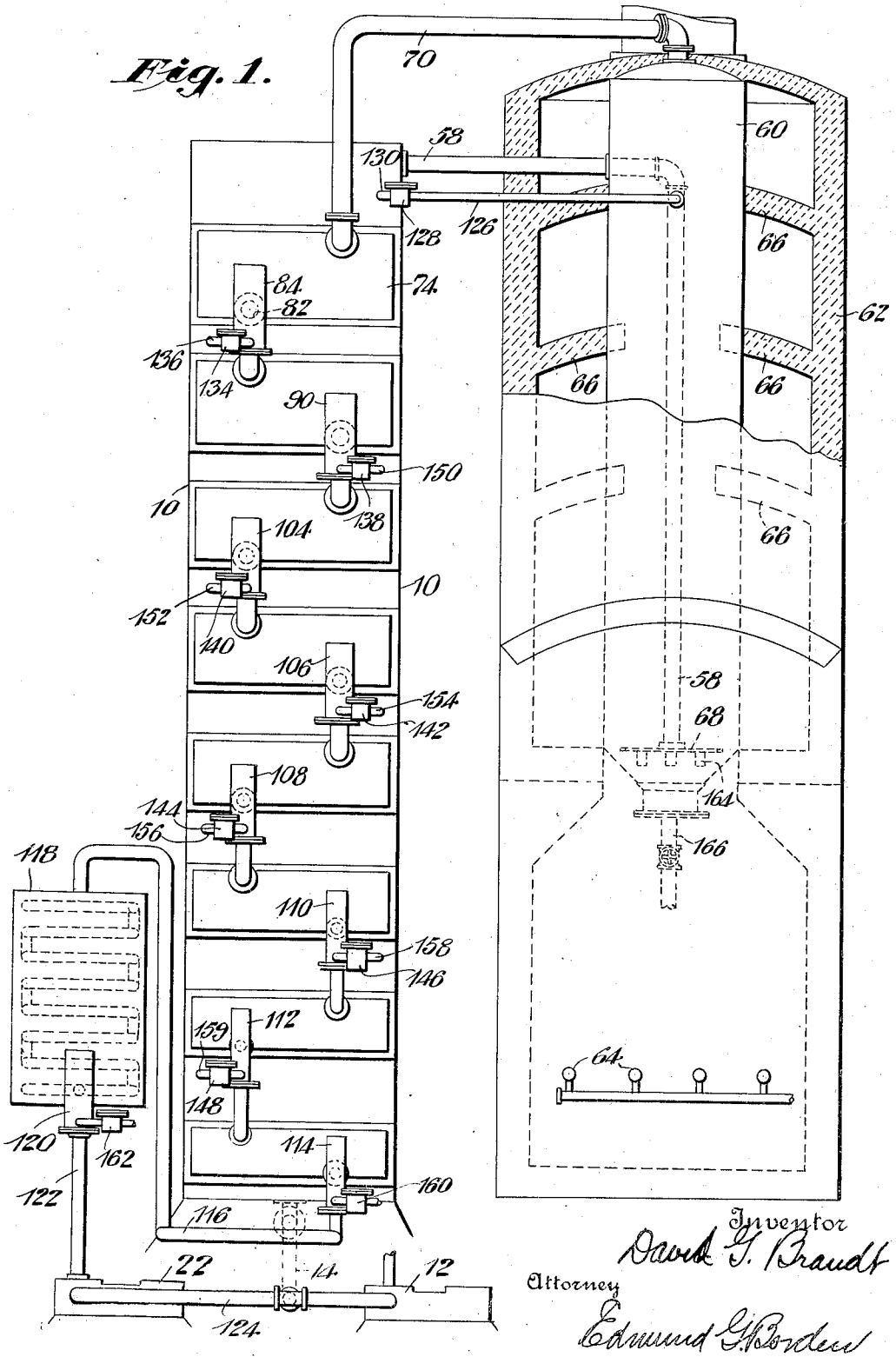
May 14, 1929. D. G. BRANDT 1,713,254

PROCESS FOR DISTILLING LIQUID MIXTURES

Filed March 24, 1920 4 Sheets-Sheet 1

Fig. 1.



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PROCESS FOR DISTILLING LIQUID MIXTURES

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Fig. 2.

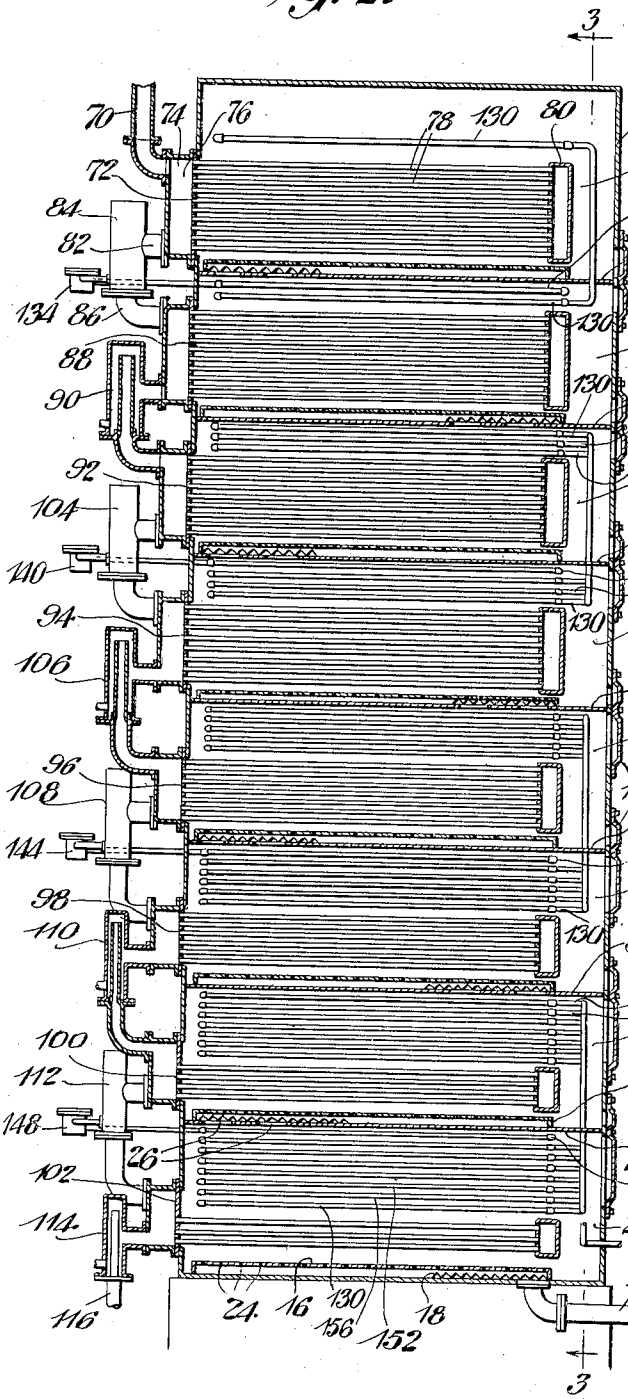
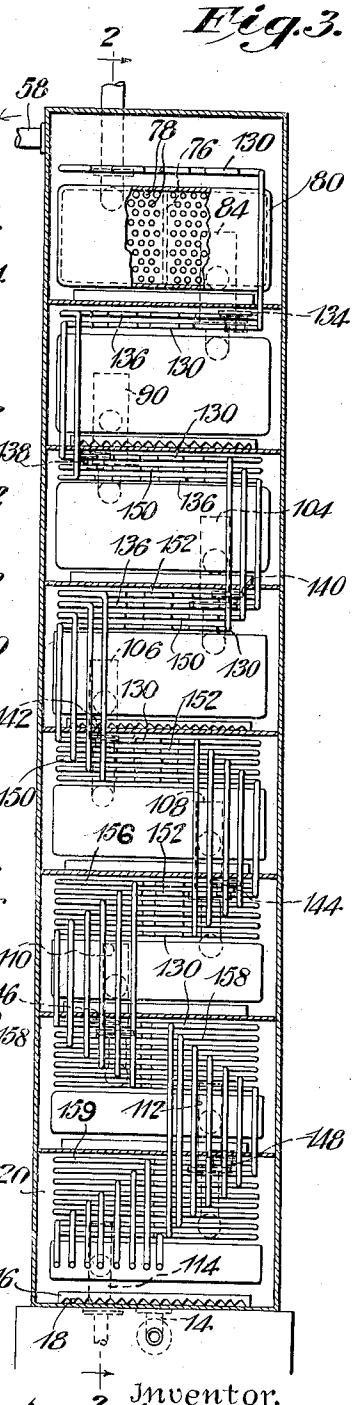


Fig. 3.



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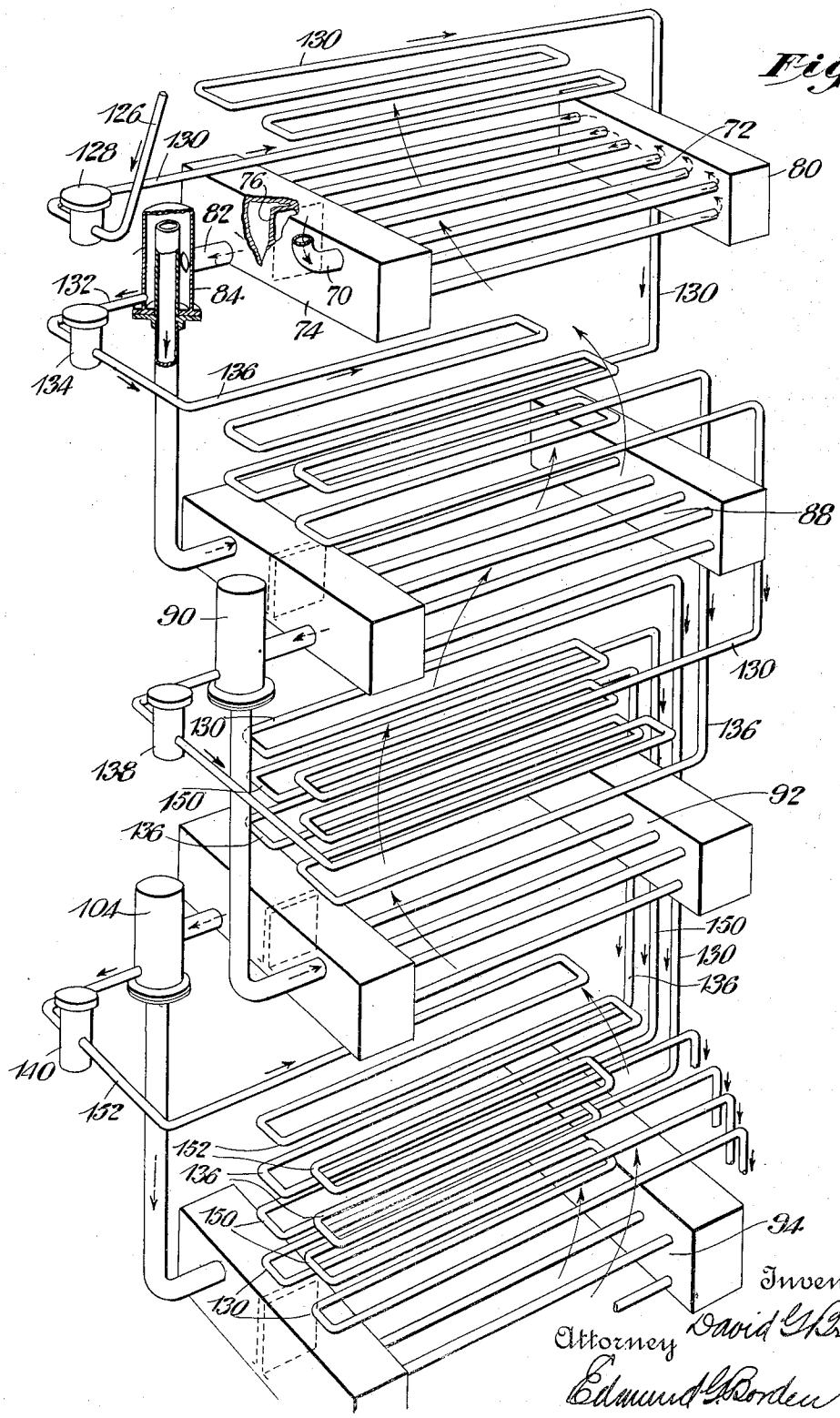
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PROCESS FOR DISTILLING LIQUID MIXTURES

Filed March 24, 1920 4 Sheets-Sheet 3

Fig. 4.



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PROCESS FOR DISTILLING LIQUID MIXTURES

Filed March 24, 1920 4 Sheets-Sheet 4

Fig. 5.

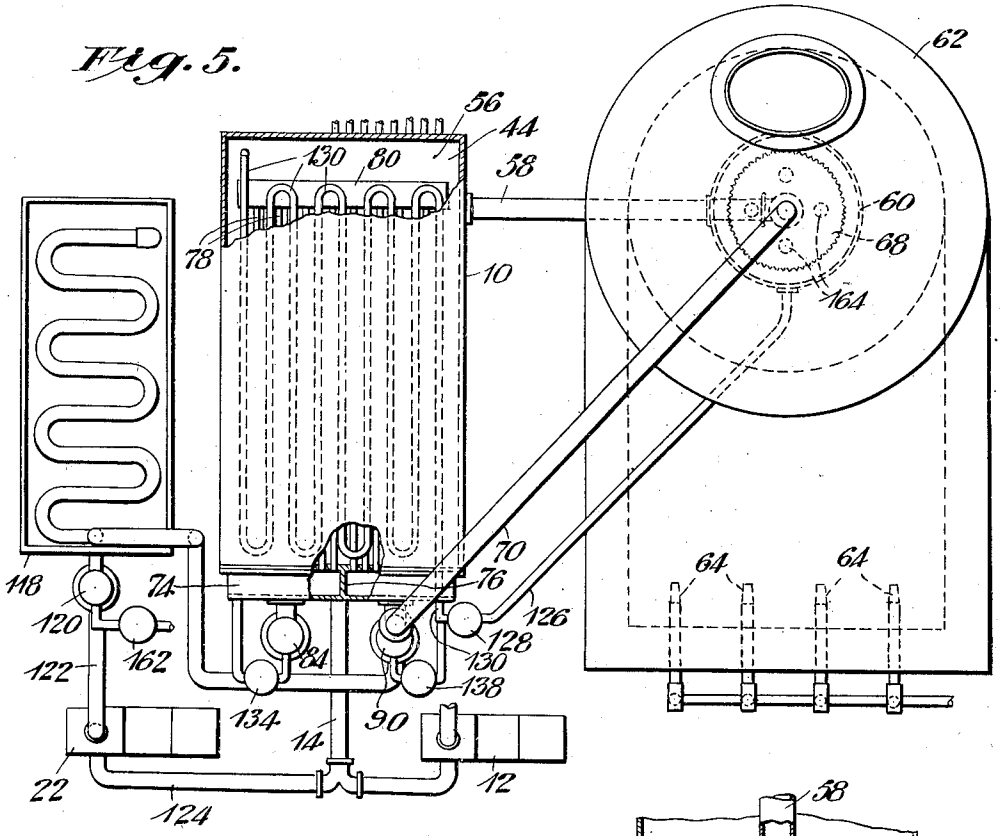


Fig. 7.

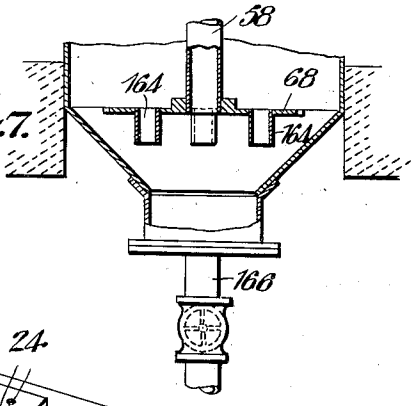
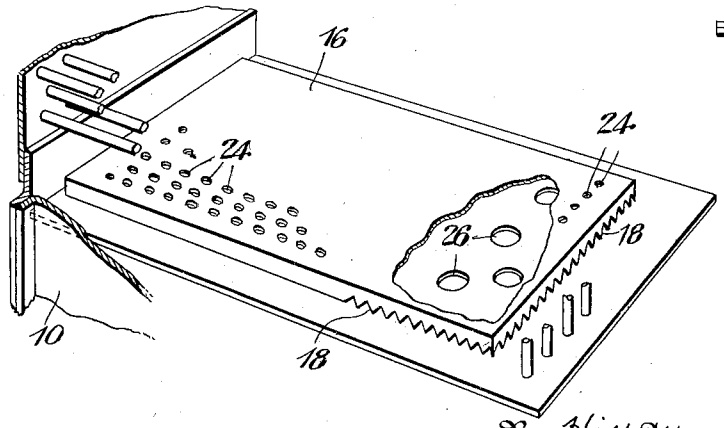


Fig. 6.



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UNITED STATES PATENT OFFICE.

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PROCESS FOR DISTILLING LIQUID MIXTURES.

Application filed March 24, 1920. Serial No. 368,221.

The present invention relates to a process for distilling liquid mixtures, and more particularly to a process for refining petroleum and similar substances.

Crude petroleum is composed principally of a mixture of hydrocarbons comprising substantially all of the constituents which make up the various commercial products obtained by the refining operations, from the lightest, most volatile products such as naphtha and gasoline to the semi-solid lubricating greases and waxes. To obtain the principal commercial products from the crude petroleum it is, therefore, only necessary to separate the constituents of the petroleum by successive distillations into fractions lying within certain boiling point and density limits, and to remove by suitable chemical treatment those impurities which impart a disagreeable odor or color to the product.

To effect this fractionation, it is customary to slowly heat the petroleum in large cylindrical boilers by direct heat of a fire and to separately condense the vapors produced at different temperatures. The petroleum can not, however, be separated directly into its various commercial products by a single distillation in this manner, because the boiling points of the constituents of the crude petroleum vary gradually or by almost imperceptible steps, from the lightest to the heaviest, and the vapors produced at any particular temperature in turn comprise a mixture of hydrocarbons having boiling points extending over a comparatively wide range. The crude fractions thus obtained are, therefore, redistilled several times to separate them into more sharply defined fractions, and the latter are treated with purifying chemicals to produce commercial grades of gasoline, kerosene, lubricating or fuel oils, waxes, and other products. The distilling process is sometimes varied by continuously passing the petroleum successively through a series of stills maintained at progressively higher temperatures and recovering a separate fraction from each still, and may be further modified by distilling the heavier fractions with steam to lower the distilling temperature and thereby lessen the tendency of the hydrocarbons to decompose. In each distillation there is a large consumption of heat which is due principally to the inefficient method of heating the body of oil and of cooling the condensing vapors since the net energy change caused by the separation of the petroleum into the various fractions is negligible. This loss of heat is increased when steam distillation is employed in distilling the heavier hydrocarbons, since an additional amount of heat is required for the vaporization of the steam, all of which is lost when the steam is again condensed with the condensing fractions.

In each distillation in the method described above, the heavier constituents of the petroleum are subjected to a comparatively high temperature for a long period of time. This long continued heating tends to overheat or decompose a portion of the petroleum, more especially in the case of the heavier lubricating oils, to lower the viscosity, and to form tarry and unsaturated compounds which discolor and injure the product. An increased amount of chemicals is therefore required in subsequently purifying the oil and very frequently the oil is permanently discolored and the quality of the product deteriorated.

The main object of the present invention is to provide a process of fractionally distilling liquid mixtures with a minimum consumption of heat, and a minimum decomposition of the liquid undergoing distillation.

A further object of the invention is to provide a process of distilling hydrocarbon oils in which the heat of condensation of the fractions obtained is recovered and returned to the process.

A further object of the invention is to provide a process of distilling petroleum in which the heavier constituents of the petroleum may be distilled under a partial pressure without the use of steam or other medium requiring the use of additional quantities of heat.

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 is a front elevation, partly in section, of a distilling apparatus adapted to carry out the process of the invention;

Fig. 2 is a sectional elevation of a fractionating column forming a part of the distilling apparatus, taken on line 2—2 of Fig. 3;

Fig. 3 is a sectional elevation of the fractionating column, taken on line 3—3 of Fig. 2;

Fig. 4 is a perspective view showing the interior arrangement of a portion of the condensing and cooling coils in the fractionating column;

Fig. 5 is a plan view, with parts broken away, of the distilling apparatus shown in Fig. 1;

Fig. 6 is a detailed sectional view in perspective, of the oil and gas distributing element of the fractionating column; and

Fig. 7 is a detailed sectional view of a portion of the boiler or vaporizer.

In the present invention the crude petroleum to be treated is passed in a continuous stream through a series of combined heat recovery and fractionating chambers in a countercurrent direction to, and in a heat interchanging relation with hot vapors and liquids produced in a later step of the process. The chambers form a series of temperature zones in which the petroleum is heated to progressively higher temperatures and an increasing proportion of its constituents is vaporized. The vapors are immediately absorbed and carried out of the liquid by currents of inert gas which are bubbled through the liquid parallel to the direction of flow of the oil, and which serve to agitate and circulate the liquid and promote a rapid and efficient transfer of heat from the hot vapors and liquid to the fresh oil undergoing treatment.

The heated oil is finally heated to a still higher temperature and an additional quantity of oil is vaporized in a boiler or still heated directly by the combustion of fuel. During the final heating and vaporization of the oil, gas and vapors from the heat recovery and fractionating chambers are continuously bubbled through the heated oil to promote uniform heating and the additional vapors produced are absorbed by the gas and carried out of the boiler. From the boiler, the gas and vapors pass through a series of condensers placed in the fractionating chambers and are cooled to progressively lower temperatures by the inflowing stream of crude petroleum. A portion of the vapors is condensed in each condensing coil, the higher boiling fractions being condensed in the chambers receiving vapors in nearest communication with the boiler and progressively lighter fractions being condensed in each successive condenser. In passing successively through the condensers, the gas is cooled by the crude petroleum and is deprived of substantially all of the petroleum vapors, and, after being still further cooled to remove the the last traces of condensable vapors, is returned to the first fractionating chamber and mixed with fresh inflowing crude petroleum to be treated. To recover the heat remaining in the unvaporized residues remaining in the boiler and in the hot condensates formed in the condensers, the hot boiler residue passes from the boiler directly through the fractionating chambers parallel to the condensing vapors and the condensate from each condenser is also passed through succeeding cooler chambers before leaving the apparatus.

Referring to the accompanying drawings, oil to be treated is supplied to a fractionating and heat recovery column 10 (Fig. 1) by means of a feed pump 12 and enters the bottom of the column through an inlet pipe 14. The oil supplied to the column is received under an inverted perforated tray 16 (Figs. 2, 3 and 6) resting on the bottom of the column 10, and flows under a series of notches 18 on the lower edge of the tray (Fig. 6) and upwardly through a chamber 20 formed in the lower portion of the fractionating and heat recovery column. A current of gas is simultaneously forced into the inlet pipe 14 by means of a pump 22, spreads throughout the space under the tray 16 and passes upwardly into the chamber 20 through a number of perforations 24 distributed throughout the area of the tray (Fig. 6). The oil is heated in its upward passage through the chamber 20 by means of a number of heating coils therein and the rapid and uniform heating of the oil is promoted by the agitation and circulation of the oil caused by the upward passage of bubbles of gas from the openings 24. The most valatile constituents of the oil are vaporized by the heating and are immediately absorbed in the upwardly passing gas. The oil and gas reaching the upper part of the chamber 20 flow together through openings 26 (Fig. 6) in a horizontal partition 28 and are received beneath an inverted, perforated tray 30 arranged similarly to the tray 16. The oil and gas separate beneath the tray 30 and the oil flows through notches on the under edge of the tray and enters a second heat recovery and fractionating chamber 32 maintained at a temperature somewhat higher than that of the chamber 20. The gas separated beneath the tray passes through openings in the top of the tray and bubbles upwardly through the oil in chamber 32. A further portion of the constituents of the oil, having a somewhat higher boiling point than those vaporized in chamber 20, are vaporized in chamber 32 and are absorbed in the upwardly passing gases. In this manner, the oil and gas, together with the vapors evolved, pass upwardly through a series of partitions 34, 36, 38, 40, 42 and 44 dividing the column 10 into corresponding heat recovery and fractionating chambers 46, 48, 50, 52, 54 and 56. These chambers are maintained at progressively higher temperatures, and fractions of oil of progressively higher boiling points are

successively vaporized therein. The openings 26 for the passage of oil and gas in the partitions separating the chambers are positioned alternately at opposite sides of the chambers to compel the oil to pass back and forth thru the chambers and to obtain a uniform treatment of the oil. Each of the chambers 46 to 56 are also provided with gas and oil distributing trays arranged similarly to the trays 16 and 30.

In passing successively through the heat recovery and fractionating chambers, the greater portion of the oil is vaporized and from the uppermost chamber 56 the vapors, gas and unvaporized oil pass through an outlet pipe 58 to a final heating and vaporizing still or boiler 60 positioned within a furnace 62. The furnace 62 may be heated by means of fluid fuel injected through burners 64 (Figs. 1 and 5) and the products of combustion are caused to pass back and forth through the furnace around the boiler 60 by means of baffles 66 (Fig. 1), the lower part of the still being maintained at the highest temperature by direct contact with the hottest products of combustion. The mixture of oil, vapors and gas is conducted through the pipe 58 into the lower part of the boiler and passes under a baffle or distributing plate 68 positioned a short distance above the bottom of the boiler. The gas and liquid from the pipe 58 flow outwardly to the edge of the distributing plate 68 and upwardly through the boiler, the gas passing upwardly through the oil in a number of bubbles and serving to agitate and circulate the oil during heating. In the boiler 60 vapors which have a boiling point somewhat above the highest temperature reached in the fractionating column 10 are vaporized and absorbed in the mixture of gas and vapors formed in the fractionating column and pass outwardly from the still 60 through a vapor pipe 70. Other types of boilers may, however, be employed with the column, but the above type is preferred.

When vaporizing the oil in contact with a body of gas a distinct advantage is obtained in that the partial pressure under which the vaporization of the oil takes place, and accordingly the temperature of vaporization, is materially lowered. By lowering the vaporizing temperature the tendency of the heavier oils to decompose during vaporization is lessened and a lighter colored, more easily refined product is obtained. In the first steps of the evaporation, in which the most volatile oils are vaporized, a lower temperature is required and the need for a lowering of the boiling point by the presence of an inert gas is not very urgent. The vaporization of the low boiling constituents, however, increases the volume of gas originally supplied so that, as the gas and vapors reach the final vaporizing chambers 52, 54, and 56 for instance, a proportionally very large amount of gases and low boiling vapors are present and the boiling point of the high boiling constituents is lowered in the same manner as though these higher boiling constituents were evaporated in a steam still using an enormous quantity of steam. All of the vapors produced, together with the gas originally introduced into the column 10, are circulated through the remaining oil in the final still 60 so that the constituents which have the highest boiling points and which are most readily decomposed and discolored when heated are vaporized in the presence of the largest quantity of vapors and fixed gases.

The entire amount of vapors produced in the column 10 and still 60 passes through the outlet pipe 70 to a condenser 72 (Figs. 2 and 4) positioned in the uppermost fractionating chamber 56 and forming the first of a series of condensers situated in the fractionating column 10. The vapors entering the condenser 72 from the pipe 70 are received at one end of a manifold 74 which is divided into two chambers by means of a partition 76 (Figs. 2, 3 and 4). From the manifolds 74 the gas and vapors pass through a series of heat interchange tubes 78 to a second manifold 80 which is freely supported and may move back and forth as the tubes 78 expand and contract. The vapors and gas flow through the manifold 80 and return through tubes 78 to the manifold 74 on the opposite side of the dividing partition 76. The tubes 78 are cooled by contact with the oil in the chamber 56 to a temperature but slightly above that of the oil and accordingly the vapors of the heaviest hydrocarbons formed at the higher temperatures maintained in the still 60 are condensed in the coils while the condensation of the vapors produced at the lower temperature existing in the chamber 56 is avoided.

From the exit side of the manifold 74, the gas and uncondensed vapors pass through an outlet tube 82 (Fig. 4), to a liquid and gas separator 84. The condensate carried by the gas and vapor settles to the lower part of the separator and the gas and uncondensed vapor flows from the upper part of the separator through a down-take pipe 86 to a second condenser 88 positioned within the chamber 54. The condenser 88 is similar in construction to the condenser 72 and is maintained by contact with the oil and gas in the chamber 54 at a temperature lower than that of the chamber 56 but slightly higher than that of the oil in chamber 54.

In the condenser 88 those vapors which condense at a temperature above that maintained in the chamber 54 are condensed and pass to a liquid and gas separator 90 in which the condensate is separated from the uncondensed vapors. In this manner, the vapors pass in succession through a series of condensers 92, 94, 96, 98, 100 and 102 placed

respectively in the chambers 52, 50, 48, 46, 32 and 20 and maintained at a temperature very nearly that of the corresponding chambers. The condensates produced in each of the condensers 92 to 102 are separated from the uncondensed vapors and gas in a corresponding series of liquid and gas separators 104, 106, 108, 110, 112, and 114 (Figs. 1 and 2), inserted in vapor pipes connecting the condensers. When the residual gas has passed through the final condenser 102 it will have been cooled to very nearly the temperature of the crude oil entering through the pipe 14, but will still contain some of the lightest vapors vaporized in the chamber 20. To remove these lighter vapors, the gas from the final liquid and gas separator 114 is conveyed through an outlet pipe 116 and conducted to a water cooled condenser 118 (Fig. 1). In the condenser 118 the lightest vapors which it is practicable to condense are condensed and are separated from the gas in a liquid and gas separator 120. The cooled gas is withdrawn from the separator 120 through a pipe 122 and conducted to the pump 22 by which it is forced through a pipe 124 to the inlet pipe 14.

As the gas and vapors pass successively through the condensers 72 to 102, their volume is continually decreased by the condensation of the heavier vapors, with the result that when the lightest, most volatile and most difficultly condensable vapors are to be condensed the partial pressures of those vapors will have been increased by the previous condensation of the heavier vapors. The condensing temperature of the lighter vapors is correspondingly raised and condensation is correspondingly promoted. The net result of the process is: that the boiling point of the heaviest, most easily decomposed vapors, is lowered by the presence of a large volume of practically inert gases and vapors and that when the lightest, most volatile vapors are to be condensed the volume of the vapors is reduced and the temperature of condensation is brought back to normal. By the present invention, therefore, the advantage, obtained in steam distillation by lowering the boiling point of the oil through the use of a large quantity of steam, is secured without the necessity of using the extra amount of heat required to vaporize the steam and the subsequent loss of this heat when the steam is condensed.

In the present process, moreover, the heat of condensation of the condensing vapors which in the ordinary processes is given to the condenser cooling water and lost, is recovered and used to vaporize additional quantities of oil. The residual liquor and the condensates from the higher boiling fractions also contain a considerable amount of heat which may be used to heat the incoming liquid and to vaporize the lower boiling constituents of the crude petroleum. To utilize this heat of the liquid, the hot oil from the upper part of the still 60 is withdrawn through an outlet pipe 126, passes through a liquid and vapor trap 128 and enters a pipe 130 which passes in the form of a coil successively through the chambers 56 to 20 (Fig. 4). The arrangement of the coils 130 in the various chambers is shown most clearly in Fig. 4 which shows a perspective view of the piping and condenser arrangements in the successive chambers of the column 10, the path of the crude oil and gases around the coils being indicated by the arrows. The hot oil residue imparts its sensible heat to the upwardly passing crude oil and is itself cooled, as it leaves the final chamber 20, to a temperature but slightly above that of the inflowing oil. In a similar manner the condensate from the highest temperature condenser 72 is separated from the gas and uncondensed vapors in the liquid and gas separator 84, is removed through an outlet pipe 132, passes thru a liquid and vapor trap 134 and enters a second series of coils 136 extending successively through the chambers 54 to 20. In a similar manner condensates separated in the liquid and gas separators 90 to 112 are removed through liquid and gas traps 138, 140, 142, 144, 146 and 148 (Figs. 1, 2 and 4) and pass respectively through cooling coils 150, 152, 154, 156, 158 and 159 (Fig. 2) extending through the lower chambers of the column 10 being progressively cooled by an interchange of heat with incoming crude petroleum and gas. The condensate from the final liquid and gas separator 114 is at a temperature but slightly above that of the lowermost chamber 20 and is taken directly through a trap 160. The light condensate from the final condenser 118 and separator 120 is also removed through a trap 162 (Fig. 1).

Owing to the necessity of cooling the entire volume of vapors produced in the process of the upper chambers, the upper condensers are provided with a larger number of heat interchange tubes, the number gradually decreasing in each condensing chamber to a minimum in the final condenser 102. The amount of condensate obtained in each condenser may, however, be approximately the same. As the quantity of gases and vapors decreases, the extent of condenser surface is decreased to correspond. The total heating surface in each of the chambers 54 to 20 is, however, kept approximately constant, by the gradual increase in the number of condensate cooling coils in successive chambers and a substantially constant balance between the heat given up by the condensing and cooling coils, and the heat absorbed in heating the oil undergoing treatment is accordingly maintained. The total amount of heat transferring surface may be made much larger

than that obtained in the ordinary cylindrical still. By increasing the heating surface in this manner, the quantity of heat imparted to the oil undergoing treatment for a given temperature differential or temperature gradient, between the heating fluid and the oil undergoing treatment can be greatly increased, or the temperature difference required to give the desired heating effect may be decreased and thus co-operate with the agitating effect of the upwardly passing bubbles of gas to maintain a substantially constant temperature throughout each heat interchange chamber. The uniform heating of the oil is further promoted by the distribution of the heat transferring surface throughout the body of oil in place of the local heating obtained in cylindrical and similar types of stills. Moreover, the maximum temperature in any heat interchange chamber is limited by the temperature of condensation of the corresponding heating vapors, thereby preventing any accidental overheating of the oil undergoing treatment. The quantity of oil contained in the condenser chambers at any one time may also be made very small in proportion to the heating surface by a suitable proportioning and arrangement of the heating tubes and accordingly the oil may be passed through the apparatus in a comparatively rapid stream and correspondingly short time. This also tends to reduce the decomposition and discolorization of the products obtained and to produce an oil of high viscosity, since the oil is subjected to the decomposing condition for a very short period of time.

The condensers 72 to 102 are so positioned in the fractionating and heat recovery chambers 56 to 20 that they may be removed through openings in the side of the chambers and access may thereupon be had to the interior of the chambers for the purpose of cleaning and removing sediment. To this end, the inlet manifold, 74 of the condenser 72 for instance, is fastened to the side of the chamber 56 by means of bolts or other fastening means, and the heating tubes 78 of the condenser extend through an opening in the chamber wall and support the movable manifold 80. When the apparatus is to be cleaned, each condenser is disconnected from its corresponding liquid and vapor separator and from its neighboring condensers, the connection of the stationary manifolds to the chamber wall is removed and the entire condenser is withdrawn from the chamber. The distributing trays may thereupon be removed from the chamber, leaving only the liquid and condensate cooling coils and the perforated partitions in the column 10, access to which may be had through the opening in the chamber walls normally closed by the stationary manifolds of the respective condensers. Doors 163 are also provided through which the distributing trays may be removed for cleaning and repairs and to give access to the liquid cooling coils without disturbing the condensers.

A continued circulation and renewal of the oil below the plate 68 in the boiler 60 is obtained by means of a series of short tubes 164 (Fig. 7) extending downwardly through the plate 68. As fresh oil and gases pass from the tube 58 under the plate 68, they carry an additional amount of oil upwardly around the edge of the plate and draw a current of oil from above the plate through the short tubes 164 to the space below the plate. Any sediment which separates out in the boiler 60 is thereby carried to the bottom and may be removed through a draw-off pipe 166.

The operation of the process is briefly as follows: Crude oil to be treated is supplied by means of a pump 12 and inlet pipe 14 to the bottom of the still 10 and passes continuously through the series of heating chambers 20 to 56 which form a series of zones of progressively higher temperature. A current of gas is also introduced into the chamber 20 of the column and is distributed throughout the oil in each chamber by means of the inverted, perforated trays 16, the trays being so arranged that the oil flows through the serrations on the lower edge of the tray, while the gas passes upwardly through perforations in the horizontal surface of the tray. From the uppermost heat interchange chamber 56, the vapors, gas and unvaporized oil pass through the pipe 58 to the bottom of the externally heated still 60 and upwardly around the edge of the distributing plate 68. Gas and vapors from the still 60 pass in succession through the condensers 72 to 102 in the chambers 56 to 20 respectively, a portion of the vapors being condensed in each condenser and removed through the liquid and gas separators 82 to 114 and traps 134 to 160. The hot residue from the still 60 passes through a return pipe 126 (Fig. 5) and trap 128 to a coiled pipe 130 passing downwardly in succession through the condenser chambers 56 to 20. In the same manner the condensates from each of the condensers 72 to 100 pass in separate pipes through each of the chambers below them. The gas and uncondensed vapors from the final condenser 102 are removed to the water cooled condenser 118 in which the lightest vapors produced are condensed and the gas is returned to the column 10 through a return pipe 124.

Under the conditions normally obtained in the oil refining, natural gas, or tail gases or vapors from prior distillations, will be most convenient for use in the above process. Any inert gas or vapor which does not injuriously affect the products, such as carbon dioxide, nitrogen or steam, or, in case a simul-

taneous purifying and distillation of the oil is desired, sulphur dioxide may be used as the circulating gas.

With certain types of oil especially those containing a high percentage of volatile constituents, the volume of gas may be greatly reduced, or dispensed with entirely, the lighter vapors serving to sufficiently decrease the partial pressure and the boiling temperature of the higher fractions in the upper chambers of the still. In certain cases, moreover, and especially when steam is being used, it may be preferable to introduce the circulating gas at a point above the lower chamber, for instance into chambers 48 or 50, inasmuch as the lowering of the boiling point is desirable only in the distillation of the higher boiling constituents of the oil.

The number of fractionating and heat recovery chambers may be varied to vary the number of fractions which may be obtained upon a single distillation. When a large number of fractionating chambers are used, a correspondingly large number of fractions of comparatively narrow boiling point limits will be obtained. In this case several fractions may be combined to form any desired commercial product. Thus, the fractions from the chambers 20, 32 and 46 may be combined to form gasoline, while the fractions obtained in the upper chambers 48 to 56 may be variously combined to produce commercial grades of kerosene, lubricating stocks, and other products. It may be necessary in some cases to distill certain fractions to remove hydrocarbons which would be objectionable for a particular product, but when the apparatus is arranged to obtain a large number of fractions, those fractions whose boiling point limits lie well within the outer limits of the desired products may be used without further distillation, while those having boiling point limits lying near those of the desired product may require redistillation. The apparatus permits of great ease and flexibility of control for different types of oil in which the boiling point characteristics obtained in any condenser may vary with the character of the oil, since in any case the fraction may be put into that commercial product for which it is most suitable. The apparatus is especially suitable for the treatment of oils containing water, since there is no opportunity for condensing water to flow back into the still or boiler and cause foaming or "puking".

While the process has been described as applied to the refining of petroleum, it is obvious that it may be applied to the redistillation of certain mineral oil fractions or to the distillation of similar hydrocarbon oils, or similar mixtures of liquids of different boiling points. In the following claims, therefore, the term "hydrocarbon oil" is intended to cover any mixture of liquids capable of being separated into its constituents by fractional distillation.

Having described the preferred form of the invention, what is claimed as new is:

1. The process of refining hydrocarbon oils which comprises passing oil upwardly through a series of zones of increasing temperatures, passing gas upwardly through said oil, further heating the oil and gas passing from the uppermost of said heating zones, passing unvaporized liquid from said final heating downwardly through said zones, passing the gas and vapors from said final heating downwardly through said heat zones, condensing a portion of the vapors in each of said heat zones and separately passing the condensates down through the cooler zones.

2. The process of refining hydrocarbon oils which comprises passing a mixture of oil and gas upwardly through zones maintained at increasing temperatures, vaporizing a portion of the oil in each zone and absorbing the vapors evolved in said gas, passing the residual liquid from the final heating countercurrent to, and in a heat interchanging relation with, the liquid passing through said heating zones, conducting vapors and gas from the hotter to cooler zones, condensing a portion of said vapors in each zone, and passing said condensates separately through successively cooler zones.

3. The process of refining hydrocarbon oils which comprises passing a mixture of oil and gas upwardly through zones maintained at increasing temperatures, vaporizing a portion of the liquid in each zone and absorbing the vapors evolved in said gas, passing the residual oil from the final heating countercurrent to, and in a heat interchanging relation with, the liquid passing through said heating zones, separately passing vapors and gas from hotter to cooler zones, condensing a portion of said vapors in said zones, passing said condensates separately through successively cooler zones, cooling said gas from said coolest zone, and returning said gas to said zone.

4. In the process of refining hydrocarbon oil which comprises passing oil upwardly through a series of zones of increasing temperature, passing gas upwardly through said oil, heating the oil and the gas flowing from the uppermost of said heating zones, passing the gas and vapors from said final heating downwardly through said heat zones, condensing a portion of the vapors in each of said zones and separately passing the condensates through the lower of said zones.

In testimony whereof I affix my signature.

DAVID G. BRANDT.