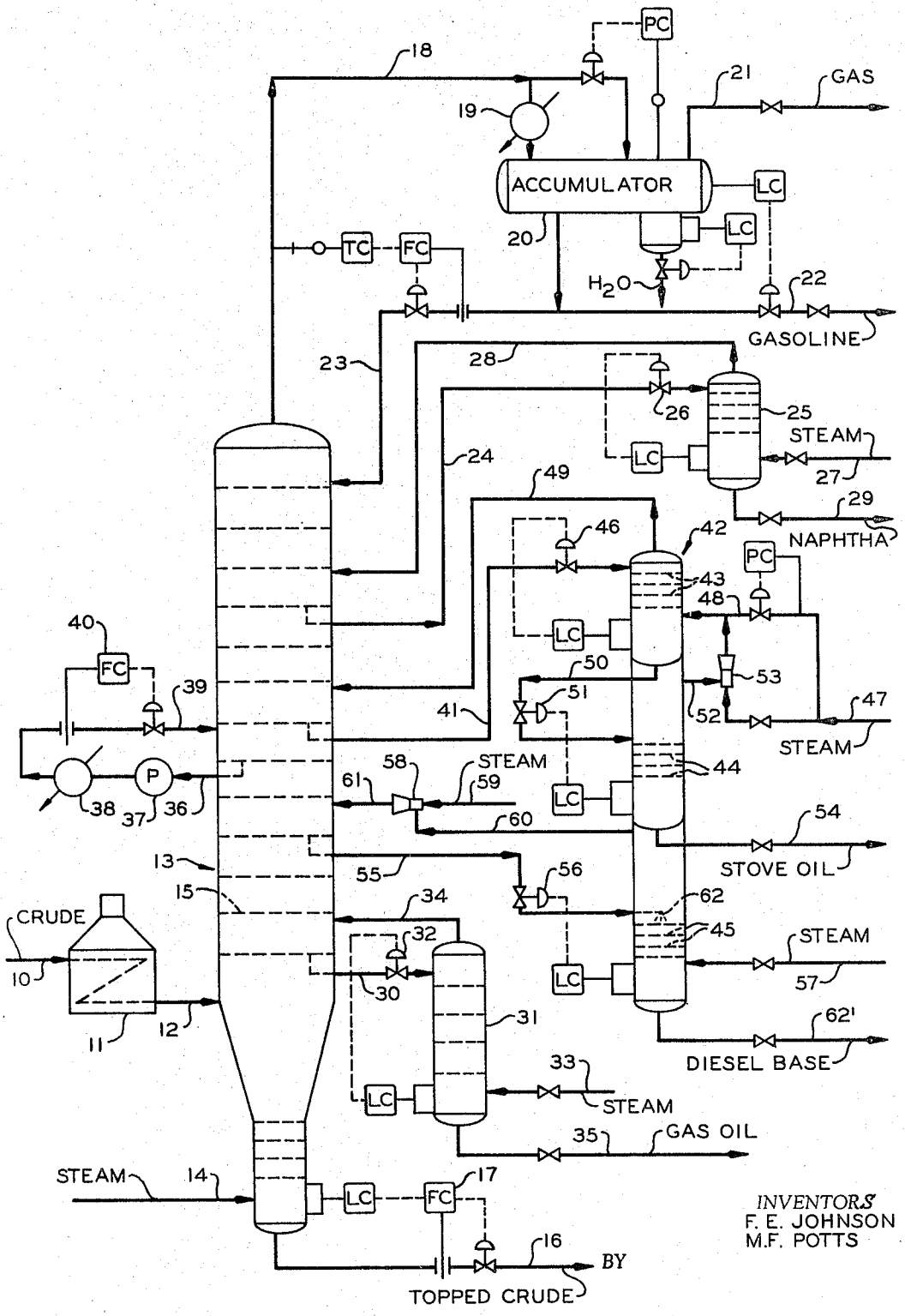
March 21, 1967 F. E. JOHNSON ETAL 3,310,487

FRACTIONATION SYSTEM

Filed Oct. 23, 1964



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United States Patent Office 3,310,487 Patented Mar. 21, 1967

3,310,487

FRACTIONATION SYSTEM

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Filed Oct. 23, 1964, Ser. No. 405,973
8 Claims. (Cl. 208—355)

This invention relates to process and apparatus for fractionation. In one of its aspects, the invention relates to the treatment of intermediate distillate fraction from fractionation by treating same in a stripper-dehydrator zone employing a stripping medium and reduced pressure stripping while automatically controlling the flow of distillate to the stripper-dehydrator zone by means of a level sensing and control device in said stripper-dehydrator zone and operative on the input line to said stripper-dehydrator zone. In another aspect, this invention relates to the control of the flow of intermediate distillates passed to side strippers from a fractionation zone responsive to the liquid level in each of the side strippers. In a further aspect, this invention relates to a unitary stripper-dehydrator apparatus comprising a plurality of intercommunicating sections wherein stripped liquid from one section is passed to another section responsive to liquid level in the latter section.

Crude petroleum is made up of hundreds of different individual components including natural gas and light gasoline, waxes and asphalts. The refining of petroleum separates these multitudinous constituents into various fractions or phases according to properties such as boiling range and viscosity. The separation of these many 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 a 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 problems and, at the same time, effecting a more economical, efficient and complete recovery of all fractions and constituents present in a crude oil, for example.

Accordingly, it is an object of this invention to provide process and apparatus for separating fractionable materials into their various component fractions.

Another object of this invention is to provide fractional distillation of a hydrocarbon oil by use of steam and reduced pressures.

Another object of this invention is to increase the amount of overhead hydrocarbon and intermediate hydrocarbon produced by a fractionating system.

Another object of this invention 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 drawing, and the appended claims.

Although the illustrated embodiments of this invention refer to the use of a 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 distillate organic and inorganic chemical mixtures or solutions. It is also to be understood that the drawing hereinafter described is diagrammatic and can 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 this invention, one or more distillate fractions or side streams removed from a fractionator are passed to a group of strippers wherein the distillates are subjected to stripping both with a fluid stripping medium and reduced pressure. In accordance with one embodiment of the invention, a unitary, combined stripper-dehydrator comprising a plurality of sections is provided for carrying out the stripping operation. Such an apparatus takes advantage of efficient utilization of heat exchange between strippers. Also, optimum stripping conditions can be selected to achieve the desired degree of separation with minimum loss of bulk liquid, e.g., distillate subjected to stripping.

More specifically, according to the invention, the rate of flow of distillate material to be subjected to stripping conditions passed to one or more side strippers associated with a fractionator are controlled responsive to the liquid level in side strippers receiving liquid to be subjected to stripping. Further, according to the invention, when applying the control of flow of distillate to be stripped in a vertical multi-compartmented stripper, liquid removed from one stripper and passed to another is regulated responsive to the liquid level in the latter section or compartment.

In a specific embodiment of the invention, a multi-compartmented, or sectioned, substantially vertical stripper-dehydrator is provided wherein the sections are serially connected, and further, wherein steam stripping is employed in one section and vacuum or reduced pressure is employed in a following section and, further, wherein the stripped vapors in the latter section are combined with the stripping medium in the first section and these vapors are all recovered and returned to the fractionator for further recovery and separation. By so operating, efficient utilization of both the vacuum producing equipment and steam and fluid stripping medium is achieved.

As indicated above, the flow of liquid to the strippers is controlled responsive to the level of liquid in a lower portion or base of each stripper. The control means which senses the level of liquid in the bottom of the 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 or from another 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 or previous stripper to the top of a succeeding 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 can be provided with internal baffles or packing in order to obtain

turbulence and/or large contact surface area as desired. However, equally as satisfactory results can be achieved by removing and not using any type of internal baffle in the 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. However, it is often preferred to utilize contact plates, e.g., perforated trays, in the strippers. It should also be noted here in relation to the above-described unitary stripper-dehydrator column that results are achieved by this single piece of apparatus which heretofore generally required not only a stripper, but also a separate vacuum or flash dehydrator which acted on a bottom flow from the stripper to primarily flash away water and some lighter distillate vapors.

Referring now to the drawing, a crude oil feed introduced by way of line **10** is passed through heater or furnace **11** to preheat the feed, and the heated feed is then passed through line **12** and introduced into a lower portion of fractionator **13**. Fractionator **13** is provided with a plurality of spaced contact trays **15**. Steam is introduced into the base of fractionator **13** by way of line **14**. A topped crude fraction is removed from the base of column **13** by way of line **16** and passed to further processing, e.g., vacuum distillation or other treatment as desired. The rate of flow of topped crude withdrawn from the bottom of column **13** is controlled responsive to flow controller **17**, which operatively regulates the position of a control valve in line **16**. Flow controller **17** is periodically reset by the liquid level in the bottom of column **13**.

Gasoline boiling range materials and lighter are removed overhead from column **13** by way of line **18** and passed through condenser **19** and condensed liquid is collector in accumulator **20**. Non-condensed gases are removed from accumulator **20** by way of line **21**. A portion of the condensed liquid collected in accumulator **20** is returned to fractionator **13** as reflux by way of line **23**. The remainder of the gasoline product is removed from accumulator **20** by way of line **22** for further processing as desired.

At one or more intermediate positions along fractionator **13**, varying degrees of lighter hydrocarbons are withdrawn and treated in side strippers, as set forth hereinbelow.

An upper plate in fractionator **13** is tapped by line **24** and carries a naphtha boiling range fraction to stripper **25**. The rate of flow of naphtha passed to stripper **25** from column **13** by way of line **24** is regulated by valve **26** responsive to the liquid level in the bottom of stripper **25**. Steam or other stripping medium is introduced into the base of stripper **25** by way of line **27**. Steam and light hydrocarbon vapors are removed overhead from stripper **25** by way of line **28** and returned to fractionator **13** at a point above the liquid withdrawal for stripper **25**. A bottom stream of stripped naphtha is removed from stripper **25** by way of line **29** for further processing as desired.

In a lower portion of fractionator **13** a gas oil stream is removed from fractionator **13** by way of line **30** and passed to stripper **31**. The flow of gas oil to stripper **31** is controlled by valve **32** responsive to the liquid level in the base of stripper **31**. Steam or other stripping fluid is introduced into the base of stripper **31** by way of line **33**, and an overhead fraction comprising stripping medium and hydrocarbons lighter than gas oil is removed from stripper **31** by way of line **34** and returned to fractionator **13** at a point above the liquid withdrawal for stripper **31**. A stripped gas oil stream is removed as bottoms from stripper **31** by way of line **35** for further processing as desired.

At an intermediate portion of fractionator **13** a side reflux loop is provided wherein liquid is withdrawn from an intermediate tray by way of line **36**, passed through pump **37**, cooler **38**, and returned by way of line **39** to a point in column **13** above the liquid withdrawal. The rate of circulation of liquid through the loop is controlled by flow controller **40**.

According to one embodiment of the invention, a stove oil fraction is removed by line **41** from an intermediate point in column **13** and passed to stripper-dehydrator **42** containing compartments **43**, **44** and **45**. The rate of flow of stove oil in line **41** passed to section **43** of column **42** is controlled by control valve **46** responsive to the liquid level in the base of section **43** of stripper-dehydrator **42**. Steam or other stripping medium is introduced into the base of section **43** by way of lines **47** and **48**. An overhead stream comprising steam and lighter hydrocarbon materials is removed from section **43** and returned to fractionator **13** by way of line **49** and introduced into fractionator **13** at a point above the liquid withdrawal for line **41**.

Stripped liquid collected in the base of section **43** is passed by way of line **50** to an upper portion of section **44**. The rate of liquid introduction into section **44** is controlled by control valve **51** responsive to the liquid level in the base of section **44**. The liquid passed to section **44** is subjected to reduced pressure or vacuum stripping by means of eductor **53**, which removes vapors from an upper section of section **44** by way of line **52**. The light hydrocarbon vapors removed from the top of section **44** by means of eductor **53** are combined with steam introduced into eductor **53** from line **47** and passed into a lower portion of section **43** through line **48** along with stripping medium bypassing eductor **53**. Steam stripped and vacuum stripped stove oil is removed from the base of section **44** of stripper **42** by way of line **54** for further processing as desired.

A diesel base distillate is removed from fractionator **13** by way of line **55** and passed through control valve **56** and introduced through spray nozzle **62** into an upper portion of section **45** of stripper-dehydrator **42**. The rate of flow of diesel fuel passed to section **45** is controlled by control valve **56** responsive to the liquid level in the base of section **45**. Section **45** of stripper-dehydrator **42** is ordinarily subjected to vacuum stripper by means of eductor **58**, which is supplied with steam by means of line **59**. Light materials stripped from the diesel material introduced into section **45** are removed through line **60** and returned, along with steam used as vacuum producing medium, into fractionator **13** by way of line **61**. If desired, steam can be introduced into the base of section **45** by means of line **57**. Stripped diesel material is removed from the base of section **45** by means of line **62'** for further processing as desired.

As can be seen from the above description, a neat and compact stripper-dehydrator is provided whereby petroleum distillates can be subjected to both steam and vacuum stripping in the same vessel. Also, vapors from the intermediate section **44**, which section is under vacuum, are passed together with the steam creating the vacuum in section **44** for use as stripping medium in section **43**. Moreover, heat from stream **62'** (stripped disel base), for example, can be utilized for heat interchange with stream **54**, or other streams as desired. Also, the compact, three-chambered apparatus described above provides efficient utilization of heat exchange by heat interchange between the separate vessels. For example, it will be observed that unit **44** is interposed between two other chambers or strippers and that heat from bottom stripper **45** is available for heating stripper **44**. Also, vapors from intermediate section **44**, which is under reduced pressure, are passed together with the steam creating the reduced pressure for use as stripping medium in top stripper **43**. Thus, the stripping medium in top stripper **43** consists of oil, as well as steam.

Example

Crude oil at a temperature of about 720° F. and at a rate of 21,000 b.p.s.d. (barrels per stream day) is introduced into a lower portion of fractionator **13**, which

contains 40 spaced vapor-liquid contact trays. Steam is introduced into the base of fractionator 13 below tray number 1. A topped crude fraction at a temperature of about 690° F. is removed from the base of column 13 by way of line 16. The amount of topped crude removed in line 16 is 6,006 b.p.s.d. A gasoline overhead fraction at a temperature of 338° F. is cooled, condensed, and collected in accumulator 20. A reflux stream is introduced onto tray 40 (top tray) at the rate of 7,718 b.p.s.d. and a gasoline product stream comprising 6,322 b.p.s.d. is recovered in line 22 for further processing.

A naphtha stream is removed from tray 32 by way of line 24 and passed to stripper 25. Ordinarily, the naphtha stripper is not operated.

A gas oil stream is removed from tray 10 by way of line 30 and is passed to stripper 31. A steam stripped gas oil stream of 2,352 b.p.s.d. is removed by way of line 35.

A stove oil stream is removed from tray 25 by line 41 and passed to dehydrator-stripper 42 and introduced into the top of section 43. Steam (150 lb. steam) at the rate of 1,950 pounds per hour is introduced into section 43 by line 47. A steam stripped and vacuum-stripped stove oil fraction at a temperature of about 435° F. is removed from the base of section 44 by line 54 at the rate of 3,718 b.p.s.d.

A gas oil stream is removed from fractionator 13 at tray 16 and passed to steam stripping section 45. Steam (150 lb. steam) at the rate of 1,370 pounds per hour is introduced into vacuum producing means 58. A stripped diesel base stream at a temperature of about 560° F., and at the rate of 2,604 b.p.s.d. is removed by line 62.

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 are provided for fractionation of a fractionable material wherein at least one intermediate distillate fraction is trapped out of a fractionator, fed to a unitary stripper-dehydrator having a plurality of intercommunicating sections, the flow of intermediate distillate from said fractionator to each stripper being controlled by a valve which is responsive to the liquid level in each stripper, the overhead from the strippers being returned to the fractionator and the underflow from each stripper being passed for further treatment and, further, wherein an intermediate distillate is subjected serially to steam stripping followed by vacuum stripping and wherein vapors from the vacuum stripping are combined with the motive fluid for steam stripping in the preceding stripper.

We claim:

1. A method of fractionation comprising introducing a suitable feed into a fractionator to produce, inter alia, intermediate distillates, removing at least one of said intermediate distillates from said fractionator, passing said intermediate distillate to a combined stripper-dehydrator zone divided into an upper section, an intermediate section, and a lower section, contacting said distillate with a stripping medium in said first section of said stripper-dehydrator to produce an overhead product, returning said overhead product to said fractionator, subjecting a bottoms product removed from said first section to reduced pressure stripping in said intermediate section to produce a second overhead product, combining said second overhead product with the stripping medium utilized to produce said first overhead, recovering stripped liquid from said second section as product, passing a second intermediate distillate from said fractionation to said lower section and therein subjecting same to stripping, returning stripped overhead to said fractionation, and recovering a second stripped product from the base of said lower section.

2. A method according to claim 1 wherein the rate of flow of liquid to each of said sections is controlled responsive to the level of liquid in each of said sections.

3. A method for fractionating a crude oil feed in a single fractionator into a plurality of distillate components which comprises passing same to said fractionator and subjecting same to distillation in the presence of steam, removing a topped crude fraction as bottoms from said fractionator, recovering overhead a gasoline boiling range material, condensing and collecting condensed material and returning a portion as reflux to said fractionator and recovering the remainder as product, passing a gas oil fraction to a side stripper responsive to liquid level in said stripper and subjecting same to steam stripping, returning an overhead fraction from said stripper to said fractionation at a point above the liquid withdrawal for said stripper producing a stripped gas oil fraction as bottoms from said stripper fraction, passing an intermediate stove oil fraction to a combined stripper-dehydrator having an upper section, an intermediate section and a lower section, controlling the rate of flow of stove oil fraction passed to said upper section responsive to the level of liquid in said upper section, subjecting said stove oil fraction to steam stripping in said upper section, passing steam stripped stove oil to said intermediate section and therein subjecting same to reduced pressure stripping, combining overhead removed from said reduced pressure stripping with steam passed to said upper section, recovering steam and pressure reduced stripped stove oil from the base of said intermediate section, and passing a diesel fuel from said fractionator to said lower section and therein subjecting same to stripping, and recovering stripped diesel base from the bottom of said lower section.

4. A multi-sectioned unitary stripper vessel comprising, in combination, an upper enclosed section, means to pass feed to said upper section, means to control the flow of feed to said upper section responsive to the level of liquid in said upper section, means to remove overhead vapors from an upper portion of said upper section, means to introduce a stripping medium into a lower portion of said upper section, means to remove liquid from the bottom of said upper section and pass same to second section of said stripper, means to control the rate of liquid passed from said upper section to said second section responsive to liquid level in said second section, steam eductor means to reduce the pressure in said second section, means for removing stripped vapors from said second section and combining same with said steam in said eductor and passing said combined stream into the base of said upper section, and means for removing liquid from the base of said second section.

5. The apparatus of claim 4 which includes a lower section in combination with said upper section and said second section which is provided with means for passing a feed to the upper portion of said lower section, means to control the rate of flow of feed to said lower section responsive to liquid level in the base of said lower section, means to produce a reduced pressure in said lower section and means connected therewith for removing stripped vapors from said lower section, and means for removing stripped liquid from the base of said lower section.

6. The apparatus of claim 5 which includes, in combination, a fractionator, means for passing a feed to be separated into a plurality of components to said fractionator, means for removing a liquid bottoms stream from the base of said fractionator, means for taking an overhead stream from the top of said fractionator, condensing same, collecting same, and returning a portion of the condensed overhead as reflux to said fractionator and recovering the remainder of said overhead as product, means connecting an intermediate portion of said fractionator with said upper section of said stripper for passing feed to said upper section, said fractionator also being connected at a point above said liquid withdrawal to the overhead vapor removal means connected to said upper section, means in a lower section of said fractionator connected to said lower section of said stripper for pass-

ing feed to said lower section, and means connecting said lower section with said pressure reducing means to return vapors to said fractionator.

7. The method of claim 3 further comprising reducing the pressure in said lower section by steam reduction, withdrawing vapor as overhead from said lower section, admixing said vapor with said steam and returning the admixture thus formed to said fractionator.

8. Means for separating hydrocarbons which includes in combination a fractionator, means for passing a feed to be separated into a plurality of components to said fractionator, means for removing a liquid bottoms stream from the base of said fractionator, means for taking an overhead stream from the top of said fractionator, condensing same, collecting same, and returning a portion of the condensed overhead as reflux to said fractionator, and recovering the remainder of said overhead as product, multi-sectioned unitary stripper vessel means comprising in combination an upper enclosed section, means to pass feed to said upper section from an intermediate section in said fractionator, means to control the flow of feed to said upper section responsive to the level of liquid in said upper section, means to remove overhead vapors from an upper portion of said upper section and pass said overhead vapors to said fractionator at an elevation above said intermediate section, means to introduce a stripping medium into a lower portion of said upper section, means to remove liquid from the bottom of said upper section and pass same to said second section of said stripper, means to control the rate of liquid passed from said upper section to said second section responsive to fluid level in said second section, steam eductor means to reduce the pressure in said second section, means for removing

stripped vapors from said second section and combining same with said steam in said last eductor and passing said combined stream into the base of said upper section, means for removing liquid from the base of said second section, a lower section in combination with said upper section and said second section which is provided with means for passing a feed from said fractionator at a point below said intermediate point to the upper portion of said lower section, means to control the rate of flow of feed to said lower section responsive to the liquid level in the base of said lower section, steam eductor means to produce a reduced pressure in the said lower section, and means connected therewith for removing stripped vapors from said lower section and mixing said stripped vapors with said steam in said eductor, means for passing the mixture of said steam and said stripped vapors thus formed to said fractionator, and means for removing stripped liquid from the base of said lower section.

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