July 1, 1930. W. G. LAIRD 1,769,698

PROCESS FOR RECOVERING NATURAL GASOLINE

Filed June 10, 1927

Fig. 1.

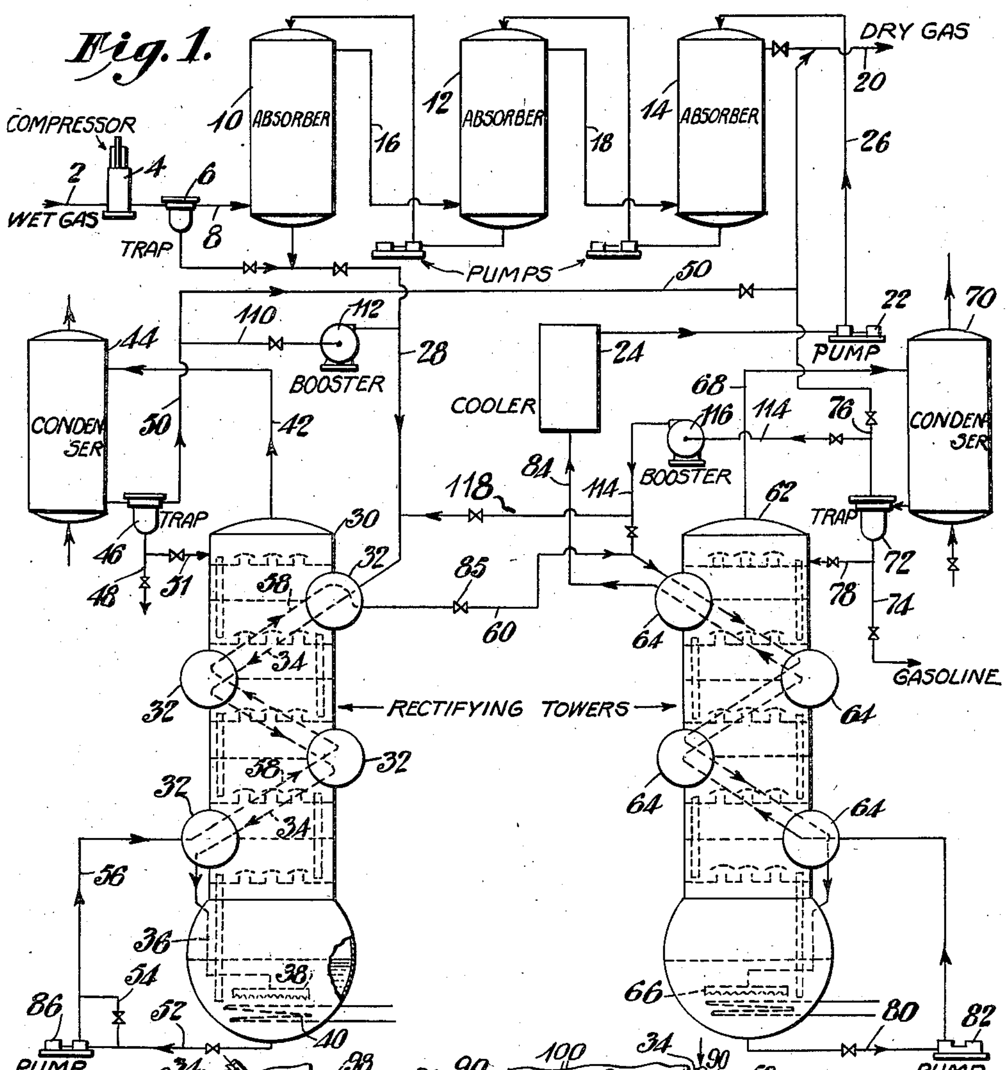


Fig. 2.

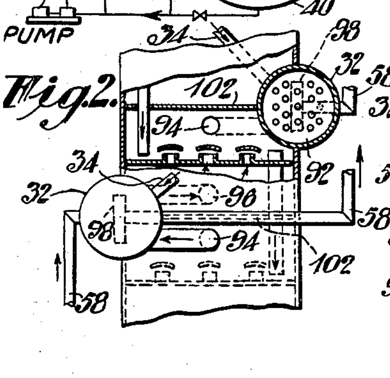
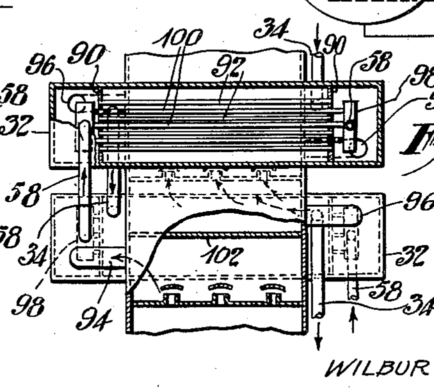


Fig. 3.



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PROCESS FOR RECOVERING NATURAL GASOLINE

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This invention relates to the treatment of natural gas for the recovery therefrom of natural gasoline.

More particularly the present invention contemplates various improvements in the processes and methods now in use for the recovery of a stable natural gasoline separate from the lighter hydrocarbon present in natural gas.

Various processes have been proposed in which it was an object to obtain natural gasoline by making a separation of what may be styled non-gasoline hydrocarbons from a mixture containing ethane, propane, butane, pentane, hexane, etc., the gasoline consisting mainly of butane, pentane and higher hydrocarbons while ethane, propane and some butane constitute the non-gasoline portion. By one process, it is proposed to absorb the mixed natural gas hydrocarbons in an absorber oil under pressure, heat the oil and absorbed hydrocarbons sufficient only to vaporize the lighter or non-gasoline constituents from the mixture then in a separate still drive off and recover the remaining gasoline hydrocarbons while maintaining the pressure. Another process distills all of the absorbed hydrocarbons from a medium at once, subjects the vapors to cooling and pressure and then introduces them into a rectifying column from which the natural gasoline is withdrawn from the bottom as liquid and the non-gasoline hydrocarbons are removed from the top of the column as vapor or gas.

In the former process a very poor separation of the respective classes of hydrocarbons is made because in distilling of the lighter hydrocarbons from the mixture some of the heavier ones are carried along and at the same time the attractive force of the heavier hydrocarbons retains large amounts of the non-gasoline hydrocarbons which will be vaporized and collected with the gasoline. This of course gives a gasoline which will have a high "outage" due to the subsequent vaporization, under atmospheric conditions, of the lighter and some of the heavier constituents. This process therefore is but slightly better than the older "weathering" methods.

The latter process while containing certain features of advantage over the former nevertheless is very expensive in that the energy expended in compressing the gas for the absorbers is dissipated by reducing the pressure on the charged absorbing medium before distillation, after which the vapors are again compressed before being subjected to rectification.

The primary object of the invention is to provide a process of recovering gasoline from natural gas in which the various steps are so correlated that the recovery of natural gasoline is achieved in a thorough and efficient manner.

Another object is to provide a process in which heat and power efficiencies are maintained at the highest possible maximum.

A further object of the invention is to provide a process in which the disadvantages pointed out above with respect to other processes will be overcome.

Further objects and advantages of the invention will appear from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic showing of apparatus adapted to carry out the novel process;

Fig. 2 is a vertical view partly in section of a portion of one of the rectifying towers;

Fig. 3 is a view partly in section of the portion of the tower shown in Fig. 2, looking from the right.

According to the process of the present invention the cold absorbing medium charged with natural gas hydrocarbons is passed from absorbers under superatmospheric pressure through a series of heating zones where the charged medium is intensely agitated and gradually heated to a higher temperature.

The mixture of vapor and oil medium thus produced is then distilled under rectifying conditions and superatmospheric pressure to remove the so-called "wild" or more volatile hydrocarbons, the most of which may be collected and bottled. The absorbing medium now containing only the gasoline hydrocarbons is subjected to a similar treatment under normal pressure to recover the gasoline as a stable product.

Referring to Fig. 1, the wet gas to be treated is drawn through the collecting main 2 by the compressor 4 and passed through a trap 6 where any liquid formed by the compression is collected and drawn off. The compressed gas, usually under a pressure of from 150 to 400 pounds per square inch, is passed by a pipe 8 into the bottom of the first of a series of absorbers 10, 12 and 14. From the absorber 10 the unabsorbed gas passes by a pipe 16 into the bottom of absorber 12 and the unabsorbed gas from the absorber 12 passes by a pipe 18 into the bottom of the absorber 14. The dry gas leaves the last absorber 14 by a valved pipe 20 by which it may be passed to any combustible gas supply system or to cracking apparatus for the production of carbon black.

The absorbing oil to be used in the absorbers to take up hydrocarbons from the natural gas is drawn by a pump 22 from a storage-cooler 24 and passed by means of a pipe 26 into the top of the last absorber 14. From the bottom of the absorbers 14 and 12 the oil partly charged with hydrocarbons is withdrawn by a pump and suitable piping and passed respectively into the top of the absorbers 12 and 10. By the time the oil has been passed through the series of absorbers counter-current to the passage of the gas the oil discharged from the bottom of the absorber 10 usually contains a substantial amount of absorbed natural gas hydrocarbons. This charged oil from the absorber 10 together with any liquid which may have been condensed by the compression and drained from the trap 6, are conducted under pressure through a pipe 28 to a rectifying tower 30. The oil containing the absorbed hydrocarbons first enters the tower 30 through the uppermost of a series of heat interchange units 32 and passes through the units in series as indicated by the dotted line 34. From the lowermost unit the oil is passed by the pipe 36 into the base of the tower where it is distributed by a distributor 38 into a body of oil maintained therein. The oil in the bottom of the tower is heated indirectly by a heating coil 40 to a temperature sufficient to distil from the absorbing oil all of the non-gasoline hydrocarbons regardless of whether or not some gasoline is also vaporized. The vapors produced by the distillation in the base of the column are subjected to rectification in the tower so that the gasoline is condensed and returned by the usual overflow pipes to the body of oil in the base of the tower. In passing upward through the tower the vapors pass alternately through liquid on bubbling cap plates and exchangers 32. The condensate formed in passing the vapors in heat exchange with the oil in the exchangers 32 flows back onto the next lower bubbling plate where it mingles with the condensate thereon and is subjected to rectification by the hot vapors bubbling through it. The vapors not condensed in the tower 30 and which comprise substantially all of the non-gasoline hydrocarbons are passed by the pipe 42 into the condenser-dephlegmator 44 by which the higher boiling of the non-gasoline hydrocarbons are condensed. This condenser 44 is preferably of the surface condenser type in which water or expanded cold gas is passed through the tubes as a cooling medium. The condensed hydrocarbons and uncondensed gas pass from the condenser to a liquid trap 46 from which the liquid may be drained by a valved pipe 48. Uncondensed gases are drawn from the trap by a valved line 50 which connects with the dry gas main 20. In order to prevent vaporization of any gasoline hydrocarbons which may have reached the upper bubble plate a valved pipe 51 is provided for passing condensed non-gasoline hydrocarbons back onto this plate.

The distillation and rectification in the tower 30 is preferably carried on under a superatmospheric pressure sufficiently high that the higher boiling of the non-gasoline hydrocarbon vapors passed to the condenser 44 may be condensed at normal temperatures (about 70° F.) These hydrocarbons may comprise some ethane, propane, and some butane and may be stored under pressure in containers ("bottles"), shipped and used as fuel for motors or otherwise.

The oil collecting in the base of the column 30 and which now contains only absorbed gasoline hydrocarbons is withdrawn by a valved pipe 52, valved by-pass 54, and a pipe 56 and passed into the lowermost heat exchanger 32 from which it is passed in series through the other units 32 as indicated by the dotted line 58. From the uppermost unit 32 the oil is passed by a valved pipe 60 into a rectifying tower 62 which is the same in structure as the tower 30. The oil enters this tower as in the former case through a series of heat exchange units 64 and is distributed into a body of oil maintained in the base of the column by a distributor 66.

The tower 62 may be heated and maintained at a much higher temperature than the tower 30 so that the vapors which leave the tower by a vapor line 68 are the vaporized gasoline hydrocarbons. These vapors are passed to a condenser 70, in structure identical to condenser 44, the condensate and vapors being passed to a trap 72 from which gasoline is withdrawn by the valved pipe 74 and passed to storage while the non-condensed gases resulting from the distillation may be sent by a valved pipe 76 to the dry gas line 20. In order to prevent removal of the absorbing medium with the gasoline vapors driven from the tower 62 gasoline may be returned to the upper plate therein from the trap 72 by a valved pipe 78. The return of condensate to the upper plate may be and preferably is controlled by the end point desired for the gasoline. The absorbing medium freed of gasoline is withdrawn from the base of the tower 62 through a valved pipe 80, by a pump 82 and passed upward through the series of heat exchange units 64 where its heat is transferred to the oil being passed downward through these units. From the uppermost unit 64 the stripped and partially cooled oil is passed by a pipe 84 to the cooler 24.

The distillation in tower 62 is preferably carried out at substantially atmospheric pressure so that the gasoline as produced will exert substantially the same vapor pressure as it would under normal conditions of use or storage. With this mode of operation a valve 85 in pipe 60 is used to reduce the pressure on the oil mixture passing from the tower 30 to tower 62. However, in case it is not desired to condense and collect the light non-gasoline hydrocarbons under pressure the tower 30 may be operated at atmospheric or other pressures, but if not operated at a pressure higher than that used in tower 62 the oil withdrawn by the pipe 52 will be passed through a pump 86 instead of through the by-pass 54.

The towers 30 and 62 are each constructed alike; they comprise a plurality of bubble cap plates alternating with the heat interchangers 32 (tower 30). Referring to Figs. 2 and 3 it will be seen that the interchangers 32 are divided by tube sheets 90 into two end compartments with an intermediate compartment through the latter of which extend tubes 92 connecting the two end compartments. The vapors passing up through the tower after bubbling through the liquid maintained on the bubble trays pass by the outlets 94 into one end compartment of the exchangers 32, through tubes 92 to the other end compartment then back into the tower proper below the bubbler plates by inlets 96. The oil introduced into the tower by the pipe 28 enters the upper exchanger 32 inside the tube sheets 90 and passes from exchanger to exchanger by the pipes 34. In each exchanger the oil enters near one end inside the tube sheet, flows around the tubes 92 and leaves near the opposite end. The hot oil passed upward through the exchangers by the pipe 56 is conducted from exchanger to exchanger by the pipes 58 which connect with small headers 98 in the end compartments of the exchangers. These headers in each exchanger are in turn connected by tubes 100 which extend through the tube sheets 90 and the compartment therebetween thus forming a continuous passage for the hot oil to pass in heat exchange with the oil between the tube sheets 90 in all the exchangers. The oil introduced between the tube sheets 90 of the exchangers 32 comprises the vapors and unvaporized oil from the preceding exchanger. These vapors together with the vapor formed in the oil around the tubes 92 and 100 cause intense agitation in the menstruum containing hydrocarbons, and thereby increases the heat exchange and amount of vaporization in the exchangers. Between the bubbler plates in the towers are interposed imperforate plates 102 which force the vapors above each bubbler plate to pass through the outlets 94 into the exchanger 32 next above.

The condensate formed in the exchangers by the heat of the vapors being transferred to the oil around the tubes 92 flows counter to the vapors through the conduits 94 and onto the bubbler plate therebelow. From each bubble cap plate the oil (condensate) not vaporized thereon by contact with the rising vapors overflows by the usual overflow pipe to the next bubble cap plate below where it meets vapors of higher temperature and from the lowermost plate the unvaporized condensate overflows into the body of oil undergoing distillation in the base of the tower.

In operating the apparatus described above it has been found desirable in some cases to pass a gas along with the oil mixtures introduced into the towers 30 and 62 in order to agitate the oil passing around the tubes 92 and 100 as well as in the base of these towers. The addition of gas also tends to dilute the vapors being evolved and therefore gives a vacuum effect distillation by reducing the partial pressure of the vapors. In order to supply gas to the charging line 28 a valved pipe 110 in which is placed a booster 112, is inserted between the gas line 50 and the line 28. A similar circuit is used for supplying gas to the oil in pipe 60 for the tower 62. In this case a valved gas line 114 containing a booster 116 delivers gas from line 76 to the line 60. Instead of using the relatively "dry" gas from the line 50 for mixing with the oil in pipe 28 gas may be passed by the booster 116 through a valved line 118 into the pipe line 28 for mixing with the oil therein.

The towers 30 and 62 are shown as composed of only four heat exchangers but this is only an example since in actual practice a larger number will usually be employed particularly in the tower 30. Likewise the number of bubbler plates may vary either as to the total number or as to the number per exchanger. A large number of bubble plates are required where accurate separation of different boiling point hydrocarbons is required.

Reference has been made to the agitation of the oil in the exchangers 32 and 64. In an actual construction of the apparatus the oil delivery pipes 34 may terminate below the tubes 92 in the form of a distributor so that agitation is secured by the bubbles of gas or vapor rising through the liquid around the tubes.

In order to effectively transfer the heat from the vapors passing through the interchangers to the advancing oil mixture a certain amount of vaporization is essential, but since the oil contains very light hydrocarbons it is evident that vaporization will occur without the return of any substantial amount of gas to reduce the partial pressure of the vapors. If no gas is returned the vaporized hydrocarbons as they are gradually evolved may be relied upon for agitating the oil in the exchangers 32 and 64. The combined vaporization and agitation of the oil in the stills or exchangers gives a very efficient heat transfer from the hotter materials passing through the tubes 92 and 100.

By the present process it is possible to obtain a stable gasoline free of propane and lower boiling hydrocarbons which as pointed out above account for the high "outages" in ordinary natural gasolines. Furthermore the vapor pressure of the final product may be regulated by controlling the amount of butane retained. Ordinarily it is not desired to have the product contain substantially over 60 percent of butane. The vapor pressure at 100° F. for a natural gasoline containing 60 percent butane is 20 pounds while it is only 11.5 pounds for one containing 40 percent. Natural gasoline of 20 pounds pressure may be shipped in insulated cars but for ordinary cars the pressure must not be over ten pounds.

While the invention has been described in detail with reference to the recovery of gasoline from natural gas it is evident that the process is equally applicable to the treatment of gases from coal carbonization, cracking or other stills, gasoline agitators and storage tanks. Therefore the expressions in the claims relative to "natural gas" are to be understood as including the gases here referred to.

Having described the preferred embodiment of the invention what is claimed as new is:

1. In the process of recovering gasoline hydrocarbons from natural gas containing non-gasoline hydrocarbons, in which natural gas is passed under superatmospheric pressure in contact with an absorbing medium whereby said medium becomes saturated with said gas, the improvement which comprises passing the said saturated medium through a series of zones of increasing temperature in a rectifying zone, then into a vapor separating zone, passing the vapors evolved from said medium and separated in said separating zone alternately through each of said zones of increasing temperature and through each of a series of bodies of condensate of said vapors whereby said vapors are partially condensed and rectified, withdrawing the non-gasoline hydrocarbon vapor from the rectifying zone and condensing higher boiling hydrocarbons therefrom, removing the absorbing medium containing the gasoline hydrocarbons from said separating zone, and recovering the said gasoline hydrocarbons therefrom by distillation.

2. In the process of recovering gasoline hydrocarbons from natural gas in which both the gasoline and part of the non-gasoline hydrocarbons are absorbed in a liquid menstruum, the improvement, which comprises passing said menstruum containing said hydrocarbons through a series of heating zones of increasing temperature, intensely agitating said menstruum containing hydrocarbons in said heating zones, passing the menstruum with the hydrocarbons into a distilling chamber where the non-gasoline hydrocarbons are vaporized therefrom, passing the vaporized hydrocarbons through said zones counter-current to and out of contact with said menstruum containing hydrocarbons, passing the menstruum containing substantially only gasoline hydrocarbons parallel with said vapors through said zones but isolated from the other materials therein, removing said menstruum from the final zone, reducing the pressure thereon and subjecting the mixture to a rectifying distillation whereby said gasoline hydrocarbons are recovered.

3. In the process of separately recovering the gasoline and non-gasoline hydrocarbons by successive distillations from a liquid menstruum containing the same, the improvement, which comprises distilling from said menstruum the non-gasoline hydrocarbons under superatmospheric pressure, cooling the menstruum containing the gasoline hydrocarbons, reducing the pressure thereon and passing it through a series of heating zones of increasing temperatures, then into a still, distilling the gasoline from said menstruum, passing the stripped menstruum through said zones counter to and out of direct contact with said charging menstruum and rectifying the gasoline vapors by passing them alternately through bodies of condensate and in heat exchange with charging menstruum in said zones.

4. The process of recovering natural gasoline hydrocarbons from a liquid absorbing medium containing absorber gasoline and non-gasoline hydrocarbons, which comprises maintaining a series of alternating heating and rectifying zones, passing the charged

medium through said heating zones and into an evaporating chamber where partial vaporization of the hydrocarbons is effected, passing the vapors evolved through said series of alternate heating and rectifying zones, maintaining the temperature and pressure in the final rectifying zone such that substantially only the non-gasoline hydrocarbons escape therefrom as vapors, passing the medium containing the gasoline from said chamber, reducing the pressure thereon and subjecting the mixture to a rectifying distillation whereby said gasoline hydrocarbons are recovered from said medium.

5. In the process of producing stable gasoline from natural gas, in which natural gas containing non-gasoline hydrocarbons is subjected to the action of an absorbing medium, the improvement which comprises passing the charged absorbing medium under superatmospheric pressure through a series of heating zones of increasing temperature whereby the absorbed non-gasoline hydrocarbon content of said medium is vaporized, passing the vapors thus produced alternately through said heating zones counter to the flow of the charged medium passing therethrough and through bodies of condensate maintained in a rectifying zone, removing the vaporized non-gasoline hydrocarbons from the rectifying zone, passing the absorbing medium containing substantially only absorbed gasoline hydrocarbons through said zones counter-current to the flow of the charging medium therethrough and effecting a separation of said gasoline hydrocarbons from said medium by distillation.

6. The process of recovering stable gasoline from an absorbing medium containing absorbed natural gas hydrocarbons which comprises progressively heating the charged medium to a temperature sufficient to completely vaporize the non-gasoline hydrocarbons, subjecting the vapors produced to rectifying conditions whereby the non-gasoline hydrocarbons are separated from the medium containing the gasoline, passing the medium containing the gasoline in heat exchange with the charged medium to partially effect said progressive heating then progressively heating the medium charged with gasoline to a temperature sufficient to vaporize the gasoline content thereof and using the heat in the stripped absorbing medium to partially effect the latter progressive heating.

7. In the process of producing stable gasoline from natural gas, in which natural gas is subjected to the action of an absorbing menstruum whereby a mixture of hydrocarbons is absorbed therefrom, the improvement which comprises subjecting the menstruum containing the absorbed hydrocarbons to distillation in a rectifying tower whereby the more volatile of the absorbed hydrocarbons are separated therefrom, agitating the mixture being rectified in said tower by passing a gas in a continuous cycle through said tower, passing the menstruum containing substantially only absorbed gasoline hydrocarbons from said tower into a separate distilling zone and distilling the gasoline therefrom.

8. In the production of stable gasoline from natural gas, the process, which comprises heating an absorbing menstruum containing absorbed natural gas hydrocarbons to effect the vaporization of the lower boiling constituents, subjecting the vapors to rectification under superatmospheric pressure in a rectifying zone to separate the non-gasoline hydrocarbons from the mixture, passing the menstruum containing substantially only gasoline hydrocarbons into a second rectifying zone whereby the gasoline is recovered from said menstruum and passing a portion of the vapors remaining uncondensed from said second rectifying zone into the vapors being rectified in the first instance.

9. In the recovery of stable gasoline from an absorbing medium containing a mixture of absorbed hydrocarbons, the process, which comprises passing an absorbing medium containing the hydrocarbons into the base of a rectifying column, heating and agitating the mixture to effect the vaporization of all hydrocarbons lower than pentane, subjecting the vapors to rectification whereby substantially all hydrocarbons lower than butane are removed from said column, refluxing substantially all the butane and higher hydrocarbons in said column back into the medium, removing said medium from said column and distilling therefrom stable gasoline containing substantially no hydrocarbons lower than butane.

10. In the process of producing gasoline from a mixture of hydrocarbon gases, in which said mixture is subjected to the action of an absorbing medium to take up said hydrocarbons, the improvement which comprises subjecting the charged medium to a primary distillation treatment to effect the removal therefrom of the low boiling hydrocarbons not desired in the gasoline product, thereafter subjecting the medium containing the desired gasoline hydrocarbons to distillation in a column still, condensing the vaporized gasoline and recirculating a portion of the vapors remaining uncondensed back through the materials undergoing distillation in said still.

11. The process of recovering natural gasoline hydrocarbons from a liquid absorbing medium containing absorbed gasoline and non-gasoline hydrocarbons, which comprises passing the charged absorbing medium through a series of heating zones of increasing temperature in which the charged medium is heated and portions of the absorbed constituents vaporized, passing the vapors

formed in said zones forward and in intimate contact with the unvaporized material, separating the vapors from the unvaporized material in a zone maintained at a predetermined temperature adapted to insure vaporization of substantially all of the non-gasoline hydrocarbons, further heating the medium containing substantially only the gasoline hydrocarbons in a separate zone to vaporize the latter, and rectifying the gasoline hydrocarbons to produce a suitable gasoline product.

In testimony whereof I affix my signature.

WILBUR G. LAIRD.