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VAPOR PHASE CRACKING PROCESS

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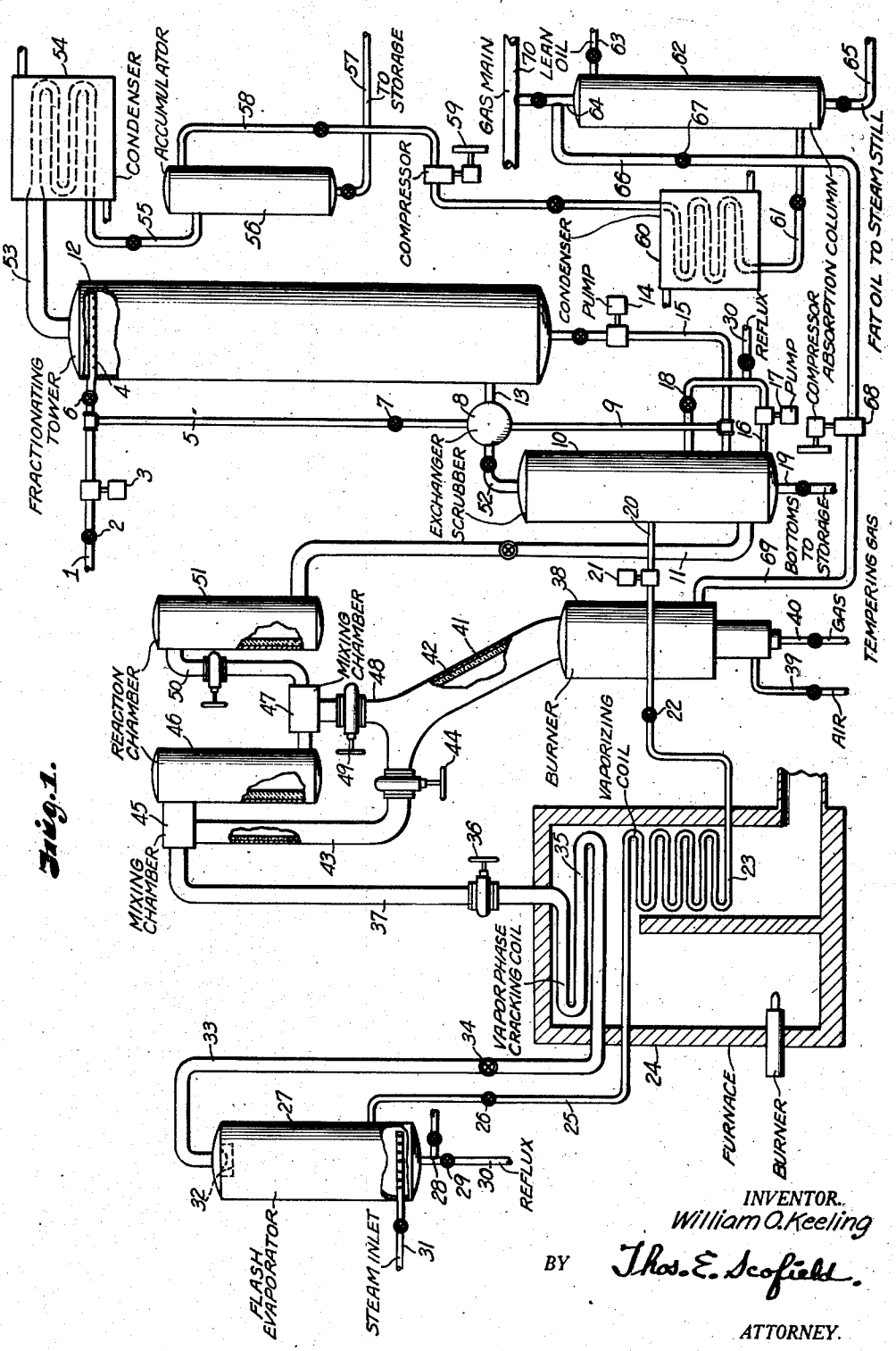


Fig. 1.

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VAPOR PHASE CRACKING PROCESS

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2 Claims. (Cl. 196—61)

My invention relates to a vapor phase cracking process and more particularly to a process in which the major portion of the heat for vaporization and cracking is supplied by indirect heat exchange and a certain portion of the conversion is carried on by direct heat exchange with the highly heated gases.

This invention is a continuation in part of my co-pending application, Serial No. 585,939, filed January 11, 1932.

In my application of Serial No. 585,939, I show a process for converting hydrocarbons in the vapor phase in which a highly heated gas is used to supply all of the heat for the conversion. It is generally conceded that a pipe still is the most economical means to heat hydrocarbon oils. The latent heat of vaporization of hydrocarbon oil is about 100 B. t. u. To raise the oil to a given temperature, an average sensible heat of about .65 of a B. t. u. per degree per pound is required. The heat of conversion is about 500–1000 B. t. u. per pound, depending upon the nature of the oil being converted. In order to raise the oil from its temperature of vaporization to a temperature required for conversion and to supply the heat of conversion, a large volume of heated gas is necessary. When a large quantity of heated gas is employed, the size of the reaction chambers and of subsequent equipment is greately increased. It is of some disadvantage to have a large quantity of gas going through the fractionating tower. Then, too, the size of the gas absorption plant is materially increased. Furthermore, the addition of large quantities of inert gases serves to reduce the calorific value of the final fixed gas extracted from the absorbing system.

It is generally conceded that the initial portion of the cracking operation is accompanied in a pipe still, such as in the vapor phase cracking processes of DeFlorez, Greenstreet, and Hall, and in the Gyro process, without the formation of excessive carbon and without material parasitic cracking. When oil is converted in the vapor phase in a pipe still, the high skin temperature of the tubes causes considerable parasitic cracking when the vapors are retained in the tubes for a sufficient length of time to accomplish the cracking of the more difficulty converted hydrocarbons. The parasitic cracking causes a heavy carbon deposition, as well as the formation of fixed gases which represents a direct loss in an operation in which the object is to obtain hydrocarbons suitable for use in motor fuels.

One object of my invention is to provide a cracking process for cracking hydrocarbons in the vapor phase which will avoid the disadvantages of cracking in a tube still and cracking solely by hot gases of combustion and will combine the advantages of each type of process.

Another object of my invention is to provide a process for cracking hydrocarbons in the vapor phase by highly heated gases in which the size of the equipment is considerably reduced.

Another object of my invention is to provide a process which will produce a motor fuel having an extremely high antiknock quality.

Other objects of my invention will appear from the following description.

In the accompanying drawing, which forms part of the instant specification and is to be read in conjunction therewith, the figure shows a schematic view of a process embodying one mode of carrying out my invention.

In general, my invention contemplates passing a charging stock in direct contact with the products of reaction to obtain heat exchange and to scrub the products of reaction. The charging stock so heated is passed through a vaporizing coil of a pipe still and heated. The heated products are flashed into vapors in a flash evaporator. Vapors are led from the flash evaporator and passed through a vapor phase cracking coil in the manner of the well known vapor phase cracking processes of DeFlorez, Greenstreet, Hall and in the Gyro process, with the important difference, however, that the cracking coil is considerably shorter and designed to permit a sufficiently rapid passage of the products therethrough to prevent more than the initial cracking from occurring. That is, the more easily cracked hydrocarbons are cracked in the pipe still and the greater portion of the heat is thus supplied. It will be obvious that the major portion of the sensible heat, the latent heat of vaporization and a portion of the heat of conversion will be supplied in the pipe still in the most efficient manner. Independently of my pipe still, I generate hot gases of combustion, though it is to be understood that the heated carrier gas might be employed if desired. The highly heated gases are then mixed with the products from the cracking coil of my pipe still in one or a plurality of stages. The mixing of the hot products of combustion in the manner contemplated by my process precludes any parasitic cracking due to the fact that the gases are thoroughly commingled. I provide a sufficient time of reaction and then pass the products of reaction through a scrubber in which any carbon present is removed and in

which operation the incoming charging stock is preheated. The products of reaction are then passed through the fractionating tower where they may be scrubbed with the incoming charging stock if desired. The head product from the fractionating tower is then condensed and the uncondensed portions are compressed and cooled and run through a gasoline absorption system.

More particularly referring now to the drawing, the charging stock which may be of any suitable character, is charged through line 1, through valve 2, and is pumped by pump 3 optionally through spray pipe 4 or line 5. The charge may be split so that a portion of it will pass through spray 4 and also through line 5. This may be controlled by valves 6 and 7 respectively. The portion of the charge passing through line 5 passes through heat exchanger 8 into line 9 where it flows into scrubber 10 in heat exchange relationship with the reaction products entering through pipe 11. The portion of the charge passing into the fractionating tower 12 through spray pipe 4 courses downwardly through the fractionating tower in scrubbing and heat exchange relationship with the products of reaction entering the fractionating tower through pipe 13 and is pumped by pump 14 through pipe 15 where it joins the portion of the charge entering through pipe 9 and passes into the scrubber 10. A reflux line 16 is provided so that a reflux may be pumped by pump 17 from the bottom of the scrubber through valve controlled line 18. The bottoms from the scrubber pass through line 19 to storage. An intermediate cut from one of the trays of the scrubber, which may be of any suitable fractionating tower construction, is pumped through line 20 by pump 21 through valve 22 through the vaporizing coil 23 of my pipe still 24. The pipe still 24 may be of any suitable construction. The oil passing through the vaporizing coil is heated to a vaporizing temperature and leaves the pipe still 24 through line 25 controlled by valve 26 and passes into the flash evaporator 27. The unvaporized portions of the heated stock are withdrawn from the flash evaporator through line 28, controlled by valve 29 and may be refluxed, if desired, through valve controlled line 30. Steam is introduced through valve controlled line 31 situated within the flash evaporator 27 to induce an added evaporation. The vapors leave the flash evaporator through mist extractor or Tracy purifier 32 and pass through line 33 controlled by valve 34 into the vapor phase cracking coil 35 in which the initial portion of the cracking in the vapor phase occurs. Valve 36 controls line 37 through which the products leave the cracking coil 35. Simultaneously with the above described operation, hot combustion gases are being generated in burner 38 into which air is introduced through line 39, and fuel through line 40.

It is to be understood that, while I have shown a particular type of burner, that any suitable means may be used for generating hot gases of combustion or, if desired, heating a carrier gas. The highly heated gases leave the burner 38 through line 41 which is lined with refractory material 42. The highly heated gases pass through refractory lined line 43 which is controlled by gate valve 44 which may be lined with refractory material or may be cooled by water circulation in order to resist the high heat of the hot gases of combustion which may be in the vicinity of 1500° F. The hot gases issuing from line 43 are commingled with the products leaving the cracking coil in mixing chamber 45, from which the admixture passes into a refractory lined reaction chamber 46 in which a sufficient time interval for reaction is allowed. If desired, in order to reduce the size of the equipment, I may crack by hot gases of combustion in a plurality of successive steps; that is, the products of reaction from chamber 46 may be admixed in mixing chamber 47 with further hot gases passing through line 48 which is controlled by valve 49 and passed through valve controlled line 50 into a second reaction chamber 51 in which a further time interval of reaction is permitted to insure the cracking of the more difficultly cracked hydrocarbons. It will be readily understood that, due to the fact that there is a complete admixture of the hot gases of combustion with the vapors to be cracked, that local overheating from which parasitic cracking results is avoided. I may choose the desired temperature to obtain any desired product; that is, at a temperature of reaction of about 1050° F., I am enabled to obtain a motor fuel having an exceedingly high antiknock quality. By raising the temperature of my highly heated gases, I am enabled to obtain a reaction temperature, which is considerably higher, and obtain benzol. Similarly, I may increase the reaction temperature still further and obtain toluol or, by a corresponding increase in temperature, obtain xylol. There is practically no limitation as to the temperature at which I may carry on my cracking operation except the limiting temperature at which I may generate hot gases of combustion. Due to the fact that a certain portion of the heat of the hot gases of combustion will be required to raise the vapors to be cracked to the conversion temperature and a still further quantity of heat will be required to effect the conversion, the temperature of the highly heated gases entering the mixing chamber is considerably in excess of the temperature of the vapors to be converted. For example, if it be desired to obtain a high antiknock motor fuel, the products leaving the cracking coil 35 and passing through line 37 will be superheated and will be at a temperature of about 900° F. At this temperature, the highly heated gases passing through pipe 43 need only be about 1350° F. to give a resultant mixture having a temperature of about 1050° F., at which temperature I have found that a motor fuel of high antiknock value is produced.

The products of reaction leave the reaction chamber 51 through valve controlled line 11 and pass into the scrubber 10 where the products of reaction pass in heat exchange relationship with the incoming charging stock entering the scrubber through line 15, pass upwardly through the scrubber, leaving it through valve controlled line 52, through heat exchanger 8, line 13, into fractionating tower 12, coursing upwardly therethrough. The vapors containing the products of reaction consist chiefly of hydrocarbons having low boiling points and a certain amount of fixed gases are withdrawn from the fractionating tower through line 53, and pass through condenser 54, valve controlled line 55, into accumulator 56. The gasoline-like hydrocarbons are withdrawn through valve controlled line 57 and pass to storage. The uncondensed gases are withdrawn through valve controlled line 58 and compressed by compressor 59, passed through cooler 60, through valve controlled line

61, into the gasoline absorption tower 62 in which the gases are scrubbed by lean oil passing into the tower through valve controlled line 63. The fat oil, containing valuable hydrocarbons, is withdrawn from the absorption column through valve controlled line 65 and passed to a still in which the absorption oil is heated to drive therefrom the light hydrocarbons absorbed thereby. These products are recovered in the usual manner. The fixed gases leave the top of the stripping column through line 64. Due to the fact that a smaller quantity of hot gases of combustion is used in my process, the gas from the absorption tower will be rich in hydrocarbon gases suitable as fuel. These may be collected in a gas main 70 and used to supply fuel gas to line 41 for use in my burner. A portion of the fixed gases is withdrawn through line 66 controlled by valve 67 and pumped by compressor 68 into line 69 for use as a tempering gas. By "tempering gas," I mean that the gas passing into the burner through line 66 is used to bring the hot products of combustion to the desired temperature. It is to be understood that, inasmuch as the hot gases are generated at about 3500° F. that, to bring them down to the desired temperature, as pointed out above, it will be necessary to cool them or temper them to the desired temperature. I do this by admixing with the hot gases a sufficient quantity of a cooler gas, coming in through line 66 to bring the hot gases to the desired temperature so that the gases leaving the burner and passing through lines 43 and 48 into the mixing chambers will be at the proper temperature for admixture with the vapors to give the desired temperature of conversion to obtain the desired product as pointed out above.

It will be understood that all lines and equipment in which high temperatures exist are suitably lagged with lagging to prevent heat losses of radiation.

It is believed that the operation of my process will be fully understood from the above description. My process has many advantages. By combining certain features of a pipe still process for converting in the vapor phase with a hot gas process of conversion, I am enabled to eliminate the disadvantages of each type process and retain all the advantages thereof. I am enabled to obtain a light product having a high antiknock value of any desired nature due to the fact that I am enabled to convert ultimately at temperatures far in excess of those capable of use in a pure pipe still process. By converting the initial portion of the hydrocarbons in the pipe still, I am enabled to reduce the size of the equipment necessary to convert by use of hot gases and to eliminate the necessity of passing a large quantity of hot gases through my fractionating and absorption system, thus enabling the size of this equipment to be greatly reduced. It will be appreciated that my system is extremely flexible and that the quantity and nature of the hydrocarbons ultimately recovered can be governed to any desired extent by the temperatures of the hot gases entering the reaction chamber or chambers. I am enabled to avoid the parasitic cracking which would result from a high skin temperature by resorting to admixing the hot gases directly with the hydrocarbons to be cracked. The products recovered will have a high antiknock value due to their composition and I am enabled to obtain these products without the formation of an excessive quantity of fixed gas.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of my claims. It is further obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is, therefore, to be understood that my invention is not to be limited to the specific details shown and described.

Having thus described my invention, what I claim is:

1. A process for converting hydrocarbon oils into hydrocarbons having a lower molecular weight, including the steps of vaporizing the hydrocarbons, passing said vapors in an elongated confined stream through a zone heated to the conversion temperature and allowing a sufficient time interval to permit the cracking of a portion of said vapors, thereafter intimately commingling an inert gas highly heated to such temperature that the resultant mixture will have a predetermined temperature, at which temperature the hydrocarbons will be converted into the hydrocarbons having the desired molecular weight, allowing a sufficient time interval to permit the reaction to take place and recovering the hydrocarbons of lower molecular weight thus formed, wherein the highly heated inert gas is admixed with the vapors being converted in a plurality of successive stages, and a plurality of successive time intervals of reaction are permitted.

2. A process for converting hydrocarbon oil into hydrocarbons of lower molecular weight including the steps of heating the hydrocarbon oil in an elongated, confined stream, to vaporizing temperatures, flashing the oil into vapors and unvaporized oil, separately removing the vapors from the evaporation zone and passing them in an elongated, confined stream at a rate slow enough to permit a conversion in the vapor phase to take place, simultaneously generating hot gases of combustion, physically commingling the hot gases of combustion with the cracked vapors in sufficient quantity and at sufficient temperature so that the resulting mixture will have a temperature in excess of 1000° F., permitting a time interval of conversion whereby further low boiling hydrocarbons are formed, passing the resulting mixture into a third conversion zone and there physically commingling further hot gases of combustion at sufficient temperature to raise the resulting mixture to a temperature in excess of 1000° F., permitting a time interval reaction whereby further desired low boiling hydrocarbons are formed, dephlegmating the products of the reaction and condensing the desired low boiling hydrocarbons.

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