means 31. Flow control means 31 is connected via line 36 to line 28 in order to detect the flow of intermediate distillate in said line 28. Flow control means 31 is also operatively connected via line 32 to temperature control means 33. Flow control means 31 is adjusted to be reset by temperature control means 33 when necessary. Temperature control means 33 is operatively connected via line 34 to temperature sensing means 35. Temperature sensing means 35 is arranged to sense the temperature in the fractionator in the vicinity of the plate from which hydrocarbon flows into line 20. Thus temperature sensing means 35, upon temperature variation in fractionator 1, actuates temperature control means 33, which in turn resets flow control means 31, which in turn either further opens or closes or restricts to some degree the opening in valve 29. Thus, it can be seen that if temperature control means 33 and flow control means 31 are adjusted so as to open valve 29 when the temperature decreases in fractionator 1 in the vicinity of temperature sensing means 35, the flow of hydrocarbon in line 28 increases, thus lowering the level in vacuum stripper 24. The lower liquid level in vacuum stripper 24 is sensed via level means 23, which in turn further opens valve 21 to increase the flow of intermediate distillate through line 20 from fractionator 1. This increased flow of intermediate distillate decreases internal reflux (cooling medium) from fractionator 1, and thereby increases the temperature in the area of said fractionator where sensing means 35 resides. When the temperature in fractionator 1 in the vicinity of sensing means 35 increases, valve 29 will be closed, at least in part, thus restricting the outflow from vacuum stripper 24, thereby raising the liquid level in said stripper and thereby causing valve 21 to close down and consequently decreasing the amount of intermediate distillate removed from fractionator 1, which increases internal reflux at this locus.

The overhead flow from fractionator 1 passes through line 40 into heat exchanger 41 and then through line 42 to accumulator 43. The lighter hydrocarbon phase passes from accumulator 43 to further treatment while the heavier hydrocarbon phase is refluxed to the fractionator via line 44.

It should be noted that reasonable variation and modification of the above disclosed invention can be made by one skilled in the art in possession of this disclosure, drawing, and appended claims without departing from the scope of this invention. For example, the topped crude from the fractionator may not be mixed with steam at all, but merely passed through a heat exchanger to a stripper. Also, the topped crude may be mixed with steam before it enters the heat exchanger, after it passes through the heat exchanger, or both before and after treatment in the heat exchanger. Also, the stripper which treats the topped crude or topped crude and steam mixture may be a vacuum unit and may be heated by other means. Further, the overhead from the stripper may be

fed into the fractionator in several different positions, for example, it could be fed into the fractionator preferably below the feed, or above the feed, or at the feed tray, or it could be mixed with the feed and the mixture be fed into the fractionator. As stated above, several vacuum strippers can be utilized to treat several different intermediate distillates. It should be noted here that when several vacuum strippers are utilized, the level control means and/or temperature control means and/or flow control means for each stripper can be coordinated with the other strippers, thereby achieving an overall temperature control means for fractionator 1. This would allow one to achieve temperature control of several sections of the fractionator automatically and at one time. Also, several of the strippers may utilize a single level control means and/or temperature control means and/or flow control means. Also note that the level control means on any particular stripper can be operated, per se, without recourse to temperature flow control or, if temperature flow control means are present, may be operated independently of these other controls. The contrary is also true, i.e., temperature and/or flow control means may be operated independently of level control means or may be utilized alone without any level control means at all. Finally, it can be seen that the gas oil recovered from the vacuum column which treats the bottom flow of stripper 12 could also be returned to fractionator 1, if desired.

Example.—Operating conditions

Fractionator (1):	
Bottom temperature, ° F. -----	750
Bottom pressure, p.s.i.g. -----	17
Tray XIII temp., ° F. -----	580
Tray XXIII temp., ° F. -----	385
Top temperature, ° F. -----	300
Top pressure, p.s.i.g. -----	15
Accumulator (43):	
Pressure, p.s.i.g. -----	5
Temperature, ° F. -----	110
Vacuum stripper (24):	
Pressure, p.s.i.a. -----	13
Temperature, ° F. -----	580
Steam stripper (12):	
Pressure, p.s.i.g. -----	20
Temperature, ° F. -----	735
Vacuum tower (14):	
Pressure, mm. Hg absolute -----	3.5
Temperature, ° F. -----	700
Rates of flow:	
Crude oil (2), b./d. -----	50,000
API @ 60/60° F. -----	34.2
Steam (3), #/hr. -----	9,400
Temperature, ° F. -----	700
Gas oil-steam (19):	
Gas oil, b./d. -----	344
Steam, #/hr. -----	500
Topped crude (6), b./d. -----	17,880
API @ 60/60° F. -----	15.8
Topped crude (7), b./d. -----	7,872
API @ 60/60° F. -----	15.8
Diesel base (20), b./d. -----	11,000
API @ 60/60° F. -----	31.4
Kerosene (50), b./d. -----	10,500
API @ 60/60° F. -----	44.0
Gasoline (51), b./d. -----	10,680
API @ 60/60° F. -----	66.8
Light gas oil (52), b./d. -----	240
API @ 60/60° F. -----	27.0
Heavy gas oil (53), b./d. -----	4,288
API @ 60/60° F. -----	21.9
Asphalt (54), b./d. -----	3,000
API @ 60/60° F. -----	6.1

Reasonable variation and modification are possible within the scope of the foregoing disclosure, drawing, and

the appended claims to the invention, the essence of which is apparatus and process for fractionation of a fractionable material wherein, in accordance with one concept of this invention, fractionator residua is stripped of contained lighter hydrocarbons which are returned to the fractionator in the area of the feed input of said fractionator, this being accomplished by mixing steam with said residua, then steam stripping the mixture and recovering the lighter hydrocarbon-steam mixture for return to the fractionator and wherein, in accordance with another concept of this invention, at least one intermediate distillate is trapped out of the fractionator, fed to a stripper-dehydrator, the flow of intermediate distillate from said fractionator to said stripper being controlled by a valve which is responsive to the level control in said stripper, the overhead from said stripper being returned to the fractionator and the underflow from said stripper being passed for further treatment through a valve which is responsive to conditions within the fractionator in the vicinity of the area from which the intermediate distillate is trapped out.

I claim:

1. A method for fractional distillation of crude oil comprising feeding crude oil into a fractionator near the bottom thereof, injecting steam into the bottom of said fractionator to produce a topped crude fraction, intermediate distillates and light distillates, withdrawing said topped crude fraction from the bottom of said fractionator, mixing steam with said topped crude fraction to produce a topped crude-steam mixture, steam stripping said topped crude-steam mixture to produce a gas oil-steam mixture, returning said gas oil-steam mixture to a point on the fractionator just below the point where the crude oil enters the fractionator, contemporaneously with the above removing at least one of said intermediate distillates from a plate in said fractionator, passing said intermediate distillate to a vacuum stripper, maintaining a subatmospheric pressure in said vacuum stripper by use of a steam eductor, controlling the flow of intermediate distillate from said fractionator to said vacuum stripper by the level of liquid in said vacuum stripper, passing the overhead from said vacuum stripper to said steam eductor and then passing the overhead-steam mixture to said fractionator in the vicinity of the plate from which the intermediate distillate was originally drawn from the fractionator, controlling the bottom flow from said vacuum stripper by the temperature in the fractionator in the vicinity of the plate from which the intermediate distillate was originally drawn, coordinating the controlling of the bottom flow from the vacuum stripper with the controlling of the flow of intermediate distillate from said fractionator so that the controlling of one is dependent on and responsive to the controlling of the other.

2. Apparatus for fractionation comprising distillation means including bottom flow removing means and intermediate distillate removing means, stripping means connected to said bottom flow removing means, overhead return means from said stripping means connected to said distillation means, second stripper means connected to said intermediate distillate removal means, bottom flow means connected to said second stripper means, flow control means connected to said second stripper bottom flow means, temperature control and flow control reset means connected to said flow control means, and temperature sensing means located in said distillation means and connected to the temperature control means.

3. The method according to claim 1 wherein said at least one intermediate distillate removed from said fractionator is sprayed into said vacuum stripper.

4. A method for fractional distillation of a fractionable material with a fractionator to produce bottoms, intermediate, and light fractions, withdrawing a bottom fraction, mixing steam with said bottom fraction to make a bottom fraction-steam mixture, steam stripping said

mixture to remove light constituents therefrom, returning said light constituents to said fractionator at a point below the point where said fractionatable material is introduced into said fractionator, removing at least one intermediate fraction from said fractionator, vacuum stripping said intermediate fraction in a vacuum stripper, controlling the flow of intermediate fraction from said fractionator to said vacuum stripper by the level of liquid in said stripper, passing the overhead from said vacuum stripper into said fractionator in the vicinity of the point at which the intermediate fraction was originally withdrawn from the fractionator, and controlling the bottom flow from said vacuum stripper by the temperature in the fractionator in the vicinity of the area of the fractionator from which the intermediate fraction was originally withdrawn.

5. The method according to claim 4 wherein said at least one intermediate fraction removed from said fractionator is sprayed into said vacuum stripper.

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