

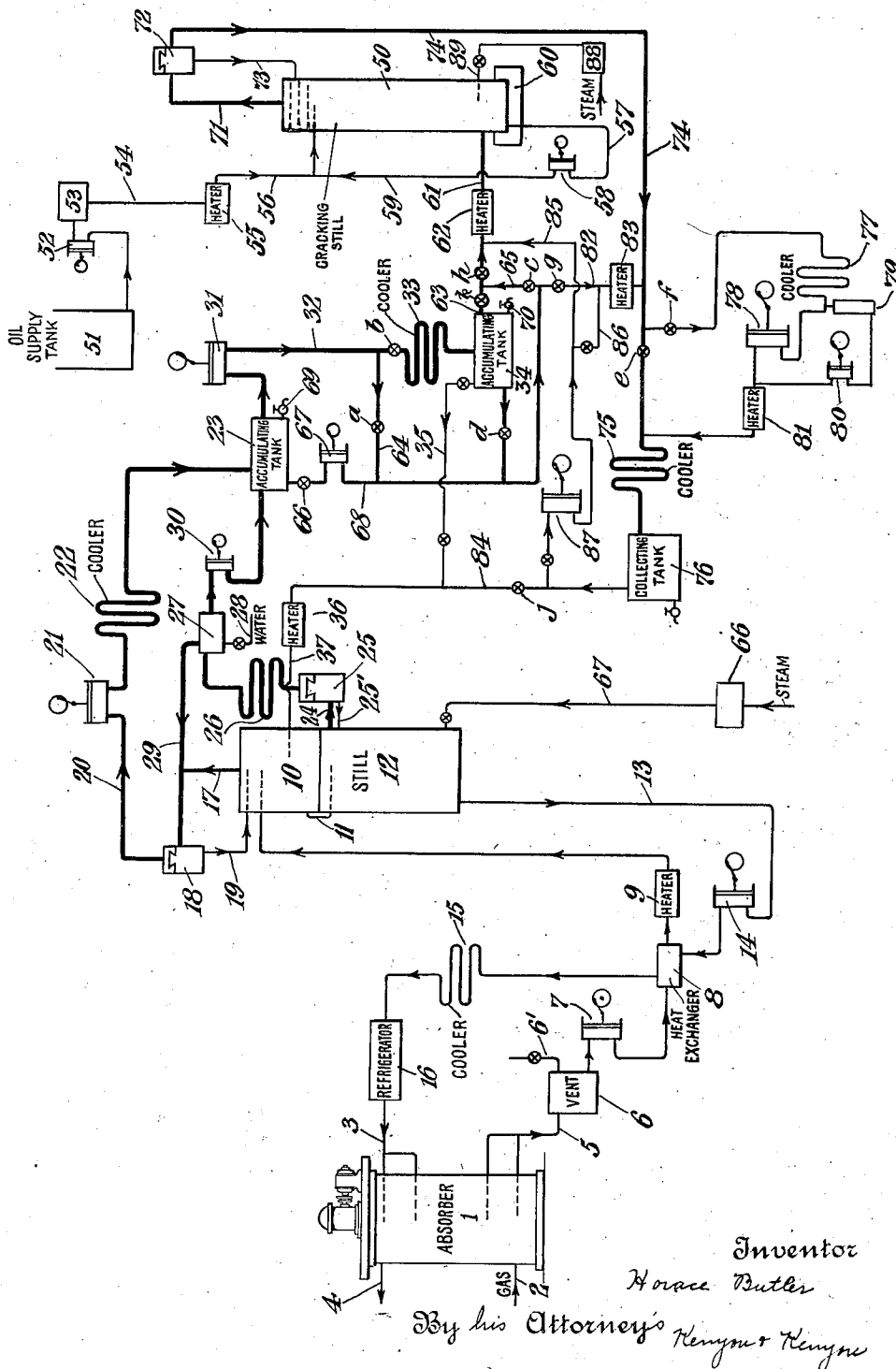
Aug. 4, 1931.

H. BUTLER

1,817,672

PROCESS AND APPARATUS FOR PRODUCING LIGHT HYDROCARBONS

Filed Dec. 27, 1926



Inventor

Horace Butler

By his Attorney's Kenyon & Kenyon

UNITED STATES PATENT OFFICE

HORACE BUTLER, OF WEST CHESTER, PENNSYLVANIA, ASSIGNOR TO RESEARCH
PROCESS COMPANY, A CORPORATION OF DELAWARE

PROCESS AND APPARATUS FOR PRODUCING LIGHT HYDROCARBONS

Application filed December 27, 1926. Serial No. 157,014.

My invention relates to apparatus and a process for producing light hydrocarbons and particularly light hydrocarbons of which gasoline is composed.

5 It has been proposed to produce gasoline by the so-called cracking of heavier hydrocarbons of crude petroleum but many difficulties are encountered in the practice of such a process including the formation of carbon
10 deposit in the still in which the cracking operation is carried on. Furthermore, it has not been found commercially possible heretofore to convert into gasoline hydrocarbons all of such petroleum or petroleum products
15 as are introduced into the cracking still.

It has also been proposed to produce gasoline from natural gas by the so-called absorption methods in which certain constituents of the natural gas are absorbed in a medium
20 contacted with the natural gas and then distilled off of such medium and then liquefied in whole or in part by compression and cooling. In such absorption processes, however, only a small part of the natural gas
25 is converted into gasoline of a readily usable form and even a large part of those hydrocarbons present in the natural gas and desirable as gasoline constituents, is not brought into the gasoline so produced.

30 Moreover, the production of gasoline by mixing light hydrocarbons such as natural gas with vapors produced by distillation of crude petroleum is impracticable because extremely high pressures would be necessary
35 to effect stable liquefaction to a reasonable extent of the resulting mixture of vapors and gases.

It is an object of my invention to provide apparatus and a process whereby the difficulties and disadvantages of previously known processes for the production of gasoline will be substantially avoided.

40 In the practice of my invention a charging material consisting of crude petroleum or fractions, residues or products thereof, that include hydrocarbons that possess boiling points so high that they are not suitable as constituents of gasoline, is subjected to cracking in a cracking zone, in liquid phase
50 or in vapor phase or in both phases suc-

cively, and hydrocarbons of suitably low boiling point are utilized in connection with the cracking operation, preferably by being introduced separately or together with other substances into the cracking zone or into the vapors thereof or in part into the cracking zone and in part into the vapors thereof, and then the resulting vapors are condensed. In such an operation the added hydrocarbons of suitably low boiling point preferably possess a resultant condensation pressure or average partial pressure as low as is compatible with the production, without change of conditions in the cracking zone, of a final product of desired initial and end points and sufficiently low to permit a reasonably complete combination and stable liquefaction of the vapors coming from the cracking zone by the use of pressure low enough to be readily produced in the commercial production of gasoline.
55
60
65
70

My invention contemplates the utilization of such suitably low boiling hydrocarbons of suitably low average partial pressure in connection with both liquid phase cracking and vapor phase cracking (independently or successively employed upon the same material) of relatively high boiling petroleum products; and it contemplates also the use of steam in the cracking operations.

75
80
85
90
95
100
Natural gas contains hydrocarbons which as originally constituted are suitable as constituents of commercial gasoline, but it also contains in large quantities constituents, such as methane, of which the partial pressure is so high that combination and stable liquefaction of the constituents of a mixture of vapors coming from a cracking operation to which natural gas has been added, cannot be obtained to a reasonable extent by the employment of known methods. In other words the utilization of natural gas in connection with the cracking of petroleum products in an effort to produce gasoline gives rise to a vapor mixture of such high resultant or average partial pressure that liquefaction thereof to a reasonable extent cannot be effected by known means. Accordingly, a specific application of my invention resides in utilizing in connection with the cracking of petroleum products in the production of

gasoline, natural gas which has been so treated as to reduce its resultant or average pressure as by elimination from the natural gas of constituents, such as methane, that possess high partial pressure. Such reduction of the resultant or average pressure of natural gas may be effected in the practice of my invention by contacting the natural gas with an absorbent medium, such as mineral seal oil, and thereby absorbing constituents of relatively lower partial pressure and then distilling from the absorbent medium, the hydrocarbons so absorbed thereby and thus producing as the vapors of such a still, a mixture of hydrocarbon vapors having a lower resultant or average liquefaction pressure than that of natural gas treated, it being well known that in such an absorption operation the hydrocarbons of higher partial pressure, such as methane, are not completely absorbed by the absorption medium. Thus, suitable low-boiling hydrocarbons are selected from the natural gas used.

In the practice of this specific application of my invention all or some desired fraction of the hydrocarbons distilled from the absorbent medium that has previously been contacted with natural gas may be introduced directly into the cracking zone or into vapors thereof or a part may be introduced directly into the cracking zone and another part into the vapors thereof, so long as enough of such light hydrocarbons enter the cracking zone to eliminate the deposit of carbon therein. In such an operation it may be advisable for mechanical reasons to subject the vapors distilled from the absorbent medium to compression or to cooling or to both of such operations, in known manner or as herein described, to reduce such vapors to a liquid state or in part to a liquid state and in part to a vapor state. If such vapors are reduced to a liquid state only in part then the uncondensed vapors alone may be utilized in connection with the cracking of petroleum products or the resultant liquid hydrocarbons of low boiling point may be so utilized, or both such liquid and such vapors may be so utilized. Thus, any desired fraction may be used of the hydrocarbons so selectively withdrawn from the natural gas.

In the practice of my invention the vapors produced by the utilization of light hydrocarbons in connection with the cracking of petroleum products may be subjected to cooling to produce a final liquid product or such final liquid product may be produced by the application of other more or less effective steps, such as the application of pressure, with or without the addition of further heat, the vapors being finally cooled. Any desired precautions may be taken in weathering (elimination of very light hydrocarbons without loss of desired hydrocarbons) of the final product.

I have found that in the practice of my invention no objectionable deposit of carbon occurs in the cracking zone and substantially all of the petroleum products introduced into the cracking chamber are converted into gasoline hydrocarbons, even though the lighter hydrocarbons utilized in connection with the cracking operation by being introduced directly into the cracking zone consist only of uncondensed vapors remaining after the vapors of an absorption-medium still are subjected to compression and cooling to produce liquid gasoline from the constituents of natural gas which had been absorbed in the absorption-medium. Merely cooling the vapors resulting from the addition of uncondensed absorption-still vapors to the cracking zone produced commercial motor fuel in a quantity greater than that of the petroleum products introduced into the cracking chamber.

In the practice of my invention uncondensed vapors of the absorption-still or uncondensed vapors coming from the cracking operation or both may be advantageously recirculated in the system by being reintroduced into the operations in which hydrocarbons from natural gas are being treated or by being introduced into the cracking zone.

When the light hydrocarbons utilized in connection with the cracking operation are derived from natural gas as above described the operations whereby gasoline hydrocarbons are obtained from natural gas and the operations whereby light hydrocarbons are utilized in connection with cracking, so cooperate with one another that one set of operations modifies the result of the other set of operations and a final product consisting of motor fuel is produced from both natural gas and heavier petroleum products, such production being substantially free of difficulties encountered in the production of gasoline from either of those sources. My invention, therefore, comprises not only the step of utilizing, in connection with the cracking of petroleum products to produce gasoline, light hydrocarbons of sufficiently low resultant or average pressure to permit reasonably complete and stable combination and liquefaction of the resultant vapors, but also the production of gasoline from natural gas and the cracking of petroleum products in such cooperative relation that the resultant vapors are susceptible of combination and stable liquefaction to a practical extent without use of excessive pressures.

In the drawing there is shown diagrammatically one form of apparatus embodying my invention and whereby my invention may be practised but it is to be understood that my invention is not limited to such embodiment which is intended to be merely exemplary and which is described only for the

purpose of aiding in the understanding of my invention.

The apparatus shown in the drawing comprises means for absorbing hydrocarbons from natural gas, means for distilling from the absorbent medium the hydrocarbons so absorbed and for then compressing the hydrocarbon vapors so evolved, means for utilizing in connection with the cracking of petroleum products all or some part of the vapors evolved from the absorption-medium still, means for obtaining liquid gasoline from the vapors coming from the cracking operation and means for recirculating uncondensed vapors.

The absorber 1 may be of any desired construction but should be so designed as to be highly efficient, preferably effecting an absorption of as much of the natural gas as possible with the exception of hydrocarbons thereof having very high partial pressures, such as methane. The natural gas is led into the absorber 1 through the inlet 2 and absorption medium, such as mineral seal oil, is led into the absorber by the inlet 3, the unabsorbed gas passing out of the absorber through the pipe 4, and oil containing absorbed hydrocarbons passing from the absorber 1 through the pipe 5. The absorber 1 is advantageously operated as in known natural gas absorption systems or various features of operation may be carried on as described in the copending application filed August 7th, 1926, by myself and Alexander Clarke, Ser. No. 127,718.

The oil containing absorbed hydrocarbons passes through pipe 5 into vent tank 6, which is provided with a vent 6', and then is passed by pump 7 through heat exchanger 8 and heater 9 into a still 10 which may resemble a fractionating tower and may be of the standard bell and washer type. In the still 10 some of the absorbed hydrocarbons are liberated from the absorption medium and it then passes through pipe 11 into steam still 12 which may resemble a fractionating tower in construction. From the steam still 12 the oil is passed through pipe 13 by means of pump 14 to the heat exchanger 8 and then to cooling coils 15 and through a refrigerating device 16 from which the oil passes to inlet 3 of absorber 1. The use of the refrigerating device 16 is optional and it may only be necessary to refrigerate some part of the stripped absorption medium, for example, the part entering the upper zone of the absorber 1.

Absorption medium containing absorbed hydrocarbons is heated in heater 9 to a temperature approaching the initial boiling point of the absorption medium, for example, 400° F. to 500° F. Steam is supplied to steam still 12 by boiler 65, the steam preferably passing through superheater 66 and pipe 67 to still 12.

Light hydrocarbon vapors liberated in still

10 pass through pipe 17 to knockout 18 in which suitable reduction of temperature eliminates undesirable fractions including lighter parts of the absorption medium, resulting liquid returning to still 10 through pipe 19. Vapors from knockout 18 pass through pipe 20 to compressor 21 where the pressure of the vapors is increased to about 40 pounds per square inch, pressures referred to herein being gauge pressures. The compressed vapors pass through cooler 22 and the resultant vapors and liquids are collected in accumulator 23.

Vapors evolved in steam still 12 pass through pipe 24 to knockout 25 from which any collected liquid is returned to still 12 through pipe 25'. Vapors pass from knockout 25 through cooling coil 26 into a separating tank 27 from which water is drained by cock 28 and from which vapors pass through pipe 29 to outlet 17 of still 10, and from which liquid hydrocarbons are passed by pump 30 to accumulator tank 23.

The hydrocarbons collected in liquid and vapor form in accumulator tank 23 will possess a resultant or average partial pressure considerably lower than that of the natural gas from which said collected hydrocarbons are derived.

Uncondensed vapors in accumulator tank 23 pass to compressor 31 where their pressure is increased to 225 to 250 pounds. The hydrocarbon vapors pass from compressor 31 through pipe 32 to cooler 33 and the resulting liquid and uncondensed vapors are collected in high stage accumulator tank 34.

With a view to improving the operation of the apparatus so far described for the absorption and distillation of the light hydrocarbons derived from natural gas a part of the uncondensed vapors in the high stage accumulator tank 34 may be carried through pipe 35 to heater 36 and introduced into the light hydrocarbon absorption system at some point preceding the condensation of the absorbed light hydrocarbons, for example, by means of pipe 37 leading from heater 36 into still 10.

Cracking chamber 50 of any suitable form and suitably operated is supplied with crude petroleum or products thereof from tank 51, the charging material in tank 51 being passed by pump 52 into feed tank 53 where the desired pressure, 225 pounds per square inch or higher, is maintained. The charging material passes from feed tank 53 through pipe 54 and through heater 55 into the upper part of cracking chamber 50 through pipe 56, and any charging material drained from chamber 50 through pipe 57 is returned by pump 58 through pipe 59 to the inflowing charging material in pipe 56. Cracking chamber 50 may be provided with a supplemental heater 60.

The charging material may be heated in

heater 55 to suitable temperatures, for example, temperatures up to 1000° F. and the pressures maintained will depend upon the temperature employed, the design of the heater, rate of flow, etc.

Light hydrocarbons of suitable average or resultant pressure are introduced into cracking chamber 50 through pipe 61 leading from heater 62. In the apparatus shown provision is made for various modifications in the utilization of the light hydrocarbons obtained from the natural gas. Thus uncondensed vapors of the high stage accumulator tank 34 may be passed by pipe 63 directly to heater 62 by opening valve *k*. Light hydrocarbons coming from the high stage compressor 31 may be passed into pipe 63 leading to heater 62 by opening valve *a* in pipe 64, closing valve *b* in pipe 32 and opening valve *c* in pipe 65. By opening valve 66, liquid in low stage accumulator tank 23 may be passed by pump 67 into pipe 68 that leads to pipe 65 that opens into pipe 63. Liquid in high stage accumulator tank 34 may be also passed into pipe 68 by opening valve *d*. Accumulator tanks 23 and 34 are respectively provided with drain cocks 69 and 70 in the event that the liquid hydrocarbons therein are to be withdrawn for immediate use or in order to be stabilized and so converted from wild gasoline into commercial gasoline.

The upper zone of the cracking chamber 50 may be of the bell and washer type of scrubber or fractionating column as indicated diagrammatically or the vapors from the cracking zone may be passed through pipe 71 to knockout 72 where undesirable fractions are eliminated, by reduction of temperature if necessary, and returned to the cracking chamber through pipe 73. Vapors from knockout 72 pass through pipe 74 and are condensed. Such condensation may be effected directly by cooler 75 and the resulting liquids and vapors are collected in tank 76 from which they may be withdrawn to storage with or without being subjected to stabilization. By closing valve *e* in pipe 74 and opening valve *f*, the resultant vapors may be subjected to compression and heat prior to their introduction into the cooler 75. To this end the vapors may be cooled for mechanical reasons in cooler 77 and compressed by compressor 78 until the pressure is sufficiently increased even up to 1000 pounds. Liquid formed upon the cooling of the vapors in cooler 77 is collected in trap 79 and returned by pump 80 to the vapors discharged from compressor 78. The products then pass through heater 81 in which the temperature may be raised to any desired point even to 1000° F. and are then passed to cooler 75.

Such light hydrocarbons as are introduced into pipe 68 may be passed into the vapors coming from the cracking still by closing valve *c* and opening valve *g* in pipe 82 that

leads into pipe 74, such hydrocarbons being heated in heater 83. Uncondensed vapors from accumulator tank 34 may be similarly passed into pipe 74 by closing valve *h* and opening valve *c*.

Uncondensed vapors in tank 76 may be returned to the distilling operation by opening valve *j* in pipe 84 or they may be recirculated in the cracking operation by passing them into the cracking chamber through pipe 85 or through the pipe 86 into the vapors coming from the cracking chamber, pump 87 being provided for that purpose.

Light hydrocarbons derived from natural gas and utilized in the practice of my invention contain some air of which the oxygen by combination with hydrocarbons is converted into steam which may assist the phenomena occurring in the practice of my invention; and if, under the conditions of operation, which will obviously vary greatly, the use of additional steam is helpful it may be employed as by passing steam through the superheater 88 and conducting it through pipe 89 into the chamber 50.

Many valves and control devices in addition to the valves that have been referred to, some of which additional valves are indicated, may be employed for regulating the flow of liquids and vapors in the practice of my invention, particularly to the end that either uncondensed vapors from accumulator tank 34 or liquids from accumulator tank 23, or liquids from accumulator tank 34, or any one or more of those fractions of the vapors distilled from the absorption medium, may be introduced into the chamber 50, or into the pipe 74, or in part into one and in part into the other.

The increase of pressure created by compressor 78 and the temperature at which the compressed gases are maintained by heater 81 may be such that that temperature and that pressure will merely assist in condensation in cooperation with cooler 75, or they may be made sufficiently high to cause cracking, polymerization and combination which are additional or supplementary to any similar effects produced in the chamber 50, or when such high temperatures and pressures are produced by compressor 78 and heater 81, the chamber 50 may be operated at lower temperatures, even at temperatures which will merely effect distillation.

From the foregoing it will be apparent that I have provided apparatus and a process whereby light hydrocarbons of suitably low resultant or average pressure, for example, suitable hydrocarbons selectively derived from natural gas, may be utilized in connection with the cracking of petroleum products to produce gasoline and whereby production of gasoline from natural gas and production of gasoline from heavier petroleum products are carried on in such cooperation that gaso-

line is economically produced with substantial avoidance of the difficulties encountered in production of gasoline by absorption or by cracking when those methods of production are separately used, and whereby cracking of relatively heavy petroleum products in liquid phase or vapor phase and cracking of lighter hydrocarbons in vapor phase and combination or polymerization in such manner as to produce gasoline of desired characteristics, are so carried out as to avoid difficulties heretofore encountered in such operations.

While I have described in great detail features of apparatus and of the operations thereof whereby my invention may be practiced, I do not intend that my invention shall be limited thereto but intend that it shall include such modifications and variations as fall within the appended claims. In this connection I would point out that the operations of absorbing hydrocarbons from natural gas and distilling them from the absorption medium and the treatment of such still vapors including recirculation thereof, may be carried out by the steps and features described in the above-mentioned application filed by myself and Alexander Clarke. Thus, in that treatment of those still vapors the pressures and temperatures may be varied and increased to effect such cracking and combination or polymerization thereof as may be desirable in the production and condensation of desired hydrocarbons from absorbed constituents of natural gas. Furthermore, the temperatures and pressures in the cracking operations herein described and in any recompression and reheating of the vapors therefrom may be varied and increased to bring about production of desired hydrocarbons in the cracking zone or in the vapors coming therefrom.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In the production of gasoline the process comprising withdrawing light hydrocarbons from natural gas by absorption, compressing and cooling said hydrocarbons, introducing uncondensed vapors of said cooling operation into a zone wherein petroleum products are being cracked in liquid phase, and cooling the vapors coming from the cracking operation.

2. In the production of gasoline the process comprising absorbing light hydrocarbons from natural gas by an absorption medium, distilling the absorbed hydrocarbons from said medium, compressing and cooling the still vapors, recirculating uncondensed vapors of said cooling operation into said distilling and compressing and cooling operations, passing remaining products of said distilling operation into a zone wherein petroleum products are being cracked in liquid phase, and cooling the resulting vapors.

3. In the production of gasoline the process comprising absorbing light hydrocarbons from natural gas by an absorption medium, distilling the absorbed hydrocarbons from said medium, compressing and cooling the still vapors, recirculating uncondensed vapors of said cooling operation into said distilling and compressing and cooling operations, passing remaining products of said distilling operation into a zone wherein petroleum products are being cracked in liquid phase, cooling the resulting vapors, and recirculating to said cracking zone uncondensed vapors of said last named cooling operation.

4. In the production of gasoline the process comprising absorbing light hydrocarbons from natural gas by an absorption medium, distilling the absorbed hydrocarbons from said medium, compressing and cooling the still vapors, recirculating uncondensed vapors of said cooling operation into said distilling and compressing and cooling operations, passing remaining products of said distilling operation into a zone wherein petroleum products are being cracked in liquid phase, further heating and compressing the vapors coming from said cracking zone, and cooling said heated and compressed vapors.

5. In the production of gasoline the process comprising absorbing light hydrocarbons from natural gas by an absorption medium, distilling the absorbed hydrocarbons from said medium, compressing and cooling the still vapors, recirculating uncondensed vapors of said cooling operation into said distilling and compressing and cooling operations, passing remaining products of said distilling operation into a zone wherein petroleum products are being cracked in liquid phase, and further compressing and then cooling the vapors coming from said cracking zone.

6. Apparatus for the production of gasoline comprising an absorber for natural gas means for distilling absorbed hydrocarbons of the natural gas from the absorbing medium of said absorber, means for compressing and cooling vapors of said still, means for recirculating to said distilling and compressing and cooling means, uncondensed vapors from said compressing and cooling means, a cracking chamber for petroleum products, means for introducing into said cracking chamber remaining hydrocarbons from said compressing and cooling means, means for cooling the vapors of said cracking chamber and means for recirculating to said cracking chamber uncondensed vapors of said last named cooling means.

In testimony whereof, I have signed my name to this specification.

HORACE BUTLER.