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[54] **LIGHT HYDROCARBON ABSORPTION AND FRACTIONATION**
4 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **208/341,** 208/351, 208/358
[51] **Int. Cl.** **C10g 5/04**
[50] **Field of Search** 208/341, 358, 351

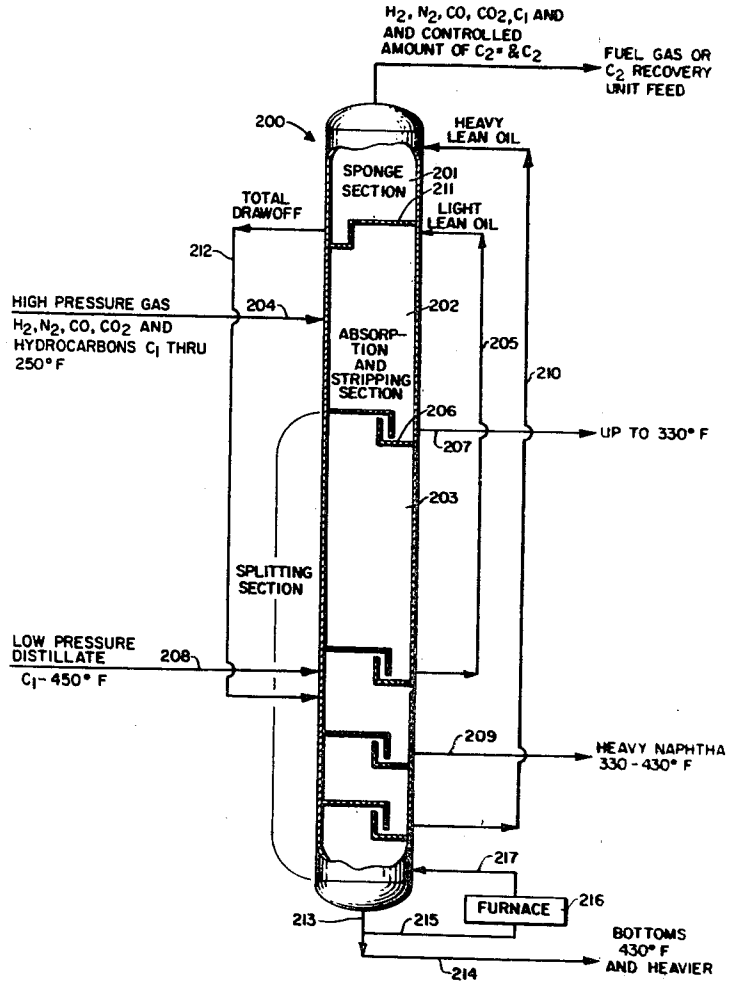
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ABSTRACT: A mixture of gaseous and liquid hydrocarbons are processed in an integrated column in which absorbing, demethanizing (or deethanizing or depropanizing) and splitting operations are combined. Gaseous feed is introduced to the absorber section and liquid feed to the absorber section and/or the splitter section. A light naphtha fraction from the splitter section is used as the primary absorbing medium in the absorber section. Heavy naphtha, also from the splitter section is used as lean oil in a sponge section, primarily to remove light lean oil from absorber section overhead. Absorber fat oil, light naphtha, heavy naphtha, bottoms and fuel gas are or can be produced as products.



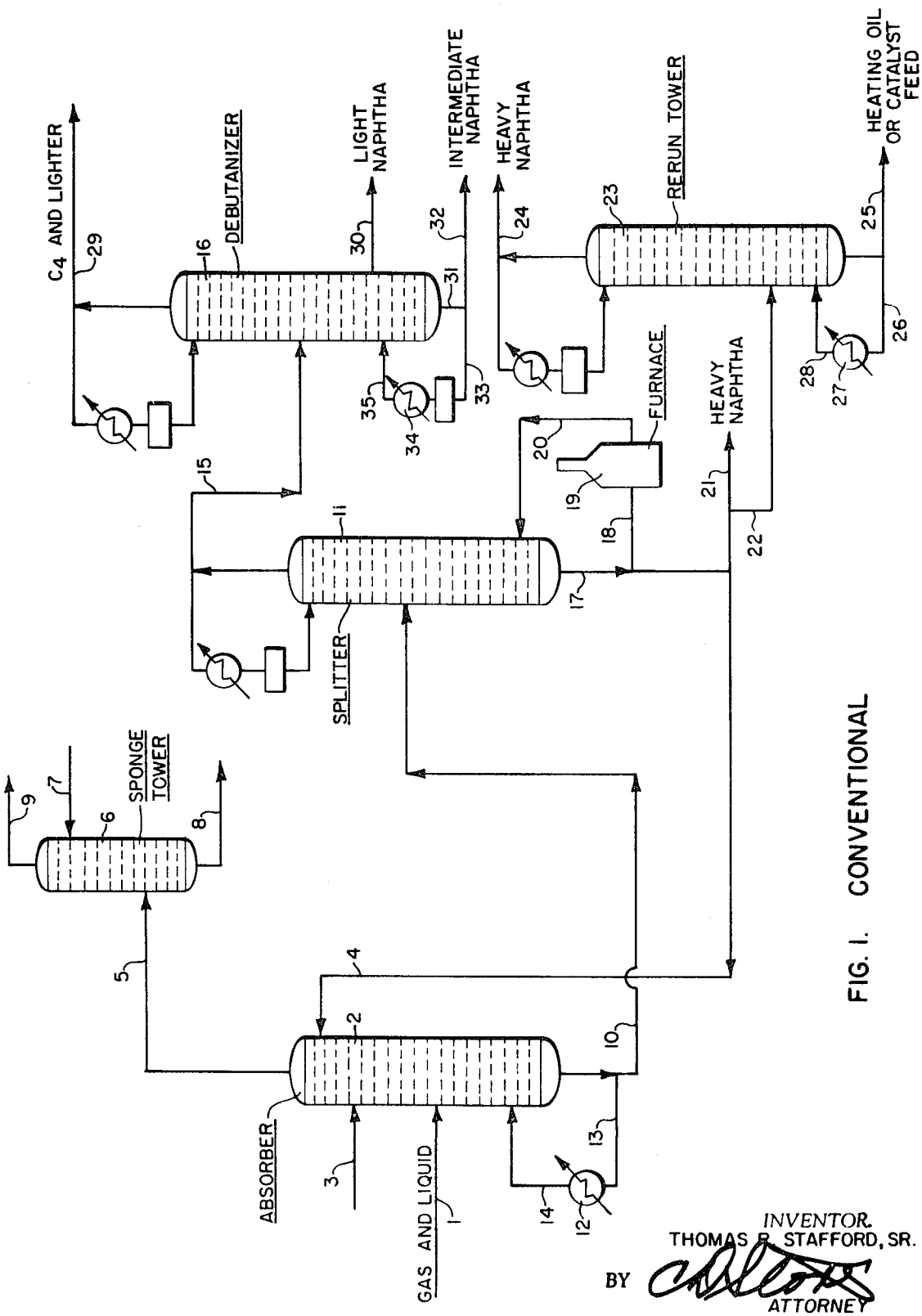
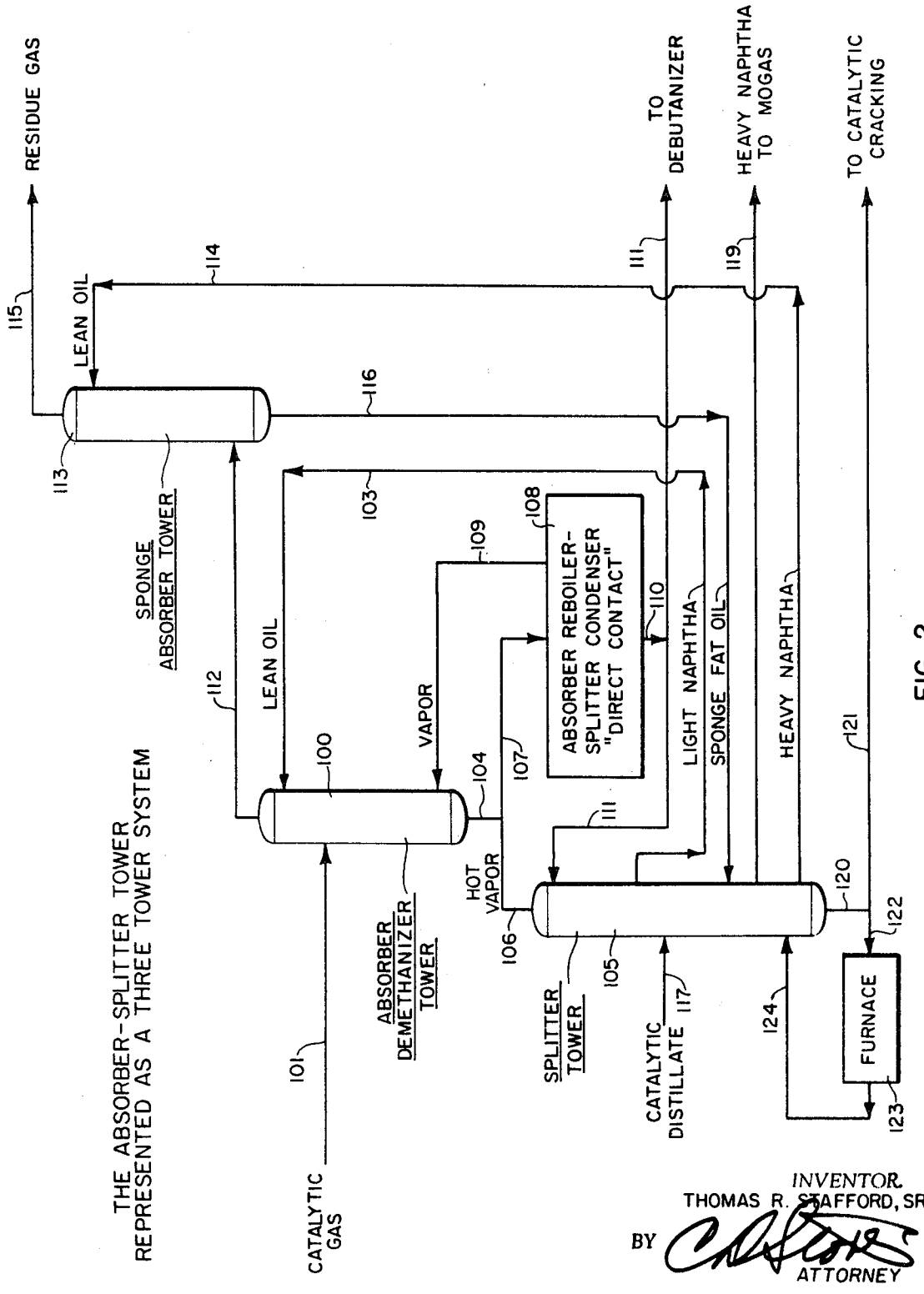


FIG. 1. CONVENTIONAL

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THE ABSORBER-SPLITTER TOWER REPRESENTED AS A THREE TOWER SYSTEM

FIG. 2.

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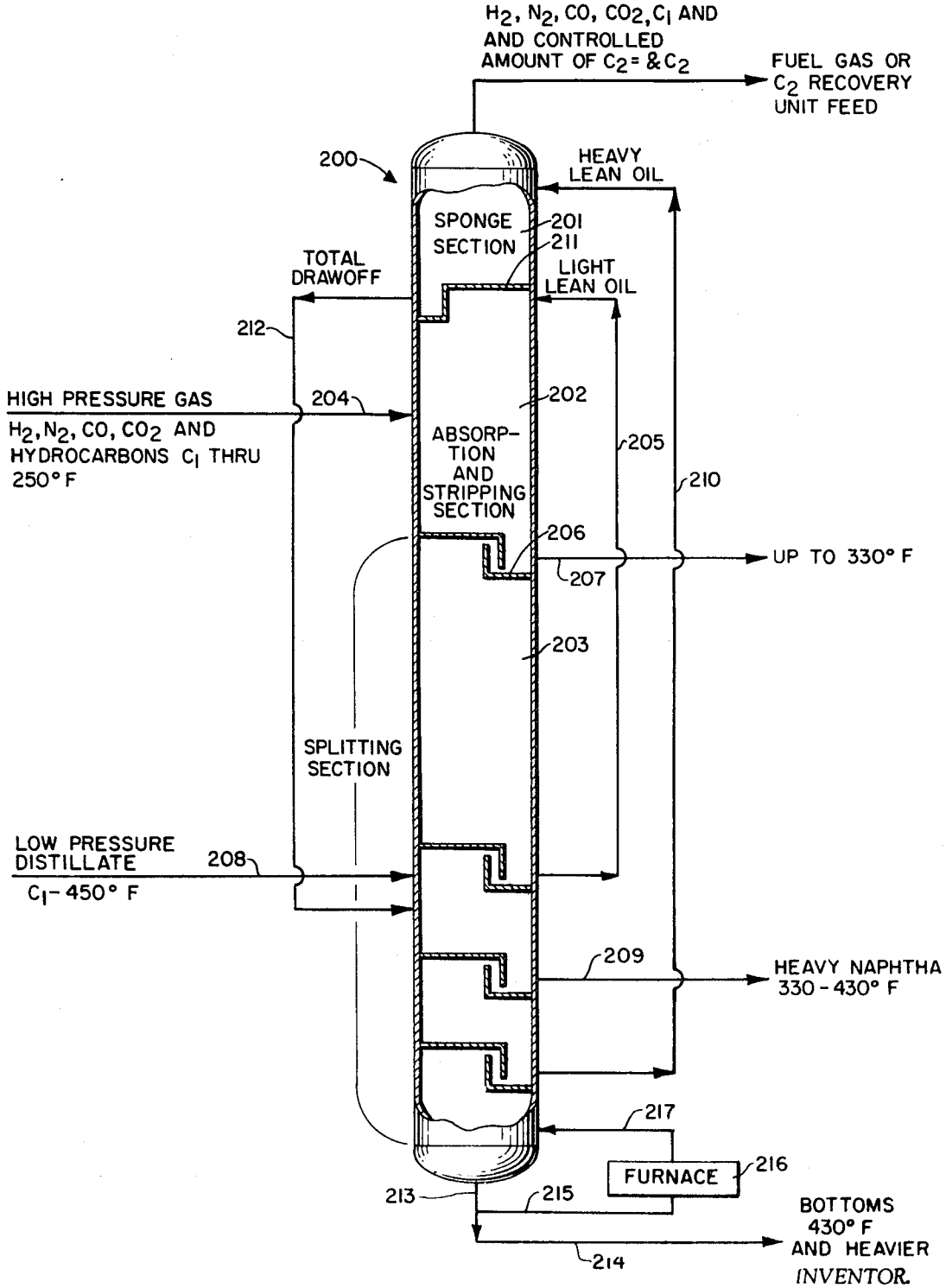


FIG. 3.

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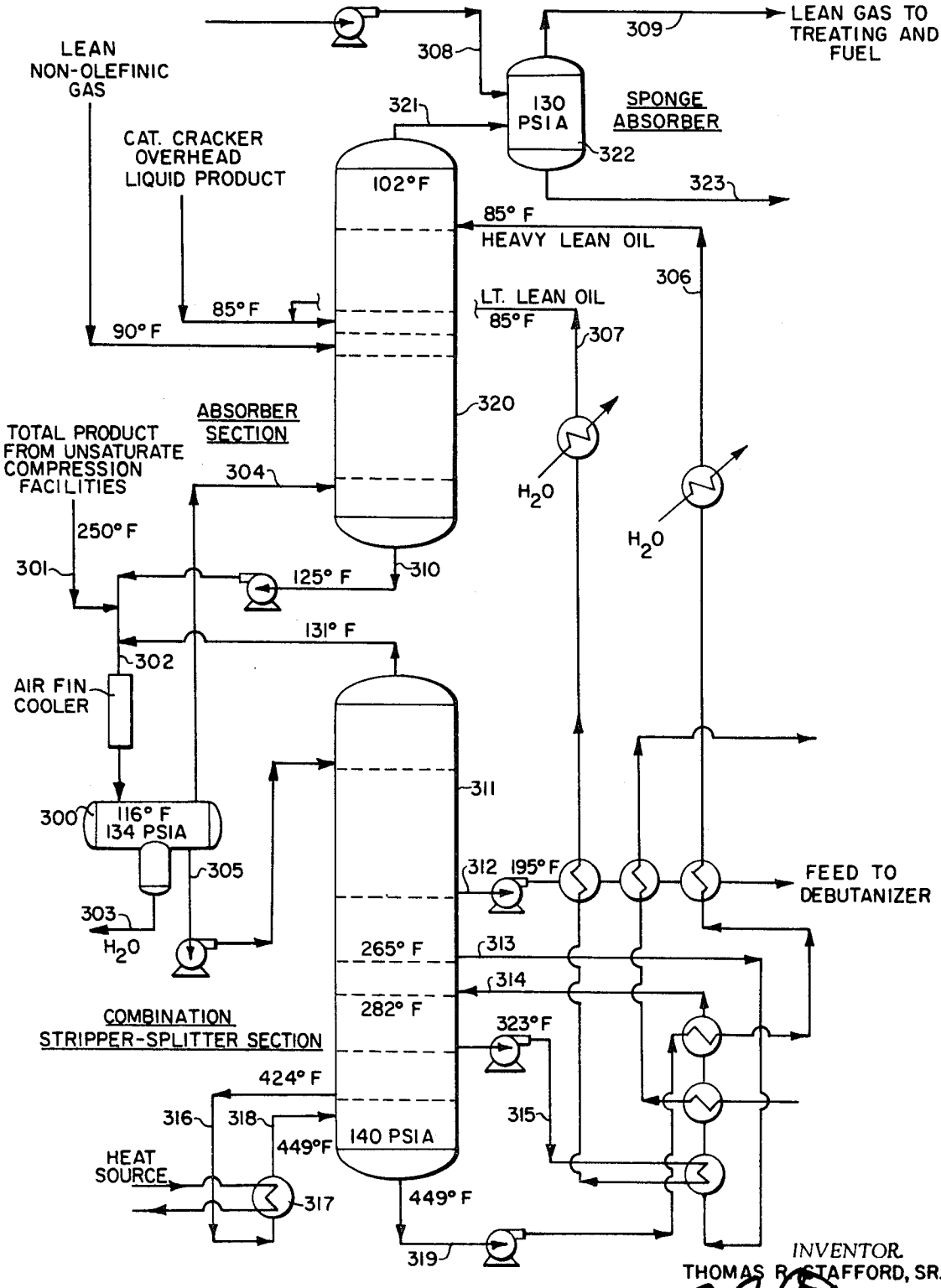


FIG. 4.

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LIGHT HYDROCARBON ABSORPTION AND FRACTIONATION

BACKGROUND OF THE INVENTION

This invention relates to an improved method for processing liquid and gaseous hydrocarbons such as the fractionator overhead from a catalytic cracking unit.

The invention combines and expands the advantages inherent in various absorbing, splitting and demethanizing flow sequences in one simple and compact absorbing and fractionating tower.

At the normal catalytic cracking unit, motor gasoline and lighter materials are produced as fractionator overhead vapor and liquid products. The vapor product contains most of the butane and lighter material and a small portion of the motor gasoline boiling range material (pentane and heavier). The liquid product consists primarily of material in the motor gasoline boiling range.

Various processing schemes are employed to recover the desired material from the vapor product and to separate the recovered material and liquid product into the desired fractions. Each of the various processing sequences has its own advantages. Common to essentially all processing schemes are absorbing, splitting and debutanizing operations. Most of the absorbers contain a heated stripping section to remove unwanted material from the fat oil product.

The conventional method for handling the overhead from a catalytic cracking fractionator introduces the gaseous and liquid products (either at the same point or at different points) to an absorption unit where absorption oil (lean oil) and heat are used to recover (absorb) the desirable material as a fat oil and purge out the undesirable material as absorber overhead tail or residue gas). The overhead from the absorber is passed to a second absorber where it is contacted with a heavier absorbent such as a heating oil fraction or heavy naphtha fraction. The overhead from this absorber is used as fuel gas (or further processed if desired) while the fat oil may be fractionated as desired. The fat oil from the first absorber is generally fed to a second tower, often called a splitter, which separates a heavy naphtha bottoms and a light overhead which can be debutanized to separate butane and lighter overhead, a light naphtha as a sidestream and an intermediate naphtha fraction as bottoms. If desired, the heavy naphtha fraction may be separated in a rerun tower into a heavy naphtha overhead and a heating oil fraction, suitable as such or as feed to catalytic cracking.

It is also known in the prior art to first debutanize the fat oil from the first absorber and then pass the bottoms from that tower to a splitter from which light naphtha is taken off overhead and heavy naphtha as bottoms. Other side streams may be removed from the splitter as desired.

Each of the towers described above requires its own heat input, usually reboiler sections, overhead product pumps and condensers, accumulator drums, heat exchangers and various pressure, temperature, flow and level control and recording systems.

SUMMARY OF THE INVENTION

The present invention provides large improvements over prior art methods by combining in one tower the functions of the several towers of the prior art. By combining absorbing, stripping and splitting operations in one tower, the following advantages result:

1. Hot vapors from the splitter section will supply heat to the stripper section (normally bottom section of a reboiled absorber tower). This eliminates the need for splitter reflux and overhead product pumps, splitter overhead condensers, splitter accumulator drum, absorber reboiler exchangers and various pressure, temperature, flow and level control and recording systems. Complete recovery of the heat contained in the splitter section overhead vapors is accomplished. In present processing schemes, splitter overhead vapor temperature levels permit recovery of only a small portion, if any, of the heat contained in this stream. The one tower will be more economical to build, operate and maintain.

2. Complete advantage is taken of the separation afforded by the partial condensation occurring in the catalytic cracking units fractionator overhead accumulator. The light motor gasoline fraction contained in the vapor product is recombined with the liquid product in such a way that this material does not have to be reseparated from the heavier motor gasoline fractions. This reduces equipment size and utility consumption.

3. Tower loadings, and therefore tower size, are reduced by the unique manner in which the vapor and liquid feed streams are introduced into the absorber splitter tower and the manner in which the product streams are withdrawn. Although the required amount of lean oil (absorbing medium) and all of the catalytic cracking unit fractionator overhead product are contained in the absorber splitter tower, these materials are distributed so that tower loadings are not excessive in any section. Controlled absorption of all components is possible at minimum tower size.

4. Because only one tower is involved and this tower feeds the overhead products of another tower, the products of thermal degradation are not present above the bottom tray of the absorber splitter. This permits the withdrawal of the heaviest motor gasoline fraction as a sidestream below the lower feed tray. This reduces tower size and utility consumption.

5. The unique flow sequence, which results when the absorber splitter tower is combined with other towers, permits absorbing, splitting and debutanizing operations to be accomplished with minimum utility consumption and minimum equipment size and number. This occurs because all material is produced as an overhead product only one time during absorbing, splitting and debutanizing operations. The overhead vapor from the splitter section (of the absorber splitter) may be considered as an overhead product. However, all heat is recovered from this material and tower loadings in the stipper section are approximately the same as that which would occur if a separate reboiler absorber was being used.

BRIEF REFERENCES TO THE DRAWINGS

FIG. **1** represents a conventional method for separating a mixture of gaseous and liquid hydrocarbons.

FIG. **2** represents the present invention in functional form to show how the invention operates and differs from the conventional form illustrated in FIG. **1**.

FIG. **3** represents the actual single tower contemplated by the present invention.

FIG. **4** shows another embodiment of the invention in which the absorber, stripper, and splitter sections are integrated.

DETAILED DESCRIPTION OF THE DRAWINGS

Conventional Design

Referring now to FIG. **1**, a gas and liquid feed stream, for example, the total overhead from the fractionator of a catalytic cracking unit (containing hydrogen, nitrogen, carbon dioxide, hydrogen sulfide and various hydrocarbons, ranging from methane to material boiling as high as 450° F.) is introduced by line **1** to absorber **2**. If desired, the liquid feed may be introduced further up the tower, as by line **3**. Light lean absorption oil is introduced by line **4** and flows down the tower absorbing both desirable and undesirable components. Unabsorbed components are removed overhead through line **5** and are passed to sponge tower **6**, where they contact heavy lean absorption oil introduced by line **7**. This lean oil generally boils in the neighborhood of 330°–430° F. However a heavier lean oil, such as 430–600 fraction may be used if desired. The sponge absorber may or may not be equipped with a reboiler. The fat oil is removed by line **8** while the overhead, consisting of H_2, N_2, CO_2, H_2S, C_1, and controlled amounts of C_2 saturates and unsaturates, leaves by line **9**.

Returning to absorber **2**, the fat oil leaves by line **10** and is passed to splitter **11**. A portion of bottoms is passed through heater **12** by line **13** and returned to the absorber **2** by line **14** to supply heat thereto. The splitter serves to separate the absorbed portions of the fat oil from the absorption oil itself and to separate the absorbed materials and liquid feed (to absorber) into the desired fractions. The lighter portions are removed by line **15** and passed to debutanizer **16**. Splitter bottoms, consisting of both recycle absorption oil and heavy product, are removed from splitter **11** by line **17** and a portion returned to absorber **2** by line **4**. A portion is also passed by line **18** through heater **19** and line **20** back to the splitter to supply heat thereto. The remainder of the absorber oil is removed as product heavy naphtha through line **21**. However, if desired, it may instead be passed by line **22** to rerun tower **23** and separated into heavy naphtha proper which is removed by line **24** and heating oil through line **25**. As usual, a portion is passed by line **26**, heater **27**, and line **28** back to the rerun tower to supply heat thereto.

The overhead from the splitter **11**, passed to the debutanizer **16** by line **15**, is stabilized to remove butane and lighter overhead through line **29**. A light naphtha fraction may be removed as a sidestream through line **30** while the bottoms are removed through lines **31** and **32** as an intermediate naphtha fraction. A portion is returned to the debutanizer to supply heat thereto by passage through line **33**, heater **34** and line **35**.

As can be seen, this conventional system requires at least four and possibly five separate towers with their attendant reboiler and reflux equipment.

THE INVENTION

Turning now to FIG. **2**, the simplest embodiment of the present improved system is described.

The unique design of this invention combines absorption, sponge absorption, demethanization (or deethanization, or depropanization) of fat oil, splitting of distillate feed and processing of fat oils into a single tower. Although the unique integration of these functions enables all of these operations to be combined into a single integrated tower, the various stages will perform the same functions as a three-tower system having separate splitter, absorber-demethanizer (or absorber-deethanizer or absorber depropanizer) and sponge absorber towers. For this reason, the absorber-splitter operation is easier to understand if the tower is considered in sections corresponding to these towers. The splitter section is used to prepare light and heavy naphtha (lean oil) for use as the absorbing medium in the absorber sections, process the fat oil from the sponge absorber section and separate the distillate feed into the desired fractions. The required heat removal in the top portion of the splitter section is provided by the liquid overflow from the bottom of the absorber-demethanizer section. The absorber-demethanizer section is used for the selective recovery of materials from the fresh feed gas. Heat required for stripping unwanted components from the fat oil is provided by direct contact with hot vapors from the splitter section. The sponge absorber section is used primarily to recover equilibrium light lean oil from the vapor leaving the absorber-demethanizer section. Overall component recovery and separation is equal to that obtained by conventional light ends processes as described in FIG. **1**.

In FIG. **2**, a gaseous stream, from catalytic cracking compression facilities, for example, and which contains various components boiling up to approximately 250° F. is introduced to absorber-demethanizer **100** by line **101** where it contacts lean absorber oil introduced by line **103**. Condensate (light liquid) may also be introduced at the point of gaseous feed introduction or bypassed directly to debutanization. The lean oil absorbs both desirable material (such as propylene and heavier) and undesirable material (such as methane and lighter). The fat oil leaves the absorber through line **104** where it contacts the overhead vapors leaving splitter tower **105** by line **106**. The mixture passes by line **107** to "condenser-reboiler" **108**. This "absorber-reboiler" representation is shown for functional purposes only and is actually several stages within the tower itself. Vapors leave "condenser reboiler" **108** and return to the bottom of the absorber **100** by line **109**. Condensate is removed from **108** by line **110** an passes to the top of the splitter tower **105** by line **111** or is removed to debutanizer (not shown).

Overhead from the absorber **100** is removed by line **112** to sponge absorber **113** where it contacts heavy lean oil introduced by line **114**. Overhead light gaseous product is removed from the sponge absorber **113** by line **115**. Bottoms (fat oil) from the sponge absorber are removed by line **116** and passed to the lower part of splitter tower **105**.

A liquid feed from the overhead accumulator of a catalytic cracking fractionator and boiling C_1 to 450° F. (low pressure distillate) is introduced to the middle portion of the splitter tower **105** by line **117**. A light naphtha fraction is withdrawn from a plate above the feed plate by line **103** and used as the lean oil in the absorber tower **100**.

A heavy naphtha fraction is removed near the bottom of the splitter tower by line **114** and used as the lean oil in the sponge tower **113**. A heavy naphtha suitable for use as motor fuel may be withdrawn at a point slightly above the heavy naphtha lean oil point of withdrawal as by line **119**. Bottoms from the splitter tower are withdrawn by lines **120** and **121** as catalytic cracking feed. A portion of the bottoms product is passed by line **122**, furnace **123** and line **124** to supply heat to the splitter tower.

It is evident that the above scheme eliminates all but one reboiler unit and all the reflux-condenser units found in the conventional setup as described in FIG. **1**. However, as pointed out above, FIG. **2** is only representative of the functional steps integrally combined in the single tower of this invention. The integrated tower utilizing the functions in the manner described in FIG. **2** is shown in FIG. **3**.

Referring now to FIG. **3**, a single tower **200** is provided with three sections, a sponge absorber section **201**, an absorber and stripper section **202** and a splitter section **203**. A gaseous feed from catalytic cracking compression facilities containing hydrocarbons with a boiling range of C_1 to 250° F. is introduced by line **204** to the absorber and stripper section **202** of tower **200** where it meets a light absorber oil introduced at 105° F. by line **205**. Condensate from the gas compression facilities may also be introduced at this point if desired or bypassed directly to debutanization. The lean oil absorbs both desirable and undesirable components from the feed and the resulting fat oil passes down the absorber, being stripped of unwanted components and accumulating on the bottom plate **206** thereof from which a sidestream containing material boiling up to 330° F. is withdrawn by line **207**. Liquid not withdrawn passes down into splitter section **203** into which the liquid phase from the accumulator of a catalytic cracking fractionator is introduced through line **208**. A light naphtha fraction is removed, above the point of accumulator liquid introduction, by line **205** as the lean absorber oil used therein. A heavy naphtha fraction boiling 330–430° F. is withdrawn by line **209** as product and a slightly heavier naphtha fraction is withdrawn at a slightly lower point through line **210** which is introduced into the top of sponge absorber section **201**. A pierced plate **211** separates the sponge section **201** from the absorber section **202**. This allows vapors to pass upward through the plate but prevents the downflow of liquid through the plate. For this reason all the sponge fat oil accumulates on plate **211** and is withdrawn through line **212** and passed to the midpart of the splitter section **203** where it is fractionated along with the feed introduced through line **208**. Heavy bottoms boiling 430° F. +are withdrawn at about a temperature of 580° F. and 140 p.s.i.g. by lines **213** and **214**. A portion is passed by line **215**, furnace **216** and line **217** back into the bottom of the splitter section **203** to supply heat thereto. The bottoms are suitable as feed to catalytic cracking or as heating oil.

It is evident that the single tower shown in FIG. 3 represents an advance over the conventional system illustrated by FIG. 1 in that only one reboiler section is needed, the vapors from the splitter section supplying heat to the absorber section.

Referring now to FIG. 4, there is presented an embodiment of the invention in which only the absorber, stripper and splitter sections are integrated while the sponge section exists as a completely separate function.

In this embodiment compressor discharge from a catalytic cracking unit (the hydrocarbon components are primarily C_1 to 250° F.) is introduced at 250° F. into a knockout drum **300** by lines **301** and **302**. Vapor from the stripper-splitter section **311** and liquid from the absorber section **320** are also introduced at this point. The knockout drum is maintained at 116° F. and 134 p.s.i.a. Condensed water is removed by line **303**, vapor by line **304** and liquid by line **305**. The vapor is introduced into the bottom portion of absorber **320**. At the same time a heavy lean absorption oil is introduced on the top stage of absorber **320** by line **306** and a light lean oil at a lower point by line **307** together with the liquid overhead from a catalytic cracking fractionator (primarily C_1–330° F.). Both lean oils are introduced at 85° F. If desired, an additional lean nonolefinic gas may be introduced at 90° F. below the point of entry of the light lean oil. Both lean oils pass down the absorber tower **305** absorbing both desirable and undesirable components. The unabsorbed gaseous constituents are removed overhead by line **321** and are passed to sponge absorber **322** maintained at 130 p.s.i.a. and fed by a heavy absorber oil by line **308**. Lean gas is removed overhead from the sponge section by line **309** while the bottoms are removed by line **323** and passed to the catalytic cracking fractionator or otherwise disposed of.

Fat oil is removed from the bottom of absorber tower **320** by line **310** at 125° F. and passed to knockout drum **300**, liquid from which is passed to the top stage of stripper-splitter tower **311**. From this tower a light side stream is removed by line **312** at 195° F. and used as feed to a debutanizer or otherwise processed. Another sidestream is removed at 256° F. at a slightly lower point by line **313**. This stream is heated by heat exchange and returned to the tower at 282° F. by line **314** at a slightly lower point than from which it was removed to supply heat thereto. A heavier fraction is removed at 323° F. by line **315**, cooled and returned to the midsection of the tower by line **307** as the light lean absorption oil. A fraction at 424° F. is removed from near the bottom of the tower through line **316**, passed through heater **317** and returned to the tower at 449° F. by line **318** to supply heat thereto. A bottoms fraction at 440° F. and 140 p.s.i.a. is removed by line **319**, cooled and returned to the top of the tower by line **306** as the heavy lean absorber oil. The use of this heavy lean oil reduces the amount of lean oil contained in the absorber gas product and thereby reduces the work of the sponge absorber.

It is obvious that the design described in FIG. 4 also combines the advantages inherent in various absorbing, splitting and debutanizing flow sequences in a simple compact operating sequence. It is also obvious that absorber tower **320** and stripper-splitter tower **311** can be integrated into a single tower with or without sponge section **307** as shown in FIG. 3.

The processes described in FIGS. 2, 3 and 4 are not necessarily limited to processing overhead from the catalytic cracking fractionator but may also be applied to similar stream from hydrocracking, reforming, coking, and crude distillation.

As set forth above, the advantages of the invention lie in the lower initial investment because of fewer towers, less auxiliary equipment and less real estate requirements. The operating costs are lower because of good fractionation efficiency, high thermal efficiency, lower maintenance and less operating manpower and because of compact and flexible operation.

The nature of the present invention having thus been fully described and illustrated, what is claimed as new, useful and unobvious and desired to be secured by Letters Patent is:

1. An improved unitary distillation and absorption process which comprises introducing a gaseous feed stream into the lower part of the absorption section of an integrated tower having sponge, stripping, absorption and splitter sections, and a heavy feed stream into the middle portion of the splitter section of the said tower, removing a light fraction from the splitter section at a point above the point of heavy feed introduction and introducing the said light fraction into the top of the said absorption section as lean absorber oil therein; withdrawing a heavy fraction from the lower part of said splitter section and introducing it into the top of the sponge section as lean absorption oil therein; withdrawing a bottoms fraction and passing a portion of said bottoms fraction through a heater and back to the lower portion of said splitter section as the only source of heat to said distillation tower, and withdrawing as products a gaseous overhead from said sponge section, a light naphtha fraction from the bottom of said stripping section, a heavy naphtha fraction from the lower portion of the splitter section and a bottoms fraction.

2. An improved unitary distillation and absorption process which comprises introducing a light fraction (in gaseous state or a mixture of gas and liquid) to a column at a point a substantial distance from the top thereof, scrubbing said light fraction with light absorber oil introduced at a point above the point of introduction of the light feed, permitting enriched absorber oils and liquid components of said light feed to descent through an intermediate portion of said column while stabilizing the liquid to remove all the lighter undesirable components therefrom, removing a portion of the thus stabilized liquid from said intermediate portion of said column as product, passing the remainder thereof downwardly through the lower portion of the column wherein it is stripped of lighter undesirable components by countercurrent contact with ascending hotter vapors, introducing a heavy liquid fraction into the said lower portion of said column and mixing it with the stabilized liquid, withdrawing a light fraction just above the point of entry of the said heavy feed portion and returning said light fraction to the upper portion of said column as the light absorber oil therein; passing the mixture of heavy feed and remaining stabilized liquid downwardly through the remaining portion of the column, withdrawing a heavy fraction from the lower portion of said column as product and withdrawing a slightly heavier fraction from a slightly lower portion of said column and introducing it to the top thereof as heavy absorber oil; passing said heavy absorber oil countercurrent to vapors to remove lean oil therefrom, and removing all of the enriched heavy absorber oil from the upper portion of said column at a point just above the point of introduction of the light absorber oil and reintroducing it into the lower section of said column at a point intermediate the point of removal of the light lean oil fraction and the said heavy fraction, reboiling the stripped remainder of said stabilized liquid and heavy feed mixture by heat exchange with a heating medium, passing the resultant vaporized portions thereof upwardly through the lower portion of the column as said ascending vapors, and withdrawing a reboiled fraction from the bottom of said column as product.

3. An improved unitary hydrocarbon distillation and absorption process comprising introducing a light (in gaseous or mixed gas and liquid states) hydrocarbon fraction boiling C_1 to 250° F. to a column at a point a substantial distance from the top thereof, scrubbing vapors with a light absorber oil introduced at a point above the point of introduction of the light feed, permitting enriched absorber oils and liquid components of said light feed to descend through an intermediate portion of said column while stabilizing the liquid to remove the undesirable material therefrom, removing a portion of the thus stabilized liquid boiling up to 330° F. as product, passing the remainder thereof downwardly through the lower portion of the column wherein it is stripped of lighter components by countercurrent content with ascending vapors, introducing a heavy hydrocarbon fraction feed, boiling primarily C_1 to 450° F., into the said lower portion of said column and mixing it

with the stripped liquid, withdrawing a light fraction just above the point of entry of the said heavy portion of the feed and returning said light fraction to the upper portion of said column as the light absorber oil therein; passing the mixture of heavy feed and remaining stripped liquid downwardly through the remaining portion of the column; withdrawing a heavy fraction boiling 330°–430° F. from the lower portion of said column as product, withdrawing a slightly heavier fraction at a slightly lower point in said column and introducing it to the top thereof as the heavy absorber oil therein; removing all of the enriched heavy absorber oil from the upper portion of said column at a point just above the point of introduction of the light absorber oil and reintroducing it into the lower section of said column at a point intermediate the point of removal of the light lean oil fraction and the fraction boiling 330°–430° F., reboiling the stripped remainder of said liquid and heavy feed mixture by heat exchange with a heating medium, passing the resulting vaporized portions thereof upwardly through the lower portion of the column of said ascending vapors and withdrawing a reboiled fraction boiling 430° F. and higher from the bottom of said column as product.

4. An improved distillation and absorption process which comprises introducing the overhead liquid product from a catalytic cracking fractionator to the absorption section of a unitary absorption-stripping-splitting column at a point a distance from the top thereof, introducing a lean absorption oil at or near the same point, introducing a heavier lean absorption oil at a higher point scrubbing ascending vapors with these lean absorption oils, withdrawing enriched absorber oils from the bottom of said absorption section and introducing said bottom fraction into a separator together with the overhead from the stripper-splitter section and the total product of the compressor discharge of a catalytic cracking unit, producing a vapor fraction and a liquid fraction from said separator, introducing said vapor fraction into the lower portion of said absorber section, introducing said liquid fraction into the upper portion of said stripper-splitter section of said unitary column, passing the liquid fraction downward through said column, withdrawing an intermediate fraction from the upper portion of said stripper-splitter -splitter section as product, withdrawing a heavier fraction from the lower portion of said stripper-splitter section and returning it to said absorption section as the light absorber oil therein, reboiling the remainder of said liquid fraction by heat exchange with a heating medium, passing the resulting vaporized portions thereof upwardly through the low portion of the column and withdrawing a reboiled fraction from the bottom of said column and returning it to the upper portion of said absorption section as the heavy absorption oil therein, withdrawing vapor overhead from said absorption section and introducing it into a sponge absorber tower, and passing it countercurrent to a sponge absorber oil introduced to the upper part of said sponge absorber, withdrawing lean gas as overhead from the sponge-absorber tower and withdrawing fat sponge absorption oil from the bottom thereof.