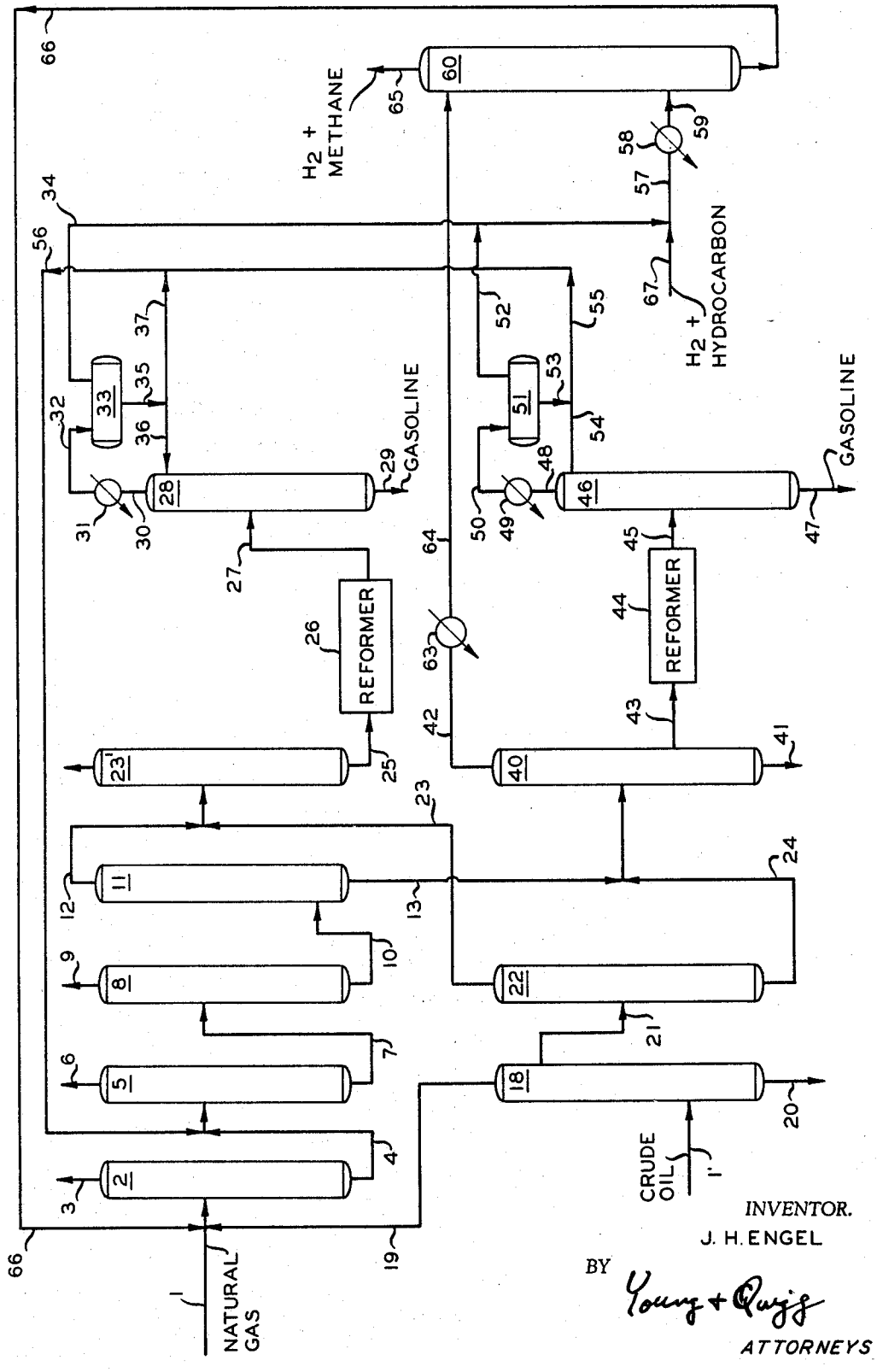
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COMBINED REFORMING OF NATURAL GAS AND CRUDE OIL NAPHTHAS

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COMBINED REFORMING OF NATURAL GAS AND CRUDE OIL NAPHTHAS

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ABSTRACT OF THE DISCLOSURE

Natural gas liquid is fractionated to remove light hydrocarbons and leave a mixture of a light gasoline fraction and a heavy gasoline fraction and these two fractions are separated, at the same time a crude oil is fractionated to form a mixture of a light gasoline fraction, a heavy gasoline fraction and hydrocarbons that are lighter than the heavy gasoline fraction, and these two gasoline fractions are separated so that the lighter hydrocarbons go with the heavy gasoline fraction, the two light gasoline fractions are combined as are the two heavy gasoline fractions, the combined light gasoline fractions are reformed as is the combined heavy gasoline fractions after the hydrocarbons that are lighter than the heavy gasoline fractions have been removed therefrom, light hydrocarbons such as butanes and lighter and hydrogen are removed from both light and heavy gasoline fractions, these two light hydrocarbon fractions are each separated into a lighter sub-fraction containing propane and lighter hydrocarbons and hydrogen and a heavier sub-fraction containing the remainder of the light hydrocarbons removed from the two gasoline fractions, the two lighter sub-fractions are combined and contacted with the hydrocarbons that are lighter than the heavy gasoline fraction, the two heavier sub-fractions are combined and used as feed for the natural gas liquid fractionation step.

This invention relates to a method for making gasoline blending stocks from at least two separate source materials with a minimum loss of materials.

Heretofore substantially different source materials such as natural gas liquids and conventional crude oil have been separately treated in separate systems to fractionate these materials into their desirable constituents such as light hydrocarbons, e.g., ethane through hexane and the like, gasoline fractions, kerosene fractions, asphalt, and the like. The separate treatment of these differing source materials has often been thought necessary because of the different processing characteristics of these materials. The use of separate systems to process differing source materials is costly in that duplication of apparatus is sometimes necessary and also because larger systems are necessarily employed with a consequent necessity of larger expenses for maintaining and operating these systems. Further, because differing systems are employed on different materials, the loss (waste) of many desirable compounds is compounded almost in direct proportion to the number of different systems employed. Thus, if a different system is employed for each material processed, desirable compound losses are much greater than would be realized if a single, unitary system were employed for processing all the different source materials. However, as explained above, it was heretofore thought necessary to employ different systems for different source materials because of the variances in processing characteristics of these source materials.

It has now been found that two or more widely differing hydrocarbon source materials can be satisfactorily processed in a single system and that with the particular system of this invention losses of desirable compounds are substantially minimized.

In the following description and claims, all octane numbers are Research Octane Numbers with 3 milliliters of tetraethyllead.

The process of this invention involves the substantially simultaneous treating of at least two hydrocarbon material sources such as a natural gas liquid material and a crude oil. Light hydrocarbons are removed from the natural gas material to leave a mixture of a light gasoline fraction and a heavy gasoline fraction which fractions are then separated from one another. A mixture of light gasoline and heavy gasoline fractions is also separated from the crude oil and thereafter these fractions are also separated from one another. The light gasoline fractions from the natural gas material and crude oil are combined and the heavy gasoline fractions from the natural gas material and crude oil are also combined. The heavy gasoline fraction separated from the crude oil also contains some hydrocarbons that are lighter than the heavy gasoline fraction itself. The combined light gasoline fractions are then reformed to form a higher octane gasoline. Thereafter, the gasoline is separated from the reformed hydrocarbon stream as one porduct of the system and the remaining lighter hydrocarbons are separated into a lighter sub-fraction and a heavier sub-fraction. The combined heavy gasoline fractions are treated so as to separate the lighter hydrocarbons therefrom and are thereafter reformed to form a higher octane gasoline. This reformed hydrocarbon stream is then treated to remove the gasoline as a product of the system and the remaining lighter hydrocarbons are separated into a lighter sub-fraction and a heavier sub-fraction. The heavier sub-fractions are then combined and returned as feed to the step wherein light hydrocarbons are removed from the natural gas material. The lighter sub-fractions are also combined and then contacted with the lighter hydrocarbons removed from the combined heavy gasoline fractions so that the lighter hydrocarbons absorb substantially everything but hydrogen and methane from the combined lighter sub-fractions. The lighter hydrocarbons and absorbed material are then returned as feed to the step wherein light hydrocarbons are removed from the natural gas material.

Thus, it can be seen that besides the products formed by the system, only methane and hydrogen are removed from the system and then these materials are removed in a controlled manner so that they can also be recovered by conventional techniques, if desired. It can further be seen that by this system, two source materials are treated at substantially the same time in a single system without any substantial loss of desirable compounds. The unique recycling features of the process of this invention contribute substantially to the reduction in desired compound loss without unduly burdening the system.

Accordingly, it is an object of this invention to provide a new and improved method for treating at least two source materials with a single system while substantially minimizing the loss in desired compounds from that system.

The drawing shows a system embodying this invention.

More specifically, the drawing shows a source of natural gas material such as natural gas liquids in line 1 and a source of crude oil in line 1'.

A typical natural gas material for use in this invention can comprise, among other things, from about 60 to about 80 volume percent, based on the total volume of the material, of hydrocarbons having from 1 to 4, inclusive, carbon atoms per molecule and from about 20 to about 40 volume percent, based on the total volume of the material, of hydrocarbons having from 5 to about 9, inclusive, carbon atoms per molecule.

The natural gas material in line 1 is passed to depropanizer 2. Propane and lighter hydrocarbons such as methane and ethane are removed from 2 through line 3.

The remainder of the natural gas mixture is passed through line 4 to debutanizer 5 wherein residual propane and normal and isobutanes are removed through line 6. The remainder of the natural gas mixture is passed through line 7 to depentanizer 8 wherein residual butanes and normal and isopentanes are removed through line 9. The remainder of the natural gas material is now composed primarily of a mixture of light gasoline fraction (residual pentanes and heavier) and heavy gasoline fraction, and is passed through line 10 to fractionator 11 wherein the light gasoline is split from the heavy gasoline, light gasoline passing overhead through line 12 and heavy gasoline passing from the bottom of fractionator 11 through line 13. The mixture of hydrocarbons in lines 3, 6 or 9 can be further treated by conventional means such as conventional fractionators to separate hydrocarbons from each mixture. For example, a mixture of propane and butanes in line 6 can be passed through a conventional fractionator wherein propane is recovered overhead from that fractionator while the butanes are recovered from the bottom of the fractionator, thereby resolving the mixture in line 6 into its basic constitutents for further use as desired.

Crude oil in line 1' is passed through fractionator 18 wherein an overhead gas material is recovered through line 19 and a topped crude bottom product recovered through line 20. Other conventional intermediate cuts can be obainted at various points along the height of fractionator 18 in a conventional manner. One such cut is a gasoline and a naphtha fraction which contains both light and heavy gasoline fractions as well as hydrocarbons which are heavier than the light gasoline fraction but lighter than the heavy gasoline fraction. The gasoline and naphtha fraction passes by line 21 to fractionator 22 wherein the light gasoline fraction is split off from the heavy gasoline fraction and also from the heavier hydrocarbon fraction. The material in line 21 can be a straight run gasoline fraction having a boiling range of from about 150 to about 380° F. The light gasoline fraction is removed overhead through line 23 and combined with the light gasoline fraction from the natural gas material in line 12. If desired, the light gasoline fractions in lines 12 and 23 can first be fractionated by use of fractionator 23' to remove butanes and lighter hydrocarbons overhead and then passing the remainder to reforming zone 26. The heavy gasoline fraction and naphtha fraction are removed from fractionator 22 through line 24 and combined with the heavy gasoline fraction from natural gas material in line 13.

The combination of light gasoline fraction from lines 12 and 23 is passed through line 25 to reforming zone 26. This combination can have an octane number of from about 60 to about 70 and a boiling range of from about 180 to about 300° F. Reforming zone 26 employs a conventional low end point reformer operation for aromatics production using a platinum catalyst. A suitable low end point reforming operation is disclosed in U.S. Patent No. 3,121,676, column 3, lines 32–40, the disclosure of which is hereby incorporated herein by reference.

Reformed product from reformer 26 will contain at least 50 weight percent, based on the total weight of the reformate, of a galosine fraction having an octane number of from about 95 to about 100 and a boiling range of from about 180 to about 340° F., the remainder being substantially hydrogen and hydrocarbons having 1 to 5 carbon atoms, inclusive, per molecule.

Reformed product from reformer 26 passes through line 27 to fractionator 28 wherein the hydrogen and C_1 to C_5 hydrocarbons are removed as overhead and the gasoline fraction is separated from the bottom thereof through line 29 as a high octane product of the system.

The overhead material from fractionator 28 is recovered through line 30. This overhead material is cooled by cooler 31 to a temperature sufficient to substantially liquefy at least 50 weight percent, based on the total weight of the overhead, of the propane and heavier hydrocarbons, leaving substantially all of the ethane and lighter hydrocarbons and hydrogen in the gaseous state. The gas and liquid emanating from cooler 31 passes through line 32 into accumulator 33 where the gas is separated from the liquid and passed into line 34. The gas in line 34 can contain at least 50 volume percent of methane, ethane, and hydrogen, the remainder being substantially other heavier hydrocarbons while the liquid in lines 35 can contain at least 50 volume percent of propane and heavier hydrocarbons up to about 5 carbon atoms to the molecule, all volume percents being based on the total volume of the gas in 34 or the liquid in 35. The liquid in accumulator 33 passes through 35 and is used in part as reflux for fractionator 28 by way of line 36 and in part passed into line 37.

The combined heavy gasoline fractions from line 13 and 24 pass into fractionator 40 which is operated under conditions such that a conventional kerosene fraction (boiling range of about 350° F. to 525° F.) can be separated from the bottom thereof through line 41 and the naphtha fraction containing hydrocarbons which are lighter than the heavy gasoline fraction can be recovered overhead through line 42. The overhead hydrocarbon fraction in line 42 can contain at least 50 volume percent, based on the total volume of the overhead fraction, of dimethylpentanes and lighter hydrocarbons, the remainder being substantially heptane and heavier hydrocarbons up to about 9 carbon atoms per molecule. The remaining heavy gasoline fraction passes from fractionator 40 to line 43 to reforming zone 44.The heavy gasoline fraction combination in line 43 contains a gasoline fraction having an octane number of from about 75 to about 85 and a boiling range of from about 225 to about 385° F. and hydrogen and C_1 to C_9 hydrocarbons. At least 50 volume percent of the material in line 43 is the reformed gasoline fraction. The heavy gasoline fraction is converted in 44 to a reformed product containing a gasoline fraction having an octane number of from about 94 to about 99 and a boiling range of from about 125 to about 425° F., as well as the hydrogen and C_1 to C_5 hydrocarbons. At least 50 volume percent of the material in line 45 is the gasoline fraction.

Reformer 44 can be operated using a conventional high end point reformed operation for the production of motor fuels and to include hydrocracking using a platinum catalyst. A suitable high end point reforming operation is disclosed in U.S. Patent No. 3,121,676, columns 3, lines 41–47, the disclosure of which is hereby incorporated herein by reference.

Reformed product from reformer 44 passes through line 45 into fractionator 46 which is operated under conditions such that the hydrogen and C_1 to C_5 hydrocarbons are removed overhead in line 48 while the reformed gasoline fraction is sepaarted from the bottom thereof through line 47 as a high octane gasoline product of the system.

The overhead material in line 48 is cooled by cooler 49 so as to substantially liquefy at least 50 weight percent, based on the total weight of the overhead, of propane and heavier hydrocarbons, leaving substantially all of the ethane and lighter hydrocarbons and hydrogen in the gaseous state. The gas and liquid effluent from cooler 49 passes through line 50 into accumulator 51 wherein the materials in the gaseous state are separated from the liquid and passed from accumulator 51 into line 52. The gas in line 52 can contain at least 50 volume percent, based on the total volume of the gas in 34, methane, ethane, propane and hydrogen, the remainder being substantially heavier hydrocarbons. The liquid in accumulator 51 passes therefrom through line 53 to be used in part as reflux for fractionator 46 by way of line 54 and can be combined in part with the liquid in line 37 by way of line 55. The liquid in line 53 can contain at least 50 volume percent, based on the total volume of the liquid in 53,

of propane and heavier hydrocarbons up to C_9 hydrocarbons to the molecule.

The combined liquids from lines **37** and **55** pass through line **56** into line **4** as feed for debutanizer **5**.

The gases in lines **34** and **52** are combined and passed by way of line **57** into cooler **58** wherein they are cooled to a temperature in the range of from about 50 to about 100° F. and from there by way of line **59** into absorber **60**.

The overhead hydrocarbons in line **42** are cooled in cooler **63**, for example, to a temperature of from about 50 to about 100° F. Cooled hydrocarbons pass from cooler **63** through line **64** into absorber **60**.

Absorber **60** is operated under conditions, e.g., from about 50 to about 100° F., and superatmospheric pressures of from about 200 to about 600 p.s.i.g., such that the countercurrently contacting hydrocarbons from lines **59** and **64** are in a condition such that the hydrocarbons in line **64** absorb substantially all of the hydrocarbons in line **59** except hydrogen and methane. The hydrogen and methane are recovered overhead from absorber **60** by way of line **65** for subsequent utilization as desired. The hydrogen can be separated and used in hydrogenation processes. The methane can be used as fuel gas. The remaining hydrocarbons, i.e., the hydrocarbons in line **64** with their absorbed hydrocarbons from line **59** pass from the bottom of absorber **60** into line **66** and thereby returned to line **1** as feed depropanizer **2**.

Optionally, the overhead gas materials in line **19** can be added to line **1** as feed for the natural gas material treating system. Line **19** can contain at least 50 volume percent, based on the total weight of the material in line **19**, hydrogen, methane, ethane, propanes, and butanes, the remainder being substantially pentanes and heavier hydrocarbons. Also optionally, a material comprising substantially completely hydrogen, methane, ethane, and heavier hydrocarbons down to 9 carbon atoms to the molecule can be added as feed for absorber **60** upstream of cooler **58** by way of line **67**.

The products of this invention have a variety of well known uses. For example, the kerosene of line **41** can be used as a burning fuel in a conventional manner, or treated for recovery of normal paraffins which can be used in the manufacture of biodegradable detergent alkylate. The products of lines **29** and **47** can be employed as blending stocks for producing high octane gasoline for use in internal combustion engines of automobiles, airplanes, and the like.

A crude oil which can be employed in this invention can have an API gravity at 60° F. of from about 30 to about 45. For example, a 50/50 volume mixture of Gulf Coast sweet and West Texas sour can be used.

Example

The process was carried out in the manner and using the apparatus as discussed hereinabove and as shown in the drawing. A flow sheet of the results was as follows:

TABLE I

	1(1) Comp., Vol. %	2 Comp.	19 Comp., Vol. %	21	12	13	23	24	25	43	42 Comp., Vol. %	29	47	34 Comp., Vol. %	37 Comp., Vol. %	52 Comp., Vol. %	55 Comp., Vol. %	65 Comp., Vol. %	66 Comp., Vol. %	67 Comp., Wt. %
Hydrogen and Methane	0.2.		0.1								0.2			48.1	0.4	32.1	0.5	89.4	0.7	2.2
Ethane	9.9		0.6								1.0			13.4	3.5	23.8	7.8	8.5	9.5	2.5
Propanes	38.7		6.8								2.3			22.1	20.6	28.7	33.0	2.1(6)	19.6	95.3
Butanes	25.0		58.8								3.5			16.4(5)	75.5(5)	15.4(5)	58.7		13.1	
Pentanes and heavier Hydrocarbons	26.2		33.7								12.8(4)								57.1	
Other	50 vol.% Gulf Coast sweet & 50 vol. % West Taxas Sour, 40-43° API at 60° F.		Straight Run Gasoline, BR(2) 156 to 372	BR 157 to 306	BR 280 to 422	BR 108 to 250	BR 250 to 382	BR 192 to 292	BR 235 to 376 ON(3) 65	ON 79			BR 187 to 335 ON 97.8	BR 139 to 412 ON 98.5						
Volume or Quantity of Flow											57 bbl. per hour			1536 lbs. per hr.	79 bbl. per hour	2954.7 lbs. per hr.	32 bbl. per hr.	827 lbs. per hr.	106 bbl. per hr.	3719.3 lbs. per hr.

(1) Number in Tables I and III corresponds to number on drawing.
(2) BR means Boiling Range.
(3) ON means octane number.
(4) See Table II.
(5) Includes pentanes and heavier hydrocarbons.
(6) Includes butanes and heavier hydrocarbons.
(7) Volume percentages include any olefins present.

TABLE II

	Vol. percent
n-Hexane	14.9
Isohexanes	11.1
Methylcyclopentanes	8.4
Cyclohexane	8.4
2,2-dimethylpentane	0.3
2,4-dimethylpentane	0.3
Other heptanes and heavier hydrocarbons	36.8

TABLE III

Operating Conditions	26	44	60
Temperature, ° F.	900 Average	909 Average	Top 85. Bottom 160.
Pressure, p.s.i.g.	350	425	480.
H_2 to hydrocarbon mol ratio.	8	7	
Space Velocity*	2.5-3	2.5-3	
Catalyst	UOP R-5	UOP R-11	

*Volumes of hydrocarbon per volume of catalyst per hour.

Reasonable variations and modifications are possible within the scope of this disclosure without departing from the spirit and scope thereof.

I claim:

1. A process for forming gasoline blending stocks comprising providing a natural gas material containing a light gasoline fraction, a heavy gasoline fraction, and hydrocarbons lighter than said light and heavy gasoline fractions; providing a crude oil containing a light gasoline fraction, a heavy gasoline fraction, and hydrocarbons lighter than said heavy gasoline fraction; (1) removing said lighter hydrocarbon from said natural gas material, leaving said light and heavy gasoline fractions; (2) seperating said light and heavy gasoline fractions from one another; (3) separating from said crude oil a mixture of said light gasoline fraction, heavy gasoline fraction, and hydrocarbons lighter than said heavy gasoline fraction; (4) separating from said mixture said light gasoline fraction thereby leaving a mixture of said heavy gasoline fraction and said hydrocarbons lighter than said heavy gasoline fraction; (5) combining the light gasoline fractions from steps (2) and (4); (6) combining the heavy gasoline fractions from step (2) and the heavy gasoline fraction and hydrocarbons lighter than said heavy gasoline fraction from step (4); (7) reforming the combination of step (5) to raise the octane number of the contained light gasoline fractions; (8) separating the reformate of step (7) into a first gasoline bottoms product and a first overhead product of hydrocarbons including butanes and hydrocarbons lighter and heavier than said butanes; (9) separating said first overhead product into two sub-fractions comprising a first light sub-fraction containing primarily hydrocarbons lighter than the propane and a first heavy sub-fraction containing primarily propane and hydrocarbons heavier than said propane; (10) separating from the combination of materials of step (6) said hydrocarbons that are lighter than the heavy gasoline fraction from said heavy gasoline fraction; (11) reforming the heavy gasoline fraction of step (10) to raise the octane number of the contained heavy gasoline fractions; (12) separating the reformate of step (11) into a second gasoline bottoms product and a second overhead product of hydrocarbons including butanes and hydrocarbons lighter and heavier than said butanes; (13) separating said second overhead product into two sub-fractions comprising a second light sub-fraction containing primarily hydrocarbons lighter than the propane and a second heavy sub-fraction containing primarily propane and hydrocarbons heavier than said propane; (14) combining said first and second heavy sub-fractions and returning the combination as feed for step (1); (15) combining said first and second light sub-fractions; (16) contacting the combination of step (15) and said removed hydrocarbons that are lighter than the heavy gasoline fraction of step (10) so that said removed hydrocarbons of step (10) absorb substantially all of said hydrocarbons in the combination of step (15) but hydrogen and methane; and (17) returning said removed hydrocarbons of step (10) and its absorbed hydrocarbons from the combination of step (15) as feed for step (1).

2. The process according to claim 1 wherein said natural gas material comprises a separate natural gas liquid containing from about 60 to about 80 volume percent of hydrogen and hydrocarbons having from 1 to 4, inclusive, carbon atoms per molecule and from about 20 to about 40 volume percent of hydrocarbons having from 5 to 9, inclusive, carbon atoms per molecule, both volume percentages being based on the total volume of the natural gas liquid; said crude oil comprises a crude oil having an API gravity at 60° F. of from about 30 to about 45, containing light gasoline fraction, a heavy gasoline fraction, hydrocarbons lighter than said heavy gasoline fraction; and wherein the step of processing said natural gas liquid and crude oil are as follows: (1) fractionating said natural gas liquid separate from said crude oil to remove said heptanes and lighter hydrocarbons and leave a first mixture comprising said light and heavy gasoline fractions; (2) fractionating said first mixture to separate same into a first light gasoline fraction and a first heavy gasoline fraction; (3) fractionating said crude oil separate from said natural gas liquid to produce a second mixture comprising hexanes and lighter hydrocarbons, the light gasoline fraction and a heavy gasoline fraction; (4) fractionating said second mixture to form a second light gasoline fraction and a second heavy gasoline fraction containing said hexanes and lighter hydrocarbons; (5) combining said first and second light gasoline fractions to form a third mixture; (6) combining said first and second heavy gasoline fractions to form a fourth mixture; (7) reforming said third mixture to form a fifth mixture comprising a gasoline fraction having an octane number of from about 95 to about 100 and a boiling range of from about 180 to about 340° F., and hydrogen and hydrocarbons having 1 to 5, inclusive, carbon atoms per molecule; (8) fractionating said fifth mixture to recover therefrom the gasoline fraction described in step (7) as a first product of the process and to leave a sixth gaseous mixture comprising said hydrogen and hydrocarbons having 1 to 5, inclusive, carbon atoms per molecule; (9) cooling said sixth mixture to form a seventh gaseous mixture comprising hydrogen and hydrocarbons having 1 to 3. inclusive, carbon atoms per molecule, and an eighth liquid mixture comprising hydrocarbons having 3 to 5, inclusive, carbon atoms to the molecule; (10) fractionating said fourth mixture to separate therefrom a ninth mixture comprising hexanes and lighter hydrocarbons and leave a tenth mixture comprising a heavy gasoline fraction and hydrogen and hydrocarbons having 1 to 5, inclusive, carbon atoms per molecule; (11) reforming said tenth mixture to form an eleventh mixture comprising a gasoline fraction having an octane number of from about 94 to about 99 and a boiling range of from about 125 to about 425° F. and hydrogen and hydrocarbons having 1 to 5, inclusive, carbon atoms per molecule; (12) fractionating said eleventh mixture to recover therefrom the gasoline fraction described in step (11) as a second product of the process and to leave a twelfth gaseous mixture comprising hydrogen and hydrocarbons having 1 to 5, inclusive, carbon atoms per molecule; (13) cooling said twelfth gaseous mixture to form a thirteenth gaseous mixture comprising hydrogen and hydrocarbons having 1 to 3, inclusive, carbon atoms per molecule, and a fourteenth liquid mixture comprising hydrocarbons having 3 to 5, inclusive, carbon atoms per molecule; (14) combining said eighth liquid mixture and said fourteenth liquid mixture to form a fifteenth mixture; (15) returning said fifteenth mixture as feed for step (1); (16) combining said seventh gaseous mixture and said thirteenth gaseous mixture to form a sixteenth mixture; (17) contacting said sixteenth mixture and said ninth mixture under conditions such that said ninth mixture absorbs substantially all of said sixteenth mixture except hydrogen and methane, and thereby forms a seventeenth mixture; and (18) returning said seventeenth mixture as feed for step (1).

3. The process according to claim 2 wherein step (3) of claim 2 also produces a gaseous mixture comprising hydrogen, methane, ethane, propanes, butanes and pentanes and heavier hydrocarbons as a gaseous mixture which is passed as feed to step (1) of claim 2; and a separate mixture comprising primarily hydrogen, methane, and ethane and heavier hydrocarbons is added to said sixteenth mixture before it is contacted with said ninth mixture.

4. The process according to claim 1 wherein said combined light gasoline fractions prior to reforming are characterized by a boiling range of from about 180 to about 300° F. and an octane number of from about 60 to about 70; said combined heavy gasoline fractions prior to reforming are characterized by a boiling range of from about 225 to about 385° F. and an octane number of from about 75 to about 85; said natural gas material is characterized by having a composition of from about 60 to

about 80 volume percent hydrogen and hydrocarbons having from 1 to 9, inclusive, carbon atoms per molecule and from about 20 to about 40 volume percent of hydrocarbons having from 5 to 9, inclusive, carbon atoms per molecule; and said crude oil is characterized by having an API gravity at 60° F. of from about 30 to about 45.

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