Nov. 1, 1938. P. OSTERGAARD 2,134,836

VAPOR FEED CONDENSER AND STABILIZER

Original Filed Oct. 3, 1936 2 Sheets-Sheet 1

Fig. 1.

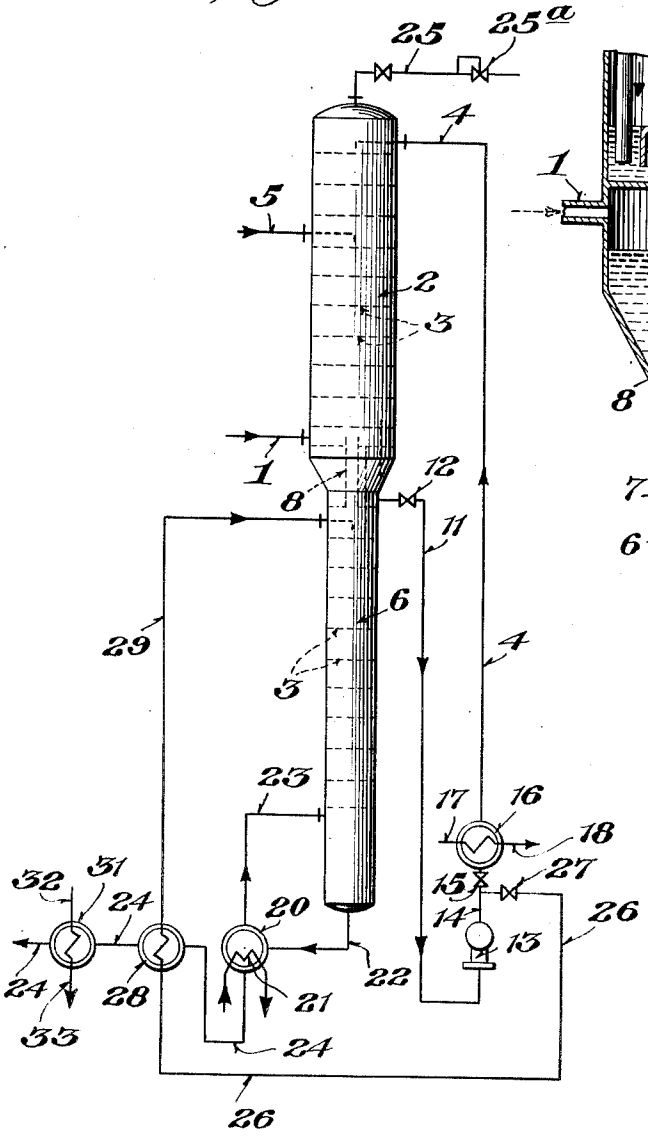
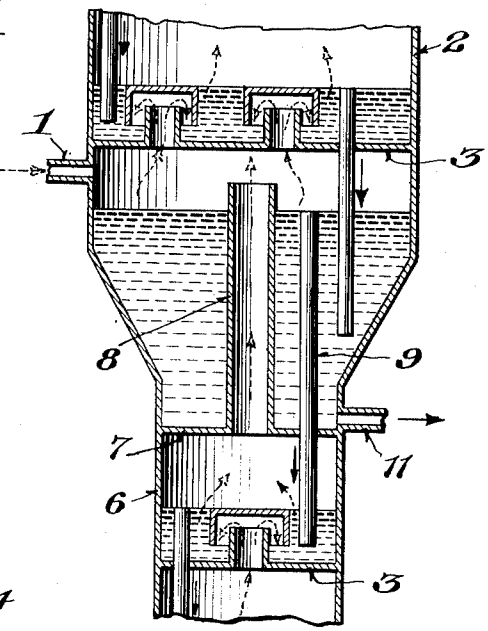


Fig. 2.



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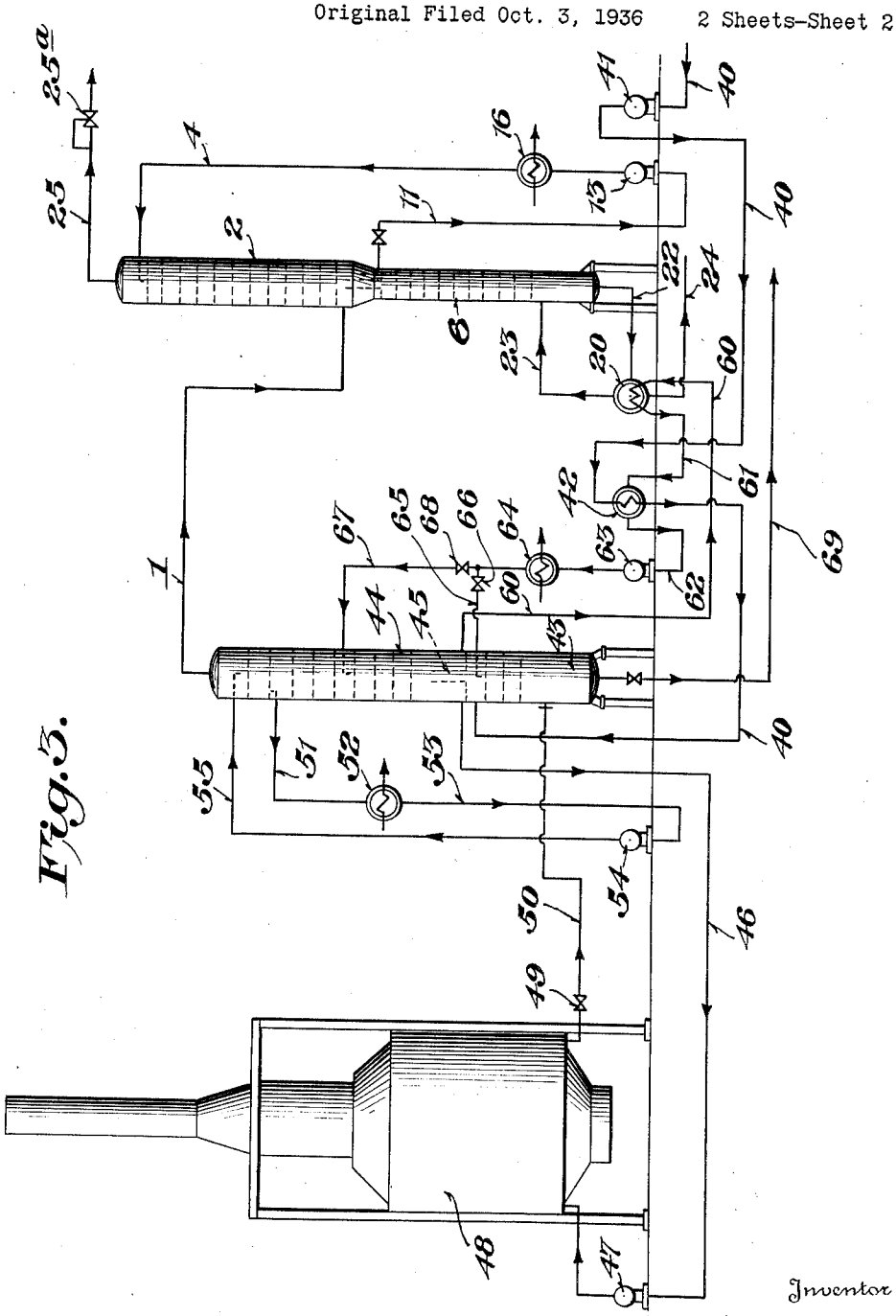


Fig. 5.

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Patented Nov. 1, 1938

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UNITED STATES PATENT OFFICE

2,134,836

VAPOR-FEED CONDENSER AND STABILIZER

Povl Ostergaard, Mount Lebanon, Pa., assignor to Gulf Oil Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Application October 3, 1936, Serial No. 103,947
Renewed July 21, 1938

4 Claims. (Cl. 196—11)

In my prior copending applications Serial No. 52,717, filed December 3, 1935, of which this application is in part a continuation, and Serial No. 97,295, filed August 21, 1936, I have disclosed various processes of cracking hydrocarbon oil, involving recirculation of certain normally gaseous constituents, primarily those having three and four carbon atoms per molecule, to the oil-cracking zone, and as a part of the operating cycles disclosed in the aforesaid applications, I have disclosed novel condensing and stabilizing means, applicable to all types of oil-cracking and vapor-recovery operations but having an especial utility with respect to the recovery of stabilized gasoline from vaporous mixtures containing high proportions of fixed gases and normally gaseous hydrocarbons too light to be included in the final stabilized gasoline product.

My present application is directed to such condensing and stabilizing means, without regard to the particular oil-cracking cycles disclosed in the aforesaid applications, and as applied to the recovery of stabilized gasoline in other types of processes, for example, simple oil-cracking processes and gas-polymerization processes.

By far the most common procedure employed in the prior art for the recovery of stabilized gasoline from vaporous mixtures previously freed from constituents higher boiling than gasoline has been to subject the partly fractionated vapors containing gasoline, lower-boiling hydrocarbons and fixed gases, to condensation, either at atmospheric pressure or under the pressure of the cracking or polymerization operation, and then to subject the condensate thereby obtained to stabilization for the removal of undesired low-boiling constituents. This procedure is in some instances satisfactory for simple oil-cracking operations where the proportion of fixed gases and low-boiling normally gaseous hydrocarbons to gasoline is not especially high, but leaves much to be desired with respect to the sharpness of separation, and especially in operations in which the proportion of low-boiling normally gaseous hydrocarbons and fixed gases in the total vapors to gasoline is increased; for example, in oil-cracking processes of the character described in my aforesaid copending applications, and in gas-polymerization operations. The process and apparatus of my invention, while useful with respect to oil-cracking operations of any kind, are of especial advantage and utility with respect to the latter types of processes.

In accordance with my invention, the gasoline-containing vapors, comprising a mixture of gasoline, fixed gases and intermediate hydrocarbons, primarily those containing three and four carbon atoms per molecule, after being freed from constituents higher boiling than gasoline, are delivered as vapors to a fractionating zone, where they are subjected to fractionation and rectification in order to condense unstabilized gasoline constituents, including, of course, some normally gaseous hydrocarbons too light to be included in the final gasoline product. The unstabilized condensate thereby obtained is separated into two portions, one portion being cooled and recirculated to the aforesaid fractionating zone as a cooling, condensing and refluxing medium therefor, while the remaining portion is delivered to a stabilizing zone. In the stabilizing zone, the latter portion is reheated or reboiled in order to rectify it and to separate undesired low-boiling constituents, these being returned to the first-mentioned condensing and fractionating zone while the resultant stabilized gasoline is withdrawn from the lower portion of the stabilizing zone. Fixed gases and low-boiling hydrocarbon constituents too light to be included in the stabilized gasoline are withdrawn from the upper portion of the initial condensing zone, and may be scrubbed, if desired, for the recovery of the relatively high-boiling constituents contained therein, e. g., butane, propane and the corresponding olefins.

As an additional or alternative feature, a part of the unstabilized condensate not delivered to the stabilizer may be subjected to heat exchange with the hot stabilized gasoline leaving the lower part of the stabilizer, or the reboiler attached thereto, and the thereby preheated oil may then be returned to the stabilizing zone, in order to effect a useful recovery of heat and to further assist in the rectification and stabilization.

In order that my invention may be fully set forth and understood, I now describe, with reference to the drawings accompanying and forming a part of this specification, a preferred manner in which my invention may be practiced and embodied. In these drawings,

Fig. 1 is a more or less diagrammatic elevational view of apparatus for recovering stabilized gasoline from gasoline-containing vapors, in accordance with my present invention;

Fig. 2 is a vertical sectional view of a portion of the apparatus illustrated in Fig. 1; and

Fig. 3 is a more or less diagrammatic elevational view of apparatus for cracking hydrocarbon oil, illustrating the application of my inven-

tion to an oil-cracking process of otherwise conventional character.

Similar reference numerals designate similar parts in the several views of the drawings.

Referring now to the drawings and more particularly to Fig. 1, vapors comprising a mixture of vaporized gasoline, normally gaseous hydrocarbons and fixed gases, and from which constituents higher boiling than gasoline have been previously removed, are introduced through a pipe 1 into a condensing and fractionating column 2, the interior of which is provided with suitable gas-and-liquid-contact devices 3, such as bubble trays or the like. The vapors pass upward through the column 2 and are subjected to partial condensation and rectification therein under the influence of a cool liquid refluxing medium supplied to the upper portion of the column 2 through a line 4. Additional refluxing and cooling may be provided, where desired, by introducing naphtha or other suitable gasoline-like liquid through a pipe 5, located at any desired point in the column 2.

The lower portion of the column 2 is so constructed as to provide for the accumulation therein of unstabilized condensate recovered from the vapors during their passage through the column 2. In the present instance, in which the condensing column 2 is joined to and forms an extension of a stabilizing column 6, the columns 2 and 6 are conveniently separated by a suitable weir device comprising a plate 7, a vapor uptake pipe 8 and a liquid downflow pipe 9. A portion of the unstabilized condensate collecting on the plate 7 is withdrawn through a pipe 11 having a valve 12 and passes to a pump 13, by means of which this condensate is delivered through a line 14 having a valve 15 to a heat exchanger 16 provided with pipes 17 and 18 for respectively introducing and removing a cooling liquid. The cooled condensate leaving the heat exchanger 16 then passes through the line 4 into the upper portion of the condensing column 2.

The remaining portion of the unstabilized condensate collecting on the plate 7 passes through the downflow pipe 9 into the stabilizing column 6, the interior of which is similarly provided with suitable gas-and-liquid-contact devices 3. The lower portion of the stabilizing column 6 is provided with suitable means for supplying heat, which may take the form of a heating coil located in the bottom of the stabilizing column 6, but which, in the preferred instance illustrated in Fig. 1, comprises a separate reboiler 20 containing a suitable coil 21 for steam or other heating fluid. Liquid collecting in the bottom of the stabilizing column 6 passes to the reboiler 20 through a line 22 and vapors liberated in the reboiler 20 are returned to the stabilizing column 6 through a line 23, stabilized gasoline being withdrawn from the reboiler 20 through a line 24.

By reason of the heat applied in the reboiler 20 and the constant influx of relatively cool unstabilized distillate through the downflow pipe 9, a stabilizing and rectifying action takes place, driving off from the unstabilized gasoline condensate such relatively low-boiling constituents as are not desired in the final product. These vapors pass upward through the pipe 8 into the condensing column 2 and are subjected to scrubbing and fractional condensation along with the vapors introduced through the pipe 1.

Fixed gases and uncondensed low-boiling hydrocarbons too light to be included in the final gasoline product are removed from the top of the condensing column 2 through a line 25 having a pressure-regulating valve 25a, and, where desired, are then subjected to a further scrubbing for the recovery of constituents such as propane, butane and corresponding olefins, as well as ethane and ethylene wherever the recovery of the latter proves desirable for any reason.

In order to recover a portion of the heat supplied to the reboiler 20, a portion of the unstabilized condensate passing through the pump 13 may be diverted through a line 26 having a valve 27 and leading to a heat exchanger 28 located in the line 24. In the heat exchanger 28 this diverted portion of the unstabilized condensate picks up heat from the relatively hot stabilized gasoline leaving the reboiler 20; the heated condensate is then returned through a line 29 into the stabilizing column 6, preferably at a point near the top thereof.

A second cooler or heat exchanger 31 may be provided in the line 24 at a point subsequent to the heat exchanger 28 along the flow of the stabilized gasoline. This heat exchanger or cooler 31 is provided with an inlet pipe 32 and an outlet pipe 33 for supplying and removing, respectively, any suitable cooling medium, such as water or oil. The cooled stabilized gasoline leaving the cooler 31 through the line 24 is then delivered to storage or to suitable treating apparatus.

In the operation of the apparatus described hereinabove, the ratio of condensate delivered to the heat exchanger 16 and the stabilizer 6, and the amount of heat supplied to the reboiler 20 are so regulated, with reference to the pressure under which the operation is conducted, and the character and rate of feed of vapors to the condensing column 2, that the finished stabilized gasoline represents all or substantially all of the desired gasoline constituents contained in the vapors initially supplied, but is at the same time free from undesired low-boiling normally gaseous hydrocarbons too light to be included in the final gasoline product, i. e. is stable. It will readily be understood, however, that no fixed rule can be given as to the exact line of separation to be followed; for example, gasoline produced for winter sale may well include a higher proportion of butane and the like than is true in summer. Moreover, the extent of stabilization will vary somewhat in accordance with the value to the refiner of propane and butane, considered as separated products; where a market for these products exists or where they are to be subjected to polymerization, it may prove desirable to remove more of these constituents from the gasoline than would otherwise be the case.

In general, my invention is of especial utility with respect to operating pressures of from two hundred to three hundred pounds per square inch, but it will readily be understood by those skilled in the art that the operation may be conducted under higher or lower pressures in accordance with the results desired and the character of the vapors treated. Where lower pressures are employed, it will in general be advisable to scrub the gases leaving the condensing column 2 for the recovery of the relatively high-boiling constituents contained therein; for this purpose, conventional oil-scrubbing means may be employed.

One of the advantages achieved in the practice of my invention resides in the fact that it is possible to obtain a very close line of separation between the desired gasoline constituents and

the lighter constituents present in the vapors from which the gasoline is removed, this advantage holding true even where the vapors which contain the gasoline also contain an exceptionally high proportion of constituents intermediate between fixed gases and gasoline, for example, butane and the like. Another advantage resides in the fact that my invention makes it possible to reduce the amount of equipment required for the purpose in view as compared with prior methods and apparatus. An additional advantage of considerable importance resides in the fact that the heat-transfer surface required for particular installation is reduced as compared with prior condensing and stabilizing means; this results from the high heat-transfer coefficient which can be obtained in a liquid-to-liquid heat exchanger. Thus, the fact that the exchange of heat taking place in the heat exchanger 16 is between two liquids represents a distinct advantage over operations in which vapors are passed through a vapor-to-liquid heat exchanger for condensation.

It will be obvious to those skilled in the art that whereas I have shown, as a preferred embodiment, a form of apparatus in which the condensing column 2 and the stabilizing column 6 form parts of a single fractionating column, the stabilizing column and condensing column may comprise separate units, with suitable vapor and liquid connections corresponding to those illustrated. However, the form illustrated in the drawings is preferred, and has important operative and constructional advantages.

While, as I have indicated hereinabove, my invention may be applied to the recovery of stabilized gasoline condensate from various types of gasoline-containing vapors, I have illustrated in Fig. 3 the application of my invention to a particular type of oil-cracking cycle wherein my invention may be employed to advantage.

Referring to this figure, an oil to be cracked, for example, a reduced crude or a gas oil, is supplied through a line 40, wherein is located a pump 41 and a heat exchanger 42, to an evaporator or separator 43 receiving cracked vapors through a line 50. Liquid residue from the evaporator or separator 43 is withdrawn through a line 69, while cracked vapors pass upward into a fractionating column 44. In the instance shown, the separator 43 and the fractionating column 44 form sections of a single column, these sections being separated by a suitable trap-out tray 45. The vapors passing upward through the fractionating column 44 are cooled and partially condensed for the removal of cycle stock or gas-oil constituents. A portion of this condensate is removed from the trap-out tray 45 through a line 46 and delivered by a pump 47 to a suitable cracking furnace 48, where the oil is subjected to elevated temperature and pressure and cracked for the production of gasoline. The resulting cracked vapors then pass through the line 50 into the separator or evaporator 43, their pressure being reduced, if desired, by means of a valve 49 located in the line 50. The necessary cooling for the fractionating column 44 may be supplied in various ways, for example, by withdrawing condensate from the upper portion of the column 44 through a line 51, this condensate passing through a cooler or heat exchanger 52 and then into a line 53, from which it is returned by a pump 54 and a line 55 to the top of the fractionator 44.

The fractionated vapors, now freed from constituents heavier than gasoline, pass from the fractionating column 44 through the line 1 into the condensing column 2, where they are subjected to condensation and fractionation in the manner described hereinabove, gases and low-boiling hydrocarbons being removed through the line 25 while unstabilized condensate passes into the stabilizer 6 and the reboiler 20. The operation of the condensing column 2 and the stabilizing column 6 is conducted in the manner already set forth herein and need not be described again.

In the present instance, however, the heat required for reboiling in the stabilizer 6 or reboiler 20 may conveniently be supplied by hot gas-oil condensate withdrawn from the bottom of the fractionating column 44. For this purpose, I provide a line 60 which delivers a portion of the condensate collecting on the trap-out tray 45 to the reboiler 20, through which it passes in indirect heat-exchange relation to the gasoline withdrawn from the bottom of the stabilizer 6 through the line 22. The hot gas-oil condensate, after passing through the reboiler 20, then passes through a line 61 to the heat exchanger 42, and thence through a line 62 to a pump 63 and a further heat exchanger 64. A portion of the cooled condensate may then be returned as reflux to the separator 43 through a line 65 having a valve 66, while the remaining portion passes through a line 67 having a valve 68 into the fractionating column 44. It will be obvious that all of this cooled gas-oil condensate may be delivered either to the separator 43 or to the fractionator 44, as occasion warrants, or that this cooled gas-oil condensate may be otherwise disposed of in any desired manner.

Similarly, the process and apparatus of my invention may be applied to other types of oil-cracking operations and to gas conversion operations, or wherever it is desired to recover stabilized gasoline from a vaporous mixture containing gasoline and lower-boiling hydrocarbons and fixed gases.

While I have described my invention hereinabove with respect to various illustrative examples and preferred embodiments, it will be obvious to those skilled in the art that my invention is not limited to the operative details of such examples or embodiments, but may variously be practiced and embodied within the scope of the claims hereinafter made.

What I claim is:

1. The method of recovering stabilized motor fuel from a vaporous mixture containing vapors of normally liquid gasoline-like components in admixture with vapors of lower-boiling hydrocarbons and fixed gases but substantially free from constituents of higher boiling point than gasoline, which comprises delivering said vaporous mixture at a temperature substantially above atmospheric and under a high pressure into a rectifying column and therein cooling said mixture to condense unstabilized higher-boiling components of said mixture, withdrawing from said column a portion of said unstabilized condensed components, cooling said portion to a temperature substantially below that of the vaporous mixture entering the column and returning it to the upper part of said column as a cooling, condensing and refluxing medium, passing the remaining portion of said unstabilized condensed components downward through a second rectifying column and applying heat thereto to reboil and stabilize the same, passing the vapors thereby evolved into said first-mentioned column, with-

drawing uncondensed gases and vapors from the top of said first-mentioned column and withdrawing stabilized condensate from the bottom of said second column.

2. The method of recovering stabilized motor fuel from a vaporous mixture containing vapors of normally liquid gasoline-like components in admixture with vapors of lower-boiling hydrocarbons and fixed gases but substantially free from constituents of higher boiling point than gasoline, which comprises contacting said vaporous mixture under a high pressure in a condensing zone with a flow of relatively cool, unstabilized condensate to condense higher-boiling components of said mixture, cooling a portion of the unstabilized condensate thereby obtained and employing it as the above-mentioned condensing medium, separately rectifying and stabilizing the remaining condensate, delivering vapors thereby liberated to said condensing zone, and separately withdrawing stabilized condensate and uncondensed vapors from the system.

3. Apparatus for recovering stabilized motor fuel from a vaporous mixture containing vapors of normally liquid gasoline-like components in admixture with vapors of lower-boiling hydrocarbons and fixed gases but substantially free from constituents of higher boiling point than gasoline, which comprises: a condensing and rectifying column; means for supplying said vaporous mixture thereto; means for dividing unstabilized condensate reaching the bottom of said condensing column into two portions; means for withdrawing one portion of said unstabilized condensate, means for cooling said portion and means for returning it to the upper part of said condensing column; a stabilizing and rectifying column adapted to receive the second portion of the unstabilized condensate from said condensing column, and having heating means located therein; means for returning vapors evolved in said stabilizing column to the condensing column; means for withdrawing uncondensed gases and vapors from the top of the condensing column; and means for withdrawing stabilized condensate from the bottom of said stabilizing column.

4. The method of recovering stabilized motor fuel from cracked vapors containing cracked gasoline constituents in vapor form in admixture with vapors of lower boiling hydrocarbons and fixed gases but substantially free from constituents of higher boiling point than gasoline, which comprises delivering said vaporous mixture under high pressure into the lower portion of a condensing column, maintaining a continuous cyclic flow of unstabilized condensate from the lower part of said column into the upper portion of said column, cooling the thus recycled condensate as it passes between the points of removal from and introduction into the column to a temperature substantially below that of the vaporous mixture introduced to said column, thereby subjecting the said vapors to a condensing action and producing additional unstabilized condensate, delivering the excess condensate, over and above that recycled as aforesaid, into the upper portion of a stabilizing and rectifying column and permitting it to pass downward through said stabilizing column, applying heat to the lower portion of said stabilizing column to volatilize undesirable light constituents condensed in the condensing column, passing the vapors thereby liberated into the lower portion of the condensing column for further contact with the aforesaid recycled condensate, removing uncondensed vapors from the upper portion of the condensing column, and removing stabilized gasoline condensate from the lower portion of the stabilizing column.

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