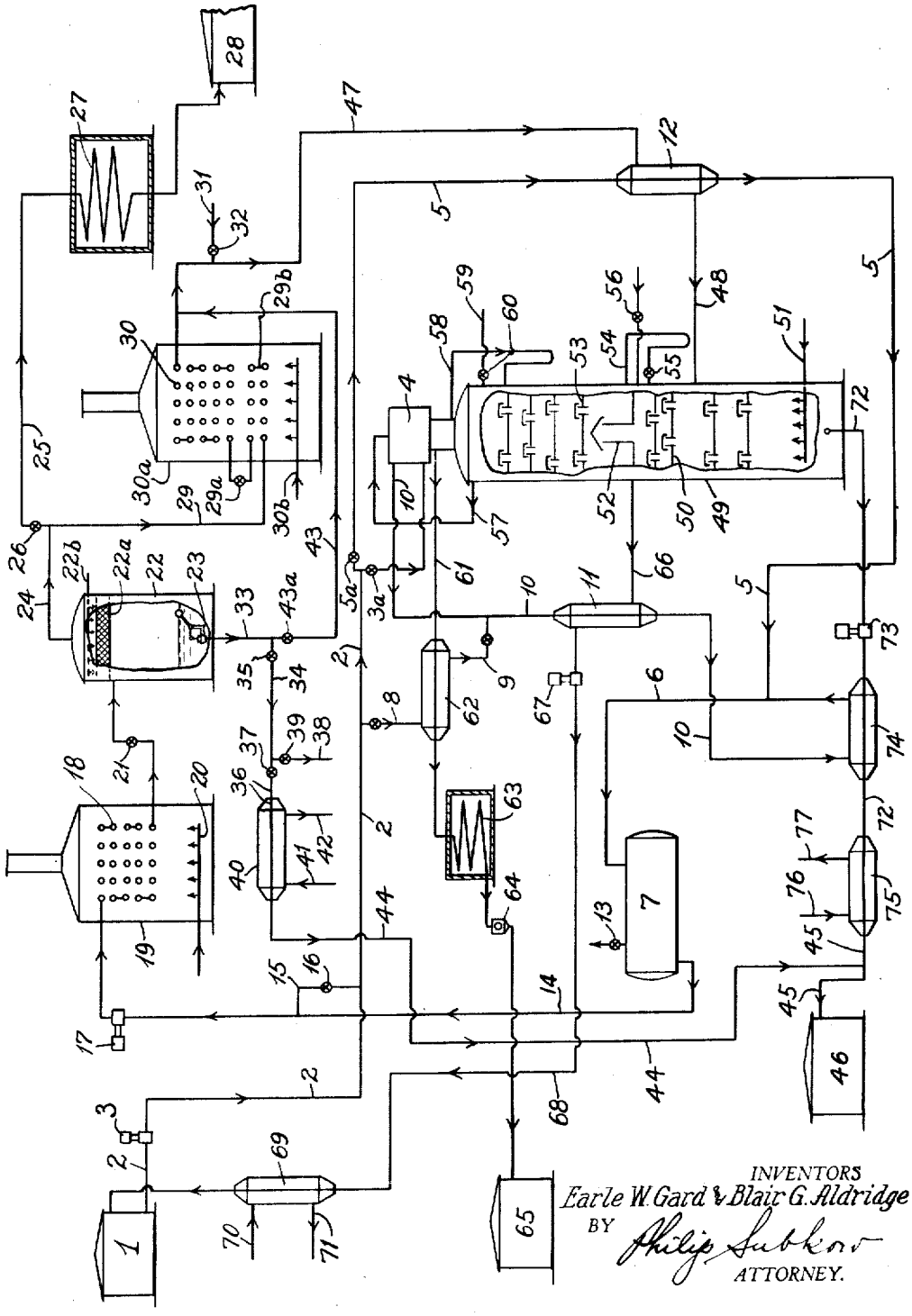
June 26, 1934. E. W. GARD ET AL 1,964,686

METHOD FOR VAPOR PHASE CRACKING OF OIL

Filed April 19, 1929



INVENTORS
Earle W. Gard & Blair G. Aldridge
BY Philip Subkow
ATTORNEY.

Patented June 26, 1934 1,964,686

UNITED STATES PATENT OFFICE

1,964,686

METHOD FOR VAPOR PHASE CRACKING OF OIL

Earle W. Gard, Los Angeles, and Blair G. Aldridge, Long Beach, Calif., assignors to Union Oil Company of California, Los Angeles, Calif., a corporation of California

Application April 19, 1929, Serial No. 356,464

4 Claims. (Cl. 196—61)

This invention relates to a process and apparatus for cracking oil in the vapor phase. One feature of this process resides in the generation of vapors at high pressure, in the passage of this high pressure vapor into a cracking coil where the vapor is heated to cracking temperatures. Preferably no resistance is placed to the flow of vapor except that inherent in the coil itself, that is, no back-pressure is maintained on the vapors other than that due to the frictional resistance of the passage of the vapor through the coils and condenser, etc.

We have discovered that successful vapor phase cracking depends upon high velocity of the vapors through the cracking coils since this results in uniform heating and prevents carbon deposition. We have found it advantageous to generate the vapors at very high pressure and to expand the vapors into the vapor phase cracking coils. Oil is heated at high pressure, vapor removed under high pressure from the vaporizer and expanded through coils where heat is imparted to crack the same.

We have found that in order to prevent excessive coke formation it is desirable to insure that the oil entering the vapor phase cracking coils be free as possible of liquid particles. It, therefore, is an object of this invention to introduce vapor free of liquid to pass at high velocity through the vapor phase cracking coils. This is accomplished in one form by heating the oil under pressure and distilling it under pressure with provision to remove liquid from the vapor and expanding it through the vapor phase cracking coil. The back-pressure on the vapor-oil separator may be only the frictional resistance set up to the passage of the vapor through the cracking coils and separating equipment.

We have found that it is desirable to raise the vapors to their cracking temperature as rapidly as possible. This cracking temperature may be several hundred degrees higher than the temperature of the vapors as they are generated. The expansion of the vapors into and through the coil causes a drop in temperature which militates against their rapid elevation to the cracking temperature. We have found it advisable to superheat the vapors before expansion into the vapor phase cracking coil.

By generating the vapors by a flashing process the vapors are generated at a high rate and forced through the cracking coils at a high velocity.

It is therefore an object of this invention to heat oil at relatively high pressure and pass the vapors from the oil so heated at high velocity through cracking coils where the vapors are decomposed.

It is another object of this invention to insure the passage of liquid free vapor through the aforementioned cracking coil where the vapors are decomposed.

It is a further object of this invention to heat oil at high pressure, expand the heated oil through the vapor cracking coil where the vapors are decomposed.

It is a further object of this invention to insure the passage of liquid free vapor through the vapor cracking coils just before mentioned.

It is a further object of this invention to distill oil at relatively high pressure and expand the oil vapor through vapor cracking coils where the vapors are decomposed.

It is a further object of this invention to generate vapors at a high rate so that a high velocity of travel through the cracking coils may be obtained.

It is a further object of this invention to superheat the vapors before expansion into the vapor phase cracking coil.

Another mode of operation is to heat the oil at high pressure and to flash it into an oil and vapor separator and to pass the vapors through additional vapor phase cracking coils.

The invention will be better understood by reference to the drawing which shows schematically the preferred form employed for carrying out the process.

Oil contained in tank 1, which may be of the nature of fuel oil, gas oil or kerosene distillate, is passed through line 2, and pump 3, and split at valves 3*a* and 5*a*, part of the oil going through the dephlegmator 4, in heat exchange with the vapors therein, and part going through line 5, as will be hereafter explained. The oil passing from dephlegmator 4, passes through line 10, and heat exchanger 11, in heat exchange with oil passing from 49 and through heat exchanger 74. The oil in line 5, passes through heat exchanger 12, and joins with the oil passing from heat exchanger 74, in line 6. The oil from line 6, passes through surge tank 7, which is controlled by line 13, for the venting of any vapors generated therein. The oil passes through line 14, and is pumped under high pressure by pump 17 to coil 18. A by-pass 15, controlled by valve 16, is provided to permit oil in line 2, to pass directly to the coils 18. An additional by-pass is provided to permit oil from line 2, to pass through heat exchanger 62, via lines 8 and 9, to join with the oil in 10. The oil under high pressure is passed through coil 18,

positioned in furnace 19, heated by 20. The pressure in the coil may be controlled by valve 21. The heated oil passes into vaporizer 22; 22 may have a mist extractor such as tiles 22*a*, washed with an oil fraction similar to the evolved vapors introduced through 22*b*. The pressure in the coil 18, and vaporizer 22, is controlled by valves 26, 29*a*, 23, 35, 43*a* and 21. The vapors issuing from vaporizer 22 via 24 may be passed through 25, controlled by valve 26, condenser 27, into container 28. Vaporizer 22, may be heated additionally if desired.

In the process described, however, the vapors pass through line 29, and superheater coil 29*b*, controlled by valve 29*a*, into coils 30, positioned in furnace 30*a*, heated by burner 30*b*. The unvaporized portion in vaporizer 22, is passed through fluid control valve 23, via 33, valve 35, and line 34, and either through line 38, controlled by valve 39, to a further cracking furnace for viscosity reduction, or is passed through cooler 40, via valve 37, in line 36, cooled by cooling fluid introduced at 41, exiting at 42, and the cooled oil is passed through line 44, where it joins oil in line 45, to storage tank 46. All or part of the oil from 22, may be by-passed through valve 43*a* and line 43, to be injected into the heated vapors passing from coils 30. Additionally an oil of a characteristic such as oil similar to that contained in tank 1, may be introduced through line 31, controlled by valve 32. The commingled oil and vapors pass through line 47, to heat exchanger 12, and are introduced through line 48, into the distillation column 49. At the bottom of this tower may be introduced super-heated steam or gas at 51, to aid in the stripping of the condensate generated in this tower. The vapors and condensate pass counter-current in 50, condensate is removed in 72. The vapors issue through throat 52, into rectifying section. The condensate collected at the bottom of this upper section is passed through trap 54, and valve 55, together with additional cooling fluid if desired, through 56. The vapors in the upper section pass through bubble caps 53, the vapors issuing at the top through 57, downward to the dephlegmator 4; the condensate is trapped off at 58, to pass into the upper part of rectification column together with the additional cooling fluid if desired, introduced through line 59, controlled by valve 60. The uncondensed vapors issuing from line 61, pass through heat exchanger 62, cooler 63, pass into look-box 64, and into tank 65. Part or all of the condensate collecting at the bottom of the upper section of the distillation column 49, is withdrawn through 66, passes through heat exchanger 11, and is pumped by pump 67, through line 68, and cooler 69, wherein it is cooled by a cooling fluid introduced at 70, and withdrawn at 71. The cooled oil is introduced in tank 1, to be recycled in the process. The unvaporized portion is withdrawn through 72, and pumped by pump 73, through heat exchanger 74, and line 72, into heat exchanger 75, where it is cooled by cooling fluid introduced at 76, and exited at 77, and is passed via line 45, into tank 46.

As one example of this process, the operation on gas oil will be described.

Gas oil is passed through coil 18, as previously described, under from 500 to 1500 pounds pressure. In this coil, it may be either merely heated to a distillation temperature at the pressure to be maintained in 22, i. e., to about 700° F., or it may be heated above the distillation temperature to get some cracking, i. e., to about 800° F. Assuming the process is operated to merely vaporize the oil in 22, it will be sufficient that the oil is pumped through coil 18, at such pressure as to maintain in vaporizer 22, a vapor pressure of about 500 to 750 pounds, controlled by the pressure valves, as previously described. If, however, cracking is to occur, a pressure of about 1000 to 1500 pounds is maintained in coil 18. However, the preferred amount of cracking is such that not more than 20% conversion occurs in the coils, it having been found that under those conditions, coils 18, are practically uncarbonized, and in view of the fact that the additional cracking is to occur in the vapor phase, it is inadvisable to carry this liquid phase cracking in coil 18, beyond a certain point. The oil passes through valve 21, into vaporizer 22, the vapor pressure in this vaporizer will vary from 300 pounds up to the higher pressure maintained in coil 18, and the temperature of the oil may be from 600° F. upward. However, it has been found advisable, when operating on a gas oil wherein the conversion is not much higher than 20%, or where there has been no conversion in coil 18, to maintain a pressure of about 500 to 750 pounds. Starting up the apparatus, a by-pass is provided to permit the passage of the vapors through condenser 27, to permit the building up of pressure in vaporizer 22, and proper temperature in coil 18, about 800° F. When the proper conditions have been established, the vapor is then passed through coil 29*b*, where it is superheated enough so that on expansion into coil 30, via 29*a*, the vapors are not cooled too low and the heating to their cracking temperature retarded. For example the vapors are superheated 250° F., i. e., to about 1000 to 1100° F. The vapors are then passed through valve 29*a*. The vapor is thus expanded into a region of lower pressure since the only pressure on the vapors is the back-pressure of the coils and the resistance of the apparatus. Since, however, the coils may build up a pressure to 150 pounds, this constitutes the back-pressure on the vapors. This pressure may be increased by manipulation of valve 29*a*, to control the back pressure on the vaporizer, as shown above. The vapors thus pass through the coil at extremely high velocity. Instead of using a valve at 29*a*, it is preferred to use a properly designed orifice. This will insure the highest possible velocity of the vapors through coil 30, where the vapors are heated at high temperature, i. e., from 800 to 1200° F., as is usual in vapor phase cracking. In view of the very high velocity of the vapors and the relatively small coils employed in 30, as compared with ordinary cracking coils, the cracking temperatures may be adjusted to the best operating conditions. The heating efficiency will be at maximum. This we believe happens due to the fact that the efficiency of the heat transfer in this process permits the elevation of the whole volume of the gas passing through the tubes to substantially the same temperature. In the present processes, in which the vapors pass through the heated tubes at much lower rate, the interior of the gas is at much lower temperature than the tube surfaces, so that, due to poor heat transfer, the tube must be heated to a much higher temperature to obtain the average temperature which we can obtain by our process.

While it is preferred to design the length of the coil to give the proper cracking time in the furnace, i. e., by providing the length of coil, the cracking time may also be controlled by regulating the back-pressure on the vapor phase cracking coil by means of a valve on the outlet of the

coil (not shown) as will be evident to those skilled in the art.

When the oil has passed from the vapor phase cracking coil, it is immediately contacted with a stream of oil, as for instance, the oil passing from 22 or fresh oil from 1 through line 31. The purpose of this injected oil is to partially cool the vapors so that they may undergo rectification and also agglomerate any fixed carbon or tars which have been generated in the cracking process. The stirring action in the tube 30 is so great that no tar or carbon is deposited in the coils. The heat of the vapors may act additionally to crack the injected oil. The mixed vapor and oil at a temperature of 775° F. pass through an exchanger 12, which acts to partially heat the oil passing through the process, through line 5, to 600° F. and the mixed vapor and oil are introduced into tower 49 at a temperature of 625° F. This is a combined stripping and fractionating tower functioning in the conventional manner; its operation is quite evident from the former description. The tower is controlled by the reflux dephlegmator 4, and by the introduction of the cooling oil through 59 and 56, so that the desired end point gasoline is removed through 61, condensed and collected at 65. Reflux collecting at the bottom of the rectifying section of the tower 49 and partially withdrawn through 66, gives up part of its heat at 11 to the incoming charging stock and is passed through cooler 69, to be recycled through the process. This condensate is substantially of the character of the gas oil introduced through line 2. The residue collecting at 72 will be the cracked residuum consisting of the heavy ends produced in coil 30 plus the heavy ends of the injected oil. It is withdrawn through line 72 passed through heat exchanger 74 and 75 and collected in 46.

In an alternative method of operation the oil heated at high pressures is flashed into 22, valve 29*a* being wide open. In other words, the only back-pressure on the chamber 22 is the back-pressure of the system due to frictional resistance to the flow of vapors through 30 and the fractionation apparatus.

By providing a separator and mist extractor the passage of liquid particles into the vapor phase cracking coils will be prevented. The prevention of such introduction of liquid is an important feature of this process since it prevents the deposition of carbon caused by the distillation of the oil at high temperatures.

The flashing of the vapor by the sudden expansion of the oil against merely the back-pressure of the system insures high velocities through the cracking coils.

The previous example of the operation will apply equally to this case. The oil is heated in the coils 18, to about 500 to 1500° F. depending on the character of the oil and the amount of conversion. Thus, operating on fuel oil, the oil may be heated to 600° F. and flashed, or it may be heated to 800 to 900° F., cracked partially, say to 20% conversion, and the vapors superheated 200° to 250° F. in coil 29*b* and expanded.

In operating the above process the rate of generation of vapor is high, that is, much greater than that obtained by ordinary distillation where the vapors pass directly through the vapor phase cracking coils. In fact the velocity through the coils may be controlled by the rate of generation of the vapors. Thus by heating harder and/or increasing the velocity of travel of the oil through the primary heating coils 18 the rate of vaporization and the velocity of travel through the coils 29*b* and 30 may be controlled. In like manner the sudden expansion of the oil heated at high pressure into the vaporizing drum, as explained above, aids in this effect. It would be desirable to obtain as high a rate of vapor generation as possible. This will be easily controlled by the operation, as will be understood by those skilled in the art.

In operating on a heavy gas oil or on a fuel oil, the residuum withdrawn from 22, will be of the nature of a 10 to 15 Baumé road oil. This oil may be cracked to produce a low viscosity, high gravity oil by a cracking operation which does not form a part of this invention and will not be further described.

The above description is not to be taken as limiting my invention, but as merely illustrative of the best manner of carrying it out, and many variations may be made thereon as will be recognized by those skilled in the art.

The invention being described in the appended claims:

I claim:

1. A method of cracking oil which comprises heating oil at superatmospheric pressure in an advancing stream to a temperature of about 700°–900° F., partially releasing the pressure and vaporizing said oil to separate a vapor substantially free from liquid particles from the liquid fraction, superheating said separated vapor to a temperature of about 1000° F. at substantially the pressure of said vapor separation materially reducing said pressure and subsequently cracking said vapor while in the vapor phase at a pressure substantially less than is maintained in the first heating stage, and quenching the vapor products leaving the cracking zone with a portion of said liquid fraction.

2. A method of cracking oil which comprises heating oil at superatmospheric pressure of the order of 1000 to 1500 pounds per square inch and at a temperature of about 800°–900° F. while in an advancing stream to partially crack said oil in the liquid phase, partially releasing the pressure and vaporizing said oil to separate a vapor substantially free from liquid particles from the liquid fraction, superheating said separated vapor to a temperature of about 1000° F. at substantially the pressure of vapor separation, materially reducing said pressure, and subsequently cracking said vapor while in the vapor phase at a pressure substantially less than is maintained in the first cracking stage, and quenching the vapor products leaving the cracking zone with a portion of said liquid fraction.

3. A method of cracking oil which comprises heating oil in an advancing stream under superatmospheric pressure of the order of 500 to 1500 pounds per square inch and at a temperature of about 700°–900° F., separating a vapor substantially free from liquid particles from said heated oil at pressures substantially lower than that used in the aforesaid heating, superheating said separated vapor to a temperature of about 1000° F. at substantially said last mentioned pressure, substantially releasing the pressure on said superheated vapor and cracking said vapor in the vapor phase at said released pressure, and quenching the vapor products leaving the cracking zone with a portion of the liquid fraction obtained in the aforesaid separaion.

4. A method of cracking oil which comprises heating oil at superatmospheric pressure of the order of 1000 to 1500 pounds per square inch and

at a temperature of 800°–900° F. while in an advancing stream to partially crack said oil in the liquid phase, separating a vapor substantially free from liquid particles from said partially cracked oil at pressures substantially lower than that used in the aforesaid heating, superheating said separated vapor to a temperature of about 1000° F. at substantially said last mentioned pressure, substantially releasing the pressure on said superheated vapor and cracking said vapor in the vapor phase at said released pressure, and quenching the vapor products leaving the cracking zone with a portion of the liquid fraction obtained in the aforesaid separation.

EARLE W. GARD.
BLAIR G. ALDRIDGE.

CERTIFICATE OF CORRECTION.

Patent No. 1,964,686. June 26, 1934.

EARLE W. GARD, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, line 9, for "agglomerate" read to agglomerate or dissolve; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of September, A. D. 1934.

Leslie Frazer
Acting Commissioner of Patents.

(Seal)

at a temperature of 800°–900° F. while in an advancing stream to partially crack said oil in the liquid phase, separating a vapor substantially free from liquid particles from said partially cracked oil at pressures substantially lower than that used in the aforesaid heating, superheating said separated vapor to a temperature of about 1000° F. at substantially said last mentioned pressure, substantially releasing the pressure on said superheated vapor and cracking said vapor in the vapor phase at said released pressure, and quenching the vapor products leaving the cracking zone with a portion of the liquid fraction obtained in the aforesaid separation.

EARLE W. GARD.
BLAIR G. ALDRIDGE.

CERTIFICATE OF CORRECTION.

Patent No. 1,964,686. June 26, 1934.

EARLE W. GARD, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, line 9, for "agglomerate" read to agglomerate or dissolve; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of September, A. D. 1934.

Leslie Frazer
Acting Commissioner of Patents.

(Seal)