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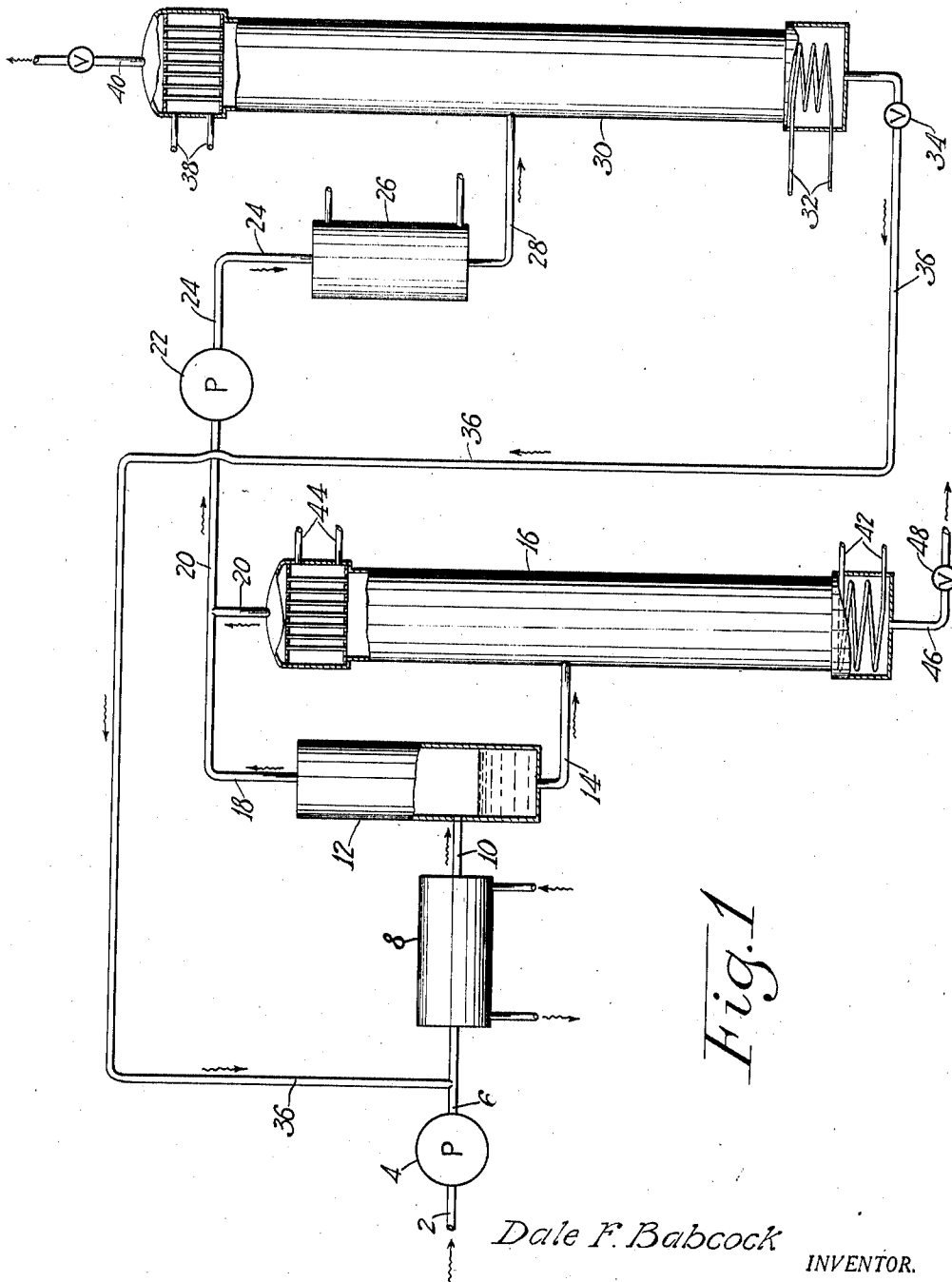
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FROM CRACKED PETROLEUM HYDROCARBONS
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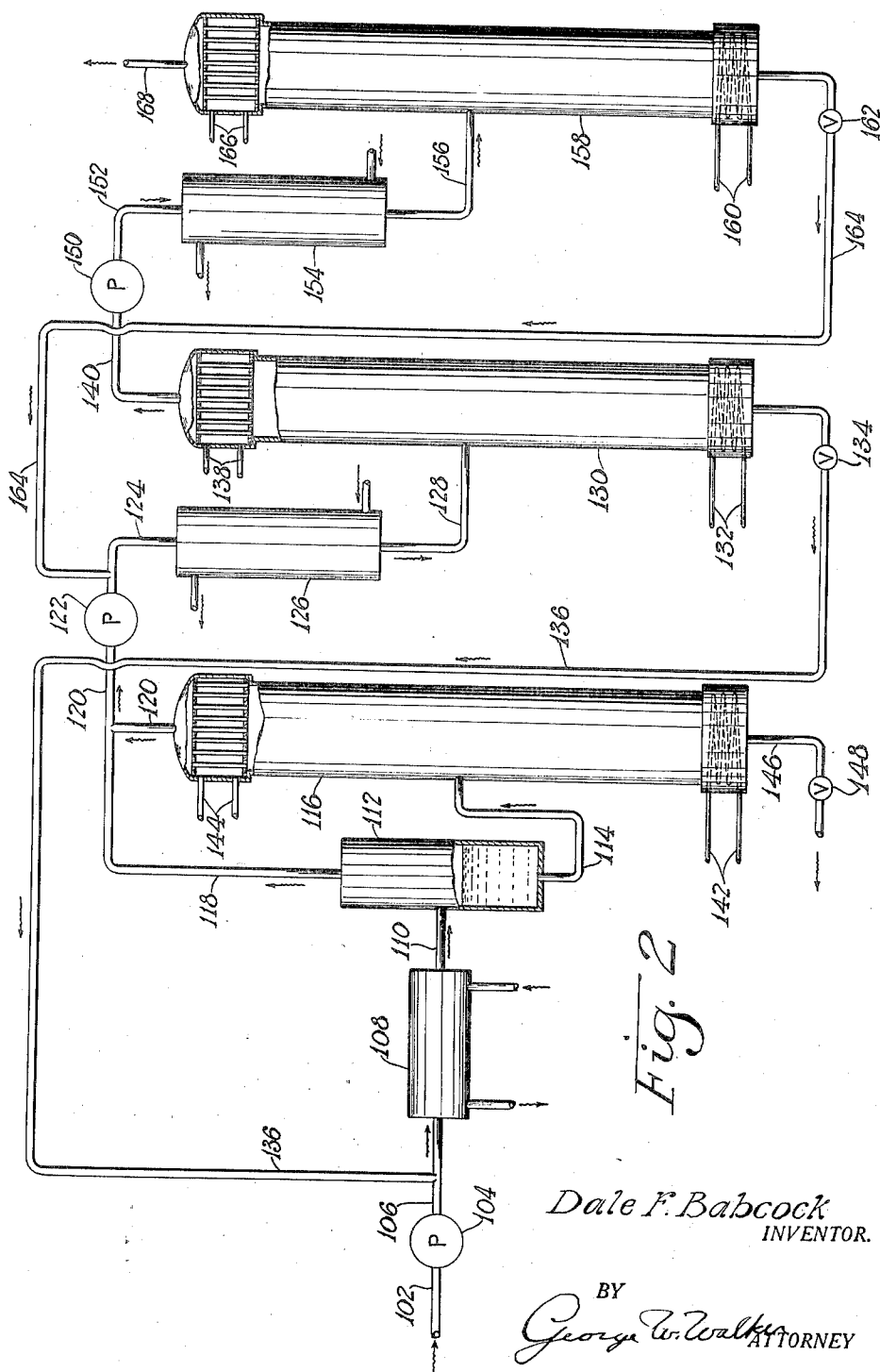
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APPARATUS AND A PROCESS FOR THE RECOVERY OF GASOLINE FROM CRACKED PETROLEUM HYDROCARBONS

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Application October 14, 1937, Serial No. 168,891

2 Claims. (Cl. 62—122)

This invention relates to a process for the separation of mixtures of gaseous hydrocarbons by liquefaction and fractionation, and more particularly to the recovery of hydrocarbons containing in excess of three carbon atoms per molecule from a complex gas mixture.

The pyrolysis of petroleum materials, as practiced in commercial vapor phase cracking operations, produces both liquid and gaseous products.

10 These cracked gases are usually saturated with materials boiling in the gaseous range which must be recovered prior to use of the gas in other processes or for fuel.

15 In the gasoline refining industry this recovery of gasoline is often effected by compressing the cracking gas to a moderate pressure, cooling and thereby liquefying a portion of its gasoline content. The uncondensed gases, still under pressure, are then forced up through a scrubbing
20 tower, countercurrent to a light oil which scrubs the remaining gasoline from the fixed gases. The low-boiling gasoline is then distilled from the "fat" oil, which is then recycled to the scrubbing operation. The distillate is joined with the liquid
25 fraction separated after compression, and the mixture is introduced into a stabilizing column where the low-boiling components which are too volatile to be used in gasoline are distilled off. I have found it much more expedient to recover
30 and to stabilize the gasoline content of the cracked gas in a different manner.

One object of this invention is to provide a simple and efficient process whereby the components of a complex mixture of gaseous hydrocarbons, which are usually a stable liquid at ordinary
35 conditions of temperature and pressure, are recovered from the gas mixture. Another object is to provide a method for the recovery of a relatively non-volatile liquid product such as gasoline, free from such constituents as hydrogen,
40 methane, ethane, ethylene, and propylene from a mixture of hydrocarbon gases produced by cracking petroleum products. Still another object is the separation of the gasoline fraction from a
45 mixture of gases obtained by cracking petroleum products. A further object is the provision of an apparatus for the accomplishment of the above ends. Other objects will appear hereinafter.

These objects are accomplished by the following
50 invention which comprises compressing the gas mixture, cooling and separating the liquid formed, which comprises principally gasoline, rectifying the liquid fraction so that the more volatile gases are separated from the materials
55 boiling in the gasoline range, combining the gaseous fraction from the gas and liquid separation step with the gaseous fraction from the rectification step and further compressing same to a higher pressure, cooling the thus compressed gases and rectifying the resultant fluid so as to

separate all of the fraction boiling within the gasoline range as a liquid and the more volatile components as a gas, reducing the pressure on this second liquid fraction to the pressure of the first part of the system and combining the resulting fluid with the effluent from the first compression step.

The accompanying drawings represent diagrammatically complete apparatuses for the separation of the components of this fluid mixture. 10 Figure I is the simplest modification of the apparatus and embodies a process which has but two compression stages. Figure II is a modification of the apparatus in which three compression stages are used. It is understood that the details of this apparatus, which are well known to those skilled in the art, have been omitted for the sake of clarity and that modifications in the details of construction and in arrangement of parts may be made without departing from the spirit of the invention. The following represents
20 a description of the processes and apparatuses shown in the two figures of the drawings.

In the modification represented by Figure I the crude gas enters the first stage of compressor 4
25 via conduit 2 under substantially atmospheric pressure. The gas is compressed to about 6 atmospheres and passes to water cooler 8 and separator 12 via conduits 6 and 10. The condensed liquid is passed by gravity flow from separator
30 12 through conduit 14 into the middle of rectifying column 16. Reflux is provided in this column by heating calandria 42 with steam and cooling condenser 44 with water. The stabilized gasoline produced at the base of rectifier 16 is removed from the system by way of conduit 46
35 and valve 48. The non-condensable vapors leaving the top of rectifier 16 are combined with the vapor leaving separator 12 and passes to compressor 22 via conduit 20. The gaseous fractions
40 from the separator 12 are combined with the non-condensable vapors from the rectifier 16 by introducing via conduit 18 into conduit 20. These vapors are compressed to 33 atmospheres, cooled to room temperature by means of water
45 cooler 26 and pass to rectifier 30 via conduit 28. Reflux is produced in this rectifier by heating calandria 32 with steam and cooling condenser 38 with water. The non-condensable gas leaving the top of rectifier 30 via conduit 40 passes
50 to a low temperature separation system where pure ethylene and propylene are recovered. The liquid from the base of rectifier 30 is expanded through valve 34 and conduit 36 into conduit 6 where it mixes with the vapors leaving compressor 4.

In Figure II the crude gas enters the first stage of compressor 104 by conduit 102, the gas is compressed to about 3 atmospheres and passes to water cooler 108 and separator 112 via conduits

106 and 110. The condensed liquid is passed by gravity flow from separator 112 through conduit 114 into the middle of rectifying column 116. The reflux is provided in the rectifying column 116 by heating the calandria 142 with steam and cooling the condenser 144 with water. The stabilized gasoline produced at the base of the rectifying column 116 is removed from the system by way of conduit 146 and valve 148. The non-condensable vapors leaving the top of rectifier 116 are passed to the second stage of the compressor 122 via conduit 120. The gaseous fractions from the separator 112 are combined with the non-condensable vapors from the rectifier 116 by introducing via conduit 118 into conduit 120. These combined vapors are compressed by compressor 122 to a pressure of about 10 atmospheres, cooled to room temperature by means of water cooler 126 and passed into rectifier 130 via conduits 124 and 128. Reflux is produced in rectifier 130 by heating calandria 132 with steam and cooling condenser 138 with water. The liquid from the base of rectifier 130 is expanded through valve 134 to 3 atmospheres pressure and conducted via conduit 136 to conduit 106 where it is mixed with the vapors leaving compressor 104. The non-condensable gas leaving the top of rectifier 130 is conducted via conduit 140 to the third stage of the compressor 150 where it is compressed to 33 atmospheres. The thus compressed gas is then conducted by conduit 152 through water cooler 154 and conduit 156 into the rectifying column 158. Reflux liquids in rectifying column 158 are produced by heating calandria 160 with steam and cooling condenser 166 with water. The liquid from the base of rectifier 158 is expanded through expansion valve 162 to a pressure of 10 atmospheres and then via conduit 164 is introduced into 124 where it mixes with the vapors leaving compressor 122. Non-condensable gas leaves the rectifier 158 via conduit 168, at the top thereof.

The process described herein is an improvement over the process described in the copending application Serial No. 30,031, of C. H. Greenewalt, in that the liquid in the process herein is essentially free of low boiling materials. It is therefore more advantageously employed as an absorption oil to promote the condensation of high boiling components from the intermediate pressure gas.

Example

A gas of the following composition that had been produced by the vapor phase cracking of petroleum was processed according to the modification of the invention as shown by Figure I.

	Mole per cent
Hydrogen	8
Methane	20
Ethylene	25
Ethane	10
Propylene and propane	17
C ₄ hydrocarbons	10
C ₅ and heavier hydrocarbons	10
	100

This gas was compressed to six atmospheres, combined with the expanded liquid from the high pressure rectifier, cooled to 30° C., the liquid separated from the vapor and the liquid processed in the intermediate pressure rectifier. The base of this rectifier was heated with steam to 117° C., at which temperature essentially all of the butylene

and more volatile components were expelled from the liquid producing gasoline containing essentially only C₅ and heavier hydrocarbons. The condenser of the intermediate pressure rectifier was cooled to 30° C. The vent gas from this rectifier was combined with the vapor from the separator and the mixture compressed to 34 atmospheres. The compressed gas fed directly to the middle of the high pressure distilling column, the base temperature of which was maintained at 155° C. The liquid remaining in the rectifier base at this temperature was continuously expanded to the intermediate pressure of six atmospheres and combined with the effluent from the first stage compressor. This liquid had the following composition:

	Mole per cent
Propylene and propane	5
C ₄ hydrocarbons	26
C ₅ and heavier hydrocarbons	69
	100

The vapors leaving the top of the high pressure rectifier at 25° C. contained essentially all of the butylene and lighter components originally contained in the crude gas together with about 1/2 of 1 mole per cent of C₅ hydrocarbons.

It is desirable to heat the base of rectifiers 30 and 158 to such a temperature that essentially all of the butylene and more volatile components are driven from the liquid. However, many crude gases contain such a quantity of polymer and gum-forming materials that this procedure is impractical. Under such a condition the base of rectifiers 30 or 158 may be heated to a temperature below that at which polymerization takes place allowing the liquid which is expanded from the base of this rectifier to contain appreciable quantities of butylene and propylene.

The compression system outlined in Figure I contains only two stages. The compression system may contain three stages as shown by Figure II or even a larger number of stages may be used. In every case it is obvious additional rectifiers will be required with the liquid from the highest pressure rectifier being expanded back into the discharge line from the next highest pressure compressor exactly as shown herein.

In my experiments I desired to produce a stabilized gasoline at the base of rectifiers 16 or 116 which was essentially free of butylene and more volatile components. In the gasoline industry it is oftentimes desirable to leave up to 5% of butylene in the liquid. This may be accomplished in the process herein described by reducing the temperature in calandrias 42 or 142 to say 100° instead of 115° as mentioned in the above example.

This process has the advantage of recycling a minimum quantity of intermediate boiling material and thereby reducing the power used for operating the compressors. Also in the present invention no liquid or gaseous product attains a temperature lower than that of cooling water, thus eliminating troublesome freeze-ups that might occur if temperatures are used below the freezing point of water, in view of the fact that the incoming gas contains a small amount of water. A further power savings is accomplished by expanding the high pressure liquid from the rectifier into the effluent from the next lower compressor. This liquid acts as an absorbing oil condensing from the effluent certain of the heavier fractions that would normally remain in the gas and be recompressed to the higher pressure.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended patent claims.

I claim:

1. The process which comprises compressing a gaseous mixture from cracked petroleum hydrocarbons containing a gasoline fraction and gases that are lower boiling than said gasoline fraction, cooling the compressed gases to effect liquefaction of said gasoline fraction, separating said gasoline fraction therefrom, rectifying the separated gasoline fraction by counter-current flow of reflux liquors and by boiling the liquid at the base of the rectifying column in order to establish refluxing conditions and expel the lower boiling hydrocarbons from the liquid gasoline, combining the gaseous fraction obtained from the rectification step and the gaseous fraction obtained from the gas and liquid separation step, compressing said gaseous fraction in a plurality of compression stages, said stages being characterized in that there is a cooling and rectifying step between each stage of compression, said rectifying steps being operated by counter-current flow of refluxing liquors and by boiling the liquid at the base of the rectifying column in order to establish refluxing conditions and separate as a liquid gasoline and expel the lower boiling hydrocarbons therefrom, said process being further characterized in that the gasoline fraction from the higher pressure stage is expanded to the pressure of the next lower pressure stage and combined with the effluent from the next lower pressure stage.

2. An apparatus for separating the components of a fluid mixture which comprises the following elements in combination: a gas and liquid separator and a multi-stage compressor together with a cooler and a rectifier for each compression stage, means for introducing the fluid mixture into the first compression stage, means for passing the fluid mixture from the first compression stage through the cooler connected therewith into the gas and liquid separator, means for passing the liquid from the gas and liquid separator into the rectifying column adapted for operation with the first compression stage, means for withdrawing the gaseous fraction from the gas and liquid separator and the gaseous fraction from the rectifying column and combining same and introducing said combined gaseous fractions into the second compression stage, means for removing the liquid fraction from the bottom of the rectifying column; separate means for withdrawing the gases from the top of the rectifier in each compression stage except the first and last and introducing said gases into the next higher compression stage, separate means for passing the compressed gases from each compression stage above the first through the cooler for each compression stage into the rectifying column for each compression stage, separate means for withdrawing the gases from the rectifier of the last compression stage, and separate means for withdrawing the liquid from each of the rectifying columns for each of the compression stages except the first and for combining said liquid with the effluent from the compression stage next lower in pressure.

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