Oct. 13, 1936. M. J. BURKHARD 2,057,004

METHOD AND APPARATUS FOR DISTILLATION OF HYDROCARBONS

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Fig. 1,

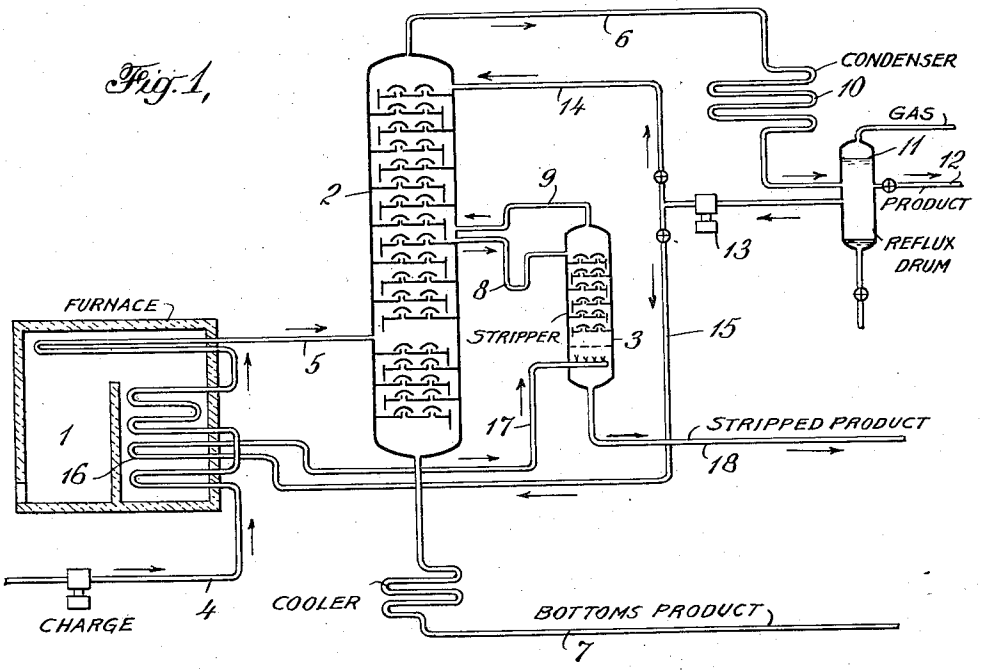
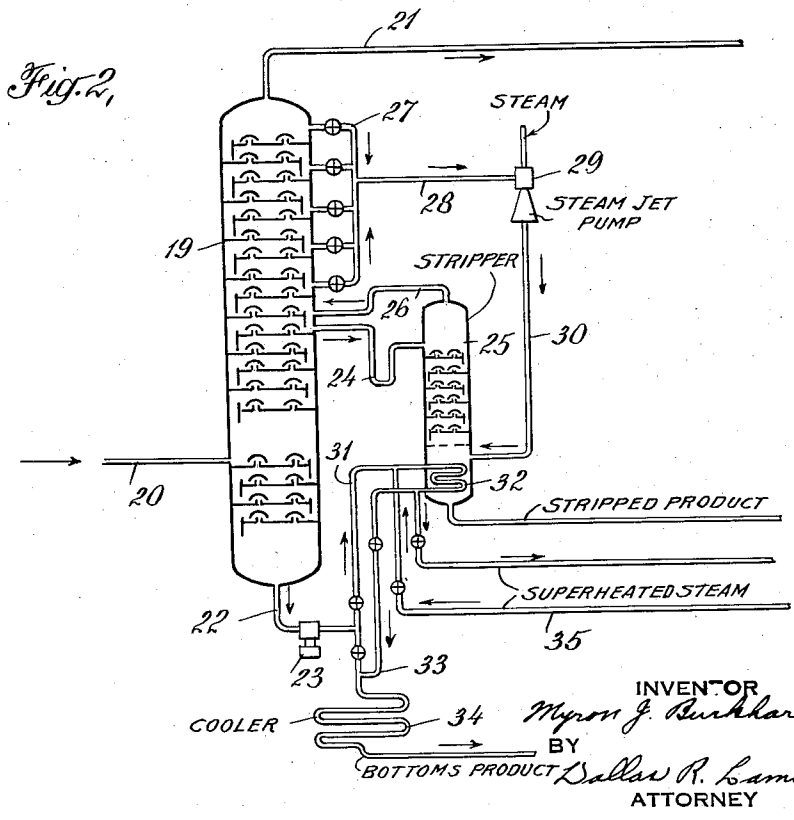


Fig. 2,



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Fig. 3,

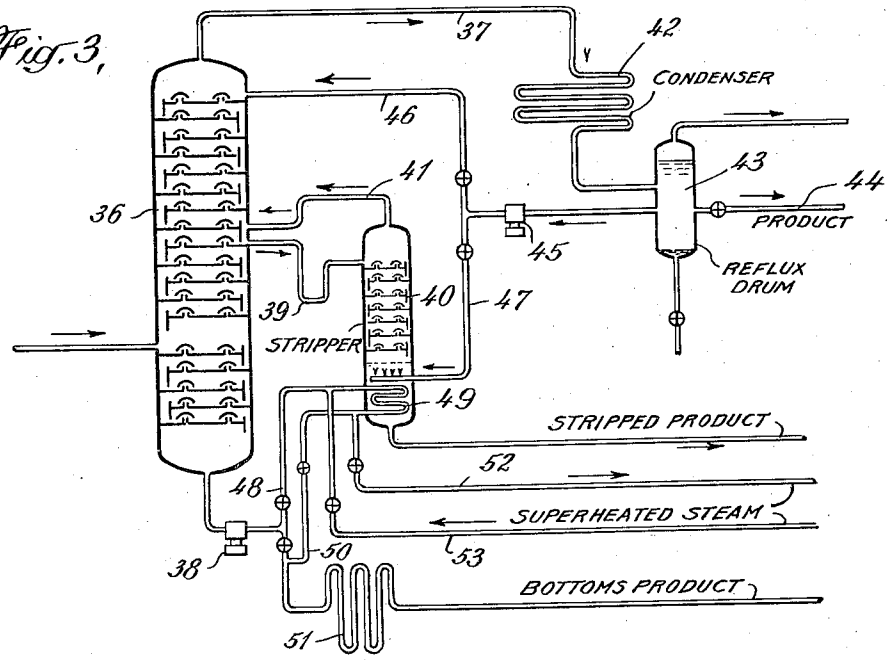
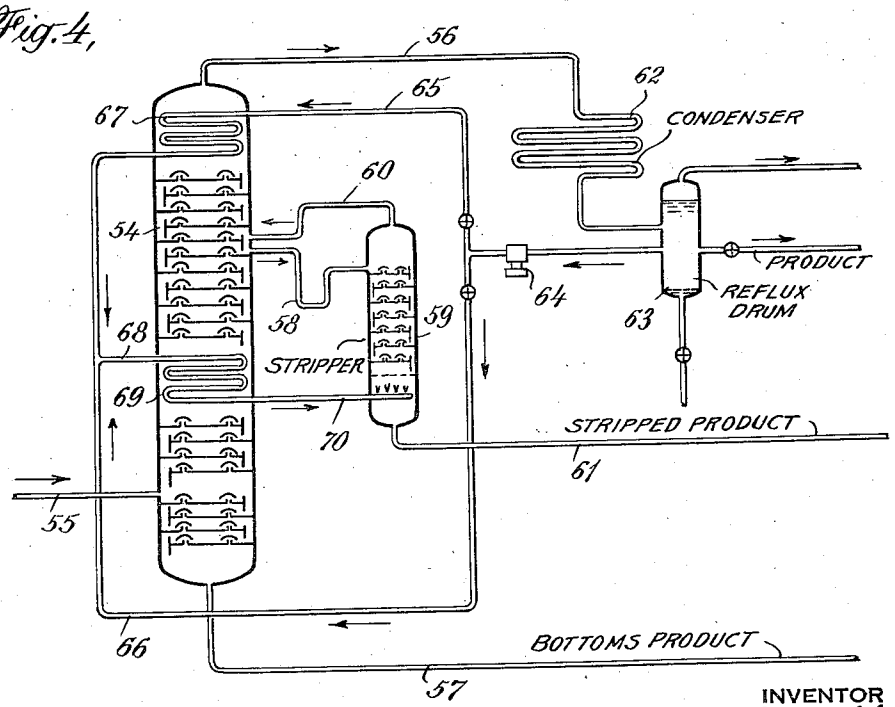


Fig. 4,



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Fig. 5,

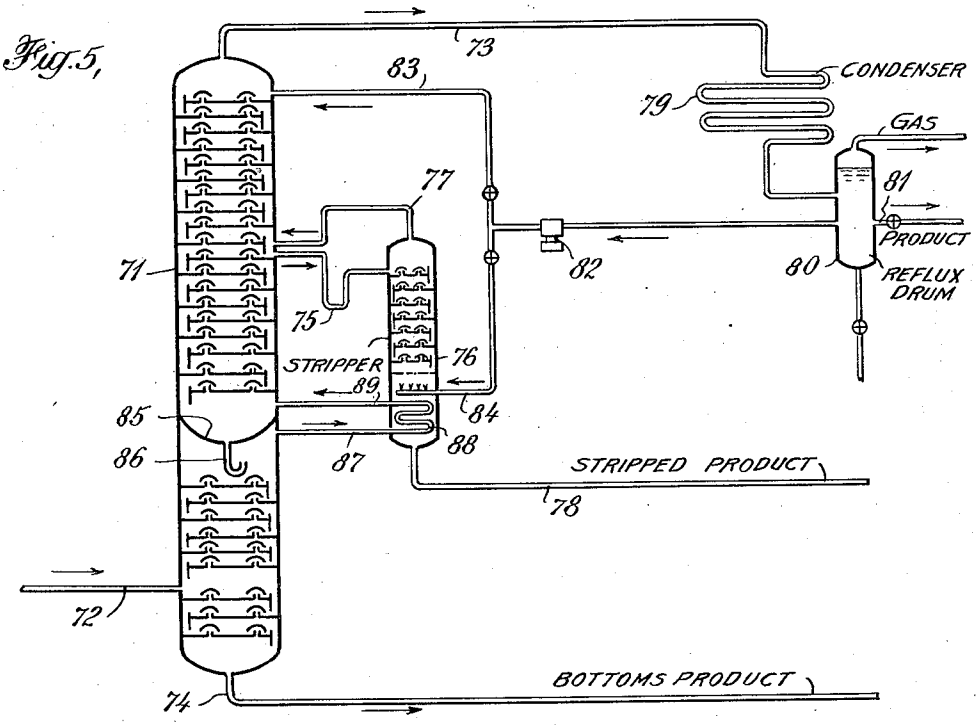
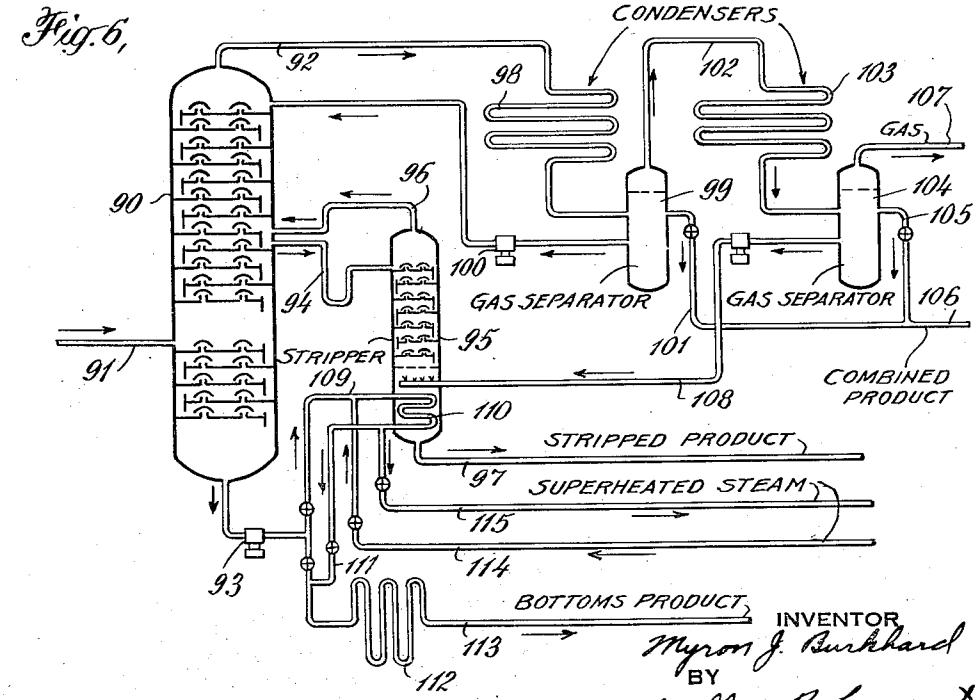


Fig. 6,



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UNITED STATES PATENT OFFICE

2,057,004

METHOD AND APPARATUS FOR DISTILLATION OF HYDROCARBONS

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Application August 26, 1933, Serial No. 686,882

2 Claims. (Cl. 196—94)

The present invention has particularly to do with processes and apparatus for the distillation of hydrocarbons or in general, with fractionation and distillation of mixtures showing the general properties commonly found in hydrocarbon mixtures. That is to say, it is applicable to the fractionation of a series of homologous compounds differing only slightly from one another in boiling points, any fraction of which series is usually composed of numerous members of slightly different boiling points rather than a single member of definite boiling point.

The invention is specifically directed to processes and apparatus for the production of intermediate fractions of controlled initial vaporization point. For instance, in the primary distillation of crude oils and in various other distillation processes of similar intent, the vapors comprising a part or all of the products to be distilled from the original charge are introduced into a fractionating tower in which it is customary to take overhead as vapor, certain light products, to take from the bottom the vaporized charge as a heavy product, and to take from one or more levels within the fractionating tower, streams of condensate known as "side streams" which side streams approximate finished products. This invention has to do with processing these side streams in order to remove from them light material, and with apparatus for such processing.

The operation of a fractionating tower when analyzed, presents two counter-flowing streams. The first stream, that of vapor, arising from the point of entry of vaporized material, passes upwardly, becoming relatively lighter and more free from materials heavier than that desired as an overhead fractionator product. The second stream, that of reflux liquid, descends in the column, and in descending, changes from a composition approximating that of overhead product, to one approximating that of bottoms product. The interchange of light and heavy materials between the counterflowing vapor and liquid streams takes place upon the plates of the tower and the liquid on each plate represents an equilibrium product. That is to say, it is theoretically free from all portions which would be vapor at the temperature of the plate in question, also from all products which would condense at a temperature higher than that of the plate in question. On a perfect plate this would be the case. In commercial practice, fractionating apparatus varies widely from perfect efficiency, and the above statement is not rigorously true. As a matter of practical fact, the liquid on each plate is generally free from serious contaminations of heavier material but is not free from lighter material. If then, this condensate from a particular plate be withdrawn to serve as one of the products of the fractionating operation, it is usually desirable to remove from it the lighter materials which are included in it.

The removal of these lighter materials is carried out chiefly for two reasons: The lesser reason is of course return of light products to the column so that they might be recovered with the main fraction to which they belong. The more important reason is that these side streams are usually intended for a product which is sold under a flash specification, and the light ends must be removed to a degree sufficient to meet these specifications.

Present practice of removing these light ends comprises withdrawing the side stream into a stripping tower usually erected independently of the main tower, although in some instances a portion of the main tower may be set aside for this function. The two types of towers are referred to as "external" and "internal" side stream stripping towers, respectively. In the stripping tower the side stream liquid descending over bubble plates is contacted with steam to remove the light ends. This use of steam is quite effective for the purpose intended, but is in many cases a fairly costly operation. To begin with, many refineries are so situated that supplying water fit for steam generation is a costly process requiring extensive wells and pumping systems, and in most cases, requiring water softening operation. Heat must be supplied to make steam, and heat is costly. Only a small portion of the heat in steam at line pressure is utilized in expansive prime movers, and remaining heat, although it represents most of that put into the steam at the boiler house, is at a low temperature level, so exhaust steam requires superheating before its use in distillation equipment due to the fact that the temperature levels encountered are usually above the temperature level of exhaust steam. Further, when the steam is fed into a distillation unit, the condensed water representing pumping and softening cost is usually not recovered for boiler use due to the difficulty of separating it from entrained oil. There is usually sufficient heat wasted, (by way of flue gases, etc.) in distillation equipment to carry all of the heating requirements called for by a stripping medium, without going to the expense of putting heat into water in a boiler. Additionally, other stripping media are available within the distillation unit, and it is possible

by proper use of these stripping media, to avoid the items of water supply cost and cost of steam generation.

It has therefore been an object of this invention to provide a method of side stream stripping which will avoid the use of steam with its attendant costs and to provide apparatus in which this method might be carried out. A further object has been the provision of methods of using waste heat normally available in distillation processes for finishing the side streams of such processes. Further objects have been the provision of means for using steam without such contamination of the condensate as would unfit it for boiler feed, and such further objects and advantages obtained therefrom as may hereinafter appear.

Theoretically, stripping is believed to follow the general rule of partial pressures. That is to say,—at any given temperature the vapor above the liquid being stripped is thought to be composed of steam and light fractions present in molecular percentages, according to the ratio of the vapor pressures of water and of the light fractions respectively at the temperature level existing. It is probable however, that in conditions such as this, where it seems that the use of more steam than called for by this relation is required, that the action is not entirely one of so-called "steam distillation" but one rather of agitating the liquid sufficiently by contact with a gaseous phase to give the light material an opportunity to disengage itself and vaporize. "Steam distillation" as a term is broader than the use of water vapor alone, as any other material which would be vaporous at the conditions of operation, would be useful. For instance, the effect of steam distillation can be obtained by passing incondensable natural gas through the liquid. Or it might be obtained by passing any other light hydrocarbon which could be vaporized at the temperature of operation. In terms of pound-mols of stripping medium used there is in effect a practical equilibrium between the use of any of these and of steam. If the operation is one strictly following the "steam distillation equations" the molecular fraction of stripped materials in the vapor will be carried equally well. If the operation appears to depend on agitation, a mol. of any material in the vapor state occupies the same space as a mol. of water vapor at the same temperature.

We have then, various agencies which may be used for stripping and which are: steam; gases such as air, carbon dioxide, flue gas, etc.; incondensable petroleum gases; and light, condensable petroleum fractions. The use of gases containing oxygen is not to be recommended because of the dangers of oxidation of products, leading to loss of color, sludging, etc. Both inert gases and incondensable petroleum gases have the following disadvantages: 1—they are comparatively expensive to handle; 2—they may not be superheated easily; 3—the presence of incondensable gases renders the operation of condensing product expensive, requiring either a great expansion of condensing equipment or the installation and operation of vapor recovery systems and entailing an inescapable loss of product otherwise condensable.

The remaining stripping medium, light condensable petroleum fraction, lends itself very well to the operation. The fraction used may be one commonly handled and produced by the distillation unit itself, such as a light overhead product, and it may be had for only the cost of pumping. In addition, the presence of such a gas will increase, rather than decrease the efficiency of condensing equipment, as the proportionate amount of incondensable gases present is decreased.

In order that the manner and method of handling this stripping medium may be understood, reference is now made to the drawings attached to and a part of this specification.

Figs. 1, 2, 3, 4, 5, and 6 set forth various methods in which it may be used.

Fig. 1 represents a method of using condensed overhead fractionator products for side stream stripping. In this figure, 1 is a furnace, 2 a fractionating tower, and 3 a side stream stripping tower. Charge enters furnace through line 4 and is discharged through line 5 into fractionator 2, an overhead product being taken through line 6 and a bottoms product through line 7. A side stream is removed through line 8 and introduced into tower 3, vapors from which are returned to tower 2 by line 9. The overhead product from tower 2 passing through line 6 is condensed in 10 and collected in reflux drum 11. Finished product passes out through line 12. A portion of the condensed overhead is withdrawn from 11 by pump 13. Some of the product from pump 13 is passed through line 14 to enter the top of fractionator 2 as wet reflux for the control thereof. The remainder is passed through line 15, superheated to a sufficient degree in coils 16, placed in furnace 1, and introduced to stripper 3 by line 17. Stripped product is removed from 3 by line 18.

In Fig. 2, 19 is a fractionating tower to which vapors are introduced by pipe 20, overhead product is removed by pipe 21, and bottoms product is removed by line 22 and pump 23. From one of the plates in this tower there is removed by means of line 24, a side stream, this stream being discharged into stripping tower 25. Vapors from stripping tower 25 are returned to fractionator 19, through line 26. In order to strip the material going through tower 25, vapor is removed from any desirable point in tower 19, above line 24, by means of manifold 27 and pipe 28. The pumping means by which this vapor is removed may be a fan or other device such as a steam jet pump shown at 29, and this vapor is forced through line 30 to enter the lower portion of stripping tower 25. In order to get sufficient reboiling heat for the operation of stripping tower 25, I may divert a portion or all of the bottoms product from fractionator 19 and pump 23 through line 31, coil 32 in the bottom of tower 25, and line 33, whereby it is returned to pass through the bottoms cooler 34, with other bottoms product. If desired, I may alternatively use superheated steam brought in by line 35 and passed through coil 32. It will be noticed that this steam is used in a closed coil and therefore is not in any way contaminated with oil, and its condensate may be returned to the boiler for steam generation.

Fig. 3 shows a variation of Fig. 1, using condensed overhead as stripping media. In Fig. 3, 36 is the main fractionating tower, discharging overhead product through line 37 and bottoms product through pump 38. A side stream is taken through line 39 to stripper 40, vapors from which return through line 41. As before, fractionator overhead passing through line 37, is condensed in 42 and collected in reflux drum 43, a portion being withdrawn as product through 44. A portion of the condensed overhead is taken from drum 43 by pump 45 and sent through line 46 as wet reflux for the control of fraction-

ator 35. A further portion is introduced through line 47 into stripper 40 to act as stripping media. Reboiler heat for stripper 40 is had by bypassing a portion or all of the bottoms product from tower 35 and pump 38 through line 48 to coil 49 in the bottom of stripper 40, returning it by line 50 to pass through cooler 51. Alternatively if desired, coil 49 may be heated by superheated steam passing through lines 52 and 53.

Fig. 4 shows another method of getting reboiler heat for the operation of the side stream stripping tower. In this figure, 54 is the main fractionating tower fed by vapor line 55 and having overhead product taken to line 56 and bottoms product through line 57. A side stream is withdrawn through line 58 to stripper 59, vapors from which are returned through line 60 and stripped product from which is removed by line 61. As before, the overhead products from the main tower are condensed in 62 and collected in drum 63. A portion of them are returned by pump 64. This condensed product from pump 64 may pass optionally through line 65 and/or line 66 as desired for purposes of tower control. Line 65 connects with reflux condensing coil 67, placed in the top of tower 54 and line 66 connects as a bypass around that reflux condenser coil 67, allowing accurate control of the top temperature of 54. The condensate from 67 and 66 joins in line 68 to pass through coil 69 located at some point in the tower below the level of line 58, and the condensate thus heated to a temperature at or even above the level of the liquid flowing down through stripper 59, is introduced into stripper 59 through line 70 to act as stripping medium.

Fig. 5 sets forth still another way of getting reboiler heat for the side stream stripping tower. In this case, 71 is the main fractionator supplied with vapors through line 72, delivering overhead through line 73 and bottoms product through line 74. A side stream is removed through line 75 and sent to stripper 76. Vapors from the stripper are returned through line 77 and stripped product is withdrawn through line 78. As before, overhead product is condensed in condenser 79 and collected in reflux drum 80. A portion is removed as product through line 81 and a further portion is returned to the system by pump 82. Some of this passes through line 83 to act as wet reflux for control of the fractionator, and some of it passes through line 84 to act as stripping medium in stripper 76. A partition 85 is placed in tower 71 at some point below the level of line 75. This partition is equipped with a goose neck or other device 86, so that liquid may pass down through it while the rising of vapors past the partition is prohibited. Vapors from below the partition are passed through line 87 which should be pitched to drain back to tower 71, and passed through coil 88 in tower 76, returning to tower 71 by line 89. These vapors coming from a point in tower 71 which has a higher temperature level than the liquid withdrawn through line 75, will give up reboiler heat to stripper 76.

In Figure 6, 90 is the main fractionator, fed through line 91, overhead product vapors being removed through line 92 and bottoms through line 93. Side stream product is removed through line 94, to stripper 95, vapors from which are returned to fractionator 90 by line 96. Stripped side stream product is removed through line 97. Overhead product passing through line 92 is partially condensed in condenser 98, and this condensate is separated in separator 99. Reflux for the control of the fractionator top temperature may be returned from separator 99 by pump 100, and product condensate removed through line 101. Uncondensed vapors are removed from separator 99 through line 102 and condensed in condenser 103. This condensate is collected in separator 104 and comprises a very volatile fraction of the total overhead product. Condensate is withdrawn from 104 through line 105 and combines with condensate from 99 in line 106. Uncondensed gases are withdrawn through line 107. A portion of the condensate from 104 is passed through line 108 to the bottom of stripper 95, there to act as a stripping medium. Due to its volatility, this medium presents advantages over the use of a portion of the total condensate. Due to the fact that amounts withdrawn from separators 99 and 104 by means 100 and 108 are practically constant, the material passing out through line 106 is of practically constant composition and at all times approximates the composition of an overhead distillate totally condensed in one step. In order to supply reboiling heat to stripper 95, I make use of line 109, bringing fractionator bottoms from pump 93 to coil 110. This oil returns through line 111 to the main stream of bottoms product which is cooled in cooler 112 and withdrawn, through line 113. I may alternately use superheated steam in coil 110, making use of lines 114 and 115.

From the above descriptions it may be seen that my method of stripping side streams contemplates the use of various combinations of several stripping media and of several methods of gaining reboiler heat. I may use as stripping medium either vapors from a point in the main column above that at which the side stream arises,—or I may use condensed overhead product of the fractionator, or I may use a light, but condensable fraction of that overhead. It is of course entirely possible, and entirely within the contemplation of my invention to make use of vapors or condensates of similar character arising from sources entirely separate from the system from which the side stream arises. The vapor used might be from an entirely separate fractionating system, and the liquid might be from storage. In combination with the particular stripping medium selected, I may use any of the several methods of heating, alone or in combination, such as liquids or vapors from a higher temperature portion of the main fractionator passed through the stripper in a closed heater coil, examples of the liquid so used being either fractionator bottoms or refluxing liquid from a point in the main fractionator below the side stream origin; or I may use steam, either live or exhaust, separately superheated or superheated with waste heat from the distillation system, in a closed coil in the stripping tower, so that clean condensate water may be recovered. If the stripping medium be liquid at the point where it is first picked up, I may convey reboiling heat to the stripping tower by superheating the stripping medium either by waste flue gas heat within the distillation unit, by heating it in coils within the main fractionator, or by other suitable means.

All of these methods are applicable to systems of fractionation operating under any pressure, either sub-atmospheric, atmospheric, or super-atmospheric.

It is realized that numerous mechanical and process equivalents exist for these disclosures, and these equivalents are contemplated as being

a part of this invention except insofar as it is limited by the following claims.

I claim:

1. That method of fractionating hydrocarbons which comprises introducing hydrocarbon vapors into a main rectification zone, in which a stream of vapors is contacted in countercurrent with the stream of liquid condensed therefrom, removing a portion of the liquid stream from said rectification zone at a point intermediate its ends, introducing such portion to a second fractionating zone, contacting it therein with a portion of the vapor stream of the main fractionator withdrawn in vapor form from a point in the main fractionator where the temperature level is lower than the temperature of the withdrawn liquid portion and introduced to the second fractionator as a vapor, returning said vapors to the main fractionator, supplying heat to said second fractionator to assist in vaporization of the light material entrained in the withdrawn liquid portion and removing said liquid portion from said second fractionator as a product stripped of light ends to a desired degree.

2. Apparatus for fractionating hydrocarbons and the like comprising a fractionator, feed means therefor, means for removing overhead product therefrom, means for removing bottom product therefrom, means for removing a liquid side stream therefrom, a stripper into which said side steam is discharged, means for removing a vapor from the fractionator at a point lower in temperature than the temperature of the side stream and introducing it to the bottom of said stripper, means to return vapor from the stripper to the fractionator, and means for heating said stripper.

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