My Invention relates to a process for the pyrolytic decomposition of hydrocarbons to form gasoline-like hydrocarbons suitable for using as a motor fuel having high antiknock qualities. The process is usually known as a "cracking" process and relates more particularly to the cracking of hydrocarbons in the vapor phase by hot gases of combustion.

When fuel is burned with no excessive air, the temperature of combustion is between 3,000° and 4,000° F. These temperatures are too high for efficient cracking and accordingly they must be tempered or brought down to about 1500° F. in order to give an efficient cracking process.

In an application of William O. Keeling, Serial No. 860,576, now U. S. Patent 1,991,750, a method of tempering the combustion gases by means of a cooler, inert gas is disclosed.

This application relates to a process in which the combustion gases are tempered in a novel and more efficient manner.

When a great volume of gas is introduced into the fractionating tower, many disadvantages result. The equipment must be made of a larger size. The volume of gas to be compressed for absorption purposes is so increased that the process becomes expensive. The use of a cooler, inert gas to temper the combustion gases represents a direct loss of heat besides increasing the volume of the gases to be handled.

One object of my invention is to avoid the disadvantages above pointed out.

Another object of my invention is to provide a process in which the hot gases of combustion are tempered by means of heat exchange.

A further object of my invention is to employ the gas heat for topping the charging stock, vaporizing the charging stock for conversion into the vapor phase and supplying heat for other purposes such as distilling the rich absorption oil which contains gasoline or the generation or high superheating of steam.

Still another object of my invention is to provide a vapor phase cracking process in which hot gases of combustion are used to supply the cracking heat which is flexible of control and efficient in operation.

Still another object of my invention is to check the reaction to prevent over-cracking by means of shock chilling the products of reaction.

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

The figure shows a diagrammatic view of one embodiment of the process of my invention.

In general, my invention consists in burning fuel and air with surface combustion in a furnace to supply hot gases of combustion substantially devoid of free oxygen. I charge crude oil from storage through suitable heat exchangers through a coil situated within the furnace. The temperature of the hot gases of combustion will be lowered and lose part of their heat in heating the incoming charge during its passage through the topping heating coil. The heated products are discharged into a fractionating tower preferably 10 of the bubble type, whence the vapors are withdrawn overhead, condensed and passed into a separator. The gasoline is withdrawn from the separator and passed to storage. A fraction collects in the separator and is refluxed into the 15 bubble tower. The reflux condensate from the bubble tower may be pumped to storage and forms in part the cracking stock which is used in my process. The reflux condensate may, if desired, be pumped directly through suitable heat exchangers into an accumulator tank.

Oil is pumped from the accumulator tank through suitable heat exchangers, through a second coil situated in my furnace where the heat necessary to convert a substantial portion of the charging 25 stock into vapors is supplied. The heated charging stock is passed into a flash evaporator whence the vapors are withdrawn and passed to the cracking zone. In the cracking zone the vaporized hydrocarbons encounter the hot gases of 30 combustion which have been tempered to about 1500° F. The hot gases of combustion admixing with the vapors bring the mixture to about 1500° F, at which temperature cracking takes place rapidly. The increase in volume is accommodated by a progressively increasing cross sectional area. After leaving the cracking zone, the products of the reaction are shock chilled by means of an oil spray. The products, after being chilled, pass into a tar separator. The tar laden quenching oil is drawn through a cooler and pumped to storage and may be used for fuel oil. The vapors and gases are passed through a sectional entrainment condenser and then into a fractionating tower. The condensate from the 45 entrainment condenser collects in suitable pockets and may be passed either into the separator or into a fractionating tower depending upon their nature and character.

The reflux condensate from the fractionating 50 tower is withdrawn and pumped through a cooler in order to reduce the temperature thereof to render it suitable as a quenching medium. After passing through the cooler, it is passed through the sprays in order to be used in the chilling zone.
A portion of the reflux condensate of the fractionating tower may be diverted into the accumulator for recycling. The vapors and uncondensed gases withdrawn from the fractionating tower 5 are cooled and passed into a separator from which the water is withdrawn. The uncondensed gases from the separator are compressed and cooled and passed into a receiver. The condensate is withdrawn as gasoline and passed to storage 10. The gases from the receiver are passed into an absorber where they are scrubbed with a lean oil in a gasoline absorption process.

A fat oil drawn from the bottom of the absorber is passed into a steam still to recover a gasoline fraction. The fixed gas is passed into a gas main to supply fuel for the burner of the furnace. More particularly referring now to the drawing, the crude oil from storage is charged through line 1 and pumped by pump 2 through heat exchanger 3, through heat exchanger 4, through topping heating coil 5, where the crude oil being charged is heated. The heat imparted to the incoming crude lowers the temperature of the combustion gases. The oil leaves the topping heating coil through line 6 and is charged into the fractionating tower 7. This tower is preferably of the bubble type but it is to be understood that any suitable fractionating tower may be employed. The topped oil is withdrawn through line 8 and pumped by pump 9 through heat exchanger 4. If valve 10 be closed and valve 11 be opened, the oil will pass through cooler 12 into storage 13. The cooler 12 is cooled by circulating water from any suitable means. The pump 14 will pump oil from the cracking stock storage tank 13 if valve 15 be open. If valves 15 and 11 be closed and valve 10 open, the topped crude will pass through line 16 into line 17 to pump 14.

The vapors from the bubble tower 7 are withdrawn through line 18, through heat exchanger 3 into cooler 19 where they are condensed. The condensate passes through line 20 into separator 21. The gasoline is withdrawn through line 22 and passed to storage. A fraction is withdrawn from the separator through line 23 by pump 24 and pumped back into the bubble tower 7 as a reflux. The topped crude is pumped by pump 14 through heat exchanger 25, through heat exchanger 26, through heat exchanger 27, whence it passes through line 28 into the accumulator 29. The charging stock thus preheated is withdrawn through line 30 by pump 31 and is pumped through line 32, it being understood that valves 33 and 34 are open and valve 35 is closed. The charge passes from line 32 through the tubing 36 of the sectional entrainment condenser 31 and leaves said condenser through line 38 passing through valve 34 into line 39, through the vaporizing heating coil 40. The products of combustion in the furnace are tempered by losing some of their heat to the charging stock passing through coil 40. The heated charging stock leaves the coil 40 through line 41 and passes into the flash evaporator 42. The unvaporized oil from the flash evaporator may pass through line 43, through valve 44, through line 45, into the accumulator 29. Line 45 extends from the accumulator 29 to the flash evaporator 42 and serves as a vapor release line permitting any vapors in the accumulator to escape into the flash evaporator. If desired, valve 44 may be closed and valve 45 may be open so that the unvaporized oil will pass through line 47 into line 48 through cooler 49, where it is pumped by pump 50 to storage as fuel oil. The vapors from the flash evaporator will pass through line 51 and be discharged into a mixing zone 52. Valve 51' controls the vapor flow.

Gas is withdrawn from the gas main 53 through branch line 54 and passed through pump 55 into gas supply tank 56, whence gas is withdrawn through line 57' being controlled by valve 58' into the mixing chamber 59' of a surface combustion burner. Compressed air, controlled by valve 61', and the gas mixture from the receiver are passed into an absorber where they are scrubbed with the refractory granules 62' of the surface combustion burner 63'. The hot gases of combustion will pass into the furnace 64' and be tempered by heat exchange with the material passing through 15 coils 65 and 66 respectively to the mixing zone 52, whence a commingling of the hot products of combustion are tempered to about 1500° F. will take place with the hydrocarbon vapors coming from the flash evaporator 42. After admixture 20, the temperature will be about 1050° F. and cracking or pyrolytic decomposition will take place rapidly.

As cracking takes place, the volume of the products will increase and, in order to prevent the building up of pressure, a progressively increasing cross sectional area of the cracking chamber is provided.

Inasmuch as the cracking will take place very rapidly, at the temperature of 1050° F., I resort to 80 snoot chilling or cracking chamber of quenching to reduce the temperature of the products of reaction from oil 46 to 700° F. To do this by means of oil sprays 53', 54', 55', and 56', oil spray 58' being located in the tar separator 57. The temperature 35 of 700° is low enough to prevent any further reaction and high enough to permit the distillate to escape in the vapor state into the fractionating tower 25. The heavy, tarry fuel oil, however, will accumulate in the bottoms of the separator 57. 40 This tar laden quenching oil is withdrawn through line 59 which joins with line 47 and permits the fuel oil bottoms to be passed through the cooler 48 to fuel oil storage.

The vapors from the tar separator 51 pass over 45 head through line 59 into a sectional entrainment condenser 31, whence they pass in counterflow relation to the incoming charging stock which is passing through tubes 38. The hot vapors from the evaporator 42 pass through line 50 into the charging stock which in turn will be heated. The condensate is allowed to collect in compartments 60, 61 and 62. The condensate may be withdrawn from the respective compartments and selectively passed into the separator or the fractionating tower through lines 53 and 64 respectively. The condensate may be supplied as desired by means of valves 65, 66, 67 and 68, so that all or part of the condensate collected in the sectional entrainment condenser 31 may be passed to either the separator or the fractionating tower as desired and depending upon the nature of the condensate. The vapors and gases leave the sectional entrainment condenser through line 69 and pass into the fractionating tower 10. The reflux condensate from the fractionating tower may pass through valve 54 into the accumulator 52. The reflux condensate from the fractionating tower may pass through heat exchanger 27, through line 72, through pump 73, through cooler 74 and through line 75 into line 76, which terminates in 70 a manifold for the quenching sprays. The quenching sprays pass through valve controlled lines 77, 78, 79, and 80. If desired, portion of the reflux condensate from the fractionating tower may be diverted through valve 75.
10 trolled line 81 and allowed to pass into the accumu-

later for recycling.

The vapors and gases from the fractionating
tower pass through line 82, through heat ex-
changer 29, through cooler 53, through line 84
into separator 85. Inasmuch as the products of
combustion will contain chiefly carbon dioxide,
nitrogen and superheated steam, a portion of
the superheated steam will be condensed in cooler
83 and will form water in the bottom of the sepa-

ator 85. This water is withdrawn through line
86. The gasoline-like hydrocarbons are with-
drawn through line 87 and passed to storage.

The gases from the separator will contain a
15 quantity of gas rich in gasoline-like hydrocar-
bons. Accordingly, I propose to withdraw it
through line 88 and compress the gas in com-
pressor 89, pass it through cooler 90 into receiver

91. Cooling and compressing will precipitate
20 further gasoline-like hydrocarbons which are
withdrawn through line 92 and pass into line
87 to storage. The gases from the receiver are
withdrawn through line 93 and passed into the

gasoline absorption tower 94 where it is scrubbed
25 by lean oil entering through line 95. The fixed
gas is withdrawn through line 96 into gas main
93. The fat oil from the bottom of the absorp-
tion tower 94 is withdrawn through line 97 and

pased to a steam still for the distillation there-
from of the gasoline-like hydrocarbons.

2. The process of converting hydrocarbon oil

30 into gasoline-like hydrocarbons of lower molecu-
lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
oil to be cracked in indirect heat exchange with
said hot combustion gases to reduce the tempera-

ture of the gases and effect a heating of the oil
substantially without pyrolytic decomposition,
 subjected the hydrocarbon oil thus heated to a
topping operation, passing the topped hydro-
carbon oil in indirect heat exchange with said
35 combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a va-
porizing stage, directly commingling said vapors
with said tempered products of combustion and
permitting a pyrolytic decomposition of said hy-

drocarbons to take place to form gasoline-like

hydrocarbons having a lower molecular weight.
2. The process of converting hydrocarbon oil

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lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
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said hot combustion gases to reduce the tempera-
ture of the gases and effect a heating of the oil

45 substantially without pyrolytic decomposition,
subjecting the oil thus heated to a topping op-
eration, passing the topped oil as the hydrocarbons
to be cracked in indirect heat exchange with said
combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a vapor-
izing stage, directly commingling said vapors
with said tempered products of combustion, per-
mitting a pyrolytic decomposition of said hydro-
carbons to take place to form gasoline-like hy-
drocarbons having a lower molecular weight, and

stopping said reaction by spraying oil into the re-
acting mixture after the reaction has progressed

50 a desired extent whereby over-cracking is pre-
vented.

3. The process of converting hydrocarbon oil

55 into gasoline-like hydrocarbons of lower molecu-
lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
oil to be cracked in indirect heat exchange with
said hot combustion gases to reduce the tempera-
ture of the gases and effect a heating of the oil

60 substantially without pyrolytic decomposition,
subjecting the oil thus heated to a topping op-
eration, passing the oil as the hydrocarbons to
be cracked in indirect heat exchange with said
combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a vapor-
izing stage, directly commingling said vapors
with said tempered products of combustion; per-
mitting a pyrolytic decomposition of said hydro-
carbons to take place to form gasoline-like hy-
drocarbons having a lower molecular weight,
fractionating the products of reaction, and with-

65 drawing the reflux condensate from the frac-
tionating stage.

4. The process of converting hydrocarbon oil

60 into gasoline-like hydrocarbons of lower molecu-
lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
oil in indirect heat exchange with said hot com-

65 bined with the combustion gases, the latter

70 being maintained at selected, controlled tem-
peratures of reaction, a motor fuel having a high
octane number and high antiknock value is ob-
ained. The process eliminates parasitic crack-
ing which accompanies conventional cracking

methods, in which the hydrocarbons are con-
verted in tubular containers and heated by ex-
ternal circulation of the combustion gases ther-

in. The intimate mixture of the combustion
gases with the hydrocarbon vapor produces a

distribution of heat impossible with the conven-
tional tubular cracking processes.

Having thus described my invention, what I

75 claim is:

1. The process of converting hydrocarbon oil

10 into gasoline-like hydrocarbons of lower molecu-
lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
oil to be cracked in indirect heat exchange with
said hot combustion gases to reduce the tempera-
ture of the gases and effect a heating of the oil

20 substantially without pyrolytic decomposition,
subjecting the hydrocarbon oil thus heated to a
topping operation, passing the topped hydro-
carbon oil in indirect heat exchange with said
combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a va-
porizing stage, directly commingling said vapors
with said tempered products of combustion and
permitting a pyrolytic decomposition of said hy-
drocarbons to take place to form gasoline-like

hydrocarbons having a lower molecular weight.

2. The process of converting hydrocarbon oil

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to be cracked in indirect heat exchange with said
combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a vapor-
izing stage, directly commingling said vapors
with said tempered products of combustion, per-
mitting a pyrolytic decomposition of said hydro-
carbons to take place to form gasoline-like hy-
drocarbons having a lower molecular weight, and

stopping said reaction by spraying oil into the re-
acting mixture after the reaction has progressed

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lar weight which includes the steps of generating
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said hot combustion gases to reduce the tempera-
ture of the gases and effect a heating of the oil

50 substantially without pyrolytic decomposition,
subjecting the oil thus heated to a topping op-
eration, passing the oil as the hydrocarbons to
be cracked in indirect heat exchange with said
combustion gases to lower their temperature,
flushing the oil thus heated into vapors in a vapor-
izing stage, directly commingling said vapors
with said tempered products of combustion; per-
mitting a pyrolytic decomposition of said hydro-
carbons to take place to form gasoline-like hy-
drocarbons having a lower molecular weight,
fractionating the products of reaction, and with-

55 drawing the reflux condensate from the frac-
tionating stage.

4. The process of converting hydrocarbon oil

60 into gasoline-like hydrocarbons of lower molecu-
lar weight which includes the steps of generating
hot combustion gases, passing the hydrocarbon
oil in indirect heat exchange with said hot com-
4. In order to reduce the temperature of the gases and effect a heating of the oil substantially without pyrolytic decomposition, subjecting the oil thus heated to a topping operation, passing the topped oil as the hydrocarbons to be cracked in indirect heat exchange with said combustion gases to lower the temperature thereof, flashing the oil thus heated into vapors in a vaporizing stage, directly commingling said vapors with said tempered products of combustion, permitting a pyrolytic decomposition of said vapors to take place to form gasoline-like hydrocarbons having a lower molecular weight, fractionating the products of the reaction, withdrawing the vapors and gases from the fractionating stage, cooling said vapors and gases, withdrawing the condensate formed in the cooling stage, and subjecting the uncondensed gases to gasoline absorption treatment.

MAURICE B. COOKE.