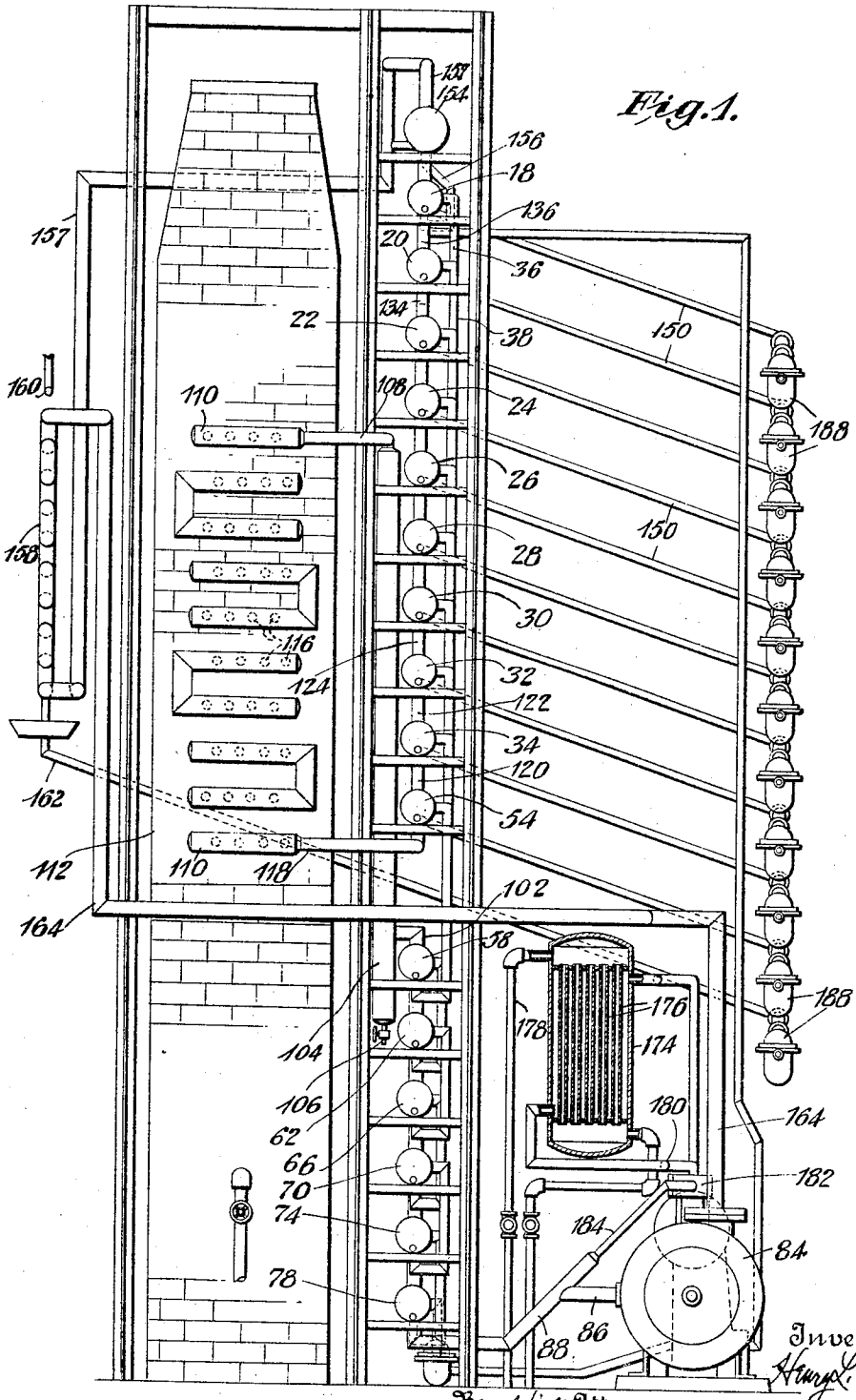
Feb. 21, 1933. H. L. DOHERTY 1,898,245

PROCESS OF DISTILLING OIL

Filed Feb. 4. 1920 4 Sheets-Sheet 1

Fig. 1.



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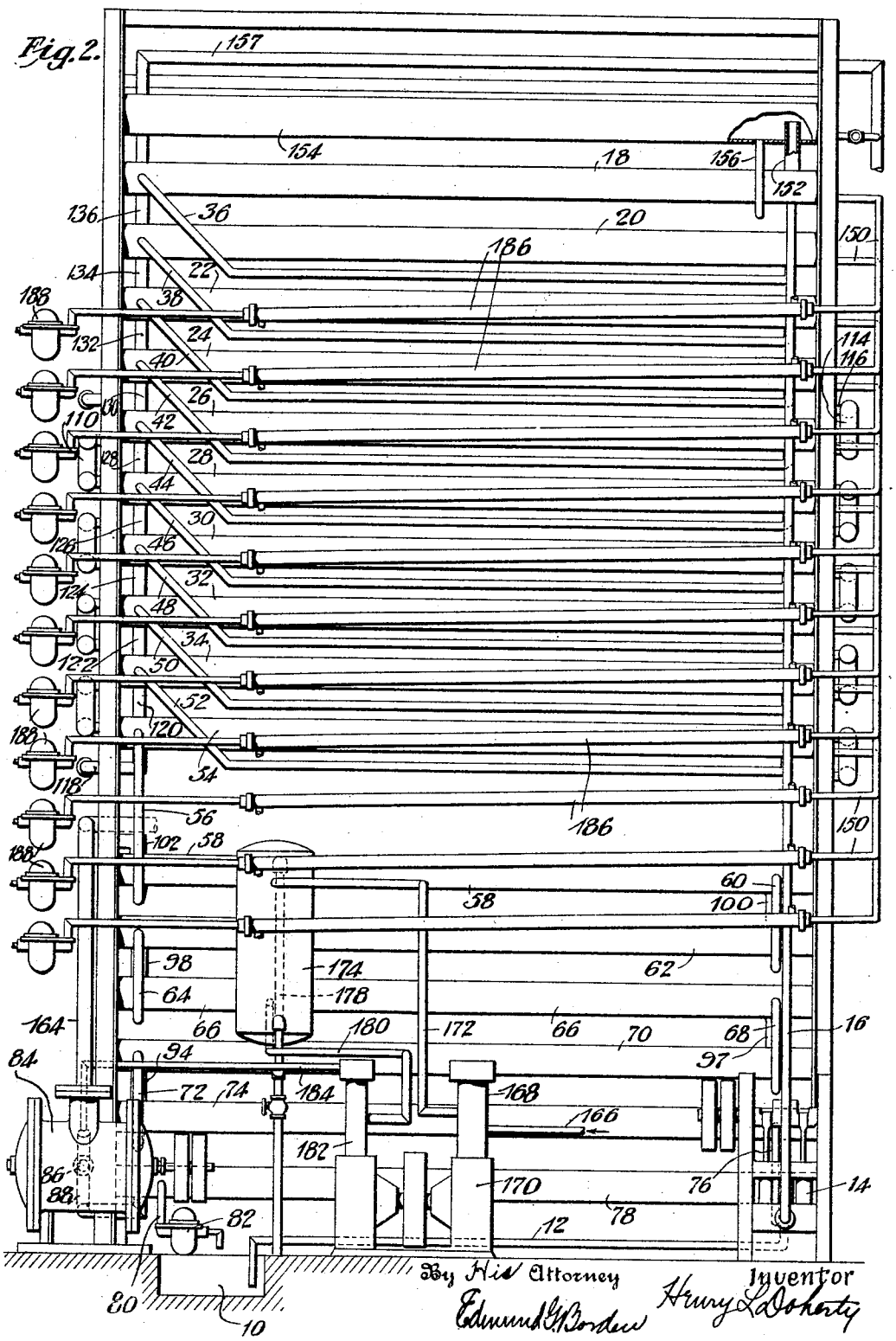
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PROCESS OF DISTILLING OIL

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Fig. 2.



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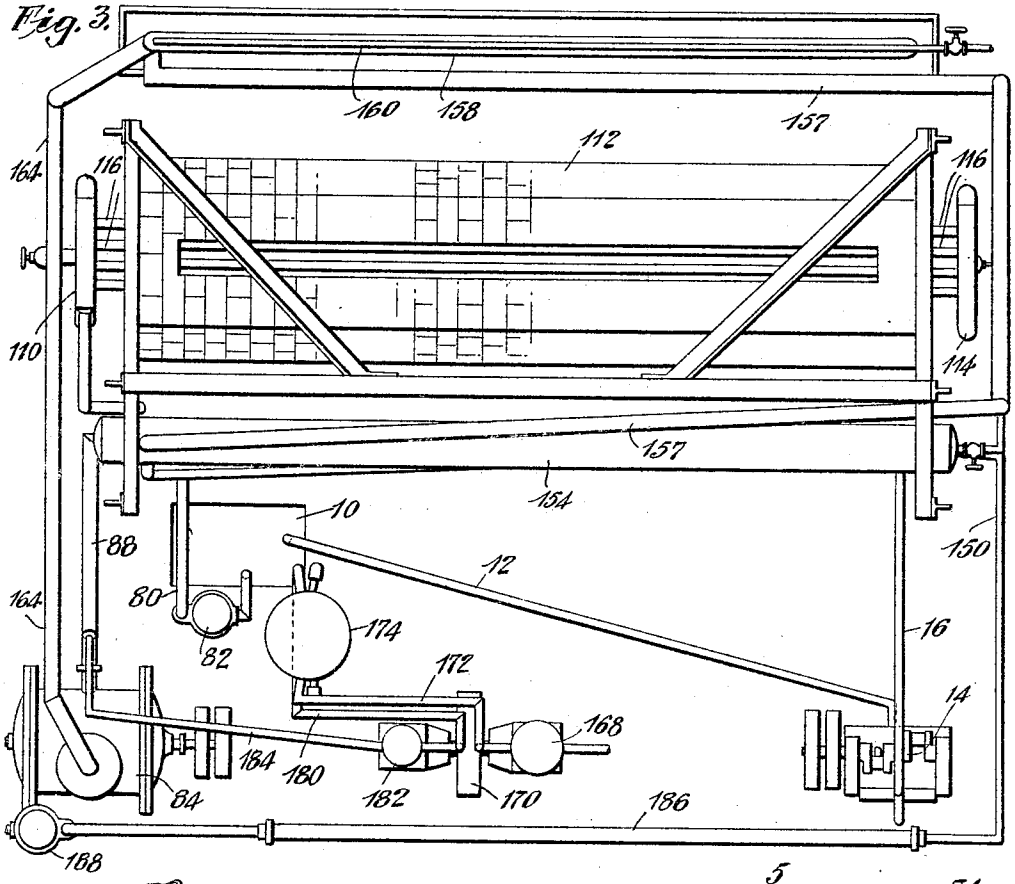
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PROCESS OF DISTILLING OIL

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Fig. 3.



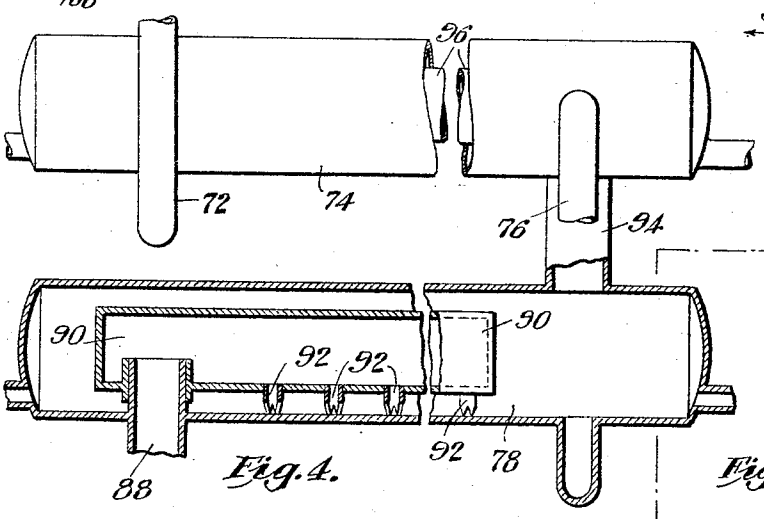


Fig. 4.

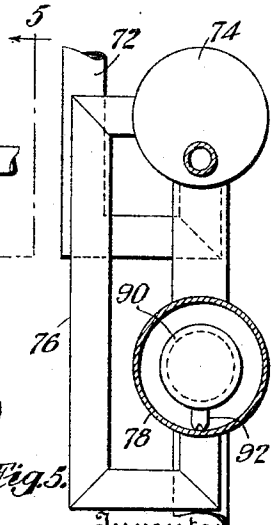


Fig. 5.

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PROCESS OF DISTILLING OIL

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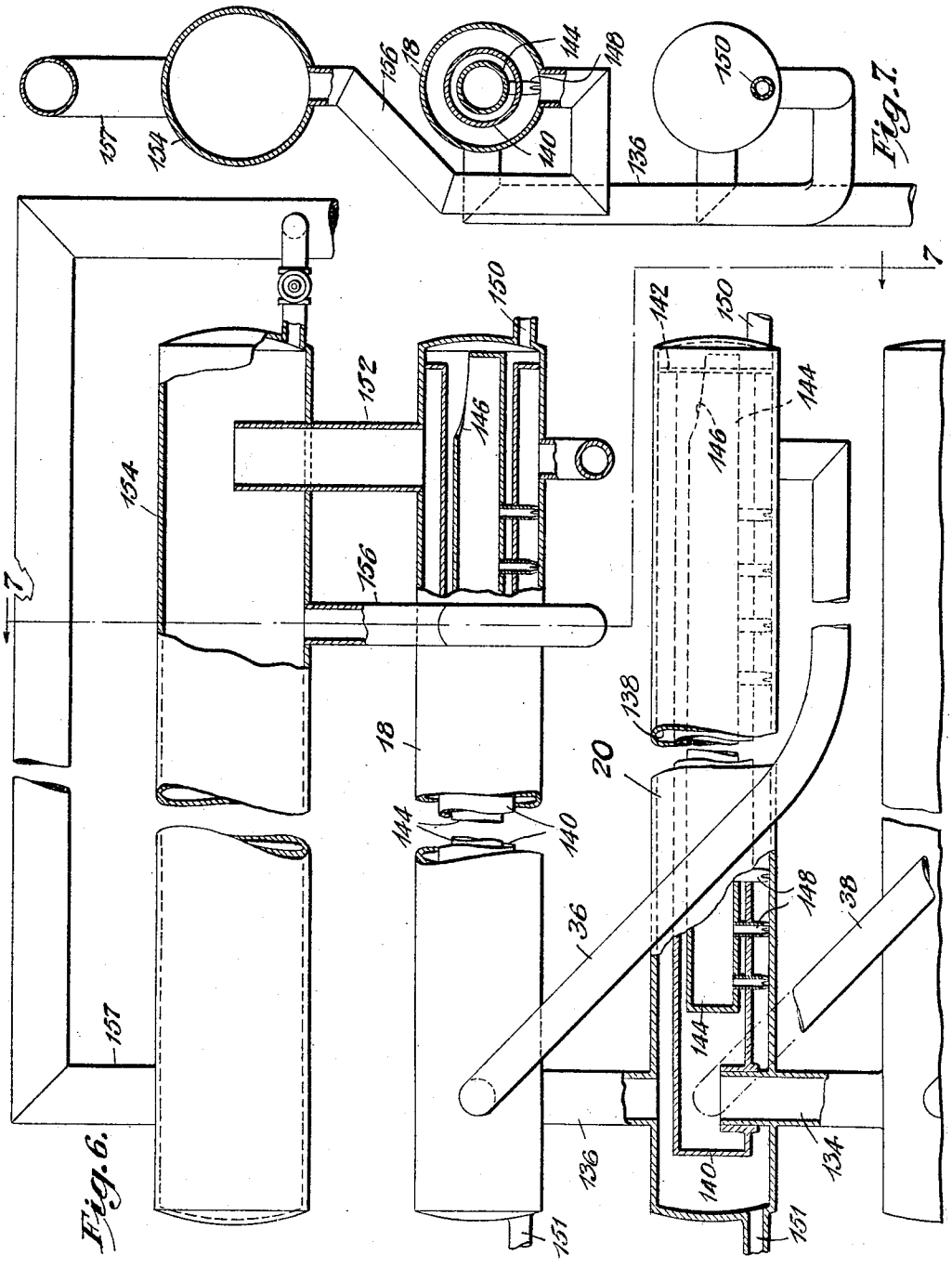


Fig. 7.

Fig. 6.

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UNITED STATES PATENT OFFICE

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PROCESS OF DISTILLING OIL

Application filed February 4, 1920. Serial No. 356,263.

The present invention relates to a process of distilling oil, and more particularly to a process of distilling and decomposing hydrocarbon oils to produce low boiling point hydrocarbons from higher boiling point hydrocarbons.

When a mixture of heavy hydrocarbon oils containing little or no light hydrocarbon constituents is distilled under pressure, the products of distillation are found to contain a larger quantity of light hydrocarbons than was present in the original mixture, the light constituents being formed by the decomposition or breaking up of the heavy hydrocarbons. The production of light hydrocarbons such as gasoline in this manner is, however, accompanied with the formation of permanent hydrocarbon gases and free carbon which decreases the yield of the products obtained and make the process commercially uneconomical. The formation of free carbon moreover produces a deposit on the heated walls of the still and thereby interferes with the operation of the process on a commercial scale.

All of the factors which tend to increase the formation of carbon and permanent gases are not known, but the quantity of gases formed is generally increased at temperatures above that necessary to effect the decomposition of the heavier hydrocarbons. The tendency towards the formation of permanent gases would, therefore, be increased by the local overheating incident to the transference of heat into the body of oil through the still walls of the ordinary type of still. This local overheating also tends to increase the building up of a deposit of carbon on the inner walls of the still, which occurs at times to such an extent as to cause the overheating and burning out of the still itself. The yield of gasoline constituents is also diminished and the amount of permanent gases increased by permitting the lighter hydrocarbons formed by the decomposition of the heavy hydrocarbons to remain for a considerable period of time in contact with the heated walls of the still before passing to the condenser or to be repeatedly subjected to the high temperatures in the still.

The primary object of the present invention is to provide a process of treating heavy hydrocarbon oils to produce lighter hydrocarbons with the formation of a minimum amount of carbon and of permanent gases.

Another object of the invention is to provide a process of distilling hydrocarbons in which the hydrocarbons are uniformly heated and local overheating is avoided or eliminated.

A further object of the invention is to provide a process in which oil is destructively distilled and the products of distillation are fractionally condensed by an interchange of heat with incoming fresh oil.

A further object of the invention is to provide a process in which the lighter constituents of a mixture of hydrocarbon oils undergoing treatment are removed before the oil enters the decomposing zone of the still.

With these and other objects in view, the invention consists in the process described in the following specification and defined in the claims.

The various features of the invention are illustrated in the accompanying drawings; in which:

Fig. 1 shows a side elevation of an apparatus for carrying out the preferred form of the invention;

Fig. 2 is a front elevation of the oil cracking apparatus shown in Fig. 1;

Fig. 3 is a plan view of the apparatus shown in Figs. 1 and 2;

Fig. 4 is a detail view, partly in section, of a series of heat interchange elements for absorbing heat from the tarry residue produced in the cracking of the oil and returning said heat to the cracking operation;

Fig. 5 is a view of the heat interchange elements shown partly in section taken on the line 5—5 of Fig. 4;

Fig. 6 is a front elevational view, partly in section, of a series of fractional condensers, used in separating the constituents formed by cracking the oil; and

Fig. 7 is a view of the fractional condensers shown, partly in section, taken on the line 7—7 of Fig. 6.

In treating oil in accordance with the pres-

ent invention, the oil is passed downwardly in a series of successive bodies and is heated by means of a heat transferring gas to successively higher temperatures in its downward movement until it reaches a temperature at which the heavy constituents of the oil are decomposed or cracked into lighter hydrocarbons. From this point of highest temperature, the liquid hydrocarbons remaining undecomposed, together with the tar and carbon formed by the decomposition, pass downwardly as a series of bodies, which are progressively cooled by contact with cold heat transferring gas passing upwardly to the cracking zone, and leave the apparatus after being cooled by contact with the gas.

The heat transferring gas is progressively heated to a higher temperature in passing up through the hot liquid leaving the cracking zone and attains a temperature approaching that of the cracking zone. The heated gas is then passed through a series of tubes heated directly by a gas flame and is thereby raised to a temperature above that at which the cracking reaction takes place. The heated gas is then passed through the liquid in the cracking zone imparting its heat to the liquid and causing the decomposition or cracking of the heavy hydrocarbons in the oil. After passing through this cracking zone, the gas, together with the cracked vapors formed from the heavier hydrocarbons, passes into a heat transferring relation with the body of downwardly moving oil immediately above it, thereby condensing the heavier portions of the cracked vapors and heating the downcoming oil by the latent heat of liquefaction of the condensing vapors.

The gas and cracked vapors remaining after the condensation of the heavier constituents are then bubbled through the body of liquid to impart an additional amount of heat and to vaporize and absorb any lighter vapors which may be contained in the body of liquid. The gas in bubbling through the oil also stirs the oil and thereby increases the efficiency of heat transfer between the downcoming oil and the condensing vapors. In this manner, the gas passes upwardly through the downwardly passing bodies of oil, being cooled progressively in its upward passage and condensing in each stage the fraction of vapors condensable at the temperature maintained therein. Through these operations, the greater part of the heat remaining in the gas as it leaves the cracking zone is given up to the incoming fresh oil and returned to the cracking operation. From the uppermost body of oil, the gases and any cracked vapors which may be contained therein are passed through a water cooled condenser to remove the last traces of gasoline vapors, and the gas is returned to the hot residues produced in the cracking operation to be reheated and recycled through the apparatus. The fractional condensates produced in the different stages of the apparatus are removed and may be blended to produce commercial grades of gasoline, naphtha, kerosene or other products, or in the case of the heavier members, may be returned to the process and decomposed into lighter products.

Referring more specifically to the execution of the process in the apparatus of the accompanying drawings oil to be treated is withdrawn from an oil supply tank 10 through a pipe 12 and forced by means of a pump 14 through a pipe 16 to the uppermost of a series of condenser heaters 18, 20, 22, 24, 26, 28, 30, 32 and 34 (Figs. 1 and 2) in which it is heated to progressively higher temperatures by means of an upwardly passing heat transferring gas. The oil enters and fills the uppermost condenser heater 18 to the level of an overflow pipe 36 through which it overflows to the next lower condenser heater 20. In a similar manner, the oil overflowing through the pipe 36 partly fills the condenser heater 20 and overflows through an overflow pipe 38. In this manner the oil flows successively downwardly through the condenser heaters through a series of overflow pipes 36, 38, 40, 42, 44, 46, 48, 50 and 52 and enters a cracking chamber or still 54 in which it comes directly into contact with gas heated to the highest temperature and is thereby heated and decomposed into lower boiling hydrocarbons. From the cracking chamber 54 the residual oil containing carbon and tar formed by the decomposition of the oil, overflows through an overflow pipe 56 to a heat interchanger 58 forming the uppermost of a series of heat recovery interchangers.

The oil residue fills the heat interchanger 58 to the level of an outflow pipe 60 (Fig. 2) at the other end of the interchanger through which it overflows to the next lower interchanger 62. In this manner the residue flows from the interchanger 62 successively through an overflow pipe 64, interchanger 66, overflow pipe 68, interchanger 70, overflow pipe 72, interchanger 74, and overflow pipe 76 to the lowermost heat interchanger 78. In the heat interchangers 58, 62, 66, 70, 74 and 78 the residual oils are cooled to progressively lower temperatures by direct contact with a current of cool heat transferring gas passing upwardly to the cracking chamber 54. The cooled residual oil is withdrawn from the lowermost interchanger 78 through an overflow pipe 80 and a trap 82.

Gas for transferring heat to the downcoming oil, as described above, is forced under pressure by means of a pressure blower 84 through a delivery pipe 86 and gas inlet pipe 88 to the lowermost heat interchanger 78 and enters a horizontal cylinder 90 contained within the interchanger (Figs. 4 and 5).

The gas fills the cylinder 90 and passes downwardly through a number of short pipes or nipples 92 extending into the body of oil in the heat interchanger 78. The gas then bubbles upwardly through the body of liquid in the heat interchanger 78 and passes through a connecting pipe 94 to a gas distributing cylinder 96 positioned in the heat interchanger 74 similarly to the position of the distributing cylinder 90 in the heat interchanger 78. In this manner, the gas is bubbled successively through the heat interchangers 70, 66, 62 and 58, passing from one interchanger to another through connecting pipes 97, 98 and 100, placed alternately at opposite ends of the heat interchangers. Through this passage of the hot residue from the cracking chamber countercurrent to the passage of the heat carrying gas, the hot residue is cooled to the temperature of the incoming gas and the gas is in turn heated by the abstraction of heat to very nearly the temperature obtaining in the cracking chamber 54. From the uppermost heat interchanger 58, the heated gas passes through an outlet pipe 102 (Fig. 1) to an upright pipe 104 of somewhat larger diameter serving as a "catch-all" to separate out any entrained liquids from the gas and permit their withdrawal through a draw-off valve 106.

From the top of the pipe 104 the gas passes through a connecting pipe 108 to the uppermost of a series of manifolds 110 positioned adjacent to the outer wall of a gas fired furnace 112 (Figs. 1 and 3). Each of the manifolds 110 is connected to a corresponding manifold 114 (Fig. 3) at the opposite side of the furnace by means of a number of heating tubes 116 extending through the furnace. The gas entering the uppermost of the manifolds 110 passes successively back and forth through the heating tubes 116 and the connecting manifolds 110 and 114, and is heated to a temperature above that maintained in the lowermost cracking chamber 54.

From the lowermost of the manifolds 110, the heated gas is withdrawn through a pipe 118 and bubbled through the hot oil in the cracking chamber 54. In passing through the oil the hot gas is divided into a large number of very small bubbles uniformly distributed throughout the body of hot oil and thereby heats every portion of the oil to a uniformly high temperature. By regulating the temperature, pressure and volume of the gas, any desired temperature may be imparted to the oil without causing a local overheating of the oil such as is caused in heating oil by conduction from the wall of a heated still. The oil may, therefore, be maintained uniformly at the temperature most favorable for decomposing or cracking the particular oil undergoing treatment to obtain the largest possible amount of the desired lighter hydrocarbons. The lighter hydrocarbons formed by the cracking of the oil in contact with the gas are immediately vaporized and absorbed by or mixed with the hot gases passing upwardly through the oil.

From the cracking chamber 54, the gases pass upwardly through a vapor pipe 120 to the lowermost condenser heater 34 in which the cracking reaction may continue and in which a part of the heavy hydrocarbons may be condensed and removed from the heat transferring gas. The gas and uncondensed vapors pass in a similar manner upwardly to the condenser heaters 32 to 18 through vapor pipes 122, 124, 126, 128, 130, 132, 134 and 136. The hydrocarbons formed in the cracking reaction and carried with the gases are progressively condensed and removed from the circulating gases, the heavier of the condensable hydrocarbons being condensed in the lower of the condenser heaters and condensates having a slightly lower boiling point condensed successively in the condenser heaters immediately above.

The hydrocarbons condensing in the lower condenser heaters are ordinarily too heavy for blending to form gasoline or naphthas and are therefore returned to the oil cracking process. It is highly desirable to prevent the condensation of the lighter condensates in the lower condenser heaters from which they would be returned with the heavier hydrocarbons to the cracking reaction, since the heating of the lighter hydrocarbons in the cracking still tends to decompose them still further to permanent gases. The vapors are therefore condensed in the condenser heaters 18 to 34 in such a manner as to form a large number of sharply defined fractions which contain constituents boiling at the temperatures maintained in the condenser heater and containing a minimum of lower boiling hydrocarbons. The sharpness of definition of these fractions is promoted by maintaining the oil substantially uniform in temperature throughout each condenser heater and in continuously circulating the oil in the condenser heater so as to bring fresh bodies of oil into contact with the wall of the condenser on which the vapors are condensed, thereby maintaining the temperature of the dividing wall between the condensing vapor and the oil substantially uniform.

To this end the gases and cracked vapors passing into the condenser heaters are first brought into a heat interchange relation with the downgoing oil in such a manner that those of the cracked vapors which are condensable at the temperature of the oil in the condenser heater are completely condensed and removed. The gas and uncondensed vapors are then bubbled through the body of oil in the condenser heater, thereby agitating and circulating the oil, absorbing any light hydrocarbons contained in the oil and carrying the absorbed hydrocarbons to the con-

denser heater immediately above. All light constituents are thereby removed from the downgoing oil and a very efficient transfer of heat from the upgoing gases to the oil in each condenser heater is also obtained so that the gas leaves the condenser heater at substantially the temperature of the oil contained therein.

The construction of the condenser heaters for obtaining this successive cooling and contacting of the heat transferring gas with the downcoming oil is illustrated in the sectional view of the condenser heater 20 shown in Figs. 6 and 7. The condenser heater comprises an outer shell 138, through which the vapor pipe 134 passes, and an inner cylinder 140 into which the pipe 134 opens. The cylinder 140 is closed at the end nearest the pipe 134 and is separated at the other end from communication with the interior of the cylinder 138 by means of a supporting flange 142. A second cylinder 144 is placed within and spaced from the inner walls of the cylinder 140 and has an opening 146 at the end opposite the gas inlet pipe 134. A number of short pieces of pipe, or tubing, 148 having serrated lower ends are fastened in the lower side of the cylinder 144 and extend through the wall of the cylinder 140 to the bottom of the outer shell 138. The hot gases passing upwardly through the connecting pipe 134 enter the cylinder 140 and pass through an annular space between the cylinders 140 and 144 to the opening 146 in the cylinder 144. In passing through the annular space between the cylinders 140 and 144, the gases are brought into intimate contact with the walls of the cylinder 140 and the condensable constituents are condensed, collected in the lower part of the cylinder, and withdrawn through a draw-off pipe 150 at the opposite end of the condenser heater. The gas entering the cylinder 144 will, therefore, be substantially free from those constituents which condense at the temperature maintained in the condenser heater. The temperature of the oil in the condenser may be determined by means of thermometers or pyrometers inserted through openings 151 in the shell 138.

From the cylinder 144 the gases pass through the distributing pipes 148 and pass out of the serrated lower ends of the pipes in a large number of very fine bubbles. As the bubbles of gas pass upwardly through the liquid in the condenser heater they are cooled by intimate contact of the liquid to substantially the temperature of the liquid before passing through the connecting pipe 136 to the condenser heater 18 immediately above. A much better fractionation of the vapors is thereby obtained. After passing through the uppermost condenser heater 18, the heat transferring gas will have been cooled to approximately the temperature of the incoming oil and will have been freed from all vapors condensable at this temperature. From the uppermost condenser heater 18 the gas passes through a connecting pipe 152 to a collecting chamber or "catch-all" 154 in which any entrained oil or foam is allowed to separate from the gases and is returned to the condenser heater 18 through a return pipe 156.

From the collecting or expansion chamber 154 the gas passes through an outlet pipe 157 to a series of condenser coils 158 at the side of the furnace 112 (Figs. 1 and 2). The condenser coils 158 are cooled by means of water trickling over the coils from a spray pipe 160 and the last traces of gasoline or naphtha vapors obtainable are condensed, separated out, and withdrawn through a draw-off pipe 162. From the condenser coils 158 the cooled gas is drawn through an exhaust pipe 164 to the inlet side of the pressure blower 84 and again circulated through the apparatus.

Due to the high gas pressure and to the high temperature maintained throughout the gas circulating system, a certain amount of gas disappears through leakage or through absorption in, or union with, the oils undergoing treatment to form gasoline hydrocarbons. To make up this loss, natural gas or other types of hydrocarbon gas is supplied through a supply pipe 166 to the first cylinder 168 of a two-stage compressor 170. The compressed gas from the cylinder 168 passes through a pressure pipe 172 to a water cooled cooler 174. In the cooler 174 the gas comes in contact with the outer surfaces of a number of tubes 176 (Fig. 1) through the interior of which water is circulated from a cold water suply pipe 178. From the cooler 174 the cooled gas passes through a pipe 180 to a second cylinder 182 of the compressor 170 and is compressed and forced through a pipe 184 to the gas inlet pipe 88 where it joins with the gas from the pressure blower 84.

The condensates withdrawn from the condenser heaters 18 to 34 and through the pipes 150, and from the condenser 158 through the pipe 162, are cooled by means of water cooled condensers 186 and withdrawn from the apparatus through traps 188. The condensate from the condenser 158 and from the uppermost of the condenser heaters may be blended to provide commercial gasoline and naphthas and the heavier condensates from the lower condenser heaters returned to the cracking still to be broken up into lighter hydrocarbons. The particular point at which the condensates will be separated to be blended into commercial products or to be returned to the cracking operation will depend upon the characteristics required of the commercial articles.

Although the chamber 54 has been de-

scribed as a cracking chamber, the various oils being treated will often be cracked throughout a large range of temperatures and therefore the condenser heaters 34, 32 or 30 possibly might be within the range of the cracking zone or a zone in which the temperatures are sufficiently high to decompose the oil while in contact with the heated gas. The term "cracking zone" therefore, is intended to include those condenser heaters and the cracking chamber in which decomposition of the oil takes place.

In the above process oil distillation products, such as kerosene, gas oil and fuel oil produced may be used as the raw material undergoing cracking, or a crude oil may be subjected directly to the process, since the lighter constituents will be removed in the upper condenser heaters before the oil is subjected to the main cracking reaction.

The present invention constitutes, as to common subject matter, a continuation of my pending application, Serial No. 211,537, filed January 12, 1918, for a process of distilling oil. The process of the present application is described in the application above referred to as being carried out in connection with a different form of apparatus.

Having described the process, what is claimed as new is:

1. A process of distilling oil comprising passing oil under superatmospheric pressure as a series of connected bodies of gradually increasing temperature through a still, conducting gas in a cyclic path countercurrent to said oil, withdrawing said gas from the still at a mid-point thereof, heating the gas and returning it to the still, vaporizing oil in said bodies and circulating the vapors through the still with the gas, and fractionally condensing the vapors by a heat interchange with oil in preceding cooler bodies.

2. A process of distilling oil, comprising passing oil and a heated gas countercurrent and under superatmospheric pressure through a still, controlling the supply of heat to said gas to maintain the highest temperature of the oil at a point intermediate the ends of said countercurrent path, and segregating from said oil a series of fractional condensates of definite boiling points, the boiling points of the fractions being progressively higher as the oil descends in the still.

3. A process of distilling oil, comprising passing oil and a heated gas countercurrent and under superatmospheric pressure through a still, controlling the supply of heat to said gas to maintain the highest temperature of the oil at a point intermediate the ends of said countercurrent path, and segregating from said oil a series of fractional condensates of definite boiling points, the boiling points of the fractions being progressively higher as the oil descends in the still, and maintaining each of the fractional condensates in heat-conducting relation to said oil and gas.

4. A process of distilling oil, comprising passing oil and a heated gas countercurrent through a still, controlling the supply of heat of said gas to maintain the highest temperature in the still at a point intermediate the ends of the countercurrent path of said oil and gas, and maintaining said oil and gas under superatmospheric pressure during its countercurrent flow.

5. A process of distilling oil comprising continuously passing oil through a still in liquid form, heating the oil progressively and evaporating portions thereof as it advances through the still by passing a heated gas in direct heat transferring relationship therewith, said gas being introduced independently of the oil being distilled so as to create a partial pressure other than the partial pressure of the vapors formed from the oil, circulating said gas and oil in counter-current paths throughout the still, and heating the gas to sufficiently high temperatures to crack portions of the oil.

6. A process of distilling oil comprising passing oil and a hydrocarbon gas in countercurrent paths while in contact throughout a still, said gas having a composition such as to exert a partial pressure other than the partial pressure of the vapors derived from vaporization of the oil, maintaining the oil and gas under superatmospheric pressure, heating the oil in stages to progressively higher temperatures by means of said gas, and heating the gas to sufficiently high temperatures to crack the hotter portions of the oil.

7. A process of distilling oil, comprising passing oil as a series of connected bodies through a still, conducting a heated gas countercurrent through the oil, holding said gas and oil under pressure, maintaining the temperature of the gas sufficiently high to crack said gas and oil, and separating from the oil a series of fractional condensates as the oil advances to remove the more volatile constituents before the oil reaches the hottest zone of the still.

8. A process of distilling oil, comprising passing oil as a series of connected bodies through a still, conducting heated hydrocarbon gas countercurrent through said oil, holding said oil and gas under pressure, maintaining the temperature of the gas sufficiently high to crack the gas and oil, separating from the oil a series of fractional condensates as the oil advances, and holding said condensates in heat-conducting contact with said oil and gas.

9. A process of distilling oil, comprising passing oil and a heated gas countercurrent through a still under pressure and controlling the supply of heat of said gas to maintain the temperature sufficiently high to crack the oil and to hold the highest temperature in the still

at a point intermediate the ends of the countercurrent path of said oil and gas.

10. A process of distilling oil, comprising passing oil and a heated gas countercurrent through a still under pressure, controlling the supply of heat to said gas to maintain the temperature sufficiently high to crack the gas and oil and to hold the highest temperature in the still at a point intermediate the ends of the countercurrent path of said oil and gas, and segregating from said oil a series of fractional condensates at different points in said countercurrent path.

11. A process of distilling oil, comprising passing oil through a still as a series of connected bodies, conducting a gas countercurrent through said oil, heating said gas to a temperature sufficiently high to crack the gas and oil, at intervals removing from the still volatile constituents of the oil, and permitting only the higher boiling vapors to come into contact with the most highly heated gas.

12. A process of distilling oil comprising passing oil as a series of connected bodies of gradually increasing temperature through a still, conducting gas in a cyclic path countercurrent to said oil and in direct contact therewith, withdrawing the said gas from the still at a mid-point thereof, heating the gas to a temperature adapted to crack the oil when the gas is brought into contact therewith, and returning the gas to the still, vaporizing oil in the said bodies and cracking the oil in some of them, circulating the vapors through the still with the gas, and fractionally condensing the vapors by a heat interchange with oil in preceding cooler bodies.

13. A process of distilling oil comprising continuously passing oil as a series of segregated bodies through a still, circulating a gas which imparts a partial pressure other than the partial pressure exerted by vapor derived from the oil, through the oil bodies in a counter-current path to the path of circulation of the oil and in direct contact with the oil bodies, maintaining the oil and gas under superatmospheric pressures and cracking temperatures, and separating a fractional condensate from each oil body, said condensates differing from one another in accordance with the temperature of the oil body from which each condensate is derived.

14. A process of distilling oil, comprising passing oil as a series of separate and connected bodies through a still, bubbling a gas in series through said bodies supplying the heat for cracking the oil solely by the heat in the gas, and controlling the temperature and pressure of said gas to maintain conditions for cracking oil in some only of said bodies.

15. A process of distilling oil, comprising passing oil as a series of separate and connected bodies through a still, bubbling a heated gas through said bodies, maintaining different temperatures in said bodies, condensing vapors in heat-transferring relationship to but out of contact with said bodies, and conducting the oil distillation under superatmospheric pressure.

16. A process of distilling oil, comprising passing oil as a series of separate and connected bodies through a still, maintaining different temperatures in said bodies, condensing vapors in heat-transferring relationship to but out of contact with said bodies, passing a heated gas through said bodies, passing said gas in heat-transferring relationship to said condensates, and conducting the distillation under superatmospheric pressure.

17. A process of distilling oil, comprising passing oil as a series of separate and connected bodies through a still, bubbling a heated gas in series through said bodies, controlling the temperature of said gas to progressively increase the temperature of the oil as it advances through the still, condensing vapors in heat-transferring relationship to but out of contact with said bodies, and conducting the distillation under superatmospheric pressure.

18. A process of treating heavy hydrocarbon oils to produce lighter hydrocarbons which comprises continuously passing said oil under pressure through a series of fractional condensers to a still, heating said oil in said still to a temperature sufficiently high to decompose said heavy hydrocarbons to lighter hydrocarbons, passing the vapors from said still successively through bodies of oil in said fractional condensers in a direction opposite to that of the flow of said oil, and recovering oil fractions in said condensers.

19. A process of treating heavy hydrocarbons to produce lighter hydrocarbons which comprises passing said oil under pressure continuously through the cooling compartments of a series of fractional condensers to a cracking still, heating said oil in said still to a temperature sufficiently high to decompose said heavy hydrocarbons to lighter hydrocarbons, passing vapors from said still successively through condensing compartments of said fractional condensers in a direction counter to that of the flow of said oil, and passing currents of gas through said oil in said condensers in such a manner as to agitate said oil and produce currents of oil to and from the walls of said condensing compartments.

20. A process of fractional distillation and condensation of oil which comprises flowing the oil to be treated through a series of stills heated to successively higher vaporizing temperatures and condensing part of the vapors given off in each still by absorbing heat therefrom, first by condensate of these vapors formed in a still of lower temperature and

then by the liquid oil in said still of lower temperature.

21. The process of distilling oil which comprises passing oil in a continuous flow successively through a series of heating zones of progressively increasing temperatures from the point of introduction of the oil, circulating a gas through the heating zones countercurrent to the flow of oil through said series of zones, heating the gas before introducing it into the highest temperature zone, collecting a fractional condensate in each zone and passing the gas through a final condenser after it leaves the lowest temperature zone and before it is reheated to be passed into the highest temperature zone.

22. A process for non-destructive distillation of hydrocarbon oil comprising passing it in one direction through a narrow elongated still while being subjected to heat, injecting oil vapor from a previous distilling operation into the oil at a plurality of points along its passage through said elongated still to cause foaming and agitation of the oil and causing said oil vapor to flow through said elongated still concurrently with the oil, whereby the liquid and vapor phases are maintained in intimate contact and the mean vapor tension raised, and separating the vapors by fractional condensation.

23. A process for non-destructive distillation of hydrocarbon oil, comprising heating the oil, injecting vapor into said oil at a plurality of places, maintaining concurrent flow of the liquid and vapor phases, whereby to agitate said oil, keeping the liquid and vapor phases thereof in intimate contact so as to raise the mean vapor tension, separating the lighter and heavier fractions, and leading the lighter fractions to a second body of oil that is being heated and injecting said lighter fractions into said second body of oil, so as to agitate it and keep the liquid and vapor phases thereof in intimate contact and so raise the mean vapor tension.

24. A process for non-destructive distillation of hydrocarbon oil, comprising heating the oil, injecting vapor into said oil at a plurality of places in concurrent flow, whereby to agitate said oil and keep the liquid and vapor phases thereof in intimate contact, separating the lighter and heavier fractions, and leading the lighter fractions to a second body of oil that has been preliminarily heated and injecting said lighter fractions into said second body of oil while it is subjected to further heating.

25. A process for fractionally distilling and condensing oils, which comprises passing the oil to be treated through a series of combined vaporizing and condensing zones of increasing temperature, passing the vapors formed in each zone into indirect heat exchange with oil in the next cooler zone to effect partial condensation of said vapors, withdrawing the condensate formed in each zone, and mingling the uncondensed portion of the vapors from each zone with the oil being distilled in the next zone of lower temperature.

26. The process of distilling hydrocarbon oils, which comprises passing oil to be treated through a preheating zone and then into a distilling and vaporizing zone, passing vapors from the vaporizing zone in indirect heat exchange with oil being preheated in said preheating zone to condense a portion of said vapors, then passing the remaining uncondensed portion of said vapors in direct and intimate contact with the oil in said preheating zone thereby to agitate the oil while being indirectly heated by said vapors passing in indirect heat exchange therewith, and passing the vapors from said preheating zone into a further condensing zone.

27. The process of cracking petroleum oil by direct contact of superheated gases with petroleum oil constituents in a cracking zone, which comprises passing petroleum oil, a portion of the constituents of which is to be cracked into a vaporizing zone in heat exchange with hot gases and vapor products from said cracking zone, vaporizing substantial portions of such oil in said vaporizing zone, conducting the petroleum constituents desired to be cracked from said vaporizing zone into said cracking zone, heating a heat carrier gas to a temperature sufficient to further heat and crack the oil constituents introduced into said cracking zone, passing said heated gas into said cracking zone in intimate contact with the said oil constituents introduced thereinto, conducting the resulting mixture of gas and vapor products into said vaporizing zone, subjecting the said products to condensing conditions to separate readily condensible constituents from uncondensible gases, and heating the separated uncondensible gas to a high temperature to supply at least in part said heat carrier gas for cracking the oil constituents introduced into said cracking zone.

In testimony whereof I affix my signature.

HENRY L. DOHERTY.