Nov. 26, 1935. W. L. GOMORY 2,022,280

ART OF AND APPARATUS FOR CONVERTING HYDROCARBONS

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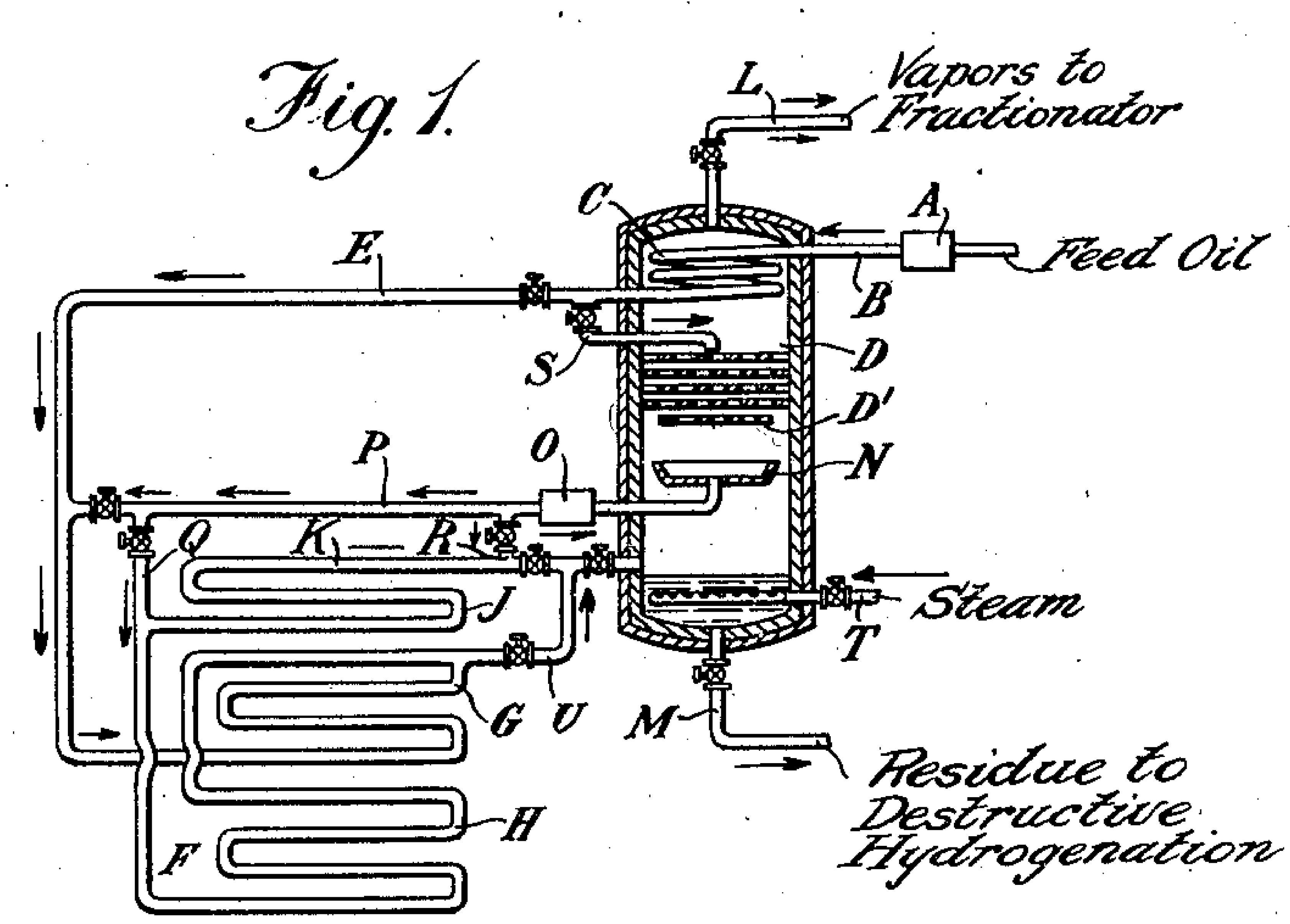
Fig. 1.



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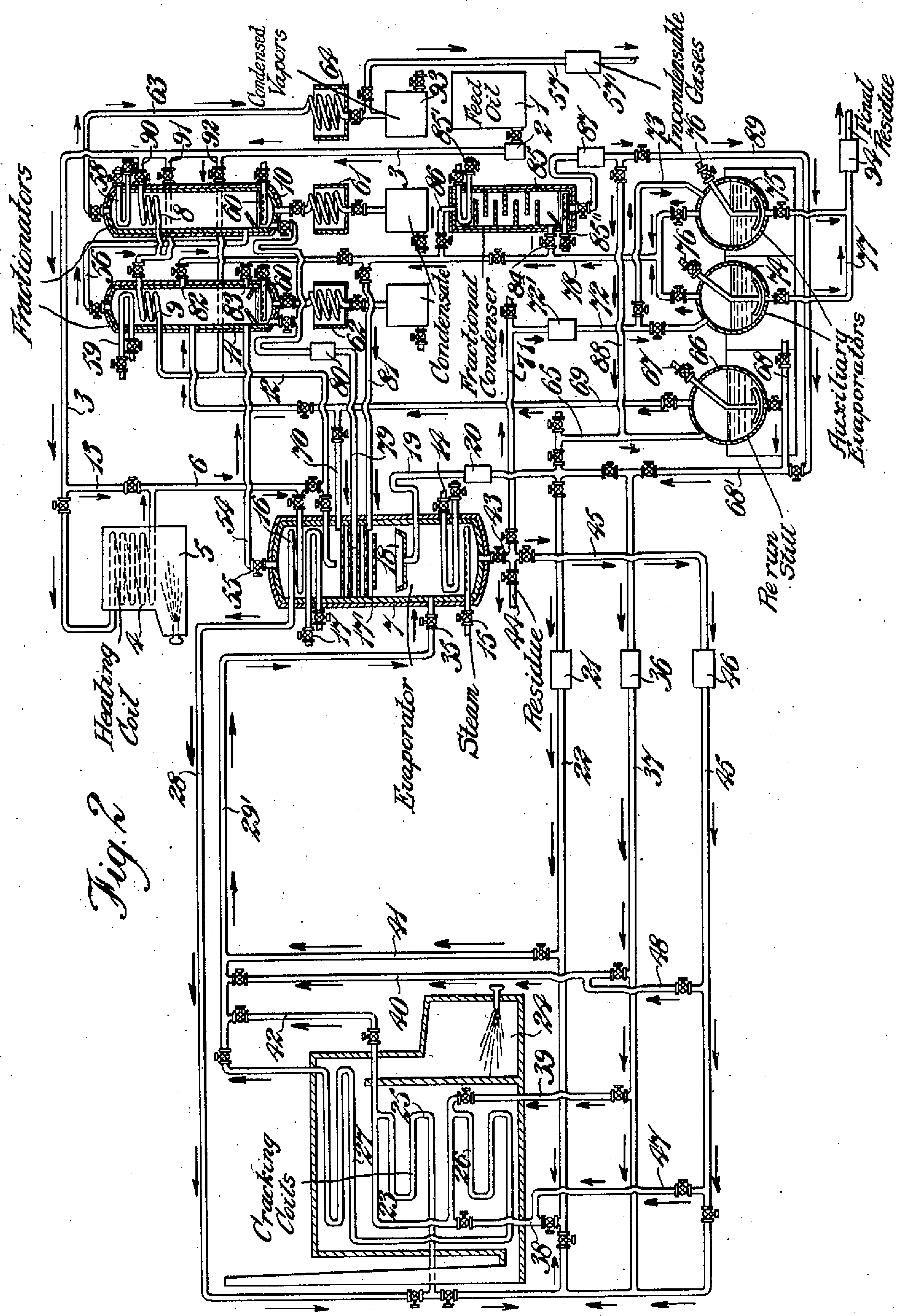

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2,022,280

ART OF AND APPARATUS FOR CONVERTING HYDROCARBONS

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In Great Britain July 15, 1930

8 Claims. (Cl. 196—48)

This invention relates to the conversion of hydrocarbons and more particularly to the treatment of petroleum oils for the production of low-boiling products therefrom and the said invention has for its object to provide an improved and efficient process and apparatus for obtaining in a continuous operation a maximum yield of low-boiling products with a small initial outlay and a small maintenance cost and with the minimum production of products of low market value.

I am aware of processes in which the oil is heated under pressure to a cracking temperature in a coil and then maintained therein for a very short period of time, for instance 50 to 100 seconds, and is then expanded into a tank with or without simultaneous and instantaneous cooling to materially below the cracking temperature, for instance, to 480 degrees F.

In such processes, on account of the very short reaction time given to the oil in the coil at the cracking temperature, the amount of decomposition that takes place is comparatively small, therefore no commercial yield of gasoline can be obtained without subjecting the original oil to a large number of retreatments which obviously materially increase the cost of working these processes.

Moreover owing to the sudden and material cooling of the stream of oil entering the tank a great amount of uncracked oil is removed with the residue, so that the gasoline which could be recovered therefrom is lost. Furthermore a great amount of heat is uselessly removed from the system.

My improved process at once eliminates all these disadvantages and enables a maximum yield of gasoline to be obtained with lowest cost and minimum formation of products of low market value.

According to my invention the oil to be treated is passed under high pressure through a heating and cracking zone, for instance a continuous heated coil or series of coils, in which it is heated to cracking temperature and subsequently maintained therein at such temperature for sufficient time, for example, 2 minutes or more, to obtain maximum conversion of the oil without undue formation of carbon. The products are passed to a vaporizing zone, which is under reduced pressure, the temperature of the stream of oil entering said zone being regulated without permitting the temperature of the oil in said zone to drop below that at which most of the uncracked constituents will vaporize, i. e. below about 580° F. the vapours are fractionated, the uncondensed low-boiling fractions are removed and condensed, the reflux condensate is recovered and returned either to the inlet of the heating and cracking zone or to various intermediate points thereof, and the residue is withdrawn from the vaporizing zone. The residue removed from the vaporizing zone may advantageously be subjected to a destructive hydrogenation treatment.

The desirable cracking temperature and pressure and the reaction time will vary with the nature of the material to be treated. Temperatures of 750° to 1250° F., pressures of 150–3000 lbs. per square inch or more and a reaction time of two minutes or more than two minutes are employed, depending on the nature of the material.

The vaporizing tower or evaporator is operated at materially reduced pressure, preferably at atmospheric pressure; and the temperature of the stream of oil entering the vaporizer may be regulated by the introduction therein of cooler oil, for example reflux condensate obtained in the system, in such a manner that a constant temperature is maintained at the bottom of the vaporizing zone or tower, this temperature being sufficiently low to ensure that no material cracking shall take place, at the same time the temperature is not permitted to fall below that which is necessary to ensure the vaporization of all the uncracked fractions which are adapted to be further cracked, and to prevent the formation of a large amount of residue. This temperature should lie between 580 degrees F. and 750 degrees F.

The temperature at the top of the vaporizing tower or evaporator is regulated in any convenient manner (for instance by passing the feed oil, or any other oil, through cooling coils located in the top of the evaporating tower or by spraying oil into the tower) so that only light cracked vapours are allowed to pass to fractionators and condensers and so that all the other fractions which have vaporized will be condensed and recovered as reflux condensate.

Furthermore, the residue obtained in the evaporator may be introduced either wholly or partly into the inlet of the heating and cracking zone; or the said residue may be introduced at an intermediate point or points of the coil or series of coils, which forms the combined heating and cracking zone. The residue may also be introduced into the stream of oil at the outlet end of the coil. The residue may moreover be introduced into the system at two or more of the positions above mentioned.

The reflux condensate from the vaporizing zone is continuously returned without substantial loss of heat either wholly or partly into the inlet of the coil or series of coils; or the said reflux condensate may be introduced at an intermediate point or points of the coil or series of coils. Part of the reflux condensate may advantageously be introduced into the stream of oil at the outlet end of the coil or series of coils to regulate the temperature of such stream of oil as it enters the evaporator. The reflux condensate may however be introduced into the system at two or more of the positions above mentioned.

A further means of effecting the regulation of the temperature of the stream of oil entering the evaporator consists in that part of the oil from the coil or series of coils is taken from an intermediate point in such coil or series of coils and is introduced into the stream of oil passing from the coil or coils into the evaporator.

The quantity of reflux condensate introduced into the stream of heated oil or cracked products passing from the heating and cracking coil or coils to the evaporator is so regulated that it will control the temperature of the oil before the same enters into such evaporator, or will control the temperature of the oil in the evapoator. Furthermore part of the oil passing through the coil or coils may be taken from an intermediate point of the coil or coils and introduced into the stream of heated oil passing to the evaporator, in order to regulate the temperature thereof.

The reflux condensate before it is introduced into the coil or coils, or into the outlet of the coil or coils as above mentioned, is advantageously subjected to distillation at atmospheric or super-atmospheric pressure for the purpose of separating the light fractions from the same.

The light vapours separated from the reflux condensate are introduced into the fractionator or fractionators either separately or together with the vapours obtained in the vaporizing zone. Or if desired such light vapours may be introduced into the vaporizing zone. Moreover the vapours obtained from the reflux condensate may be partly introduced into the vaporizing zone, e. g. the heavier fractions, and partly into the fractionator or fractionators, e. g. the lighter fractions. Or the said light vapours may be fractionated in a separate fractionator.

In order to convert the residue, which is continuously withdrawn from the evaporator, into more valuable products, such cracked residue is advantageously subjected to destructive hydrogenation, such as shown in my co-pending application Ser. No. 475,099, filed August 13, 1930.

The residue removed from the vaporizing zone may, if desired be subjected to a second vaporization at atmospheric or super-atmospheric pressure, so that the amount of residue is materially reduced and additional valuable light hydrocarbons are obtained therefrom, the vapours so obtained being preferably introduced into the first vaporizing zone, the final residue being withdrawn and if desired subjected to destructive hydrogenation in any suitable manner, for example, as described in my copending application Ser. No. 475,099, filed August 13, 1930.

The vapours obtained from the residue in the second vaporizing zone may be introduced into the fractionator or fractionators. The vapours obtained from the residue in the second vaporizing zone may be separately fractionated or they may be partly introduced into the first vaporizing zone and partly into the fractionator or fractionators receiving the vapours from the evaporator, e. g. the heavier and lighter fractions respectively.

In some cases it may be desirable to subject the residue from the first vaporizing zone to a second vaporization at atmospheric or super-atmospheric pressure in such a manner as to vaporize all volatile matter contained in the residue, so that, besides a small amount of coke, a great amount of more valuable light products is obtained. The resulting solid residue is removed and the vapours are preferably introduced into the first vaporizing zone or evaporator or if desired they may be introduced into the fractionators or into both the first vaporizing zone and the fractionators. The vapours obtained from the residue in the second vaporizing zone are advantageously subjected to fractional condensation, the uncondensed vapours being passed into the first vaporizing zone or into the fractionators, or into both the first vaporizing zone and the fractionators, and the condensed heavier fractions being returned to the system with or without subjecting them to distillation in a still, which may be the still in which the reflux condensate from the first evaporating zone is re-run.

In all the above forms of my improved process the vapours may be separated into good end point gasoline and other valuable fractions by passing them through fractionators and rectifiers provided with controlled cooling, which cooling may be effected either by the feed oil or by means independent thereof.

A novel feature of my invention comprises subjecting the uncondensed vapours and gases to dissociation and conducting the dissociated vapours and gases to a destructive hydrogenation plant so that they may be used in the destructive hydrogenation of hydrocarbons, as shown in my co-pending application Ser. No. 475,102, filed August 13, 1930.

The reflux condensate obtained in the fractionator or fractionators may be introduced into the vaporizing zone for redistillation.

The pressure in the still, in which the reflux condensate from the first or primary vaporizing zone is re-run, is maintained at a higher value than that in the first vaporizing zone or in the fractionators. Furthermore a higher pressure is advantageously maintained in the auxiliary or secondary vaporizing zone than in the first or primary vaporizing zone. Generally speaking, different pressure conditions may be maintained in the various parts of the system. Or uniform pressure conditions may be maintained in the coil and in the evaporator.

The present invention also comprises suitable apparatus for carrying into practice the several forms of my improved process.

In order that the invention may be fully understood reference will be made to the accompanying drawings in which

Figure 1 shows in diagrammatic form an arrangement of the heating and cracking zone and evaporator in accordance with the present invention and

Figure 2 shows in diagrammatic form a more fully developed form of apparatus according to my invention.

Referring to Figure 1, the oil to be treated is forced by means of a pump A through line B into cooling coil C which is arranged in the upper part of the evaporator D, and thence through line E into the inlet end of the section G of a heating and cracking coil F which comprises three pipe sections, G, H and J. The oil passes first through section G, then through section H and finally through section G. Cracked oil is discharged from the coil F through valved line K into the evaporator which preferably has baffle plates D' suitably disposed therein to ensure a thorough contact between ascending vapour and descending liquid. Steam may be injected into the evaporator D through spray pipe T.

Uncondensed vapours are withdrawn from the evaporator D through a valved line L to fractionators and condensers, (not shown) whilst the unvolatilized residue formed in the evaporator is withdrawn therefrom through valved line M and passed to a destructive hydrogenation plant or otherwise suitably disposed of. The reflux condensate produced in the evaporator is collected in a pan N from which it is withdrawn and forced by means of pump O through line P to the inlet of the section G of the coil F. Part of the reflux condensate may be passed to an intermediate point, of the coil for example the inlet of section J through branch line Q or to the outlet end of said section through branch line R. Part of the oil passing through the coil F may be withdrawn from an intermediate point thereof such as the outlet of section G through line U and introduced into the stream of oil passing from the outlet of the coil to the evaporator D. Cool feed oil may be introduced into the evaporator D through branch line S.

Referring to Figure 2, the oil to be treated is drawn from any convenient source of supply 1 by means of a pump 2 and is forced through line 3 into a heating coil 4 located in a furnace setting 5, the oil then passing through line 6 into an evaporator 7. Valved by-pass lines 90, 91 and 92 are provided in line 3 whereby a regulated amount of feed oil may be sent through cooling coils 8 and 9 located in the upper parts of the fractionators 10 and 11 respectively, and thence through line 12 into line 6. A by-pass line 13 is also provided in line 3 whereby all or part of the feed oil may be passed directly to the evaporator 7 without passing through heating coil 4. A heating coil 14 is provided in the lower portion of evaporator 7. Moreover steam may be injected into the evaporator through spray pipe 15. A cooling coil 16 is provided in the upper portion of the evaporator 7 through which feed oil passing from line 6 to heating and cracking coils 23 may be passed whilst a further cooling coil 17 is provided in the evaporator, so that the cooling may be controlled by means which are independent of the supply of feed oil. Baffle plates 17' are suitably disposed within the evaporator 7 to ensure a thorough intermingling of ascending vapour with descending liquid and the evaporator is advantageously heat insulated. Reflux condensate formed in the evaporator 7 is collected in a pan 18 from which it is withdrawn through line 19 by means of a pump 20. Reflux condensate is forced by reflux pump 21 through line 22 into the inlet of the heating and cracking coil 23 which is located in a suitable furnace setting 24. The heating and cracking coil 23 comprises three pipe sections 25, 26 and 27 which are situated in different positions in the furnace and feed oil from cooling coil 16 is passed to the inlet of the heating and cracking coils 23 through line 28. The heating and cracking coils may advantageously be built up of a series of straight pipes in accordance with standard practice, e. g., with the ends of the pipes extending through the flue walls and suitably connected by headers having apertures provided with removable plugs to permit inspection of the pipes.

Heated and cracked oil from the coils 23 passes through line 29' having a pressure reducing valve 35 into the evaporator 7.

Reflux condensate from the evaporator 7 may also be passed by means of pump 36 through line 37 to the inlet of the coils 23 and the reflux condensate may be passed to intermediate points of the coils through lines 38 and 39 or to the outlet end of the coils through branch lines 40 and 41. Heated oil may be withdrawn from an intermediate point of the coils 23 through line 42 and introduced into the stream of cracked oil passing from the outlet end of the coil through line 29' into the evaporator 7.

Residue is withdrawn from the bottom of the evaporator 7 through line 43 and may be withdrawn from the system by line 44 or passed through line 45 to the inlet of the heating and cracking coils 23 by means of residue pump 46. Said residue may be passed to an intermediate point of the heating and cracking coils 23 through branch pipe 47 or to the outlet of the heating and cracking coils through branch pipes 48 and 40.

Vapour from the evaporator 7 passed through line 54, having a pressure control valve 55, into the lower portion of fractionator 11 from the upper portion of which vapour is withdrawn by line 56 to a second fractionator 10. Cooling coils 58 and 59 are provided in the upper portions of the fractionators 10 and 11 respectively to provide cooling means independent of the supply of feed oil, whilst spray pipes 60 are provided in the lower portion of the fractionators for the injection of steam. The fractionators 10, 11 are preferably heat-insulated. Condensate from the fractionators 10 and 11 is withdrawn through coolers 61 and 62 to storage whilst vapour from fractionator 10 is withdrawn through line 63 to a condenser 64 from which condensate is passed to tank 93. Incondensable gas is separated from condensate in tank 93 and is withdrawn through line 57 by pump 57'. Preferably the incondensable gas is used as a make-up gas in a destructive hydrogenation plant.

The vapours and gases not condensed may be subjected to dissociation and the dissociated vapours and gases are conducted to a destructive hydrogenation plant so that they may be used in the destructive hydrogenation of hydrocarbons, as shown in my co-pending application Ser. No. 475,102, filed August 13, 1930.

Part or all of the condensate from the fractionators 10 and 11 may be passed by pump 80 to the evaporator 7 through line 79.

When it is desired to subject the reflux condensate from evaporator 7 to distillation prior to its return to the coils 23, the reflux condensate is passed through line 65 into the re-run still 66 into which steam can be passed through line 65 and which still can be heated directly or otherwise. Residue from the re-run still 66 may be withdrawn from the system through line 68 or returned to the coils through line 68' and line 37.

Vapour is withdrawn from the re-run still 66 through line 69 to fractionator 11 or all or part of the vapour may be passed through branch pipe 70 to the evaporator 7.

In cases where it is desired to subject the residue from the evaporator 7 to a second vaporization, such residue is withdrawn from the evaporator by pump 72' through lines 71, 72 and branch line 73, into auxiliary evaporators 74 and 75, which can be heated by the injection of steam through spray pipes 76 or by direct heat or both. Final residue from the auxiliary evaporators is withdrawn by pump 94 through line 77, and is passed to a hydrogenation plant or is otherwise suitably disposed of. Vapour from the auxiliary evaporators 74, 75 is withdrawn through line 78 and is passed either to evaporator 7 through line 81 or into fractionator 11 through branch lines 82, 83. Or if desired, such vapour may be passed through line 84 to a fractional condenser 85 from which uncondensed vapours are returned through line 86 either to the evaporator 7 or to the fractionator 11. The fractional condenser 85 is heat insulated and is provided with a cooling coil 85' in the upper portion thereof, and with a spray pipe 85'' for direct steam in the bottom thereof. The condensed heavier fractions from the fractionator 85 are passed by pump 87 either to the re-run still 66 through line 88 or to the coils 23 through lines 89, 68' and 37.

Valves are suitably disposed throughout the apparatus to control the flow of oil to the different parts of the system and to enable any desired pressure to be maintained therein. All the lines conveying oil into the heating and cracking coil or to the outlet thereof, are provided with check valves to prevent the hot products from backing into these lines, whilst all the lines conveying hot oil are heat-insulated.

I claim:

1. A method of converting hydrocarbon oils which comprises heating the oil to a cracking temperature in a heating coil, transferring the hot products from the heating coil to a vaporizing zone, collecting a reflux condensate in said vaporizing zone, subjecting the reflux condensate to distillation in a separate reflux stripping zone, passing an unvaporized liquid fraction from the stripping zone to said heating zone, subjecting the nncondensed vapors from the vaporizing zone to fractionation in a separate fractionating zone, conducting the vapor fraction evolved in the reflux stripping zone partly to the vaporizing zone and partly to the fractionating zone, and removing and condensing vapors from the fractionating zone.

2. A method substantially as described in claim 1, in which a portion of the oil undergoing heating in the heating coil is withdrawn from an intermediate point of the coil and injected into the hot products being transferred from the heating coil to the vaporizing zone.

3. A method substantially as described in claim 1 and in addition thereto, the steps of subjecting residual liquid from the vaporizing zone to distillation in a distillation zone and returning the vapor fraction evolved in said distillation zone to the vaporizing zone.

4. In an apparatus for the conversion of hydrocarbon oil, the combination of an heating coil, a vaporizer, a transfer line connecting the heating coil and the vaporizer, a partial condensing means, means for recovering reflux condensate in said vaporizer, a separate reflux condensate stripper, means for conducting reflux condensate from the vaporizer to the stripper, a separate fractionating means for recovering a condensate from the uncondensed vapors from the vaporizer, means for conducting said vapors from the vaporizer to the said fractionating means, a vapor line for conducting vapors from the stripper to the vaporizer and to the fractionating means, and means for passing bottoms from the stripper to the heating coil.

5. An apparatus substantially as described in claim 4 and in addition thereto, a still and means for conducting residue from the vaporizer to said still and for conducting vapors from the still to the vaporizer.

6. In an apparatus for the conversion of hydrocarbon oils the combination of a heating coil, a vaporizer, a transfer line connecting the heating coil and the vaporizing zone, a fractionating column adapted to receive vapors from the vaporizer, a reflux stripper, a still, means for conducting reflux from the vaporizer to the stripper and for conducting residue from the vaporizer to the still, a second fractionating column adapted to receive vapors from the still, means for conducting reflux condensate from said second fractionating column to said reflux stripper, and means for removing and condensing vapors from the first and second fractionating zones and the stripper.

7. Apparatus of the character described comprising a heating and converting means adapted for heating and maintaining oil at cracking temperature and under pressure and means for supplying oil under pressure to the inlet of the heating and converting means, vaporizing means into which the products from said heating and converting means are discharged under reduced pressure, the said vaporizing means being provided with means for recovering and separately withdrawing vapors, reflux condensate and residue and being also provided with cooling means in the top and heating means in the bottom thereof, means for delivering the charging oil through the above mentioned cooling means located in said vaporizing means to said heating and converting means, means for supplying reflux condensate obtained in said vaporizing means to the inlet and outlet of said heating and converting means and to intermediate points thereof, means for discharging oil from an intermediate point of said heating and converting means into the stream of products passing from said heating and converting means to said vaporizing means, separate distilling means connected to said vaporizing means to separately receive reflux condensate and residue from said vaporizing means, and means for removing and condensing vapors formed in the vaporizer and the distilling means.

8. Apparatus of the character described comprising a heating and converting means adapted for heating and maintaining oil at cracking temperature and under pressure and means for supplying oil under pressure to the inlet of the heating and converting means, vaporizing means into which the products from said heating and converting means are discharged under reduced pressure, the said vaporizing means being provided with means for recovering and separately withdrawing vapors, reflux condensate and residue and being also provided with cooling means in the top and heating means in the bottom thereof, means for delivering the charging oil through the above mentioned cooling means located in said vaporizing means to said heating and converting means, means for passing charging oil directly into said vaporizing means, means for supplying reflux condensate obtained in said vaporizing means to the inlet and outlet of said heating and converting means and to intermediate points thereof, means for discharging oil from an intermediate point of said heating and converting means into the stream of products passing from said heating and converting means to said vaporizing means, separate distilling means connected to said vaporizing means to separately receive reflux condensate and residue from said vaporizing means, and means for removing and condensing vapors formed in the vaporizer and distilling means.

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