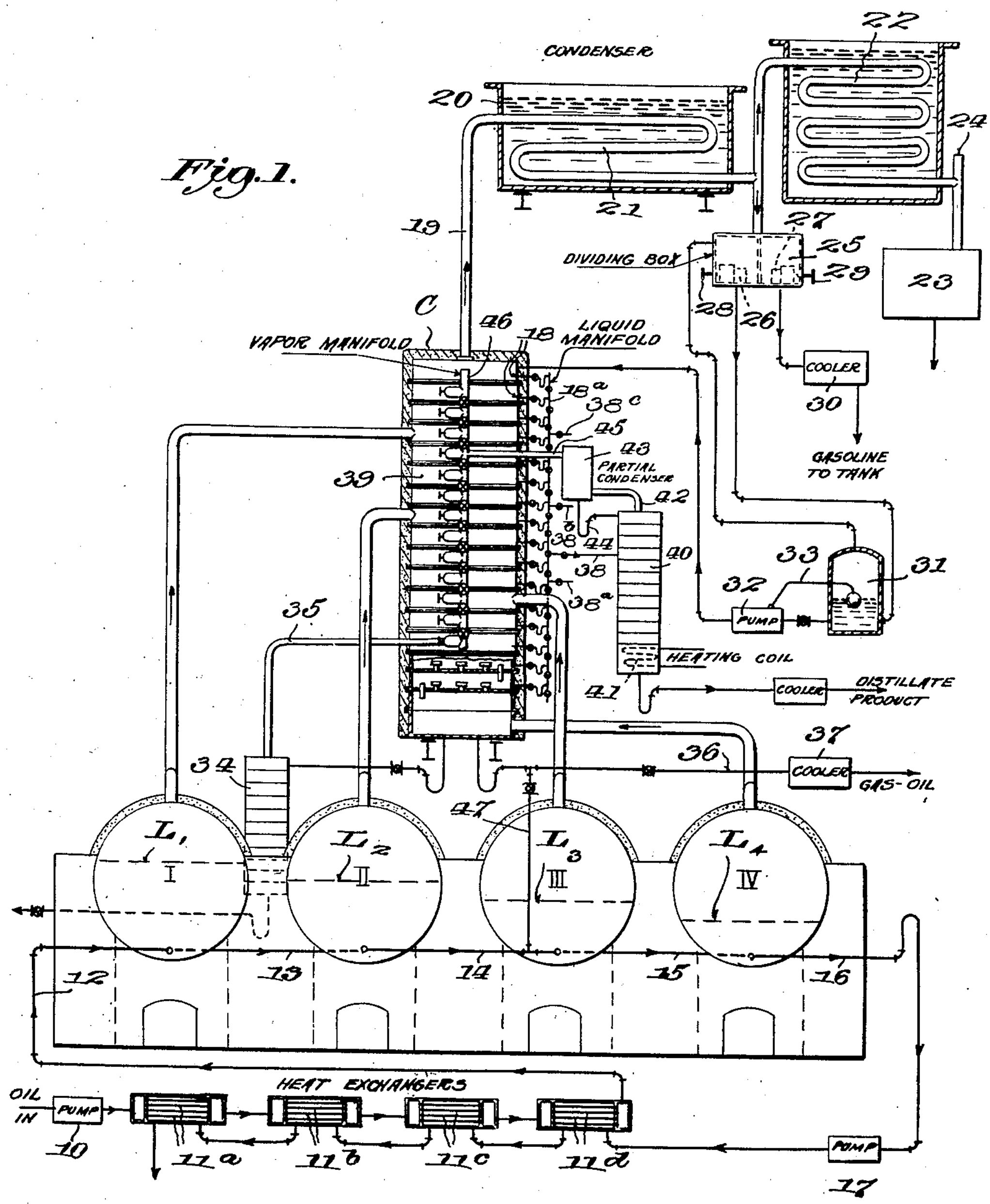
July 19, 1932. E. H. LESLIE ET AL 1,868,466

DISTILLING PROCESS AND APPARATUS

Filed June 29, 1925 3 Sheets-Sheet 1

Fig. 1.



Inventors
Eugene H. Leslie,
Edwin M. Baker,
By [signature] their Attorneys

July 19, 1932. E. H. LESLIE ET AL 1,868,466

DISTILLING PROCESS AND APPARATUS

Filed June 29, 1925 3 Sheets-Sheet 2

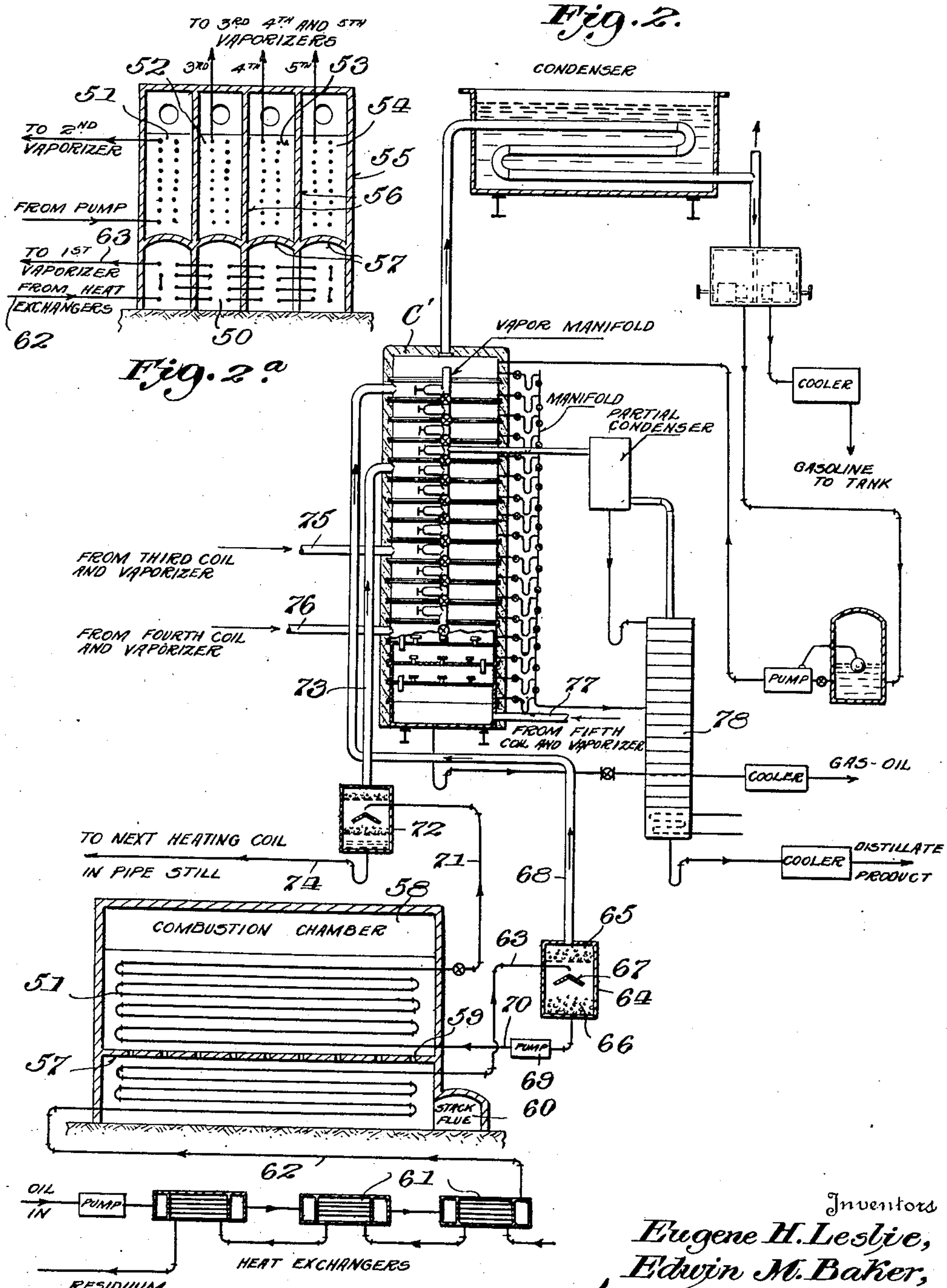


Fig. 2a

Fig. 2.

Inventors
Eugene H. Leslie,
Edwin M. Baker,

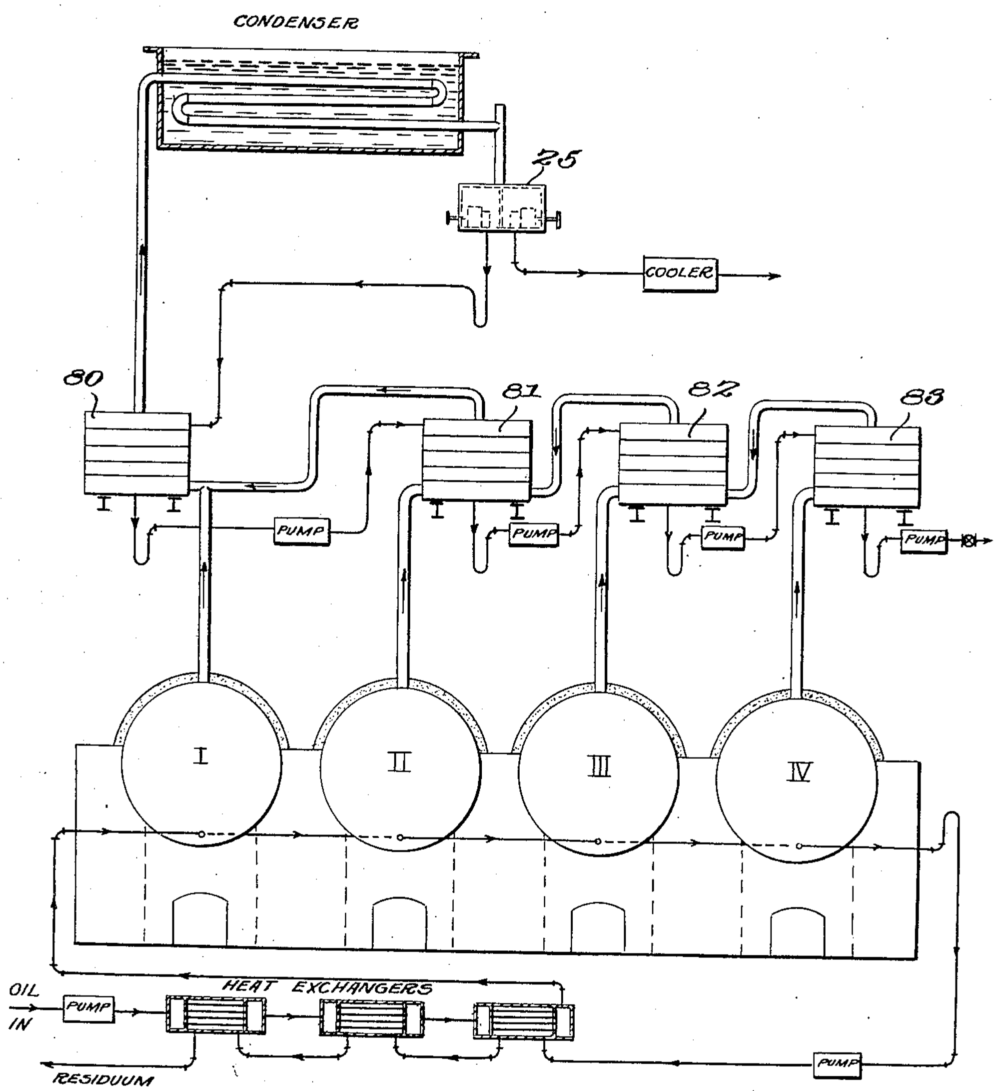
By Stewart & McKay
their Attorneys

July 19, 1932. E. H. LESLIE ET AL 1,868,466

DISTILLING PROCESS AND APPARATUS

Filed June 29, 1925 3 Sheets-Sheet 3

Fig. 3



Inventors
Eugene H. Leslie,
Edwin M. Baker,

By Steward McKay
their Attorneys

Patented July 19, 1932 1,868,466

UNITED STATES PATENT OFFICE

EUGENE H. LESLIE AND EDWIN M. BAKER, OF ANN ARBOR, MICHIGAN

DISTILLING PROCESS AND APPARATUS

Application filed June 29, 1925. Serial No. 40,421.

This invention relates to distilling processes and apparatus; and it relates more particularly to processes of and apparatus for distilling petroleum to produce therefrom one or more distillates of closely controlled composition, together with a residuum substantially free of components properly characterizing the distillate or distillates sought.

A principal object of the invention is to provide a simple, effective, and economical method for the continuous distillation of petroleum or other liquid of mixed composition for production of distillates of the character above mentioned. A further object of the invention is to provide apparatus whereby the foregoing object may be achieved while at the same time utilizing to a large extent previously installed refinery equipment, such as batteries of stills, by associating with such equipment suitable fractionating apparatus, thus providing a complete apparatus system appropriate for practicing the invention at the lowest cost consistent with the accomplishment of the desired result.

While the invention is not restricted to the field of petroleum distillation, its greatest present utility is in that field. Accordingly, in explaining the underlying principles of the invention hereinafter, reference will be made more particularly to petroleum distillation by way of a concrete illustrative example.

In the continuous distillation of petroleum as heretofore practiced, the operating equipment is usually composed of a continuous still battery, the stills of which may or may not be fitted with towers, dephlegmators, or in general, fractionating condensers. Assuming the use of some form of fractionating condensers with the stills, the conventional mode of operation has been as follows:

The incoming oil is first passed through heat exchangers and then flowed through the stills in series which are suitably heated to effect continuous stage-wise distillation of the oil passing serially through the stills of the battery. The distillation vapors, which are successively heavier from the first to the last still of the battery, pass from each still into its associated fractionating condenser wherein a relatively heavy portion of the vapor condenses, the condensate flowing back to the still. Vapors from the tops of the fractionating condensers pass to water-cooled condensers, and the resultant condensates are cooled separately. The distillate from the first still of the battery (assuming crude petroleum to be the oil to be distilled) is found upon test to be almost wholly within the gasoline boiling range as fixed by standard Navy specifications, for example. For instance, if the crude oil contains 30 per cent of gasoline, the distillate from the first still comprises commonly from 5 to 15 per cent of the crude oil, depending upon the particular mode of operating the still battery. The distillate from the second still tests perhaps 90 per cent of gasoline boiling range, the other 10 per cent probably boiling somewhat above 437° F. However, this high boiling portion can be mixed into the gasoline when the light distillate from the first still is mixed with the distillate from the second still. The distillate from the second still may be say 10 to 15 per cent of the total volume of crude flowing to the battery.

Usually only about one-half to three-fourths of the distillate from the third still will be found to be of gasoline boiling range, and this constitutes what is known as "benzine" in refinery parlance. The distillate from this third still may in some cases be as much as 15 to 20 per cent of the crude oil, especially where the distillates from the first and second stills were minimum percentages. In order to secure the gasoline content of this distillate from the third still, it is customary to re-run the benzine in so-called "re-run stills", which stills are fire-and-steam stills, usually fitted with some form of dephlegmator to permit more effective separation. The distillate from these re-run stills is of gasoline boiling range and is mixed into the gasoline product. The bottoms or unvaporized portion is a light kerosene.

Assuming the battery to consist of four stills, the distillate from the fourth or last still comprises the gas oil, and in some plants includes also what is the heavy end of the kerosene. Where heavy kerosenes are to be made, this fourth distillate may be re-run to recover such heavy kerosene. More usually, however, the still battery comprises, say, about six stills, the kerosene being taken off from the fourth and possibly the fifth stills, while the gas oil is removed in the fifth and sixth, or in the sixth alone, as occasion may require.

The prior practice above outlined is open to numerous serious objections from the standpoint of the practical refiner. In the first place, it is impossible by this procedure to obtain from a given crude oil the maximum amount of distillate that will pass the standard specifications for gasoline boiling range. Furthermore, the necessity of employing re-run stills greatly increases the first cost of the installation and its subsequent upkeep, not to mention the large ground space occupied by said re-run stills. The system as a whole is also thermally inefficient and uneconomical in operation. These and other objections are overcome by the process of the present invention and certain additional advantages are also attained, as will appear more fully from the description hereinafter.

In contrast to prior methods of continuously distilling petroleum in accordance with the general procedure above outlined, the process of the present invention involves sharp fractionation of the distillation vapor coming from each of the stills of a battery, in such manner that everything that can be included in the gasoline under standard specifications leaves the distilling system and is obtained in the gasoline condensate, while everything that should not be included as gasoline leaves the system either in the form of residuum, or of gas-oil, kerosene, or the like, which may be withdrawn at one or more intermediate points in the system. Stated generally, this result is achieved by conducting the distillation vapors from all of the distilling units of the battery into a rectifying system which is essentially unitary in character in the sense that the liquid therein with which the distillation vapors countercurrently contact is provided solely by refluxing into the rectifying system condensate from the rectified vapors that leave said system. Ordinarily said rectifying system takes the form of a single column fractionator, using the term "fractionator" in the correct technical sense by which it is sharply distinguished from apparatus of the fractionating condenser type. While a structurally unitary or single rectifying column or fractionator is generally the most convenient form of unitary rectifying system to employ in the practice of the present invention, this is not a rigid requirement within the broad scope of the inventive idea here involved so long as the conditions of operation here emphasized are observed, namely, that the only counter-flowing liquid introduced as such into the aforesaid rectifying system shall be refluxed condensate from rectified vapors leaving the system.

Certain very important practical advantages result from the novel procedure characterizing the invention. In the first place, the necessity for re-run stills is entirely eliminated, while in place of such equipment it is only necessary to install a rectifying column of which the cost is relatively very small as compared to that of a battery of re-run stills and which occupies only a fraction of the ground space required by such a battery. Furthermore, as will be more fully hereinafter pointed out, the yield of salable gasoline is substantially increased and a material economy of heat units is effected, not to mention other advantages that will appear as the description proceeds.

The underlying principles of the invention can be further explained to best advantage in connection with a detailed description of a typical practical embodiment thereof that has been found to give good results in practice. In this description, reference will be made to the accompanying drawings which illustrate more or less diagrammatically typical apparatus installations useful in carrying out the process. Referring to these drawings,

Fig. 1 is a diagrammatic view in elevation of a typical plant embodying the principles of the invention, wherein a single rectifying column or fractionator is associated with a battery of four stills of the ordinary pot type;

Fig. 2 is a similar view of a plant in which a battery of pipe stills is used in place of the pot stills of Fig. 1;

Fig. 2*a* is a cross sectional view of one of the pipe stills; and

Fig. 3 is a similar view of another plant also embodying the broad principles of the invention in which, however, the rectifying system differs structurally from that illustrated in Figs. 1 and 2.

Referring first more particularly to Fig. 1 of the drawings, the crude petroleum or other oil to be distilled is pumped by the pump 10 through heat exchangers 11^a, 11^b, 11^c, 11^d, in which exchangers the heat from the hot residuum leaving the system is transferred in part to be incoming crude. From the last heat exchanger, the oil flows by pipe 12 to the first of a series or battery of stills Nos. I, II, III, IV. From still No. I, the oil passes by pipe 13 into still No. II, thence by pipe 14 into still No. III, thence by pipe 15 into still No. IV. From still No. IV, the hot outflowing residuum exits through pipe 16 and is forced by pump 17 through the heat exchangers before mentioned, countercurrently to the incoming crude petroleum as already described.

Stills Nos. I, II, III, IV are of any suitable type or form and are set in any conventional or suitable way. In the present instance, said stills are horizontal, cylindrical stills of the pot type, supported in brick work in the usual manner with their upper exposed portions covered by heavy insulating lagging. The stills and the interconnecting piping are so arranged that the oil flows into one end of still No. I and out of the opposite end into still No. II, then out of the opposite end of still No. II to still No. III and so on. The interconnecting piping between the stills should be of sufficient size to permit easy flow of oil from one still to the next without undue back pressure. When normal running conditions have been established, the oil in the respective stills of the battery stands at successively lower levels, as indicated at L_1, L_2, L_3, L_4, due to corresponding differences in back pressure from the rectifying system to be described presently. Of course, if the stills themselves are set at successively lower levels, the depth of oil in each still may be the same. In any case, the oil level in any given still should always be such that the heating surface of the still is completely covered with oil in order that local overheating may not occur at points where the still bottom is exposed to the direct fire beneath the still.

The vapors from each still are introduced into a suitable rectifying or fractionating system at suitable points. In the installation illustrated in Fig. 1, this rectifying or fractionating system consists of a single fractionating column, indicated generally at C, having an appropriate number of bubbler-cap sections which may be of any usual or suitable design. It is not essential that the rectifying column be of the bubbler-cap type, the essential point being that the apparatus be of such character as to afford full opportunity for countercurrently contacting upwardly flowing vapors with downwardly flowing liquid under conditions ensuring an approximation to equilibrium conditions at all points in the rectifying system. Such conditions can be realized in certain other forms of columns, such as packed columns, for example. In general, the distillation vapors from the several stills of the battery should be introduced into the fractionating column at such respective points that the vapors introduced at any one of said points will be, as nearly as is practically possible, in equilibrium with the vapor and liquid within the column at that point when the entire battery of stills and the column are functioning smoothly and properly in the regular course of operation.

In the present instance, it will be seen that the vapor from still No. I is almost all gasoline, although of necessity it contains a small proportion (the equilibrium proportion) of the higher boiling components of the petroleum from which the vapor was evolved. Consequently, this vapor is introduced into the column near the top but such a sufficient number of sections below the top that the small proportion of heavy oil molecules contained in this vapor will be removed by the process of countercurrent contacting within the fractionating column.

The vapor from still No. IV is the least rich in volatile constituents and is therefore introduced into the bottom section of the fractionating column C. The vapors from stills Nos. II and III are introduced at appropriate points in the column intermediate the points at which the vapors from stills Nos. I and IV are introduced. As before stated, the general principle governing the selection of the point for introducing the vapors from any of the stills into the column is that the point selected should be such that the introduced vapors will be substantially in equilibrium with the vapor and liquid within the column at that point when the entire battery of stills and the column are functioning smoothly and properly in the regular course of operation. In any given case it will be necessary to take several factors into account and to follow the general rule that the vapors should enter the column at the point where they will be most nearly in equilibrium when the column is functioning properly.

In the present example the fractionating column consists of sixteen bubbler-cap sections, but the number of sections may of course be varied depending upon the various factors of operation to be taken into account. Each section is provided with a draw-off pipe 18 for liquid, which draw-off pipe is provided with a valve and trap, as indicated. These draw-off pipes enter a header 18^a. Vapor from the top of the column is led by vapor pipe 19 to condenser 20 which may be of any desired form. In the present instance the condenser consists of a worm 21 arranged within a tank filled with cooling water, and it may be arranged to condense all the gasoline vapors passing into it from the fractionating column. As will be pointed out hereinafter, however, it is sometimes an advantage to operate this condenser in such manner that the lighter portions of the gasoline vapors escape condensation therein, and when this procedure is followed, such lighter vapors pass on into a second condenser 22, yielding a light condensate which is collected in cooler 23, so-called fixed gases or normally uncondensable vapors being vented from the system at 24. The condensate produced in condenser 20 passes from the condenser into a dividing box 25. It will be seen that the liquid enters the box at one end and thence flows through two weirs 26—27, the horizontal opening of these weirs being adjustable by manual controls 28—29, as indicated, so that the proportion of the distillate flowing through the respective weirs may be adjusted to any desired proportion. The discharge through weir 27 passes through a cooler 30 and thence to any suitable receiving tank or other place of storage (not shown). The discharge through the other weir (26) is directed back to the top of the fractionating column and constitutes the reflux to the column. This flow may be by gravity or, as in the case here illustrated, the discharge of weir 26 goes to a receiving tank 31 and is pumped therefrom by pump 32 into the top section of the column, as indicated. In the installation here shown, the feed of liquid from receiving tank 31 into the top of the fractionating column is automatically controlled by the level of the liquid in the receiving tank by float-controlled means indicated diagrammatically at 33 and arranged to govern the actuating mechanism of the pump 32, the arrangement being such that the pump automatically delivers reflux to the top of the fractionating column at the same rate that the reflux liquid runs into the receiving tank to which the suction side of the pump is connected.

The liquid condensates received in coolers 23 and 30, respectively, are usually mixed together and constitute the gasoline product of the plant.

It will be seen that in the specific procedure just described, the reflux liquid returned to the top of the fractionating column is not rich in very light gasoline vapors, these latter largely escaping condensation in condenser 20 and therefore not yielding any liquid product entering dividing box 25 from which reflux is supplied to the column. In some cases it is advantageous thus to avoid returning very light gasoline fractions to the top of the column, and while the process of the invention does not necessarily involve this specific procedure, it forms a desirable feature of the invention in its more specific aspects and has been found to work well in practice.

At 34 is indicated a small exhausting column into which liquid from the bottom of the main fractionating column C may be run. The use of this exhausting column is optional and is dependent upon the nature of the product that it is desired to obtain from the bottom of the column. Ordinarily, the apparatus may be so run that the liquid from the bottom of the column contains a negligible proportion of gasoline, say less than one to three percent. If it were desired to produce from the bottom of the column a liquid product containing no gasoline and possibly not even a lighter part of what is normally kerosene, this could be done by using the exhausting column referred to. Heat must be supplied in the form of vapor to the bottom of the exhausting column and this is done by means of a small auxiliary heater (not shown). In the present example the liquid from the bottom of the main fractionating column C is shown entering the top section of the exhausting column 34, while the vapors from the exhausting column leave through vapor off-take 35. The exhausting column is particularly useful in any case where it may be desired for any reason to run the rest of the battery in such manner that the liquid leaving the bottom of the main column contains a substantial percentage of gasoline or of other distillate below the particular cut point.

Where the exhausting column 34 is not employed, or at least operates on less than all of the liquid leaving the bottom of the column C, liquid leaves the bottom of said column C through pipe 36 which delivers it to cooler 37. In the present example this liquid may be assumed to be a gas-oil fraction. If the kerosene can not be included either in the gasoline or in the gas-oil fraction, it must be withdrawn at some intermediate point along the column. In the present instance, the kerosene fraction is withdrawn through pipe 38 and header 18^a from that section of the column C indicated at 39. This kerosene fraction is delivered into an exhausting column 40 which contains a heating coil 41 in its base. The vapors leave the column 40 through pipe 42 and pass into condenser 43 where condensate is formed and refluxes through pipe 44 back to the top of the exhausting column 40; while the uncondensed vapors are delivered through pipe 45 to vapor-manifold 46 from which they can be directed into any desired section of the fractionating column C. In this way, liquids of various compositions can be removed from the column C through suitably located draw-off lines 38, 38^a, 38^b, 38^c, and any one of the liquids so removed may be treated in an exhausting column as desired. That is, if it be found that from no section of the column can a liquid of exactly the desired composition be withdrawn directly, this procedure can be adapted to obtain a liquid of the composition desired. A liquid can be withdrawn from some one section of the column C that is of such composition that its higher boiling portion is satisfactory. The volatile end of this liquid can then be removed in an exhausting column and the vapor so formed returned to the column C at the point where it is most nearly in equilibrium when the column is operating normally.

If desired, that portion of the auxiliary exhausting column 40 above the feed section into which liquid is delivered through pipe 38 may be omitted. The sections above this feed section perform a rectifying function, and in some instances would be unnecessary because it would be immaterial whether a portion of the heavier components in the liquid fed in through pipe 38 was or not vaporized and returned to the main column C. If the upper sections of column 40 were omitted as suggested, it would mean that the liquid fed to the top of the exhausting column through pipe 38 would function as the reflux, the arrangement in this case being similar to that shown for the other exhausting column 34. Under such circumstances it would in most instances be desired to remove perhaps not more than ten per cent by volume of the liquid fed to the top of column 40. Consequently the reflux ratio would be 8 or 9 to 1, which would be ample for all requirements.

Reference has been made hereinabove to removal of intermediate products as liquids. They may, however, be removed as vapors; and to this end the rectifying or fractionating system may be provided with offtake means whereby vapor may be withdrawn from any desired section or locality. In order to avoid complicating the drawings, such means are not illustrated here but are of sufficiently well understood character not to require special explanation. The choice as to whether a given desired product should be removed as a liquid or as a vapor depends upon whether it is desired to have such product free from volatile components or free from heavy components and of particularly good color. In the first case, it should be removed as a liquid; in the second, as a vapor.

It is also feasible and desirable under some conditions to employ an auxiliary column into which vapor is introduced from the main column, but to which auxiliary column no heat is supplied in addition to that contained in the vapor itself. In such an arrangement, the auxiliary column should be provided with a reflux condenser and a certain amount of liquid should be refluxed to the top of said column, a vapor product leaving the upper part of the column and being condensed and collected. The liquid from the base of this auxiliary column, which liquid may desirably be thermally equivalent to the liquid refluxed to the top of said column, may either be returned into the main column at an appropriate point or may be collected separately as a product.

In starting the battery into operation, it may be found desirable in some cases to return the liquid from the bottom of the column C to still No. III for a time. This is because normal and regular operation of the system will not be attained immediately upon starting up, and consequently gasoline in more than the normal small amount will be found for a time in the liquid exiting from the bottom of column C. A valved return line 47, branching from line 36 and entering line 14, is therefore provided for permitting temporary return of liquid from the bottom of column C to still No. III. It is preferable to return this liquid to still No. III rather than to still No. IV because re-vaporization and recovery of all of the gasoline content of the returned liquid is thereby rendered more certain.

It is to be especially noted that the distillation vapor from each still of the battery is sharply fractionated in operating in accordance with the process of the invention. This is true even of the vapor from still No. I. The vapor from this still contains only a small amount of high-boiling hydrocarbons; and although it would be possible to include these hydrocarbons in the gasoline without making a product having an end-point above 437° F., it is undesirable to do this because, just to the extent that these higher boiling hydrocarbons are included in the gasoline, the average boiling point of the gasoline is raised, particularly in the later stages of the distillation test to which the gasoline is subjected under standard specifications. According to the present process, the greater part of the undesirably heavy hydrocarbons that formerly could be kept out of the gasoline fraction only by special means such as redistillation, can be easily excluded; while much of the gasoline formerly going into the gas-oil fraction is recovered.

In one way of operating the illustrated still battery in practicing the present process, the vapor from still No. II may correspond very closely to the "benzine" fraction above referred to as obtained in prior practice. In the present process, these benzine vapors are introduced into the column, as shown, several sections below the point at which the vapors from still No. I are introduced; and by the action of the column, this benzine vapor is fractionated in such manner that only the gasoline portion exits from the column as a vapor, while the non-gasoline portion passes down the column as a liquid. The vapor from still No. III, although it contains no light gasoline, contains a moderate proportion of hydrocarbons that boil below 437° F. This is also true of the vapor from still No. IV, although to a less degree. Both of these vapors are introduced into the fractionating column at the respectively lower points indicated and are similarly fractionated so that only such portion thereof as can properly be included in the gasoline exits from the top of the fractionating column. As a result of proceeding in the manner above described, re-running is completely eliminated; and in a plant where re-run stills form a part of the original equipment, the re-run stills may therefore be entirely dispensed with or used for some other purpose. A further advantage of the novel process, already mentioned above, is the increased yield of marketable gasoline. In actual practice it has been found that employment of the novel process in distilling a given crude, for example, results in an increased yield of gasoline amounting to from 15 to 30 per cent of the yield obtained from the same crude distilled by the described method of the prior art. Furthermore, the new process is characterized by materially reduced fuel consumption. In prior practice, where the liquids condensed in fractionating condensers are returned to the respective stills for re-vaporization, this constant re-vaporization with the absorption of sensible and latent heats materially increases the fuel consumption. This fuel consumption can be cut as much as 25 per cent or more by distillation in accordance with the present invention as above described. In addition to the advantages already mentioned, there are others possessed by the invention that are of material importance. For example, the color of the gasoline product obtained is improved over that obtained in prior practice, and consequently less acid is required in refining. Again, the easier control and more flexible operation of the battery as a whole is marked, and consequently the operating costs for labor and supervision are reduced. All these advantages attainable by the present invention result in increased revenues and reduced expenses amounting to many thousands of dollars monthly in a plant of substantial size running several thousand barrels of oil daily as such plants quite commonly do.

The plant illustrated in Figs. 2 and 2*a* is generally similar in mode of operation to that illustrated in Fig. 1 and may be used with equal and in some cases greater advantage in practicing the novel process. The principal difference is in the employment of pipe stills as primary vaporizers instead of horizontal cylindrical stills. In the present instance the primary vaporizing portion of the system consists of a battery of pipe stills which may, for example, comprise five pipe coil units, 50, 51, 52, 53 and 54, serially related and all housed within a suitable furnace structure indicated generally at 55, the interior of the furnace structure being divided vertically into four sections by partition walls 56 and horizontally by apertured partition walls 57. Each section defined by the vertical furnace walls has a combustion chamber 58 at the top, from which flame and hot combustion gases pass downwardly around one of the pipe coils 51, 52, 53, 54, and thence through apertures 59 in the wall 57 and around pipe coil 50, the gases finally passing to a suitable stack through flue 60.

The crude oil enters the system through a system of heat exchangers indicated generally at 61 and similar to that described in connection with Fig. 1; passes thence through line 62 into pipe coil 50 which is located in the lower part of the pipe still battery and which therefore is subjected to the heating effect of combustion gases at a substantially lower temperature than are pipe coils 51, 52, 53 and 54. From heating coil 50, the oil is delivered through line 63 into a flash vaporizer 64, most desirably of the type disclosed in our copending application, Serial No. 626,273, filed March 20, 1923. It is sufficient to state here that this vaporizer may consist of upper and lower sections 65, 66, filled with suitable packing, such as ring packing or the like, between which sections is located a distributing baffle 67 upon which the superheated oil from pipe coil 50 is delivered through line 63. In this vaporizer the hot oil is rapidly distributed over an enormously extended surface and a vapor flashed off which approximates the equilibrium vapor of the liquid for the temperature and pressure prevailing in the vaporizer. The vapor thus flashed off, preferably scrubbed of its entrained liquid and to some extent rectified in passing through the upper packed section 65, leaves the vaporizer through line 68 and is delivered thereby into the upper part of fractionating column C′ which may be similar in all respects to the fractionating column C of Fig. 1. The liquid remaining unvaporized in vaporizer 64 is withdrawn therefrom by pump 69 which forces it through pipe 70 into and through pipe coil 51 in the pipe still furnace where said oil is superheated at a substantially higher temperature than the oil in pipe coil 50. From pipe coil 51 the superheated oil is delivered through pipe 71 into a second flash vaporizer 72 which may be essentially similar to vaporizer 64 already described. Vapors flashed off in vaporizer 72 are delivered through line 73 into a somewhat lower section of the fractionating column C′, as shown; while separated liquid oil is drawn from vaporizer 72 through trapped line 74 by a suitable pump (not shown) and forced through the next pipe coil in series, namely, pipe coil 52. In a manner similar to that already described in connection with pipe coil 51, the oil passing through pipe coil 52 is superheated at a still higher temperature and is discharged into a third vaporizer (not shown), the vapors flashed off therein being introduced into a still lower section of the fractionating column C′ through vapor line 75, while the separated liquid oil passes into and through pipe coil 53 in the furnace where it is still further superheated and then delivered into a fourth vaporizer (not shown). From this fourth vaporizer, the flashed-off vapors pass into the fractionating column through vapor line 76, while the separated liquid oil passes into the last pipe coil 54 of the battery where it is superheated to the maximum temperature employed and then delivered to a fifth vaporizer (not shown) from which the separated vapors pass into the base of the fractionating column through vapor line 77.

The other parts of the system shown in Figs. 2 and 2*a*, and their mode of functioning, are similar to the corresponding parts shown in Fig. 1 and require no further detailed description. Where necessary or desirable, an auxiliary exhausting column (not shown), similar to that shown at 34 in Fig. 1, may be employed to treat the liquid oil leaving the base of the main column C'. One important advantage in employing the apparatus system illustrated in Figs. 2 and 2*a* is the greater efficiency that can be realized by the use of pipe coil stills as compared to bulk stills of the pot type or the horizontal cylindrical type. Furthermore, by employing vaporizers of the type illustrated at 64 and 72 in conjunction with such pipe stills, a much cleaner separation of substantially equilibrium vapors from the superheated oil is initially obtained prior to the introduction of vapors into the fractionating column from the several still units than is possible when a system of the type illustrated in Fig. 1 is employed. This renders satisfactory winning of the gasoline content of the oil more certain, but in broad principle the system shown in Figs. 2 and 2*a* does not fundamentally differ from that shown in Fig. 1.

In the system illustrated in Fig. 3, a battery of four horizontal cylindrical stills is employed as in the case of the system illustrated in Fig. 1. The rectifying system, however, differs from the specific form thereof illustrated in Figs. 1 and 2 principally in that, instead of a single rectifying or fractionating column, there are employed a plurality of rectifying or fractionating units, one for each of the stills of the battery, which are so related structurally and functionally, however, as nevertheless to constitute a unitary rectifying system within the meaning of this expression as hereinabove defined. Thus, the vapors from stills Nos. I, II, III and IV pass into the base of rectifying units 80, 81, 82 and 83, respectively. Liquid for countercurrent contacting with the vapors in the rectifying units passes in series through the four units in the order 80—81—82—83. The only liquid oil introduced into the rectifying system as such is the gasoline product refluxed from the dividing box 25 into the top section of rectifying unit 80. The liquid leaving the bottom of each of the rectifying units 80, 81 and 82 is led directly into the top of the next succeeding unit of the series, as shown; the liquid leaving the bottom of rectifying unit 83 being, in a typical instance, a gas-oil substantially free of gasoline constituents. On the other hand, the vapors leaving the top of rectifying unit 83 are introduced into the bottom of the next preceding unit 82 in the series, and so on, the completely rectified gasoline vapors finally leaving the top of rectifying unit 80 and entering the condenser as shown to yield a gasoline condensate of which at least a portion is refluxed to the top of said unit 80 as already stated.

The system just described may include also auxiliary exhausting columns of the type described in connection with the systems shown in Figs. 1 and 2, where it is desired to draw intermediate liquid products from different portions of the rectifying system in order to obtain products of certain specified characteristics.

It is also feasible to so arrange the piping connections that any one of the four rectifying units, with its cooperating still, may be cut out of the system for repairs or cleaning out, without interfering with operation of the remaining units and stills in the manner described. Such flexibility is at times very desirable in a system of this kind.

The general mode of operation of such a system as this does not differ materially from that of the other novel systems hereinabove described; but in some situations it is convenient to split up the rectifying system structurally into a plurality of serially related units of the character described, and by arranging the apparatus as described, it is possible to do this while observing the essential conditions of operation characterizing the invention and realizing its benefits wholly or in large measure.

In referring to conditions of operation such that introduction of counterflow liquid into the system is to be avoided at points other than that adjacent where rectified vapors leave the system, it is not intended to exclude from the scope of the invention herein disclosed and claimed the case where it may be necessary or advisable, as a temporary measure or otherwise, to re-run a distillate (e. g. so-called "benzine") for separation into gasoline and a heavier fraction by introducing such distillate into some appropriate point in the main column.

What we claim is:

1. Distilling apparatus comprising in combination, a plurality of stills, connected in series for flow of liquid through the entire series, a single rectifying or fractionating column, vapor lines arranged to conduct vapors from the several stills separately into different sections of said column adjacent the top and bottom of the column and at intermediate points thereof where the vapors are respectively substantially in equilibrium with the vapor and liquid of the column, condensing means into which vapors pass from said column, means for refluxing condensate to the upper part of the column, an auxiliary exhausting column connected at a point intermediate the ends of the rectifying column for withdrawing a fraction of approximately desired composition, and means for returning to said rectifying column vapor from said exhausting column at a point in substantial equilibrium with the liquid and vapor in said rectifying system.

2. Distilling apparatus comprising in

combination, a plurality of stills connected in series for flow of liquid through the entire series, a single rectifying or fractionating column, vapor lines arranged to conduct vapors from the several stills separately into different sections of said column at points thereof where they are respectively substantially in equilibrium with the vapors and liquids of the column, condensing means into which vapors pass from said column, means for refluxing condensate to the upper part of said column, an auxiliary exhausting column, means for diverting liquid thereinto from a section of said fractionating column, and means for returning to said fractionating column vapor from said exhausting column.

3. The process of distilling liquids of mixed composition which comprises passing such a liquid serially through a plurality of suitably heated distilling chambers, conducting evolved vapors from all of said distilling chambers into a unitary rectifying system, condensing rectified vapors leaving said rectifying system, providing a rectifying counterflow of liquid in contact with said vapors in said rectifying system by refluxing at least a part of the condensate from said rectified vapors to said rectifying system at a point adjacent where said rectified vapors leave said system while avoiding introduction of counterflow liquid, as such, elsewhere into said system, the evolved vapors from each of said distilling chambers being introduced into that part of said rectifying system where they will be respectively substantially in equilibrium with the vapor and liquid in said system, removing from said rectifying system an intermediate fraction of an approximately desired composition, exhausting said fraction of its more volatile portion to obtain a product of an exactly predetermined composition, returning said more volatile portion to the rectifying system at such point as to be in substantial equilibrium with the liquid and vapor in said system, and withdrawing a desired distillation product from a point in the combined rectifying and condensing system.

In testimony whereof we hereunto affix our signatures.

EUGENE H. LESLIE.
EDWIN M. BAKER.