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METHOD AND APPARATUS FOR DISTILLATION OF HYDROCARBONS

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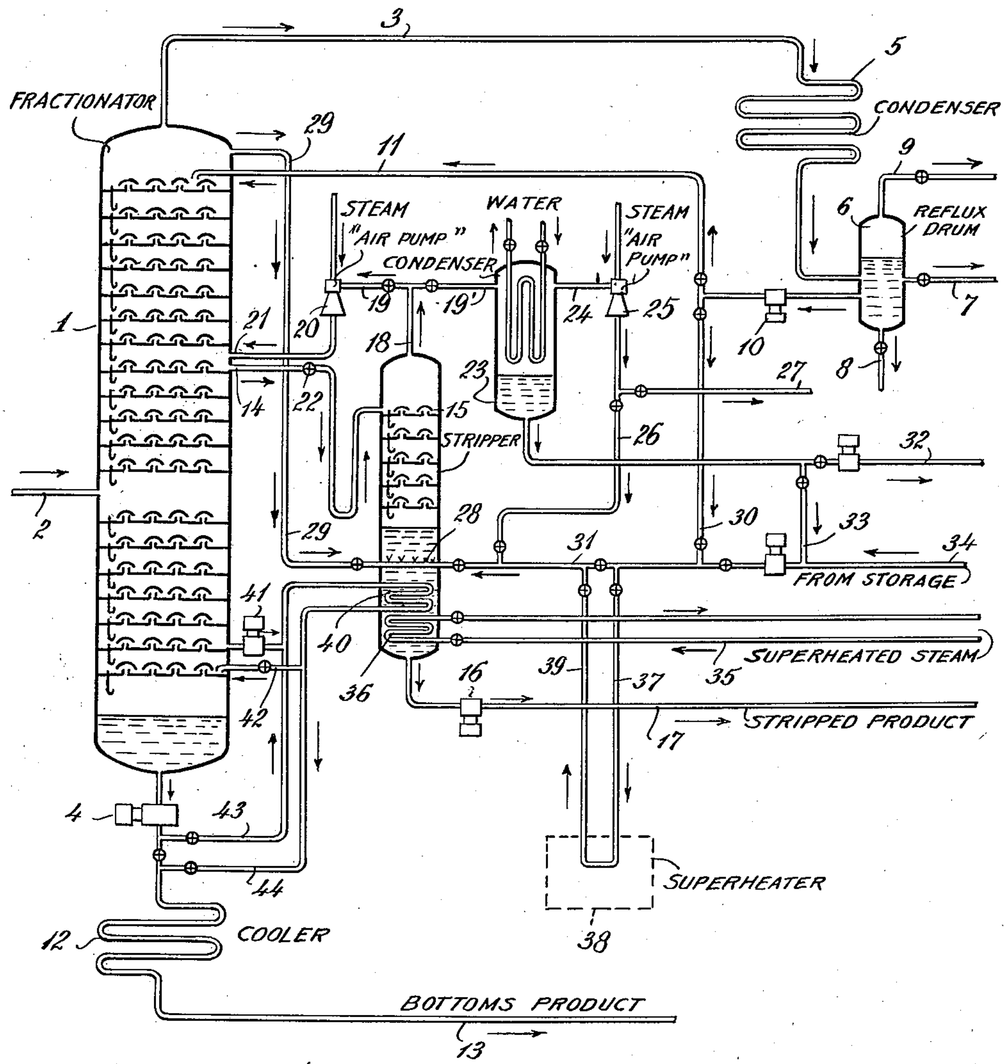

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METHOD AND APPARATUS FOR DISTILLATION OF HYDROCARBONS

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4 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 it 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 unvaporized 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. The use of steam in this manner is quite effective for the purpose intended. However, steam may be a comparatively costly agent to use in such operations.

It has therefore been an object of this invention to provide methods of stripping by the use of stripping media other than steam, and to provide apparatus in which the use of these media may be carried out. A further object has been the provision of means and methods whereby a greater accuracy of control of the stripping operation might be had. Further objects have been the provisions of means and methods for using waste heat from the main fractionation process for the operation of the side stream stripping, means and methods of using stripping media in a cyclic system, and means and methods for decreasing the total amount of heat usually called for by such a process and reducing the cost of the stripping operation, as well as such further objects and advantages 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.

With all of the media above mentioned, as in fact with all stripping media, it is necessary that the light end material dissolved or occluded in the side stream liquid be vaporized. This operation requires heat. Frequently the temperature of the stream is sufficiently high so that if it is not cooled, these light end materials will in time vaporize. Commercially, it is not economical to wait for this action. If the stripping medium introduced be at the same temperature level as the side stream liquid, it is possible to accomplish this vaporization in a much shorter time. Heat however, is costly, and a much more economical use of heat units can be made in some form of heat pump than in a mere heating operation. To express this more concretely, I have found that if the side stream stripping tower be placed under an absolute pressure less than that of the fractionator in which the side stream originates, the efficiency of action of stripping media is increased and the accuracy of control of the stripping operation is increased. In some cases a marked economy of stripping medium may also be had.

In order that my application of these principles may be understood, reference is now made to the drawing attached to and made a part of this specification.

In the drawing, 1 denotes a fractionator fed through the line 2, overhead product being removed through line 3 and bottoms product through pump 4. Line 3 communicates with condenser 5 in which the overhead product is condensed, the condensate being collected in reflux drum 6 and product removed to storage through line 7. Line 8 serves to withdraw water which might be collected in the reflux drum and uncondensable gases separated in the reflux drum are removed through line 9. Pump 10 taking suction upon the reflux drum, returns a portion of the condensate through line 11 to the top of the fractionator for control of its top temperature. Bottoms product is passed through cooler 12 and line 13 to storage. A side stream may be withdrawn through line 14 and passed into stripper 15. Stripped product from this stripper may be removed by pump 16 and line 17. Vapors from the stripper are removed through line 18 and may pass optionally as later described through lines 19 and 19'. A steam jet vacuum pump of the type known as an "air pump" is installed at 20, forcing stripper vapors into fractionator through line 21. Operation of this pump, which may or may not be equipped with a condenser as desired, serves to produce a differential pressure between stripper 15 and fractionator 1, the liquid flowing through line 14, being restrained by a valve 22. Optionally, vapors from line 18 may pass through line 19' into water-cooled condenser 23, wherein condensable constituents are condensed and collected, uncondensable vapors being removed through line 24 by "air pump" 25 discharging into line 26. These vapors may be discharged from the system through line 27. The stripping medium may be any one of the several media available. For instance, I might use the circuit 19', 23, 24, 25 and 26 in such a way that practically all of the condensable material is condensed in 23, the uncondensable gases and steam from 25 then passing through line 26 to spray 28 installed in the bottom of stripper 15 and therein acting as a stripping medium. It is also possible for me to use, while using either air pump 20 or air pump 25, vapors from the main tower at a point above the stripping level. Preferably, when doing this, I withdraw vapors from the tower through line 29, communicating with spray 28 and return those vapors to the tower through 18, 19, 20 and 21. I may also make use of condensed fractionator overhead product as a stripping medium, in which case a portion of the liquid from pump 10 is diverted through lines 30 and 31 to the spray 28. If desired, when this material is being used, air pump 20 is used and the circuit of the stripping material is through the fractionator and the main condenser. It is similarly possible to use the circuit through condenser 23, in which case the stripping medium, together with stripped light end material, is condensed and collected in condenser 23, in which case it may be removed from the system through line 32, or returned for use through line 33. It is also possible in this connection, to run condenser 23 quite hot, keep the stripping media in vaporous form, and recirculate it through line 26 as hereinbefore described. If desired, a light liquid product suitable as stripping media may be brought from storage through line 34.

In most of the cases above outlined it will be found necessary to supply some reboiler heat to the bottom of the stripping tower. This can of course be supplied by passing superheated steam from line 35 through coil 36. In this connection

I prefer to make use of indirect heat exchange in order that all of the steam may be condensed, and recovered as a clean water suitable for boiler purposes, thus avoiding incurring the loss of water by collecting it as condensate in company with oil and unfitting it for use as boiler water. If a liquid stripping medium is being used, it is quite possible to gain the necessary reboiling heat by passing that liquid from line **31** through line **37**, superheater **38** and line **39**, the superheater **38** being located preferably in a flue gas pass of the main heater, furnishing the heat for the operation of the main fractionator, although it may be separately fired, or may even be located in another unit. It is also entirely within my contemplation of this invention that instead of the indicated superheater, **38** might be partial condenser coils located at some point in fractionator **1** where the temperature level is higher than the temperature at the point of side stream withdrawal. I may also make use of heat from the hotter portions of fractionator **1**, as considerable heat at a level sufficiently high for my purposes, is frequently rejected in the liquid products from the bottom of the tower. To this end I make use preferably, of a second coil **40** in the bottom of stripper **15**. To heat this coil I may remove liquid from a low portion of the tower by pump **41**, returning it by line **42** or by the use of lines **43** and **44**, I may use bottoms product of the tower prior to cooling.

From the above description, it may be seen that my method of stripping side streams contemplates the use of vacuum or of any pressure lower than the pressure at which the main fractionator operates, combined with the use of any one or more of several stripping media, in turn combined with the use of any one or more of several methods of gaining reboiler heat.

All of these methods are applicable to any system of fractionation operating in the main tower under a pressure above the best vacuum obtainable under the particular conditions, at the particular location of the installation. In general, it will be quite widely applicable, as the practical considerations which govern the degree of vacuum obtainable will not rule so heavily in the case of the smaller quantities of vapor to be handled from the stripper, as in the case of the main fractionator. Consequently, I may say that the system herein set forth can be applied over the entire practical range of operating pressures.

It is realized that numerous mechanical and process equivalents exist for this disclosure, 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 for the fractionation of hydrocarbons and the like which comprises the steps of fractionating vapors thereof in a main fractionator, removing an overhead vapor stream from said fractionator, removing a bottom stream from said fractionator, removing a liquid side stream from such fractionator, introducing such liquid side stream into a stripping zone, removing a second vapor stream from the top of the main fractionator, introducing said second vapor stream into the bottom of the stripping zone to pass therethrough countercurrently to the liquid side stream, evacuating vapors from the stripping zone under a pressure less than that in the main fractionator at the level of side stream removal, compressing such vapors and returning them to the main fractionator at a point adjacent the removal of said side stream.

2. The method for the fractionation of hydrocarbons and the like which comprises the steps of fractionating vapors thereof in a main fractionator, removing an overhead vapor stream from said fractionator, removing a bottom stream from said fractionator, removing a liquid side stream from such fractionator, introducing such liquid side stream into a stripping zone, removing a second vapor stream from the top of the main fractionator, introducing said second vapor stream into the bottom of the stripping zone to pass therethrough countercurrently to the liquid side stream, evacuating vapors from the stripping zone under a pressure less than that in the main fractionator at the level of side stream removal, condensing readily liquefiable constituents from said vapors, and returning the uncondensed portion thereof to the bottom of the stripping zone.

3. In an apparatus for fractionating hydrocarbons and the like, a main fractionator, feed means therefor, means to remove overhead fractionator product therefrom, means to remove bottom product therefrom, means to remove a liquid side stream therefrom, a stripping tower into which said side stream is discharged, means to remove main fractionator overhead vapors from a point adjacent the top of said main fractionator, and introduce them into the bottom of said stripping tower, means to withdraw stripped side stream from the stripping tower, means to withdraw vapors from the stripping tower, means to effect such withdrawal of vapors under a reduced pressure, and means to return said vapors so withdrawn to a point in the main fractionator adjacent the point of removal of the liquid side stream.

4. In an apparatus for fractionating hydrocarbons and the like, a main fractionator, feed means therefor, means to remove overhead fractionator product therefrom, means to remove bottom product therefrom, means to remove a liquid side stream therefrom, a stripping tower into which said side stream is discharged, means to remove main fractionator overhead vapors from a point adjacent the top of said main fractionator and introduce them into the bottom of said stripping tower, means to withdraw stripped side stream from the stripping tower, means to withdraw vapors from the stripping tower, means to effect such withdrawal of vapors under a reduced pressure, a condenser through which such withdrawn vapors are caused to pass and means to return vapors remaining uncondensed to the bottom of said stripping tower.

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