Aug. 25, 1959 P. M. WADDILL 2,901,425

VACUUM DISTILLATION

Filed Dec. 28, 1953 9 Sheets-Sheet 1

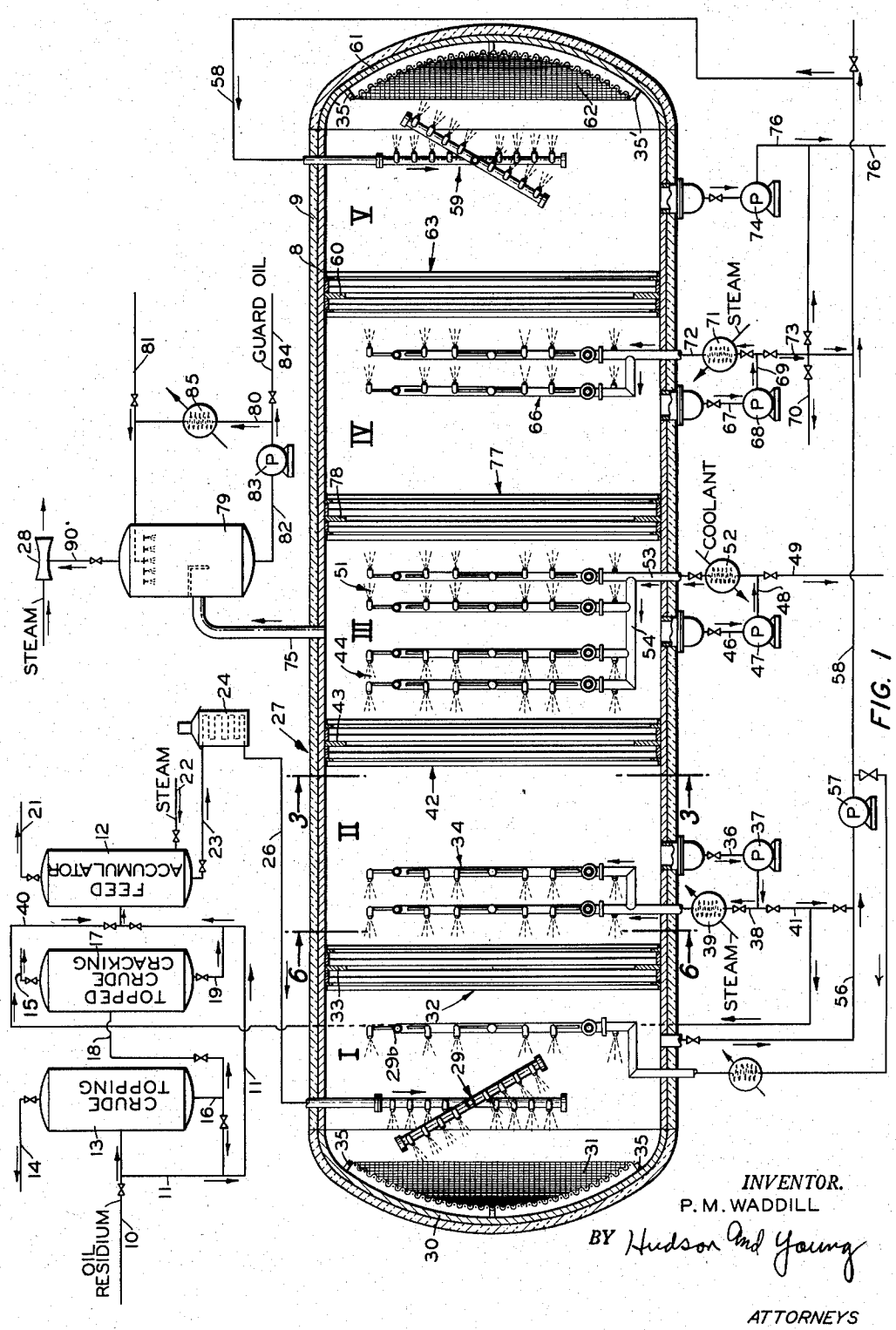


FIG. 1

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VACUUM DISTILLATION

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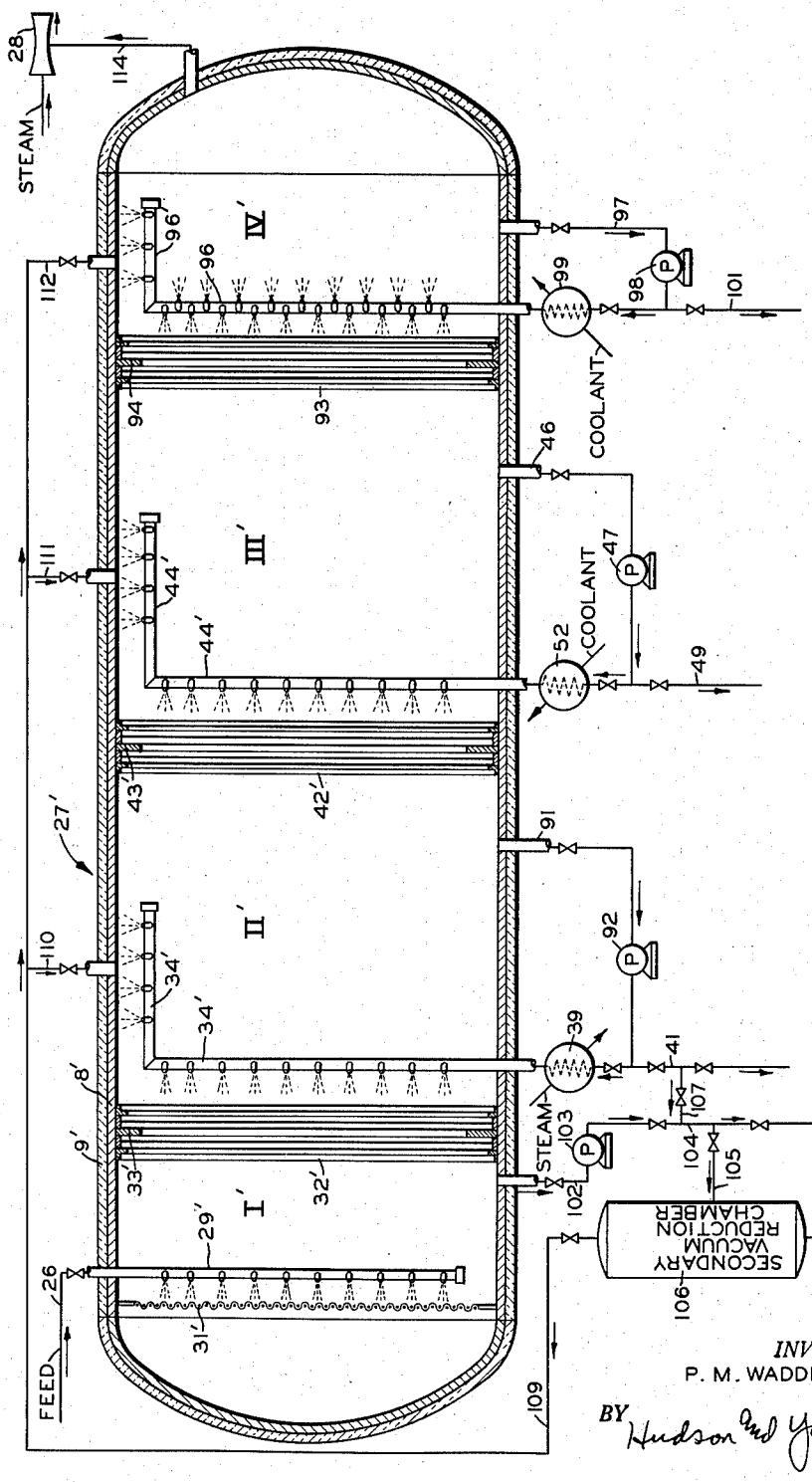


FIG. 2.

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VACUUM DISTILLATION

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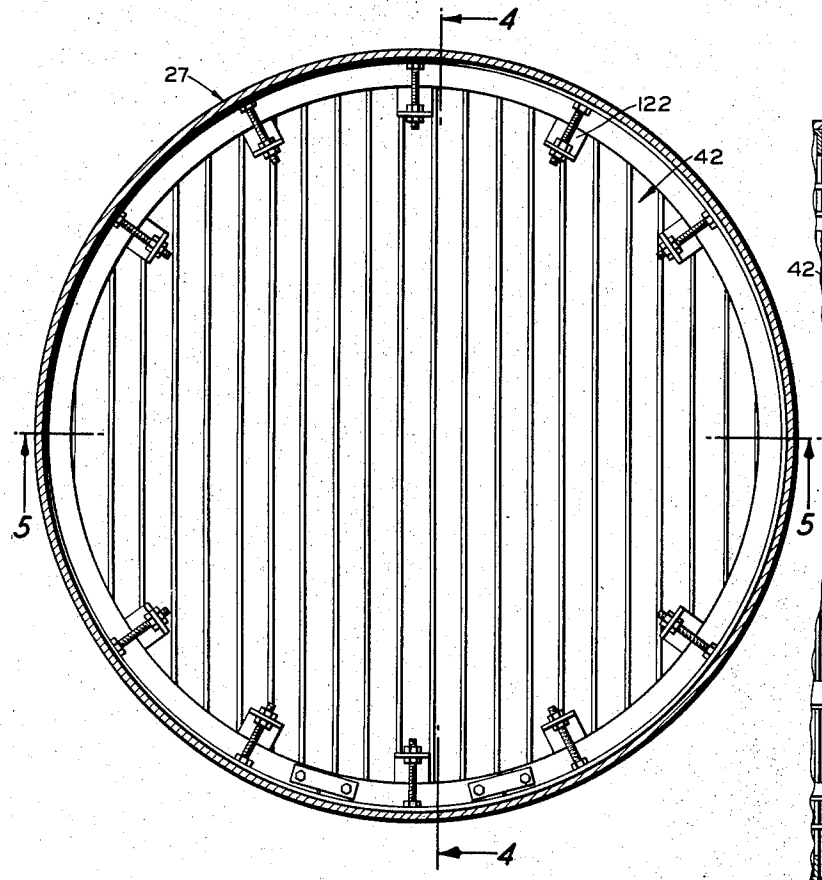


FIG. 3.

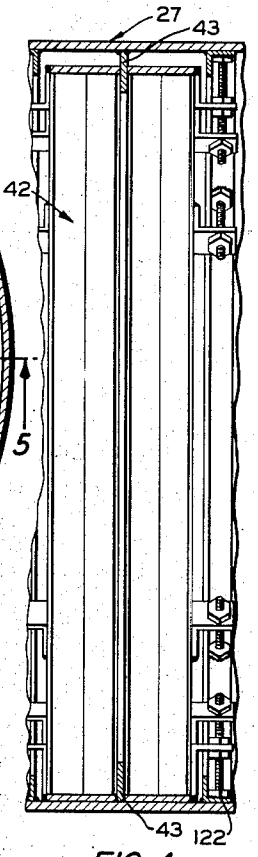


FIG. 4.

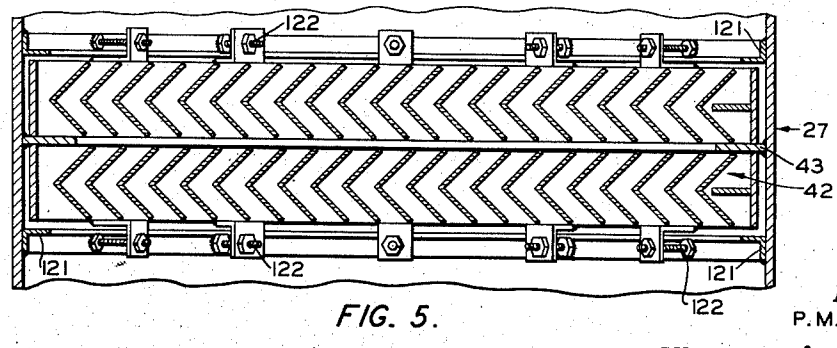


FIG. 5.

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VACUUM DISTILLATION

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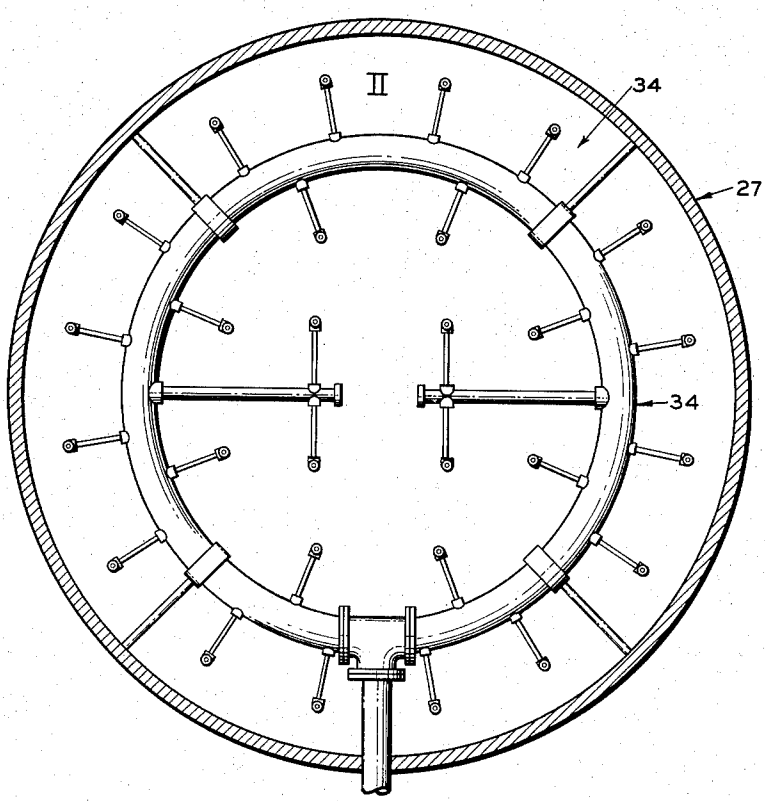


FIG. 6.

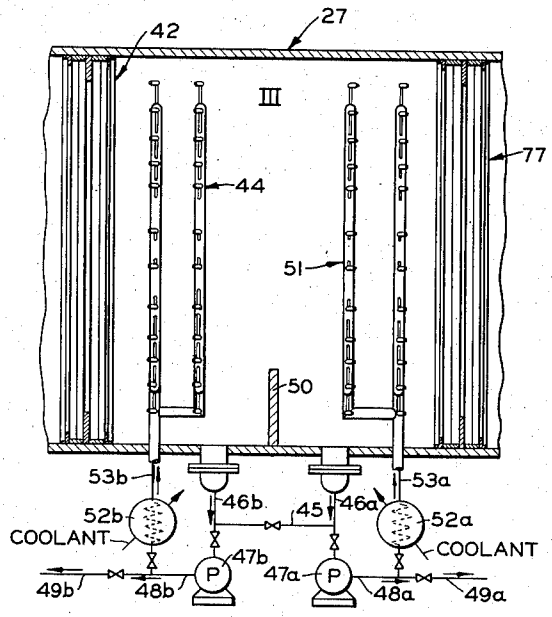


FIG. 7.

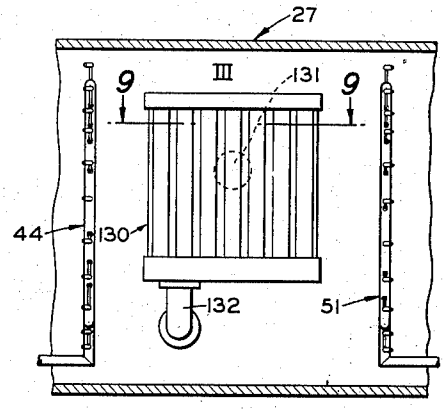


FIG. 8.

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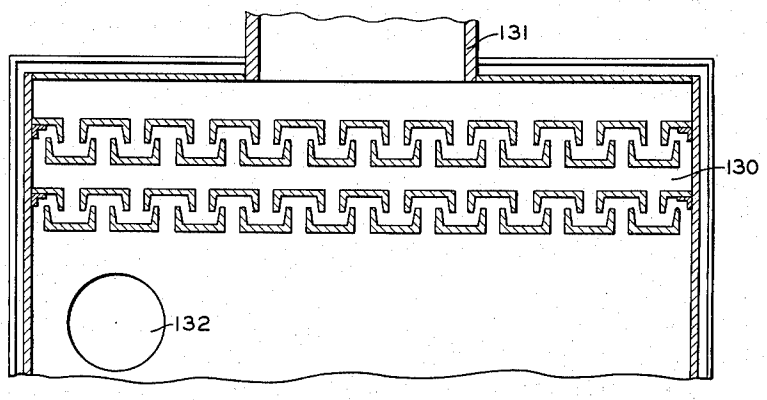


FIG. 9.

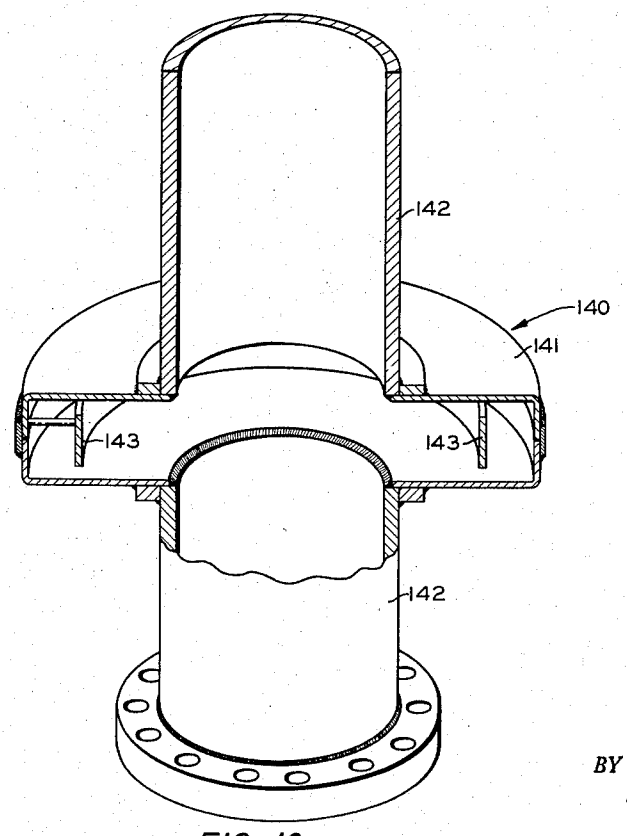


FIG. 10.

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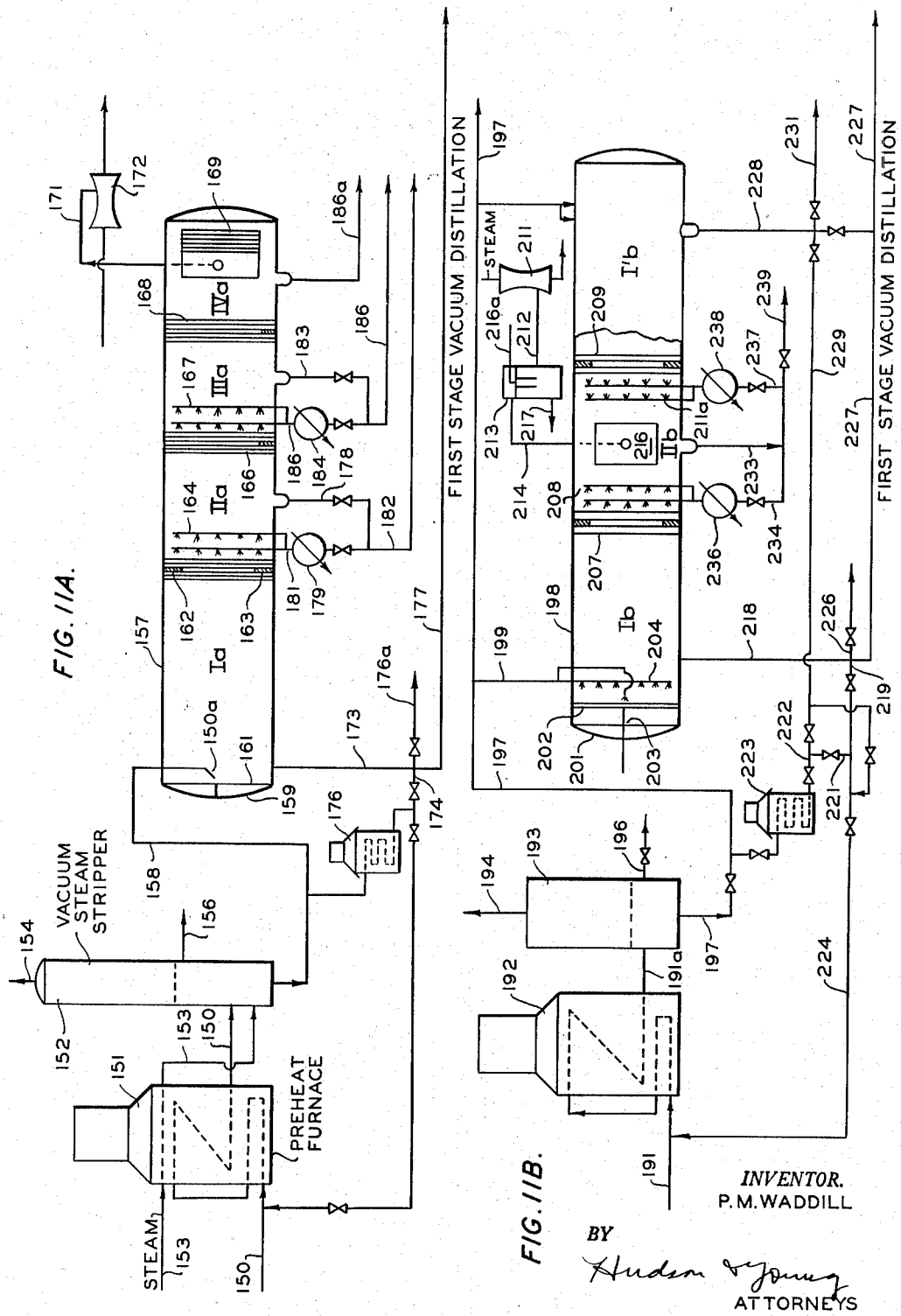


FIG. IIA.

FIG. IIB.

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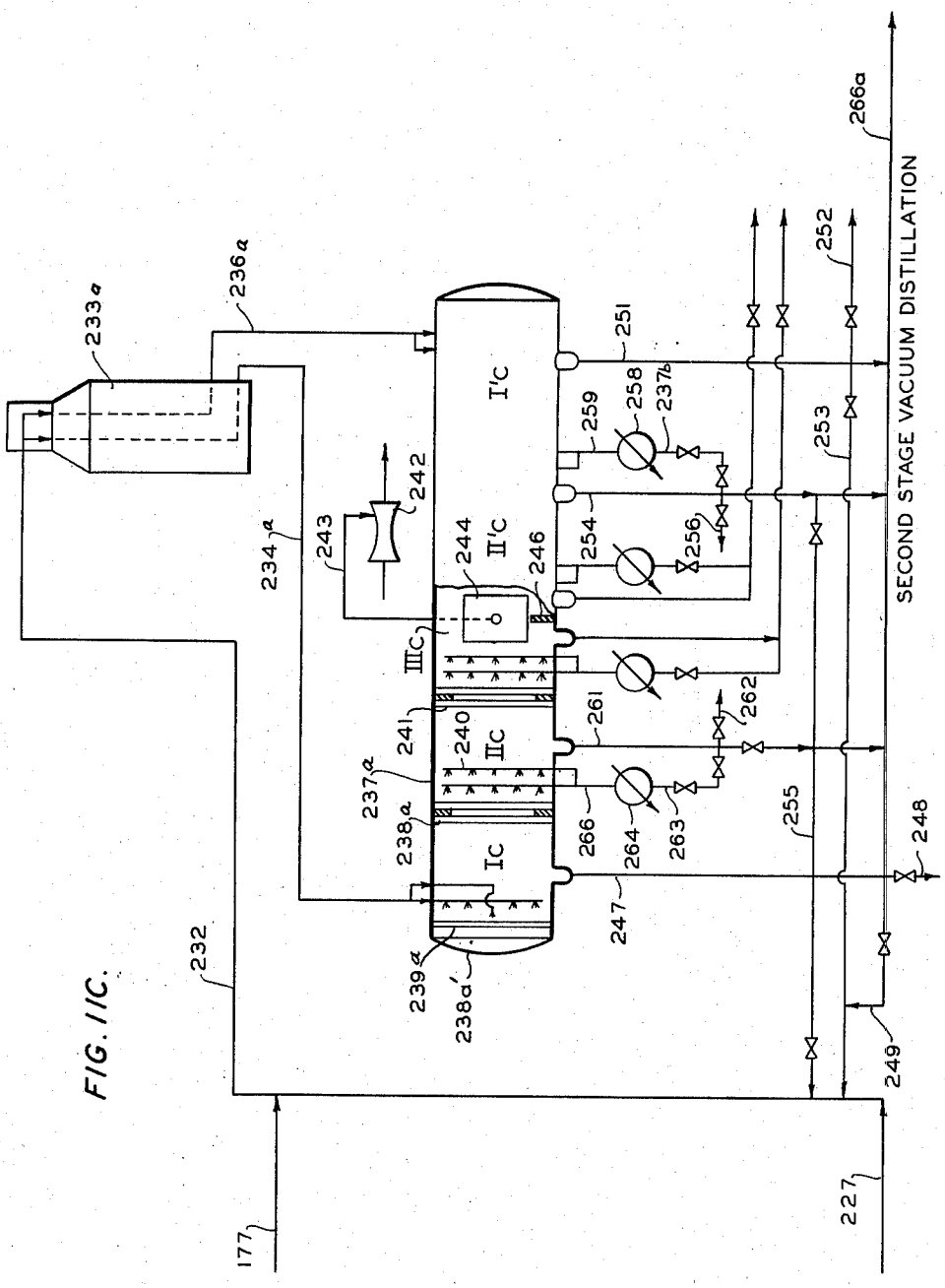


FIG. 11C.

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VACUUM DISTILLATION

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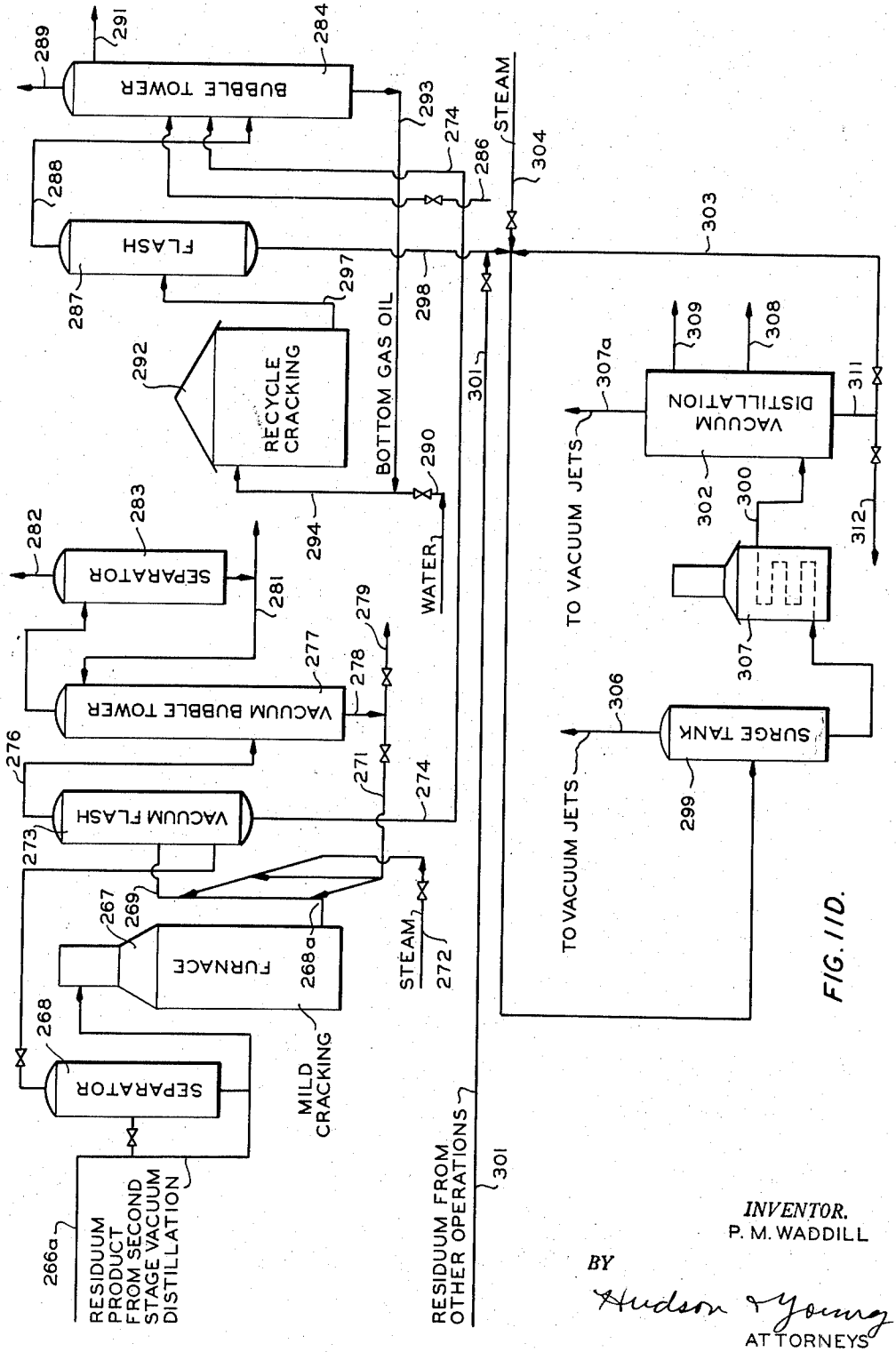


FIG. 11D.

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Aug. 25, 1959 P. M. WADDILL 2,901,425

VACUUM DISTILLATION

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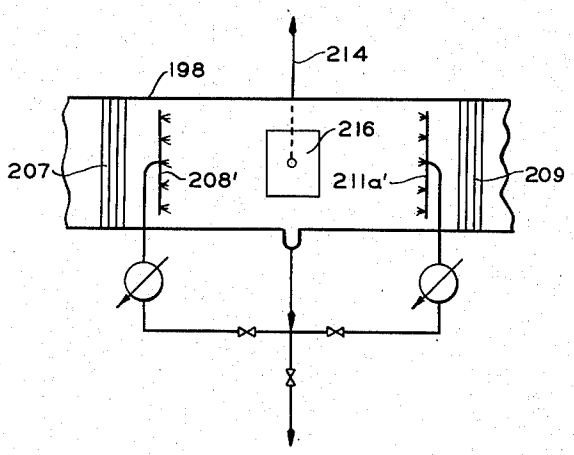


FIG. 12.

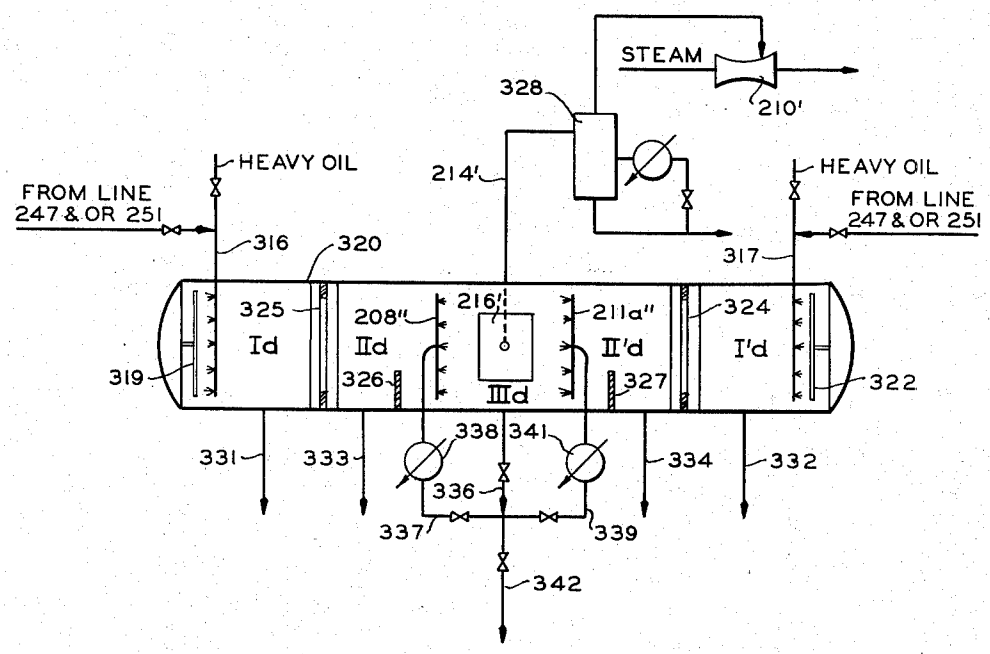


FIG. 13.

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United States Patent Office 2,901,425
Patented Aug. 25, 1959

2,901,425

VACUUM DISTILLATION

Paul M. Waddill, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Application December 28, 1953, Serial No. 400,450

31 Claims. (Cl. 208—352)

This invention relates to process and apparatus for the distillation of distillable materials. In one aspect this invention relates to the vacuum distillation of oils. In one aspect this invention relates to the distillation of hydrocarbon oils. In another aspect this invention relates to the vacuum reduction of heavy hydrocarbon oils to produce clean low carbon residue distillates in higher yields and residual high softening point pitch in lower yields than have been obtained heretofore. In another aspect this invention relates to process and apparatus wherein a hydrocarbon oil is vacuum distilled in a first stage to produce a first residual pitch distillation product and wherein the said residual product is then redistilled in a second vacuum distillation stage to produce a still higher softening point pitch. In another aspect this invention relates to process and apparatus wherein a first residual pitch distillation product is redistilled in the same distillation system to produce a still higher softening point pitch together with additional distillate fractions, without the need for heat or applied vacuum not already utilized in producing the initial residual pitch product. In another aspect this invention relates to the utilization of lower temperatures for effecting the vacuum distillation of residual oils than have been utilized heretofore. In another aspect this invention relates to a combination of process steps wherein a heavy hydrocarbon oil is vacuum reduced in a first stage and then further reduced in a second stage, and wherein residual product of the second stage reduction is subjected to a series of steps comprising visbreaking, cracking of resulting visbroken residuum, and vacuum reduction of resulting cracking residuum, to provide a final residual high melting pitch, and for conversion of gas oil distillate recovered from the second stage residuum, to lighter product. In still another aspect this invention relates to the distillation of distillable materials under conditions providing for low pressure drop across the distillation zone under high vacuum, and is advantageously applied to the vacuum reduction of residual hydrocarbon oils to provide lower yields of higher softening point residual pitch together with concomitantly higher yields of distillate. In another aspect this invention relates to a vacuum distillation process in which a distillable material is partially flash vaporized and particles entrained in resulting vapors are settled from the vapors in whole or in part as desired, prior to condensing the vapor in one or more condensing steps, at least one of which is effected in heat exchange relation of the vapors with a relatively cool liquid spray. In another aspect this invention relates to a vacuum distillation process wherein a hydrocarbon oil is partially flash vaporized, and resulting vapors are maintained at a residence time sufficient to permit settling therefrom of at least a portion of entrained particles, prior to effecting condensation of the vapors in heat exchange relation with cooler liquid spray, the latter emitted in concurrent flow relation with the said vapors so as to achieve a lowered pressure drop across the vacuum distillation chamber. In another aspect this invention relates to apparatus comprising a flat ring disposed peripherally about the inner wall of a chamber section in a substantially horizontal distillation chamber, for preventing flow of unvaporized liquid in an axial direction along the chamber side walls from the partial flashing section to a downstream section in the distillation chamber. In another aspect this invention relates to the introduction of feed into a flash vaporization section of a vacuum distillation chamber, in an upstream direction, from an open-end pipe, preferably against a coalescing surface such as provided by a wire mat, so as to facilitate separation of unvaporized feed from vapors formed. In another aspect this invention relates to the vacuum distillation of a hydrocarbon oil in a single stage by partially flash vaporizing the oil, contacting the resulting vapors with a liquid spray under temperature conditions effecting partial, or substantially no condensation of the vapors, as desired, and removal of entrainment therefrom, and then effecting substantially complete condensation of resulting vapors in heat exchange relation with a relatively cool liquid spray, emitted against the direction of flow of vapors contacted therewith.

This application is a continuation-in-part of my copending application Serial No. 241,183, filed August 10, 1951, now abandoned.

Heretofore in the vacuum distillation of residual oils, distillate fractions having high carbon residues have been obtained, together with residual pitch or tar fractions in high yield, as for example from 50–70 volume percent of residue based on the total oil charged. Furthermore the distillate fractions so produced are "dirty," that is, they are high carbon residue oils containing heavy carbonaceous materials present as a result of the entrainment of such materials in the vapors during the vacuum distillation. Such high carbon residue gas oils are undesirable as feed stock for various conversion processes. Furthermore when employing conventional oil reduction operations some of the gas oil components of the oil charge are lost to the distillation residue at the expense of gas oil yield.

My invention is concerned with the vacuum reduction of hydrocarbon oils particularly crude residua, for the recovery of clean gas oil fractions and for the concomitant recovery of residual pitch. My invention is advantageously applied to the further reduction of an initial residual pitch distillation product to provide a still higher softening point pitch and additional gas oil distillate product, and when desired, without the need for applying any heat or vacuum in addition to that already utilized in carrying out the initial distillation. My invention is further concerned with a method for the vacuum distillation of hydrocarbon oils so as to operate the distillation at any given pressure, at a lower temperature than utilized heretofore.

An object of my invention is to provide apparatus and process for the distillation of distillable materials. Another object of my invention is to provide for the distillation of a distillable material, under conditions providing for low pressure drop across the distillation zone under high vacuum. Another object of my invention is to provide for the vacuum distillation of oils. Another object is to provide for the vacuum reduction of residual hydrocarbon oils. Another object is to provide for the recovery of residual pitch from oil residua in lower yield, and having a higher softening point than has been obtained heretofore by distillation alone. Another object is to provide for the recovery of clean gas oil fractions from crude oil residua in yields higher than have been obtained heretofore. Another object is to provide pitch of improved quality for use in coke production, container manufacture, as a surfacing agent, road coating, and the like. Another object is to provide for the recovery of valuable hydrocarbons from crude oil residua.

Still another object is to provide for the vacuum distillation of a hydrocarbon oil at any given pressure level, at a temperature lower than that utilized heretofore. Still another object is to provide a process for vacuum distilling a residual hydrocarbon oil to produce an initial residual pitch of high softening point, and then for further reducing the initial pitch product in a second reduction stage. Still another object is to provide a process for vacuum distilling a residual hydrocarbon oil to produce an initial pitch residue of high softening point, and then to further reducing the initial pitch product in the same distillation system to produce a pitch residue of still higher softening point, without the need for heating or vacuum-producing means other than those employed in carrying out the initial distillation. Still another object is to provide a combination process wherein a hydrocarbon oil is vacuum reduced in two successive stages and resulting residuum product is subjected to visbreaking followed by cracking of resulting visbroken residuum and vacuum reduction of the resulting cracked residuum.

In accordance with this invention, apparatus and process are provided wherein a distillable material is partially vaporized and at least a portion of entrained particles are removed from resulting vapors, by settling same from the vapors by gravity alone, or, by contacting the vapors with a liquid spray, prior to condensing resulting vapors in one or more condensation steps, at least one of which condensation is effected by contacting the vapors in heat exchange relation with a relatively cool liquid spray; in accordance with one concept, my invention providing for introducing a distillable material into a first section of a distillation zone under flashing conditions so as to vaporize a portion of the said material, thus forming vapors containing entrained liquid particles, passing vapors from the said first section into a second and downstream section of said distillation zone and therein separating from the said vapors at least a portion of said particles entrained therein, passing vapors from said second section into a third section of said distillation zone in heat exchange flow relation therein with a spray of liquid droplets maintained at a temperature below that of the vapors contacted therewith so as to condense same, and recovering liquid product from the said distillation zone; in accordance with another concept, my invention providing an elongated chamber, preferably disposed substantially horizontally, a conduit extending into said chamber, a spray nozzle assembly in said chamber, a baffle section transversely closing said chamber and adapted to deflect liquid droplets from vapors passed therethrough and disposed intermediate said spray nozzle assembly and the end of the said first conduit, and conduit means for withdrawing liquid and any uncondensed vapor from the said chamber; another concept providing means for arresting downstream flow in an axial direction of unvaporized portions of liquid along the inner periphery of a substantially horizontally disposed distillation zone, comprising a flat ring disposed around the inner periphery of the said zone disposed downstream from its feed inlet.

In accordance with narrower concepts of my invention, the said separation of entrained particles from vapors can be effected by (1) passing the vapors in contact with a flow of atomized droplets as a spray, the latter spray being oriented to impinge on the entrained particles in such a manner that removal of entrainment occurs, such as passing the vapors against a flow of atomized droplets maintained at a temperature at least as high and under a momentum at least as great as that of entrained particles contacted therewith, whereby impinging droplets and impinged particles settle to provide entrainment-free vapors; (2) contacting the vapors with a spray of atomized droplets so as to condense a portion of the vapors and concomitantly remove entrained particles with condensate from the vapors—the direction of flow of atomized droplets, contacted with vapors, being countercurrent to, concurrent with, or transverse to the direction of vapor flow; and (3) by maintaining the residence of entrainment-containing vapors sufficiently long so as to cause at least a portion of the entrained particles to settle therefrom.

Other concepts of my invention provide for introducing feed into a flash section of a vacuum distillation chamber, in an upstream direction from an open-end pipe, preferably against a coalescing surface, whereby separation of liquid from vapors is facilitated; contacting vapors with condensing spray in concurrent flow relation to provide for lowered pressure drop across the distillation chamber at high vacuum; recycling residuum distillation product to the flashing step together with fresh feed to provide a substantial proportion of requisite sensible heat in the flashing section and to reduce requisite peak feed preheat temperatures; further reduction of initial residuum product, in one or more successive stages; further reduction of initial residuum product in a second stage, in the same distillation system, without the need for supplemental heat and/or vacuum; and subjecting residuum distillation product to a series of steps comprising visbreaking, recycle cracking and vacuum reduction to provide a final high softening point residual pitch product, together with gasoline as product.

In accordance with one embodiment of my invention, illustrated with reference to the drawings as discussed hereinafter, a distillable material such as a hydrocarbon oil residuum, generally a topped crude or a residuum from a topped crude cracking operation is heated to a temperature at which very little cracking takes place, or more desirably, none at all, such as within the limits of 600–900° F. The heated liquid is discharged into a flash, or first section, of a distillation zone, which distillation zone is maintained under subatmospheric pressure, generally at an overall absolute pressure from about 0.1 to 21 mm. Hg, and often from 0.1 to 8 mm. The heated charge upon being introduced into the first section is flashed, with the highest boiling components of the charge material remaining unvaporized. These unvaporized materials comprise residual pitch, a major proportion of which settles as liquid in the first section. As is inherent in all flash vaporization operations, particularly with heavy oils, a small portion of the unvaporized material is entrained in the flashed vapors as small finely divided liquid droplets, often appearing as a "fog" or mist. Such an entrainment of finely divided liquid droplets is typical of that also occurring in conventional vacuum distillation procedures. In conventional processes, the entrained liquid is carried on through the distillation system and is recovered in the gas oil fractions, thereby contributing to the high carbon residues so typical of those recovered gas oil fractions. As described hereafter, my invention provides for arresting these finely divided suspended materials, and for their separate recovery from the recovered gas oil distillates.

These entrained "fog-like" materials must be removed from the vapor containing them in order that "clean" distillate fractions, i.e., of low carbon residue, be recovered. This is done by passing the vapors from the flash section, i.e., the first section, into a second section of the distillation zone downstream and adjacent the first section, against an atomized oil spray, which completely blankets the path of vapor flow, maintained at substantially the same temperature or more preferably slightly above that of the vapors contacted therewith. The atomized liquid oil droplets are ejected from the spray nozzles under conditions affording each of them at least as great and preferably a greater momentum than that of each of the liquid particles also referred to herein as droplets, entrained in the vapor. In this manner the sprayed droplets impinge against the entrained droplets, and cause the impinged droplets to settle with the impinging or sprayed droplets to the bottom of the second section. It is to be understood, however, that in the practice of this embodiment, the momentum of the sprayed

material need not be equal to that of the entrained materials, as long as settling of impinged and impinging materials is effected prior to condensing the said vapors, and also, that the spray may be emitted in any predetermined direction as desired, i.e., transverse to vapor flow, concurrent therewith, or countercurrent thereto. Also, if desired, spray temperature may be below that of vapors contacted therewith, so that some condensation will take place and condensate thus provided can settle from the vapors with entrainment.

Vapors, having been contacted with the spray droplets under the conditions described, are free of entrained liquid and are passed from the second section into a third section of the distillation zone downstream from the second section and adjacent to it, against a relatively cool second oil spray, maintained at a temperature lower than that of the vapors contacted therewith, so as to condense at least a portion of those vapors as for example a temperature of from 3 to 500° F. below that of the contacted vapors. Condensate thus formed settles in the bottom of the third section. Settled condensate is recovered from the third section as clean distillation product. Similarly, the process is continued in as many additional downstream sections as desired, and any uncondensed portions of original charge are removed from the final section of the distillation zone as vapors.

The settled liquid, i.e., the pitch residue, in the first section is then withdrawn and is introduced at its existing temperature, i.e., with or without supplemental heating, into communication with a section of the distillation zone downstream from the first section, either into such a section or into a vacuum flash vessel directly in communication with such a downstream section. In either case the withdrawn residual liquid is further flash vaporized by virtue of the fact that the upstream or first section of the distillation zone operates inherently at a higher pressure than any downstream section therein, because of the presence in the first section of a larger proportion of the total vapors in the distillation zone, and accordingly, a pressure drop is developed across the entire distillation zone which is generally within the limits of from about 2–15 mm. Hg absolute, sometime being as high as 15–20 mm. Hg absolute, dependent upon the specific operation.

I prefer to carry out this embodiment of my process by introducing the withdrawn residual liquid into a section of the distillation zone downstream from the initial flash section. However, the residual pitch can be passed from the first or flash section directly to a second distillation zone generally a flash vaporization vessel maintained in direct communication with a downstream portion of the initial distillation zone. As in the preceding described embodiment, the pressure in the second distillation zone is inherently lower than that in the first or flash section of the initial distillation zone.

In the copending application Serial No. 188,604, to V. C. Cavin, W. H. Acker, and P. M. Waddill, filed October 5, 1950, now abandoned, and in the co-pending application Serial No. 343,560, filed March 20, 1953, now U.S. Patent No. 2,805,981, as a continuation-in-part of the said Serial No. 188,604, of which I am one of the inventors, a vacuum distillation process is disclosed in which the initial oil charge is partially flash vaporized and vapors are freed of entrained droplets in a second section, and then partially or completely condensed in one or more of a series of downstream zones in a manner similar to that already described above. In the process of each of these applications referred to, i.e., Serial Numbers 188,604 and 343,560, pitch residue is recovered from the first or second section as product, or can be further heated and then vacuum distilled in a separate vacuum distillation zone at a lower pressure by means of supplemental heating and vacuum producing means, separate and apart from that employed in the first distillation zone, to provide a final reduced pitch product of high softening point. As stated above, I have by one concept of this invention taken advantage of the inherent pressure drop across the vacuum distillation zone so as to further flash distill the initial residual pitch residue in the same distillation system without the need for heating or applied vacuum, other than that utilized in the initial flash distillation step.

I have provided further for conducting the flash vaporization, both in the initial flash vaporization step and in the succeeding flash vaporization step, at a temperature lower than that utilized heretofore while maintaining the pressure substantially unchanged by dispersing the feed in a finely divided state so as to charge liquid feed particles having extremely small radii of curvature. When operating in this manner flash vaporization is facilitated at a lower temperature and vapors having a density many times greater than otherwise formed are obtained, the latter resulting in decreased vapor velocities. The concomitant lower distillation temperatures eliminate the necessity for superheating the feed to attain the requisite vaporization.

For a further clarification of my invention, reference is made to the attached diagrammatic drawings. Figures 1 and 2 are diagrammatic flow sheets illustrating various concepts of process and apparatus employed in the practice of my invention. Figure 3 shows an elevation of a baffle section that can be employed in the vacuum chamber illustrated in each of Figures 1 and 2, taken along the line 3—3 of Figure 1. Figure 4 is a side elevation of the baffle structure of Figure 3 taken along the line 4—4 of Figure 3. Figure 5 is a plan view of the baffle structure of Figure 3, taken along the line 5—5 of Figure 3. Figure 6 is a cross sectional view of a preferred arrangement of sprays, employed in the apparatus of Figures 1 and 2, and is taken along the line 6—6 of Figure 1. Figure 7 is a cross sectional view of an alternative form of section III in the apparatus of Figure 1. Figure 8 is illustrative of a baffle section employed in section III of the apparatus of Figure 1, alternative to the guard assembly comprising vessel 79, to prevent flow of any entrained liquid droplets into the vacuum producing system 28. Figure 9 is a plan view of the baffle section of Figure 8 taken along the line 9—9 of Figure 8. Figure 10 is a cross sectional view of a bellows-type expansion joint for use in the hot oil lines of the apparatus of Figures 1 and 2. Figure 11 is illustrative of other concepts of my invention in which Figures 11A, 11B and 11C show process and apparatus for carrying out the vacuum distillation of a distillable material without the need for contacting vapors, from flashing, with sprayed atomized droplets to remove entrainment therefrom prior to condensation of any vapor, i.e., specifically illustrating maintaining sufficient vapor residence time so that a portion or all entrainment can settle from the vapors prior to the said condensation; and also, contacting the entrainment-containing vapor with relatively cool spray so that a portion of the vapor is condensed and entrainment is concomitantly settled therefrom together with resulting condensate. Figures 11A, 11B and 11C together are illustrative of another concept of multiple stage reduction of this invention, i.e., distilling a distillable material in one or both vessels (11A or 11B), of a first-stage reduction and then subjecting first-stage residuum product to further reduction in a second stage (vessel 11C). Figure 11D is illustrative of a series of steps comprising visbreaking, recycle cracking, and a final reduction, particularly applicable to further processing of residual second-stage product of the 2-stage reduction of Figures 11A, 11B and 11C. Figure 11, inclusive of Figures 11A, B, C, and D, is thus illustrative of a combination of process and apparatus for preparing a hydrocarbon oil feed and subjecting same to vacuum reduction in a plurality of separate stages, and for further processing resulting residual product in a series of visbreaking, recycle cracking and vacuum reduction steps to produce a final high melting residuum pitch product,

together with light hydrocarbon product, particularly hydrocarbons boiling in the gasoline range. The baffle sections, i.e., adapted to deflect liquid particles entrained in vapors passed therethrough, illustrated with reference to Figures 3, 4, 5, 8 and 9 are illustrative of those that can also be employed in conjunction with apparatus of Figures 11A, 11B, 11C, and 12 and 13 discussed hereinafter. The illustrated forms of section III of Figure 1, as illustrated in Figures 1 and 7 are also illustrative of spray, dam means, and the like employed in the central chamber sections of Figures 11B and 11C. Figure 12 is illustrative of still another form of central chamber section (such as section III of Figure 1, section III*b* of Figure 11B and section III*c* of Figure 11C) that can be employed. This latter arrangement of sprays provides for concurrent flow contact of vapors with condensing spray, thereby providing for improved low pressure drop across the distillation chamber at high vacuum. Figure 13 illustrates a distillation chamber and its operation, in which entrainment in vapors from flashing is removed at least in part, by settling, and resulting vapors are condensed in concurrent flow contact with condensing sprays; the latter is also illustrated by Figure 12. Figure 13 is illustrative of one form of apparatus and process employing the spray nozzle assembly of Figure 12, as applied to a third stage reduction of a hydrocarbon oil.

Although the illustrated embodiments of my invention refer to the vacuum distillation of a residual hydrocarbon oil, it is to be understood that my invention is not limited to the distillation of such oil but is applicable to the distillation of any distillable material such as for example vegetable, animal and mineral oils, distillable organic and inorganic chemical mixtures or solutions and juices; such as in low-temperature flash distillation of water from fruit and vegetable juices as, e.g., in the concentration of orange or other citrus juices by flashing water therefrom. It is to be understood that these drawings are diagrammatic and may be altered in many respects by those skilled in the art and yet remain within the intended scope of my invention.

Referring to Figure 1, a residual hydrocarbon oil is admitted from lines **10** and **11** directly into feed accumulator **12** for charging to the distillation system.

In one embodiment, virgin petroleum crude is admitted from line **10** into crude topping tower **13**, wherein a lighter crude oil fraction comprising light and heavy gas oils, gasoline, and a residual fraction are separated, the former being withdrawn from tower **13** through line **14** and the latter through line **16**. Virgin topped crude in line **16** is passed to feed accumulator **12** via line **11**, or preferably passed to topped crude cracking system **17** via line **18**. Oil residuum cracking product is withdrawn from cracking system **17** through line **19** and is charged to feed accumulator **12** via line **11**. Other cracking product in cracking system **17**, is withdrawn via line **15**. Accumulator **12** is maintained at about atmospheric pressure and any vapors to be vented are discharged through line **21**. Steam can be admitted to accumulator **12** through line **22** to strip out any traces of light ends and thereby reduce the load on the vacuum producing means in the distillation step to be described hereafter.

Oil charge stock such as a reduced crude, fuel oil, cracking still residue, cylinder stock, cracked topped crude or the like, as for example a residuum from topped crude cracking having a gravity within the limits of −5 to 5° API and a viscosity at 210° F. generally above 20 SFS, is withdrawn from accumulator **12** through line **23** and is passed into feed heater **24**, where it is heated to a predetermined temperature generally suitable for vacuum distillation of same described hereinafter, such as within the limits of from 600–900° F. under a pressure generally approximately atmospheric and not exceeding about 100 p.s.i.g. The heated oil is discharged from heater **24** through line **26** into vacuum distillation chamber **27**, the structural details of which are further described hereafter.

Vacuum chamber **27**, in a preferred embodiment, is horizontally disposed, and is heavily insulated by external insulation means **9** and is maintained at an absolute pressure preferably not exceeding 21 mm. Hg absolute, and often within the limits of 0.01 to 18 mm. Hg. The distillation pressure in chamber **27** is maintained by any desired vacuum producing means maintained in communication with the interior of chamber **27** at a downstream point described hereafter, such as a system of steam jets **28**.

Liquid charge from line **26** is introduced into flash vaporization section I of chamber **27** from an open-end pipe or as a spray in any desired direction, or preferably as a spray through spray assembly **29** comprised of one or more spray nozzles, in a direction toward a liquid coalescing screen such as a wire mat **31**, intermediate spray assembly **29** and the upstream end of closure **30**, under sufficient momentum to carry the unvaporized feed droplets into the porous matted area which is of such depth that liquid is arrested therein and allowed to flow out of the matted formation by gravity. Wire mat **31** is preferably supported in the end portion **30** by support means **35**. In this manner, charge emitted toward mat **31** from spray nozzle system **29** is caused to suddenly reverse its direction of flow, and separation of unvaporized portions from the vaporized portion is thereby greatly accelerated, and sprayed droplets not vaporized coalesce on mat **31** with a minimum of splashing, thereby lessening the amount of liquid entrained in vapors in section I. Discharge of the oil feed spray in section I in this manner also causes unvaporized droplets to flow against the flow of hot vapors which facilitates further vaporization of those liquid charge droplets, thus further providing for a decreased yield in residual unvaporized charge, and for increasing the yield of clean light oil distillates.

Removal of entrained unvaporized material from the vapors is also facilitated by the impingement of the sprayed feed upon the entrained material. Important factors in the introduction of the feed appear to be (1) the distance of the sprays from the wire mat or other such surface contacted, (2) the velocity of the liquid droplets with respect to the velocity of the vapors and the entrained material therein and (3) the diameter of the sprayed droplets. The distance of the sprays from the wire mat is critical in that the time allowed for effecting the desired vaporization is not sufficient to permit the atomized droplets to be reversed and to be re-entrained. The velocity is closely related to this distance for the same reason. Smaller diameter particles will afford a greater area and a shorter path for diffusion of the vapors or gases from the liquid droplets. Variation of one or more of these factors is utilized to obtain the best results in the operation of this system.

A portion of the unvaporized material in section I settles therein as liquid product. The portion of unvaporized material not settled as residual pitch in section I is entrained in a highly dispersed state in the vapors therein, appearing generally as a mist or a fog. Vapors from section I passed downstream from spray nozzle means **29**, contain these entrained droplets which must be removed in order to produce clean, low carbon residue distillates. This is done by passing the vapors downstream in distillation zone **27** from section I into adjacent section II through perforate or baffle section **32** and against the flow of an oil spray in section II from spray nozzles **34**. Perforate section **32**, with dam **33** described hereafter, transversely closes shell **8**. Section **32** comprises a plurality of openings disposed in at least two separate planes, each said plane extending in a longitudinal direction and preferably parallel with the other. Such openings in each plane are disposed from the openings in an adjacent plane, to provide as high as a 90 percent

opening between sections I and II and to provide further a circuitous path for vapor flow therethrough. Section 32 in a preferred embodiment, comprises a system of angle members as illustrated and described with respect to the drawings hereafter. The requisite structure of section 32 is such that vapors can be passed through it and oil spray impinging upon it will not pass through it. Pressure drop across baffle 32 is a fraction of a mm. Hg, generally less than about 0.5 mm. and often as low as 0.05 mm. The structure of baffle sections 42, 77 and 63, described hereafter, are similar to or can be the same as that of section 32.

Spray nozzle assembly 34 in section II is disposed so as to deliver oil spray in a direction toward perforate section 32. Atomized droplets of oil are delivered from spray nozzles 34 at a momentum higher than that of the entrained liquid droplets in the vapors contacted therewith and impinge against those entrained droplets whereby the atomized droplets and impinged droplets are caused to settle from the vapors as liquid in section II. The operation of the sprays 34 in section II is critical in obtaining the desired results. It involves the problem of properly controlling the relative momentum of the feed vapors and the sprayed liquid droplets. In section II the liquid droplets being sprayed against the direction of vapor flow impinge upon entrained droplets in the vapor stream. When this impingement occurs there is an exchange of momentum. If the sprayed droplets have the greater momentum the direction of flow of the entrained droplets will be reversed; if the momentums of the two droplets are equal the resulting momentum will be zero and the combined droplets will tend to fall to the bottom of the vessel. If, however, the entrained droplets have the greater momentum, the direction of flow of the sprayed droplets will be reversed with a resulting increase in entrainment. The ratio of the momentum of the blanket of spray to the momentum of the vapor stream, including the entrained mist contained therein is at least 1:1. This ratio may be between 1:1 and 125:1, but is preferably at least 3:1.

The temperature of the oil spray from spray nozzles 34 is maintained at a level very nearly the same as that of vapors contacted therewith. It is important that these spray temperatures be at least as high as the vapor temperatures, for oil spray temperatures lower than the vapors contacted cause some condensation of vapors not preferred in this embodiment of my invention. In most cases in order to obtain maximum efficiency it will be necessary to keep the temperature of the oil spray from nozzles 34 above that of the entering vapors to offset heat losses by radiation and thereby prevent condensation in section II. However, in some instances for special purposes it may be desirable to effect some condensation in section II in which case the spray temperature is adjusted accordingly. In sections in which partial condensation takes place, it is preferred to maintain the initial momentum of the sprayed droplets sufficiently high that even after absorbing momentum, through condensation of some of the vapors traveling in the opposite direction, the resulting momentum will still be at least as great or greater than that of the vapors or any liquid droplets entrained therein, otherwise excessive entrainment of condensate will occur. Oil charge to spray nozzles 34 is provided by withdrawing a portion of the settled liquid from the bottom of section II and recycling same to spray nozzle system 34. Total liquid is withdrawn through line 36 via pump 37, and line 41. Settled liquid from section II, for recycle to spray nozzle system 34, is passed from pump 37 to spray system 34 via line 38 and heater 39, generally a steam heater. Oil in heater 39 is heated to a temperature generally of from about 15 to 30° F. above that of the vapors passed through perforate section 32. Material passed through line 41 is substantially the same material as settled liquid in section I. If the temperature of oil from spray nozzles 34 is lower than that of vapors passed through section 32, some condensate may be formed and collected with residual pitch product in section II. In such instances it is sometimes advantageous to recycle liquid from line 41 to section I via line 40, accumulator 12, heater 24, and line 26. When liquid from line 41 is the same as that described hereafter as settled in section I, these two streams can be combined for further treatment to be described.

Vapors passed downstream in section II from spray nozzles 34 are free of entrained liquid and comprise vapor fractions of clean gas oils to be recovered as described hereafter. These vapors are passed from section II into adjacent and downstream section III through perforate section 42 against a flow of atomized oil sprayed from spray nozzles 44. Spray nozzle assembly 44 is disposed in section III so as to deliver oil spray in a direction toward perforate section 42, and is preferably the same in design as system 34, described in more detail hereafter. Perforate section 42 with dam ring 43 transversely closes vessel 27 at a point intermediate nozzle assemblies 44 and 34. Oil from spray nozzles 44 is maintained at a temperature lower than the temperature of vapors being passed from section II through perforate section 42 so as to cause substantially total condensation of those vapors upon contact therewith. The temperature of oil emitted from spray nozzles 44 is dependent on the specific distillation conditions employed, but is generally with the limits of 3 and 500° F. lower than that of the vapors contacted therewith. The momentum of the atomized oil droplets ejected from spray nozzles 44 is maintained greater than that of the vapors contacted therewith, whereby the atomized droplets with condensate thereon and impinged entrained droplets are caused to settle and to accumulate in the bottom of section III. Total condensate collected in the bottom of section III including that described hereafter, is withdrawn through oil outlet 46 via pump 47, and in part through lines 48 and 49, and in remaining part as required in spray nozzle assembly 44, and 51 described hereafter, through cooler 52, line 53 and header 54. Oil in cooler 52 is cooled to the necessary temperature lower than that of vapors passed through perforate section 42 sufficiently to provide for total condensation as described. Condensate withdrawn through line 49 is a distillate product of the process.

As described hereinabove, the operating pressure in section I is higher than that in any other section in vacuum chamber 27 for reason that most of the vapors present in chamber 27 are in section I. Consequently a gradual pressure drop is effected and each section downstream from section I operates at a lower pressure than the preceding or upstream section. In this specific embodiment illustrated, section III is in direct communication with evacuation means 28 and is under the lowermost operating pressure in the chamber. Sections IV and V are each at a lower pressure than that of section I. Settled residual pitch product from section I is withdrawn through line 56 either alone or combined with liquid from line 41 and is discharged through pump 57 and line 58 into section V which is the opposite most section in chamber 27, and operating at a pressure lower than that of section I. Liquid from line 58 is introduced into section V, which serves in this embodiment as a second flash vaporization section, as a spray through spray nozzle system 59, similar in design to spray system 29, in a direction toward (an upstream direction with respect to the path of flow), a wire mat, or coalescing means 62 similar in structure to wire mat means 31. Wire mat 62 is preferably supported in end closure 61 of chamber 27. Liquid charge admitted into section V is caused to suddenly reverse its direction of flow so as to minimize the amount of entrained liquid in vapors in section V in the same manner as carried out with respect to the charging operation in section I. A portion of the material in section V is unvaporized and settles therein as liquid and comprises a higher softening point pitch product than that

settled in section I. In this embodiment, this step may be effected without supplemental heating and while utilizing the inherent pressure drop through chamber 27 without the need for any supplemental pressure reducing means. Operating pressure in section V is often a fraction of a mm. Hg pressure and is as much as 10–15 mm. Hg absolute lower than that in section I, thereby effecting a substantial and significant flash vaporization to produce a higher softening point pitch in proportionately reduced yield together with an increased yield of desirable clean gas oil, the latter being suitable as charge stock to various hydrocarbon conversion process steps. The portion of unvaporized material not settled as liquid in section V is entrained in the vapors therein in a highly dispersed state, which vapors are passed from section V downstream into section IV through perforate section 63 of design similar to that of perforate sections 32 and 42, and against the flow of an oil spray in section IV from spray nozzle system 66, of design similar to that of nozzle system 34, and disposed to direct liquid spray toward section 63. Spray from nozzles 66 comprises atomized oil droplets having a momentum higher than that of entrained liquid droplets in contact therewith and impinge those entrained droplets whereby the atomized droplets and impinged droplets are caused to settle in section IV. The operation of sprays in section IV is the same as that described with respect to the operation of spray system 34 in section II. Accordingly the temperature of oil spray from spray nozzles 66 is maintained at a level very nearly the same as that of the vapors contacted therewith and preferably is at a temperature of from 15 to 30° F. higher than the vapors contacted therewith. Settled liquid in section IV is under some conditions of operation the same as settled liquid in section V and comprises pitch of increased softening point, i.e., relative to pitch product of section I. Settled liquid is withdrawn from section IV through line 67 via pump 68, in part returned as feed to oil spray system 66 via line 69, heater 71 and line 72. Oil in heater 71 is heated to the requisite temperature described above. Remaining liquid from pump 68 is discharged through line 73 either as separate product via line 70, or combined with residual oil withdrawn from section V via pump 74 and line 76 or recycled to section V via line 58. Residual pitch withdrawn from section V and discharged through line 76, comprises the high softening point pitch product of my process. Vapors in section IV, passed downstream from spray nozzles 66, are free of entrained liquid and comprise vaporous fractions of clean gas oils to be passed into section III and are totally condensed in section III. These vapors are passed from section IV downstream through perforate section 77 similar in design to perforate sections 32, 42, and 63, against a flow of atomized oil sprayed from nozzles 51 in section III, intermediate spray system 44 and perforate section 77, and adapted to direct liquid spray in a direction toward section 77. Oil droplets from spray nozzles 51, maintained at a temperature sufficiently lower than that of vapors to be contacted therewith have a momentum sufficiently high such that even after absorbing momentum from the vapors contacted the resulting momentum will still be at least as great or greater than the vapors or any liquid droplets entrained therein. Such droplets of entrained condensate are then removed by impingement of the sprayed droplets thereon, and total condensate formed settled in the bottom of section III and is withdrawn from section III together with other condensate formed as described above, through line 46, and comprising a portion of the distillate product of the process.

Although substantially total condensation is effected in section III, scrubbing means 79 is positioned intermediate vacuum pump 28 and section III in order to prevent delivery of any condensate particles directly to the vacuum pump, thereby maintaining the efficiency of the evacuation system at the desired level. Scrubbing system 79 comprises any conventional scrubbing means employing a scrubbing liquid, as for example a heavy hydrocarbon oil flowing in counter-current contact relation with the vapors to be scrubbed. Fresh absorption oil, for example, can be introduced into zone 79 through line 81 and withdrawn through line 82 via pump 83 and recirculated via line 81, or via line 80 and cooler 85. Oil can be withdrawn from the system via line 84, if desired. Vacuum producing means 28, e.g. a steam jet, communicates with section III via line 90, scrubber 79, and vacuum line 75.

With reference to Figure 1, I have illustrated one embodiment of my invention whereby the residual flash vaporization pitch product formed initially in chamber 27 can be flash vaporized in the same system without the need for supplemental heating or additional applied vacuum. It is by virtue of the inherent pressure drop through chamber 27, developed as I have described, by means of which this feature of my invention is made possible.

Another embodiment of my invention is illustrated with reference to Figure 2 wherein the residual pitch distillation product is withdrawn from the initial flash vaporization section and further flash vaporized in a flash vaporization zone external to the zone of the initial flash vaporization. In this embodiment the external or secondary flash vaporization step is maintained in direct communication with a downstream section of the initial distillation zone and is thereby maintained at a pressure lower than that of the initial flash vaporization. Referring to Figure 2, residual hydrocarbon feed from line 26 is introduced into flash section I′ of a horizontally disposed chamber 27′ through spray nozzle assembly 29′, similar in design to nozzle assembly 29 of Figure 1 and adapted to direct liquid spray in a direction towards coalescing means 31′. Pressure conditions in chamber 27′ are similar to those maintained in vacuum distillation chamber 27.

As described with reference to the embodiment of Figure 1, a portion of the charge is vaporized in section I′. A major proportion of the unvaporized material settles in section I′ and comprises a high softening point residual pitch product. The portion of unvaporized material not settled in section I′ is passed entrained as droplets in vapors from section I′ into adjacent section II′, through perforate section 32′ similar in design to section 32 of Figure 1, against the flow of oil spray in section II′ from spray nozzles 34′. Spray nozzles 34′, which can be the same as those of nozzle system 34, are adapted to direct spray in a direction toward section 32′. The operation in section II′ of chamber 27′ is the same as that described above with reference to chamber 27 in section II with respect to spray temperture, momentum of the atomized droplets, and settling of entrained liquid. Settled liquid in section II′ is withdrawn through line 91 via pump 92 and passed in part via heater 39 to spray nozzles 34′ and, in remaining part is withdrawn from the system through line 41. When the temperature of oil spray in section II′ is very nearly the same or not more than 30° F. higher than that of vapors contacted therewith, settled liquid in line 41 is very nearly the same as that in section I′ and can be combined with the latter if desired for use in a manner as described hereafter. Vapors passed downstream in section II′ from spray nozzles 34′ are free of entrained liquid and comprise vaporous gas oil fractions. These vapors are passed from section II′ into adjacent and downstream section III′ through perforate section 42′ against a flow of atomized oil sprayed in section III′ from spray nozzles 44′, adapted to direct oil spray toward section 42′. Perforate section 42′ is similar in design to section 42 of Figure 1. Oil spray from nozzles 44′ is maintained at a temperature lower than the temperature of vapors passed from section II′ through perforate section 42′, preferably from 5 to 75° F. lower so as to cool and condense a portion of those vapors. The condensate is formed in section III′

as described above with respect to the formation of condensate in section III in chamber **27**. Condensate is withdrawn from section III' through line **46** via pump **47** and passed in part to spray system **44'** through cooler **52**, wherein it is cooled to the oil spray temperature required in section III', and in remaining part is discharged through line **49**. Uncondensed vapors free of entrained liquid are passed from section III' into adjacent section IV' through perforate section **93** similar in design to perforate section **42'** and section **32'**, against a flow of oil spray emitted from spray nozzles **96** adapted to direct liquid spray against section **93**, and to also disperse it in other directions throughout section IV'. It is desired that in section IV' the maximum condensation be effected, i.e., the condensation of all remaining condensable vapors. It is important that a sufficient amount of oil spray be discharged from spray nozzles **96** at a desired low temperature to complete the condensation of all remaining condensable vapors in contact therewith. It is often advantageous that the temperature of the oil spray from spray nozzles **96** be as low as 100° F. Total condensate formed in section IV' is withdrawn through line **97** via pump **98** and recycled in part via cooler **99** to spray nozzles **96**, and passed in remaining part through line **101**. If desired, total condensation in section IV' can be effected under these temperature conditions by positioning baffle section **93** downstream from spray nozzles **96**, and then directing oil from nozzles **96**, only toward baffle **93** downstream therefrom (and also toward conduit **112** as shown). In such a case, total condensate is collected upstream from baffle section **93** employing a dam in vessel **27'** to prevent flow of total condensate thus formed into section III'.

Settled liquid from section I' is withdrawn through line **102** via pump **103** and lines **104** and **105** to secondary reduction chamber **106**. Residual liquid discharged from pump **103** is passed alone or in admixture as desired with liquid from line **41** introduced into line **104** through line **107**. When desired, any portion of liquid in line **104** can be withdrawn from the system directly through line **108**. Secondary vacuum chamber **106** is maintained in direct communication via line **109** with the interior of at least one downstream section of distillation chamber **27'**. In this manner, these latter sections in chamber **27'** operating under higher vacuum than that employed in section I' inherently provide for a vacuum in chamber **106** higher than that in section I' of chamber **27'**. Accordingly, settled liquid from section I' passed into chamber **106**, is further flash vaporized therein without the need of supplemental pressure reduction and without further heating, to provide further yields of gas oil fractions, and higher softening point pitch in correspondingly lower yield. Vapors formed in chamber **106** are discharged therefrom via line **109** into at least one of sections II', III' or IV' through lines **110**, **111** or **112** respectively. Whether or not vapors are discharged into all three sections or one selected section is dependent on the particular operating conditions employed in chamber **27'** which in turn affects the operating pressure in chamber **106**, and the composition of vapors discharged through line **109**. Generally the composition of distillate from chamber **106** (in line **109**) is the determining factor, such vaporous distillate being returned into that section of chamber **27'** containing settled liquid most nearly the same in composition thereto. In any case vapors passed into either sections II', III' or IV' are contacted with oil spray emitted from one or more nozzles **34'**, **44'** or **96'**, respectively, as the case may be, under conditions providing the same spray-vapor contacting already in progress in that section. Residual pitch product of high softening point is withdrawn as a product of the process from chamber **106** through line **113**.

In this embodiment vacuum reducing means **28** is in direct communication with section IV' of chamber **27'**, section IV' being the downstream-most portion and operating at the lowest pressure in chamber **27'**.

A preferred form of the perforate baffle sections **32**, **42**, **77**, and **63** of Figure 1 and **32'**, **42'** and **93** of Figure 2, is illustrated with reference to Figures 3, 4, and 5. As illustrated in these figures baffle section **42** comprises a plurality of parallel courses of angle irons, each said course substantially closing said chamber, angle irons in each of these said courses facing a common direction transversely across said chamber, and each angle in each course having its vertex positioned within the sides of the adjacent and preceding angle. Dam ring **43** (Figures 4 and 5) serves as a partial support for the angle iron baffle section **42** and also to prevent channeling of vapors from section II to section III, i.e., thereby causing vapor to pass only through the circuitous path provided by baffle assembly **42**. Seal rings **121** in conjunction with fastening means **122** provide for further supporting baffle section **42**. Figure 4, shows baffle section **42** to consist of two courses of angle irons each transversely crossing chamber **27**, and Figure 5 shows the relative position of angles in each course making up the baffle section **42**. As illustrated in Figure 5, the angle irons in all courses face a common direction transversely across the chamber **27**, and each angle in each course has its vertex positioned within the sides of the adjacent and preceding angle. Preferably, the sides of the angles in each course are parallel with the corresponding sides of the angles in the adjacent course. Dam rings **33**, **78** and **60** of Figure 1, and **33'**, **43'** and **94** of Figure 2, are preferably the same as dam ring **43** specifically illustrated in Figure 5.

Figure 6 is illustrative of one system of spray nozzles utilized in the practice of my invention. Figure 6, shows a portion of the spray nozzle assembly **34** in Figure 1 by means of which the oil spray is dispersed uniformly against the flow of vapors passing against it from baffle section **32**. It is to be understood that this invention is not limited to the particular spray system illustrated, the requisite being a spray assembly capable of spraying the spray in each section in a manner so as to uniformly distribute liquid through the vapors contacted therewith and to completely blanket the path of the vapors. It is advantageous that each spray nozzle system illustrated in either chambers **27** or **27'** be spaced away from the respective baffle section or wire mat, with which it is associated so that it is at a distance from the plane of the face of the baffle or mat of from 0 to 2 feet, but preferably less than 1 foot. Although two banks of spray nozzles are shown in each location, it should be understood that one bank may be used or more than two, if desired.

Figure 7 illustrates an alternate form of section III in chamber **27**. In this embodiment dam **50** is positioned so as to maintain the condensate formed as a result of contacting vapors passed through baffle section **42** with sprayed oil from spray assembly **44**, separate from condensate formed by contacting vapors passed through baffle section **77** with oil spray from nozzle assembly **51**. As illustrated in Figure 7 separate distillates are withdrawn through lines **46*a*** and **46*b***. In this embodiment separate oil streams are fed to the respective oil spray systems. Oil charged through spray assembly **51** is withdrawn from section III through line **46*a***, via pump **47*a***, and line **48*a***, and returned to sprays **51** via cooler **52*a***, and line **53*a***. Similarly, oil charged through spray assembly **44** is withdrawn from section III through line **46*b*** via pump **47*b***, and line **43*b***, and returned to sprays **44** via cooler **52*b*** and line **53*b***. Condensate product is withdrawn from line **46*a*** via line **49*a***, and through **46*b*** via line **49*b***.

Figure 8 is illustrative of a baffle means alternate to guard chamber means **79** of Figure 1, for preventing the escape of any entrained liquid droplets from section III into the vacuum producing means **28**. As shown in Figure 8, guard chamber or baffle section **130** is an assembly of angle irons disposed in two separate courses (see also the plan view of Figure 9) disposed so as to

provide a circuitous path therethrough. In this respect the baffle section 130 is similar in design to the baffle sections of chamber 27 and 27' described in detail with reference to Figures 3, 4, and 5, above. Vapor outlet 131 is disposed in the side of guard assembly 130 in gas tight communication with vacuum producing means 28. Liquid outlet 132 is provided in the bottom of baffle section 130. In the operation of this embodiment, uncondensed vapors in section III before reaching vacuum producing means 28 are forced to pass through the baffle section 130, thereby causing the vapors to follow a circuitous path so as to "knock out" any entrained droplets. Any liquid thus separated, is collected in the bottom of the section 130 for withdrawal through conduit 132. Baffle assembly 130 is preferably located centrally in section III. Figure 9 is a plan view (see line 9—9 of Figure 8) showing a preferred arrangement and design of the baffles in section 130.

As is the case in operating many petroleum processes, it is important in the practice of the present invention to provide means for compensating against expansion and contraction of lines carrying hot oil streams under high vacuum. Such a compensating means is the expansion joint assembly illustrated in detail with reference to Figure 10, wherein expansion joint assembly 140 is a bellows-type expansion joint comprising sealed diaphragm 141 disposed in the hot oil line 142, line 142 being exemplary of any line in the process system illustrated in Figures 1, 2, 11A, 11B or 11C, carrying hot oil under high vacuum such as lines 56, 36, 46, 67 and others, in Figure 1, and lines 102, 91, 46, and others in Figure 2. Diaphragm 141 contains concentric support ring 143 mounted internally to prevent collapse of the diaphragm 141 due to an increase in vacuum within the piping system. Support ring 143 is adapted to prevent collapse of diaphragm 141 due to the force of atmospheric pressure, without interfering with the ability of the diaphragm to absorb expansion.

I generally prefer to maintain the momentum of the sprayed droplets in each of the sections of the distillation zone sufficiently higher than that of the entrained droplets contacted therewith, so that the sprayed droplets carry on through and impinge upon the aforesaid baffle section, as for example, sprayed droplets from spray system 34 against the baffle section 32; however, when substantially total condensation is effected, the relative momentum of the sprayed droplets and the entrained droplets is not of primary importance. In this manner the function of the baffle section is to coalesce the spray, carrying with it the coalesced entrainment, i.e. droplets entrained in the vapors contacted with the spray, causing the coalesced materials to drain to the bottom of the baffle section. It appears that it is the surface tension of the oil on the surface of the baffle section that prevents re-entrainment of liquid into the high velocity vapor stream.

In another embodiment of my invention, a portion of settled liquid from section I is returned into section I as a spray 29*b* directly behind spray system 29, and sprayed droplets from spray 29, and from the said returned spray system 29*b* in section I, are sprayed toward wire mat coalescing means 31. In this manner, unvaporized feed portions entrained in vapors in section I formed as a result of the initial flash vaporization of feed ejected from spray system 29, are impinged with additional sprayed droplets under conditions of momentum already described, so as to cause all such entrainment to settle in section I. If desired, total vapor from section I, free from entrained liquid, can be condensed, thereby eliminating the need for baffle section 32, partition 33 and spray assembly 34, providing for a still lower pressure drop across chamber 27. Such operation is well applied at generally lower flow rates, or when other operating conditions are employed which reduce the severity of initial entrainment. In the present embodiment, however, the temperature of liquid droplets sprayed from system 34 in section II (Figure 1), is maintained slightly lower than that of vapors contacted therewith, so as to cause partial condensation of vapors passed through baffle section 32 and settling of same in section II, and thereby for recovery of an additional distillate product fraction. Similarly, settled liquid from section V of Figure 1, and from section I' of Figure 2 can be directed into these respective sections at a point positioned behind spray means 59 and 29' respectively to provide for settling in those sections of all entrained unvaporized feed portions, and for recovery of an additional distillate fraction in the respective downstream section, or, if desired, baffle sections 63 and 32' together with spray assemblies 66 and 34' respectively can be dispensed with.

The high softening point pitch product of my invention, particularly that withdrawn as settled liquid from section V of chamber 27 (Figure 1), and from secondary vacuum reduction chamber 106, through line 113 (Figure 2), is sufficiently devoid of vaporizable materials that it can be used in admixture with coal to produce a coal-coke of increased mechanical strength without substantial contamination of aromatic by-products of the coal coking process. It is also characterized as being very low in materials insoluble in carbon disulfide.

In one embodiment of my invention I have provided for conducting the flash vaporization steps of my process at temperatures lower than those utilized hereinbefore without the need for reducing the pressure proportionately. The practice of this embodiment is accomplished by charging the oil feed in a sufficiently high finely divided, or atomized state so that the liquid feed particles have an extremely small radius of curvature; the feed is atomized in the flash vaporization chamber so that the average radius of curvature of the liquid feed particles is less than 0.1 micron, preferably from 0.01 to 0.001 micron. In atomizing the feed particles in this manner, a larger amount of vaporization is effected than would be indicated by the normal vapor pressure curve, characteristic of that feed material, and an amount of vaporization is obtained at the operating pressure level of my process comparable to that obtained when charging feed droplets of larger radius of curvature at absolute pressure as low as about 20 microns. In this embodiment, at the operating pressure, vapors in equilibrium with the atomized feed droplets will have a density often as high as 1,000 times greater than that of vapors in equilibrium with larger radius droplets at pressure as low as about 20 microns absolute pressure. Also the vapor in equilibrium with the atomized feed droplets will be approximately 250° F. cooler than indicated by the normal vapor pressure curve. Atomizing the liquid feed in this embodiment eliminates the necessity for superheating the feed to obtain vaporization, and the concomitantly increased density of the vapors results in decreased vapor velocities; and it is possible to operate the vacuum chamber while obtaining the operating advantages generally possible only at much lower pressures, while at the same time preventing the high vapor velocities that are characteristic of normal operation.

With reference to Figure 11, a hydrocarbon oil, such as a virgin petroleum crude is introduced into preheat furnace 151 via line 150 together with steam introduced via line 153, and heated in preheater 151 to a predetermined temperature suitable for distillation described hereinafter, such as within the range of 600–900° F., and passed to vacuum steam stripper 152 together with steam from preheater 151, also heated to within the said temperature range.

In vacuum steam stripper 152 a gasoline stream is separated, and discharged via overhead line 154; a side cut of gas oil is separated, and withdrawn via line 156; and a bottom residuum product, generally containing some gas oil, is withdrawn via line 158. Residuum in line 158 at a temperature within the predetermined range is introduced into chamber I*a* of elongated distillation vessel 157,

preferably disposed substantially horizontal, under flashing conditions so as to vaporize a portion of the said residuum. Residuum from line **158** is preferably introduced into section I*a* in an upstream direction, i.e., toward end section **159** as a spray, from nozzle assembly **150***a*, against a liquid coalescing surface such as that provided by a wire mat **161**. Advantages of this method of feed introduction are set forth herein, with reference to Figures 1 and 2. However, feed from line **158** can be introduced into section I*a* from an open end pipe against a coalescing surface; or, in lieu of a coalescing surface, from an open end pipe or as a spray, in any desired direction. Vapors formed in section I*a* contain entrained liquid droplets or particles, comprising unvaporized portions of the residuum feed, which, if not removed from the vapors prior to condensation, will be present in the condensate as undesired impurities, as discussed hereinabove with reference to Figures 1 and 2. Vapors from section I*a* of chamber **157** are passed through baffle section **162**, which can be similar in design to baffle sections of Figures 1 and 2, further illustrated with reference to Figure 3, 4 and 5; transversely closing chamber **157** and supported by dam ring **163** and adapted to deflect liquid droplets present as entrainment in vapor passed therethrough. Dam ring **163** also provides for confining liquid product in section I*a*, i.e., prevents its passage into section II*a*. Dam ring **163** also prevents unvaporized liquid in section I*a*, adhering to the inner side wall of that chamber section and moving downstream, from passing into section II*a* to thus contaminate liquid product therein, and causes liquid contacting same to accumulate in section I*a*.

Vapors containing entrained droplets not deflected therefrom by baffle section **162** are passed against a flow of atomized droplets emitted from spray nozzle means **164**, the latter spray being maintained at a temperature lower than that of vapors contacted therewith so as to effect partial condensation of same and to concomitantly cause impingement of sprayed droplets with condensate droplets and entrained particles and settling of the resulting impinging and impinged droplets in section II*a*. Preferably the momentum of the atomized droplets emitted from spray **164** is at least equal to that of condensate droplets formed plus that of entrained particles contacted therewith, so that droplets of condensate and entrained particles are settled from vapors in section II*a* prior to the flow of vapors from section II*a*. However, if desired, the momentum of sprayed droplets from nozzle assembly **164** can be less than that of the entrained particles plus condensate droplets formed in section II*a*, when section II*a* is of sufficient length to permit settling of the impinged and impinging droplets prior to passage of the vapors therefrom into section III*a*. Vapors, free from entrainment are passed through baffle section **166** transversely closing chamber **157**, which can be similar in design to baffle section **162**, and are contacted in section III*a* with atomized liquid droplets emitted from spray nozzle assembly **167**, the latter at a temperature sufficiently below that of the vapors contacted therewith so as to effect substantially complete vapor condensation in section III*a*. Momentum conditions of the atomized droplets from spray assembly **167** are preferably such that impinging spray and impinged total condensate formed in section III*a* are caused to settle therein as liquid product. Vapors, free from entrained condensate are passed from section III*a* through baffle section **168**, transversely closing chamber **157**, and which can be similar in design to baffle **162**, baffle **168** serving as a deflector of any remaining liquid droplets in vapors passed therethrough. Any vapors, i.e. uncondensed in section III*a*, passed through baffle section **168** into section IV*a* are removed via internal guard chamber **169**, similar in design to baffle system **130** of Figure 8, in any event functioning as a deflector of any entrained particles that may be present in uncondensed vapors to be removed from section IV*a* via line **171** and steam jets **172**. Baffle system **169**, which can also be referred to as a liquid-vapor separator can comprise any suitable means such as an assembly of conventional "mist-extractor" baffles or the like.

During residence of vapors in section I*a*, some entrainment settles in the bottom thereof as product together with a major portion of the unvaporized liquid charge. Liquid product settled in section I*a*, comprises residuum product of the distillation in chamber **157** and is withdrawn from section I*a* via line **173**. Residuum product in line **173** can be recycled in part to section I*a* via line **174**, preheater **176** and line **158**, i.e., with fresh feed thereto, or directly from line **173** to line **150** for further preheating in **151** together with fresh feed. Residuum product can be withdrawn from the system via line **176***a* and can also be withdrawn via lines **173** and **177** for charging to a second stage vacuum reduction discussed hereinafter.

Condensate formed in section II*a* is withdrawn via line **178** and recycled in part via cooler **179** and line **181** as feed to spray nozzle assembly **164**, thereby providing liquid product from section II*a* as the source of liquid spray emitted from nozzle assembly **164**. The remaining portion of liquid product from section II*a* is withdrawn via lines **178** and **182**. Total condensate formed in section III*a* is withdrawn therefrom via line **183** and recycled in part via cooler **184** and line **186** to spray nozzle assembly **167** and emitted therefrom as the said spray. Thus, as in the case of section II*a*, the source of droplets emitted from spray **167** is total condensate recovered in section III*a*.

Although it is only a very minor amount of liquid and vapor that is passed from section III*a* into section IV*a*, if any at all, any such liquid collected in section IV*a* is withdrawn via line **186***a*.

When desired, the use of a spray in section II*a*, in chamber **157**, can be dispensed with, with the concomitant advantage of lowered pressure drop across the distillation chamber **157**. The separation of entrainment from vapors in section II*a* is generally not as complete when the said sprays are dispensed with, although some entrainment settles in section II*a*, such settling being facilitated by increasing proportionally the linear dimension of section II*a*. Also, a small amount of condensation generally occurs in section II*a*, in the absence of spray from nozzle assembly **164**, by radiation therein. Operating in this manner, the pressure drop across chamber **157** can be lowered, although, when not employing a liquid spray in section II*a*, some unsettled entrainment, i.e., particles of unvaporized feed, will be present in condensate recovered from section III*a*. Although the pressure drop lowering achieved in any specific instance is dependent upon the initial operating conditions, i.e., when employing a spray, a pressure drop lowering of up to 2 mm. Hg is often achieved when dispensing with the use of such spray.

Another fraction of hydrocarbon oil, such as petroleum crude, is introduced via line **191** into preheater **192**, wherein it is heated to a temperature in a predetermined distillation range as discussed with reference to preheating of oil from line **150**, and is then withdrawn via line **191***a* and passed into flash chamber **193**, wherein a gasoline fraction is separated, and withdrawn via overhead line **194**; a gas oil fraction is separated, and withdrawn via line **196**; and a residuum or bottoms fraction is separated, and is withdrawn via line **197**, and passed as charged to elongated vacuum distillation chamber **198**, preferably substantially horizontally disposed. A portion of charge from line **197** is introduced into chamber **198** via line **199** into end section I*b*, under flashing conditions that can be carried out as described relative to introduction of feed into section I*a* of chamber **157**, i.e. as a spray or from an open end pipe, in any desired direction, preferably upstream toward end section **201**, against

a coalescing surface such as wire mat **202**, the latter supported by support means **203** and adapted to be moved in a longitudinal direction in section *Ib*. A remaining portion of charge from line **197** is introduced into the opposite end section *I'b* under flashing conditions as described relative to introduction of feed into section *Ib*. A major proportion of the unvaporized charge in sections *Ib* and *I'b* settles in each section as liquid product. Vapors from section *Ib* containing entrained liquid particles are passed through baffle section **207** transversely closing chamber **198** and of design similar to that of baffle section **162** of chamber **157**, into central section *IIb* in contact therein with droplets of atomized spray emitted from nozzle means **208**. The temperature of droplets emitted from nozzles **208** is sufficiently lower than that of vapors contacted therewith so as to cause substantially complete condensation of the said vapors. The momentum of the atomized droplets is sufficiently high so as to cause impinging droplets and impinged droplets of condensate and particles of entrained unvaporized feed to settle as liquid product in central section *IIb*. However, if desired, the said momentum conditions may be dispensed with, it being important, in any case, that all the liquid droplets are settled in section *IIb* as product. Thus, in the event that the said momentum conditions are dispensed with, section *IIb* can advantageously be of sufficient length to permit the said settling of all liquid droplets therein.

Vapors formed in section *I'b* contain entrained particles of unvaporized feed and are passed through baffle section **209**, the latter transversely closing chamber **198** and of design similar to baffle section **207**, into section *IIb*, against a spray of atomized liquid droplets therein from spray nozzle assembly **211***a* under momentum and temperature conditions to cause substantially complete condensation of vapors contacted therewith and settling of same with entrained particles. If desired, the said momentum conditions of spray from nozzle assembly **211***a* can be dispensed with, it being important, in any event, that all condensate and entrainment be settled in section *IIb*. Vacuum is applied to the central section, i.e., section *IIb* of chamber **198** by any conventional means, as for example by steam jet means **211** connecting with section *IIb* via line **212**, external guard chamber **213**, and line **214**, the latter connecting with the interior of section *IIb* at a point intermediate spray nozzles **208** and **211***a*, through internal guard chamber **216**; the latter serving as a "mist-extractor" so as to deflect any unsettled liquid droplets from any vapors leaving section *IIb*, so as to prevent their flight to vacuum producing means **211**, such interference with vacuum means **211** seriously impairing its vacuum producing efficiency.

A preferred form of internal guard vessel **216** is illustrated in the drawings with reference to Figure 8, the latter specifically referring to its adaptation to apparatus of Figure 1, but being also illustrative of the preferred form of internal guard chamber in section *IIb* of chamber **198**. External guard chamber **213** comprises a spray and baffle means for condensing any residual vapors from line **214** and for arresting any liquid particles entrained therein. Liquid supplied to the spray system in external guard chamber **213** can be any heavy fraction of hydrocarbon oil, but is preferably liquid, originally withdrawn from section *IIb* and charged to chamber **213** via line **216***a*, withdrawn via line **217** and, when desired, recycled to line **216***a*, by means not specifically shown.

Liquid product in section *Ib* and *I'b* in chamber **198** comprises unvaporized liquid charge and contains any condensate, such as formed in either section by means of heat radiation, and also particles of unvaporized charge initially entrained in vapors therein but settled from those vapors during the flight of same through section *Ib* into the central chamber section *IIb*—or through section *I'b* into section *IIb*.

Residuum product of distillation, present in section *Ib* of chamber **198** is withdrawn via line **218**. A portion of residuum from line **218** can be recycled to section *Ib* together with fresh feed thereto via lines **219**, **221**, **222**, preheater **223** and line **197**. If desired, residuum product from line **218** can be recycled via lines **219** and **224** directly to preheater **192** and sections *Ib* or *I'b*. If desired, residuum product can be withdrawn from line **218** via line **226**, or, via line **227** for passage to further reduction in a second stage vacuum distillation discussed hereinafter.

Residuum product from section *I'b* is withdrawn via line **228**, and can be recycled to distillation chamber **198** via lines **229**, **222**, preheater **223**, and line **197**, or, if desired, via line **228** and preheater **192**, to distillation chamber **198**. Residuum from line **228** can also be withdrawn from the system via line **231**. If desired, residuum from line **228** can be withdrawn via line **227** and passed to a second stage vacuum distillation, for further reduction as described hereinafter. Total condensate collected in section *IIb* is withdrawn via line **233** and recycled in part via **234** and cooler **236** to spray assembly **208** as the source of liquid droplets emitted therefrom; is passed in part from line **233** via line **237** and cooler **238** as liquid to be emitted from spray nozzle assembly **211***a*; remaining condensate being withdrawn from section *IIb* via lines **233** and **239**.

Residuum product from distillation chamber **157** or **198**, or both, can be further reduced in a second-stage vacuum distillation system to provide a still higher softening point residual pitch product and higher overall yields of gas oil distillate. Thus, residuum product from line **177**, alone, or together with residuum product from line **227**, is passed via line **232**, preferably divided as two separate streams, and passed through preheater **233***a* and therein heated to a temperature within a predetermined range for the said second stage distillation such as within 600–900° F. A portion of the preheated residuum product is withdrawn from preheater **233***a* via line **234***a* and the remaining portion is withdrawn via line **236***a*. Residuum in line **234***a* is then passed into section *Ic* of distillation chamber **237***a* under flashing conditions therein, that can be carried out as described relative to introduction of feed into section *Ib* of chamber **198**, i.e. as a spray, or from an open end pipe, in any desired direction, preferably upstream against a coalescing surface such as that provided by wire screen **239***a*, transversely positioned in chamber **237***a* intermediate the end of conduit **234***a* in section *Ic* and chamber end portion **238***a'*. A major portion of unvaporized charge settles as liquid in section *Ic*. Vapors formed in section *Ic* contain entrained particles of unvaporized charge and are passed into adjacent section *IIc* through baffle sections **238***a*, transversely closing chamber **237***a* and which can be of design similar to that of baffle section **162** of chamber **157**. Vapors passed from section *Ic* into section *IIc* are contacted in the latter section with a spray of atomized liquid droplets maintained under temperature-momentum conditions so as to effect condensation of a portion of the said vapors contacted therewith and concomitantly cause impingement of sprayed droplets with particles of unvaporized charge and droplets of condensate, to cause settling of all liquid droplets in section *IIc* as liquid product. If desired, the momentum conditions can be such that the force of impinging droplets is below that causing settling of all droplets in section *IIc*, in which case it is important that the linear dimension of section *IIc* be sufficiently great that these droplets are substantially completely settled prior to passing of vapor from section *IIc* into the central section *IIIc*. If desired, the step of contacting vapors with spray in section *IIc* can be dispensed with, whereby a lower pressure drop across the chamber **237***a* is achieved and higher vacuum is achieved. However, in the latter event, complete settling of entrainment from vapors in section *IIc* is not achieved, although a substantial proportion of the said entrainment

is settled by virtue of the residence time of vapors in section IIc. Vapors from section IIc are passed through baffle section 241 transversely closing chamber 237a and which can be similar in design to baffle section 162 of chamber 157, and contacted in section IIIc with a spray of atomized liquid droplets maintained at a temperature sufficiently below that of vapors contacted therewith so as to effect substantially complete vapor condensation. When dispensing with the use of a spray in section IIc, condensate thus formed in section IIIc contains small proportions of feed particles entrained in vapors entering section IIIc. However, the small proportion of unvaporized charge particles present can generally be justified in view of the lower pressure drop achieved across the distillation chamber 237a and the higher vacuum resulting therefrom to provide an improved yield of gas oil and a correspondingly lowered yield of residuum.

Operation in sections I'c and II'c is the same as that respectively in sections Ic and IIc and is not specifically illustrated.

Vacuum is applied to distillation chamber 237a by means of steam jets 242, connecting with the interior of section IIIc via line 243 and internal guard chamber 244, the latter being similar in design to guard chamber 216 of distillation chamber 198. Dam means 246, in combination with spray nozzle assembly in section IIIc (also illustrated with reference to Figure 7) provides for isolation of condensate fractions in section IIIc, recovered from vapors from sections IIc and II'c.

Residuum product is withdrawn from section Ic of chamber 237a via line 247 and can be withdrawn from the system via line 248, or recycled via line 249 with fresh feed to distillation chamber 237a. Residuum from section I'c of chamber 237a is withdrawn via line 251 and can be withdrawn from the system via line 252, or recycled in part, if desired, via line 253 and 232 to distillation chamber 237a. Liquid product from section II'c is withdrawn via line 254, and can be withdrawn from the system via line 256, recycled in part as liquid spray in section II'c, when desired, via line 237b, cooler 258, and line 259. Liquid product is withdrawn from section IIc of chamber 237a via line 261 and can be withdrawn from the system via line 262, and, when desired, can be passed in part via line 263, cooler 264 and line 266 to spray nozzle assembly 240. Liquid product from lines 254 and 261 can also be each recycled to distillation chamber 237a together with fresh feed, via lines 255 and 232, and preheater 233a, these latter recycling steps being particularly advantageous when no liquid spray is employed in sections IIc and II'c.

Recycle of residuum from a vacuum distillation system with fresh feed thereto, in preferred forms, is described and claimed in the copending applications of William E. Barr and Charley H. Owen, Serial No. 351,017, filed April 24, 1953, now U.S. Patent No. 2,799,628, and Golden A. Moyer, Serial No. 316,411, filed October 23, 1952, now U.S. Patent No. 2,774,723.

By means of the second stage vacuum distillation of my invention, such as specifically illustrated, the softening point of the first stage residuum product can be increased by about 50 to 350° F., and the overall yield of gas distillate is correspondingly increased, thereby providing for lowered yields of residual pitch product, although of better quality, and higher yields of gas oil.

As illustrated with reference to Figure 11D, residuum product of the second stage vacuum distillation, above discussed and illustrated, is further processed in a series of steps comprising visbreaking, recycle cracking, and final vacuum reduction, to provide a final high softening point pitch product, and for recycle and reaction, substantially to extinction of gas oil fractions formed, to produce hydrocarbons boiling in the gasoline range as a chief light hydrocarbon product. Thus, residuum from lines 247 and/or 251, together with, if desired, gas oil distillate from lines 261 and/or 254, although the last said gas oil streams are generally withdrawn from the system for other utilization, are passed via line 266a, to visbreaking Selas furnace 267, wherein it is heated to a temperature generally of about 750 to 850° F., so as to effect mild cracking of same. It is generally advantageous to pass a stream from line 266a via separator 268, to furnace 267, whereby any relatively light fractions can be withdrawn overhead and utilized as described hereinafter. Effluent from visbreaking furnace 267 is quenched at points 268a and 269 with gas oil from line 271. Steam from line 272 is also added at point 269 for control of final quench temperature. Resulting quenched furnace effluent at a temperature such as from 710 to 750° F. is passed into vacuum flash chamber 273, maintained under about 1.0 to 10 mm. Hg from which residual product is withdrawn via line 274. Vapors from vacuum flash chamber 273 are withdrawn via overhead line 276 and passed to vacuum bubble tower 277, the latter under about 1.0 to 10 mm. Hg. Gas oil bottoms product is withdrawn from tower 277 via line 278 and is passed in part into line 271 and is withdrawn in remaining part as product via line 279. Overhead product withdrawn from vacuum bubble tower 277 comprises gasoline in line 281 and gas in line 282, separated in separator chamber 283. Residuum in line 274 if passed to a recycle cracking operation in which all gas oil product from cracking is recycled to the cracking step so that the only products are gas, gasoline, and residuum. Thus, residuum in line 274 is charged to bubble tower 284, operated under vacuum of about 10 to 100 mm. Hg to which is also charged an aromatic gas oil from line 286, preferably a sulfur dioxide extract oil together with vapors from flash drum 287, described hereinafter, via line 288. Fractionation in bubble tower 284 provides gas as an overhead product, withdrawn via line 289 and a sidestream of gasoline withdrawn via line 291, and, a bottom gas oil stream which is charged to furnace 292, via lines 293 and 294. More severe cracking conditions are maintained in furnace 292 than were maintained in furnace 267, e.g., a cracking temperature within the range of 900 to 1100° F. under about atmospheric pressure to 50 p.s.i.g. Water is injected into the feed to furnace 292 via line 290. Furnace effluent is withdrawn via 297 and charged to flash drum 287. Residuum is withdrawn from flash drum 287 via line 298 and is charged to surge tank 299. Combined with residuum from chamber 287 in line 298 is residuum from other refinery operations, in line 301, recycled pitch from vacuum flash distillation tower 302 in line 303, and superheated steam from line 304. Vacuum is applied to surge drum 299 via vacuum jets not specifically shown through line 306 to remove the more volatile components of the feed through line 306. Residuum is withdrawn from surge tank 299 and passed to furnace 307, wherein it is heated to a temperature in a range suitable for vacuum reduction described hereinafter such as about 600–900° F., preferably such that little or no cracking is effected during the heating. The heated residuum from furnace 307, via line 300 is flash vaporized in vacuum distillation chamber 302, the latter maintained under high vacuum such as in the range of 0.10 to 10 mm. Hg, applied by vacuum jets via line 307a. In chamber 302, lighter hydrocarbon fractions are condensed from the flashed vapors and recovered as products via lines 308 and 309, any uncondensed vapors being removed via the jets. Residual pitch product is withdrawn from distillation chamber 302 via lines 311 and 312, and in part, when desired, via line 303 for passage together with steam and the above-described residuum fractions in line 298 for further processing in vacuum surge tank 299.

The above-described embodiment, with reference to the combined process steps of Figures 11A and/or 11B, 11C and 11D, provides a residual pitch product of high softening point, for example in the range of 200 to 450° F., and for recycle to extinction of a major proportion of the gas oil fractions recovered during the visbreaking, cracking and vacuum reduction steps, thereby providing for gas and

gasoline as predominant light hydrocarbon product in addition to the improved residual pitch. It is to be understood that, if desired, first stage residuum product such as from chamber **157** or **198** can be charged as sole feed, or together with second stage residuum product, as desired, via line **266***a* to the steps of Figure 11D.

With reference to Figure 12, illustrative of an alternate form of spray nozzle assembly that can be employed in conjunction with apparatus of Figure 1, section III, Figure 11B, section II*b*, and Figure 11C, section III*c*, and specifically illustrated with reference to apparatus of Figure 11B, spray nozzle assembly **208′** is disposed in section II*b* in close proximity to baffle section **207** and adapted to emit spray toward inner guard chamber **216**, i.e., in a direction concurrent with direction of flow of vapors contacted therewith. Spray nozzle assembly **211***a′* is disposed in section II*b* in close proximity to baffle **209** and intermediate baffle **209** and inner guard chamber **216** and adapted to emit atomized droplets toward chamber **216**, i.e., in a direction concurrent with flow of vapors contacted therewith. This arrangement of sprays provides for concurrent flow of vapor and spray and thereby for lower pressure drop across the distillation chamber and for lower operating pressures, and thus for achieving higher overall vacuum conditions.

With reference to Figure 13, illustrative of apparatus and process employing a spray nozzle assembly of Figure 12, such as in a third stage reduction of a distillable material, such as oil residuum product of distillation recovered from chamber **237***a* of Figure 11C (lines **247** and/or **251**), is introduced into flash section I*d* of chamber **320** via line **316** under flash conditions in section I*d*, such as described with reference to flashing feed in chambers **157**, **198** and **237***a*, e.g. as described relative to introduction of feed into section I*a* of chamber **157**. Similarly, oil feed in line **317** is introduced into flash section I′*d* of distillation chamber **320**, the latter section comprising an end section of chamber **320** opposite section I*d*, under flash conditions such as those employed in section I*d*.

Vapors from sections I*d* and I′*d* are respectively passed through baffle sections **325** and **324**, these baffle sections being similar in design, if desired, to baffle section **162** of chamber **157** (Figure 11A) and functioning as deflectors of entrained liquid from vapors passed therethrough. Vapors passed through baffle sections **325** and **324** are passed into and through adjacent chamber sections II*d* and II′*d*, respectively, these latter sections being of sufficient length to provide residence time for permitting settling of at least a portion of remaining entrainment in vapors passed therethrough. Dam ring means **326** and **327** are respectively disposed peripherally about the inner side wall of chamber **320** so as to prevent flow of settled liquid respectively from sections II*d* and II′*d*, each of the said dam means respectively defining sections II*d* and II′*d* together with baffle sections **325** and **324**.

Vapors which may contain some unsettled, i.e. entrained, droplets are passed from section II*d* into section III*d* in concurrent flow relation with atomized oil droplets emitted from spray nozzle **208″**, the latter droplets maintained at a temperature sufficiently below that of vapors contacted therewith so as to cause substantially complete condensation of same by resulting heat exchange.

Vapors from section II′*d*, which may contain some remaining unsettled, i.e. entrained, droplets, are passed from section II′*d* into section III*d* in concurrent flow heat exchange relation therein with sprayed droplets emitted from spray nozzle assembly to **211***a″* at a temperature below that of vapors contacted therewith so as to effect substantially complete condensation of the said vapors by the resulting heat exchange.

Total liquid, i.e., condensate together with any remaining entrainment and sprayed droplets, is settled in section III*d*. Guard chamber **216′** through which vacuum producing means **210′** communicates with chamber **320** (via section III*d*), disposed in section III*d*, serves as a "mist-extractor" to deflect entrained droplets that may be present in any uncondensed vapors in section III*d* as discussed with reference to the inner guard chamber **216** of Figure 11B. Chamber **216′** also deflects any sprayed droplets or resulting droplets of condensate so as to prevent their flight to vacuum producing means **210′**. Any uncondensed vapor remaining in section III*d* is withdrawn via conduit **214′** connected with inner guard chamber **216′** and passed into external guard chamber **328** in contact therein with a relatively cold spray in concurrent flow relation therewith so as to condense the said vapors and prevent their flight to vacuum producing means **210′**. The specific guard chamber structure **328**, illustrated, comprises a combination of a spray nozzle assembly, for emitting atomized droplets in heat exchange relation with vapors contacted therewith, preferably in concurrent flow relation, and a baffle system for deflecting any liquid droplets that otherwise would reach vacuum producer **210′**, such a combination of nozzle assembly and baffle structure being disclosed and claimed in the co-pending application of Serial No. 400,526 filed December 28, 1953.

Liquid product is withdrawn from each of sections I*d* and I′*d* via lines **331** and **332**, respectively, and from sections II*d* and II′*d* via lines **333** and **334**, respectively. Liquid product in section III*d* is withdrawn via line **336** and recycled in part to spray nozzle assembly **208″** via line **337** and cooler **338** and to spray nozzle assembly **211***a″* via line **339** and cooler **341** and the remaining part is withdrawn via line **342**.

A ring around the inner periphery of the distillation vessel, such as ring **163** in chamber **157** of Figure 11A, which can be the same as illustrated hereinabove with reference to dam rings **33**, **43**, **78** or **60** of Figure 1 (these being illustrated in more detail with reference to dam ring **43**, see Figure 1, 4 and 5), downstream from the point of introduction of feed into the flash section, is advantageously employed to arrest flow of unvaporized liquid feed, or condensate, axially along the periphery of the distillation zone, i.e., along the chamber inner side wall in an axial direction, to points downstream therefrom; the axially flowing liquid, upon contacting the ring, being arrested and caused to accumulate in the chamber section, as settled liquid product, instead of adhering to the chamber side wall to avoid downstream liquid spray contact and/or settling and thereby accumulating downstream as undesired liquid product. Although illustrated as being employed in conjunction with a baffle section, such ring can also be employed separate therefrom or in lieu thereof. When employing the peripherally disposed ring in lieu of a baffle section and when settling entrainment downstream by gravity alone, it is advantageous to increase the length of the adjacent downstream section to facilitate settling of entrained particles therein; or, when a spray is employed ahead of the final condensing spray, it is important that the length of the first spray contacting zone be sufficient that sprayed droplets do not pass into upstream chamber sections.

It is advantageous, in any event, that such a peripherally disposed ring be intermediate the final condensing spray and the fresh feed inlet, to prevent entry of unvaporized liquid, flowing axially along the periphery of the distillation zone, into the condensation zone and accumulating therein as contaminant of condensate product.

By employing a peripherally disposed ring, as described, in lieu of a baffle section, a still greater decrease (than when baffle section is employed) in pressure drop is achieved across the distillation zone, and lower overall operating pressures are obtained.

The embodiment of Figure 13 is advantageously applied to the attainment of maximum high vacuum in a vacuum distillation system, because of the low pressure drop that is achieved as a result of the concurrent flow heat exchange relation of vapors with atomized

condensing spray and is, therefore, particularly well applied to a third stage reduction of hydrocarbon oil such as reduction of residuum product from chamber **237***a* (lines **247** and/or **251**), thus, when employing concurrent flow heat exchange relation of vapors with spray in a distillation system such as that illustrated by Figure 13, a pressure drop across the system in the range 0.10 to 18 mm. absolute Hg can be obtained, at an overall absolute pressure in the range of about 0.01 to 19 mm. Hg.

The advantages of this invention are illustrated in the following examples. The reactants and their proportions and their specific ingredients are presented as being typical and should not be construed to limit the invention unduly.

EXAMPLE I

274 barrels per hour of a Texas Panhandle topped crude representing 19.6% of the total crude is sprayed into Section I of the apparatus shown in Figure 1 as described hereinbefore. An equilibrium flash vaporization occurs at the conditions given below, and vapors therefrom are passed through section II into condensing section III as previously described. Residual pitch from section I is transferred without the addition of further heat to section V located in the opposite end of chamber **27**. In section V, a second equilibrium flash vaporization occurs at the conditions shown below and vapors therefrom are passed through section IV into condensing section III. In this manner the two gas oil vapor streams are condensed in a common chamber to yield one gas oil stream having the properties shown below. This run is made in accordance with the process described hereinabove with reference to Figure 1. A summary of yields and results of tests made on charge and product streams are tabulated in the following table.

Yields and tests

	Charge	Pitch	Gas Oil (Section III)
Barrels per Hour	274	177	97
Vol. Percent Charge	100	64.6	35.4
Vol. Percent Crude	19.6	12.8	6.8
Gravity	21.9	19.4	25.9
SUV @ 210° F			48
SFV @ 210° F		112	
SFV @ 122° F	245		
Carbon Residue			0.75

First flash—Section I

Feed temperature ..... 726° F.
Eq. flash temperature ..... 702° F.
Pressure—flash zone ..... 12 mm. Hg absolute.
Charge rate ..... 274 b/h.
Vol. percent flashed ..... 21.8.

Second flash—Section V (opposite end)

Feed temperature ..... 690° F.
Equilibrium flash temperature .. 670° F.
Pressure—flash zone (V) ..... 0.2 mm. Hg absolute.
Charge rate ..... 214 b/h.
Volume percent flashed (orig. ch.) 13.6.

EXAMPLE II

199 barrels per hour of Texas Panhandle topped crude is sprayed into section I′ of the apparatus shown in Figure 2 as described hereinbefore at a temperature of 750° F. and a pressure of 12 mm. Hg absolute. Flash vaporization occurs at an equilibrium of 716° F. and vapors therefrom are passed through section II′ into section III′ where the vapors are condensed to yield a heavy gas oil as shown in the table following. The residue from the flash vaporization in section I′ is charged to the secondary vacuum reduction chamber **106** where a second flash at the conditions hereinafter takes place. Vapors from this second flash are passed into section IV′ of the primary vacuum chamber where they are condensed. This run is made in accordance with the process described with reference to Figure 2. Yields and results of tests made on charge and product streams of both flash stages are tabulated in the following table:

First flash—Section I′

Feed temperature ..... 750° F.
Equilibrium flash temperature .. 716° F.
Pressure ..... 12 mm. Hg absolute.
Charge rate ..... 199 barrels per hour.

Yields and tests

	Charge	Pitch	Heavy Gas Oil (Section III′)
Barrels per Hour	199	139	60
Vol. Percent Charge	100	69.8	30.2
Vol. Percent Crude	14.1	9.8	
Gravity,° API	20.3	17.9	28.7
SUV @ 122° F			209
SFV @ 210° F		112	
SFV @ 122° F	311		
Carbon Residue			0.75

Second flash—Secondary vacuum reduction chamber 106

Feed temperature ..... 708° F.
Equilibrium flash temperature .. 690° F.
Pressure ..... 0.2 mm. Hg absolute.
Charge rate ..... 139 barrels per hour.

Yields and tests

	Charge	Pitch	Extra Heavy Gas Oil (Sect. IV′)
Barrels per Hour	139	107	32
Vol. Percent Charge	100	77	23
Vol. Percent Crude	9.8	7.5	2.3
Gravity,° API	17.9	16.8	21.7
SFV @ 122° F			235
SFV @ 210° F		150	
Carbon Residue			1.55

The gas oil products of the above examples are good quality cracking charge stocks. The gas oil product of Example II is particularly suitable as charge stock in carbon black manufacture. These gas oils are each produced from greatly reduced topped crudes, in yields and quality not obtained heretofore by vacuum reduction of reduced crudes.

As will be evident to those skilled in the art, various modifications can be made or followed, in the light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

Variation and modification are possible within the scope of the foregoing disclosure, drawings, and the appended claims to the invention, the essence of which is apparatus and process for distillation of a distillable material in a single or plurality of succeeding stages, the latter with or without supplemental vacuum and/or heat producing means, as desired; wherein in accordance with one concept at least a portion of entrained particles present in vapors from initial flashing of charge, are removed by settling same (by gravity alone) from the said vapors, or, by contacting the said vapors with a liquid spray, prior to condensation of the resulting vapors in one or more steps at least one of which is effected by contacting the vapor in heat exchange relation with a relatively cold liquid spray emitted in any desired direction, advantageously in a direction concurrent with flow of vapors contacted therewith so as to achieve minimum low pressure drop across the distillation zone; another concept providing an elongated chamber, preferably disposed substantially horizontally, a conduit extending into said chamber, a spray nozzle assembly disposed in said chamber, means for arresting flow of unvaporized portions of liquid, from said conduit, into downstream

chamber sections, such as a flat ring disposed peripherally about the chamber inner side wall and/or a baffle section in said chamber transversely closing same and adapted to deflect liquid droplets from vapors passed therethrough, the said deflecting means being disposed intermediate said spray nozzle assembly and the end of said conduit, and conduit means for withdrawing liquid from the said chamber; another concept comprising subjecting residuum product of this invention to a series of steps comprising visbreaking, recycle cracking, and a final reduction, to provide a high-softening point pitch product together with gasoline, as products, with concomitantly low yields of gas oil fractions, the latter being reacted substantially to extinction during the last said series of steps.

I claim:

1. A distillation process comprising the following steps in combination; providing a vacuum source in a distillation zone; introducing to said first distillation zone a distillable material at a first point in said zone and distilling at least a part of said first material at said first point introducing into a second point in said zone, which second point is at a pressure lower than that prevailing at said first point during said distillation, a second distillable material, and distilling at least a part of said second material at said second point, maintaining said zones in open vapor communication with each other the vapors resulting from distillation of said first distillable material being maintained separate from the vapors resulting from distillation of said second distillable material during their flow toward a third point in said zone having a lower pressure than said second point, substantially completely condensing within said zone the vapors resulting from each said distillation, separately removing from said zone resulting condensed vapors, and separately removing distillable materials not vaporized from each of said distillations in separate streams; removing non-condensibles from said zone; and before effecting said condensing, separating entrained liquid droplets from each of said vapor streams; each of said vapors formed at said first and second points occupying a substantially uniform over-all cross-sectional area throughout flow in said distillation zone.

2. A process of claim 1 wherein each of said vapors is condensed separately in said zone and each resulting condensate is removed in a separate stream from said zone.

3. A distillation process comprising flash distilling a first distillable material in one end of a distillation zone of substantially uniform over-all cross-sectional area; flash distilling a second distillable material in another end of said distillation zone, said one end and said another end of said distillation zone being in open vapor communication one with the other; applying vacuum to an intermediate portion of said zone; and recovering distillation product.

4. A distillation process comprising flash distilling a first distillable material in one end of a distillation zone of substantially uniform over-all cross-sectional area; flash distilling a second distillable material in another end of said distillation zone, said one end and said another end of said distillation zone being in open vapor communication one with the other; vapors from each of said flashings containing entrained particles; separating at least a portion of entrained particles from vapors from each of said partial flashings and cooling remaining vapors so as to condense at least a portion of same; applying vacuum to an intermediate portion of said zone; and recovering distillation product.

5. A vacuum distillation process comprising applying vacuum to a first and intermediate section of a closed elongated substantially horizontally disposed distillation zone; passing a first distillable material into a second section of said distillation zone adjacent said intermediate section, under flashing conditions so as to vaporize a portion of same, unvaporized materials settling in said second section; passing a second distillable material into a third section of said distillation zone also adjacent said intermediate section, under flashing conditions so as to vaporize a portion of the last said material, unvaporized material settling in said third section; passing vapors from said second section through a first liquid deflecting zone into said intermediate section in contact with a first spray maintained at a temperature lower than that of vapors contacted therewith so as to cause condensation of said vapor contacted therewith; passing vapors from said third section through a second liquid deflecting zone into said intermediate section in contact with a second spray maintained at a temperature lower than that of vapors contacted therewith so as to cause condensation of said vapors therewith; and recovering liquid from at at least one of said first, second and third sections of said distillation zone as a product of the process.

6. A distillation process comprising partially flash distilling a first distillable material in one end of a substantially horizontally disposed distillation zone; partially flash distilling a second distillable material in another end of said distillation zone; vapors from each of said partial flashings containing entrained particles; passing vapors from the first said flashing through a particle deflecting zone so as to remove at least a portion of entrainment therefrom and then in contact with a first spray of liquid particles maintained at a temperature substantially as high as that of vapors contacted therewith so as to cause impingement of sprayed and any remaining entrained particles and settling of same, and then into an intermediate section of said zone; passing vapors from the second said flashing through a particle deflecting zone so as to remove at least a portion of particles therein and then in contact with a spray of liquid particles maintained at a temperature substantially as high as that of vapors contacted therewith so as to cause impingement of sprayed and any remaining entrained particles and settling of same, and then into said intermediate section; condensing vapors in said intermediate section; applying vacuum to said zone at a point in said intermediate section; and recovering product of said process.

7. Apparatus comprising an elongated chamber of substantially uniform cross-sectional area throughout its length; a first conduit in communication with a first end portion of said chamber; a second conduit in communication with a second end portion of said chamber; vacuum producing means in communication with an intermediate portion of said chamber as the sole vacuum producing means; vapor condensing means in said intermediate portion; and conduit means in communication with each of said portions for withdrawal of fluid from said chamber, said first end portion and said second end portion being in open vapor communication with each other through said intermediate portion.

8. Apparatus of claim 7 wherein said elongated chamber is substantially horizontally disposed.

9. Apparatus comprising a horizontally disposed closed elongated shell of substantially uniform cross-sectional area throughout its length; a first conduit communicating with a first section of said shell; a second conduit communicating with a second section of said shell; a third section in said shell intermediate said first and second setcions; spray means in said third section; vacuum producing means in direct communiaction with the interior of said third shell section as the sole vacuum producing means; and outlet conduit means in each of said shell sections, said first section and said second section being in open vapor communication with each other through said intermediate section.

10. Apparatus comprising an elongated chamber; a first conduit communicating with a first end section of said chamber; a second conduit communicating with a second end section of said chamber; a first spray nozzle assembly in said chamber intermediate the ends of said first and

second conduits; a second spray nozzle assembly in said chamber intermediate said first spray nozzle assembly and the end of said second conduit; a baffle transversely disposed substantially across said chamber intermediate at least one of said conduit ends and spray assembly adjacent thereto; vacuum producing means in communication with the interior of said chamber intermediate said spray nozzles; vapor condensing means in said chamber portion intermediate said spray nozzles; and conduit means for withdrawal of fluid from each of said chamber sections.

11. In a vacuum distillation process wherein a material is partially flash vaporized in a first zone at subatmospheric pressure, the improvement which comprises separating an unvaporized portion of said material from said vapors, flowing an unvaporized portion of said material out of contact and separated from said vapors to a second zone in open vapor communication with said first zone and flash redistilling same at a pressure substantially lower than said subatmospheric pressure, so that a second flash distillation is obtained, in the same vacuum distillation system, utilizing pressure reducing means employed in maintaining said subatmospheric pressure, as the sole source of vacuum for said partial vaporization and said second flash redistilling.

12. A process for the vacuum distillation of a hydrocarbon oil residuum comprising passing such an oil into a first and upstream-most section of a distillation zone, maintained under subatmospheric pressure by applying vacuum at a single point therein, as a first spray under flashing conditions so as to vaporize a portion of said oil; applying vacuum to distillation zone at a point downstream from said first section to maintain said subatmospheric pressure; said first section containing a major proportion of vapors present in said distillation zone and thereby operating at a higher pressure than that at any downstream point in said distillation zone; a portion of unvaporized oil settling in said first section and a remaining portion being entrained in vapors therein as droplets; passing vapors and entrained droplets from said first section into a second section of said distillation zone, downstream and adjacent said first section, against a flow in said second section of atomized and impinging oil droplets emitted as a second spray; said atomized sprayed droplets in said second section having a momentum at least as great and a temperature at least as high as the momentum and temperature respectively of entrained droplets in vapor contacted therewith so as to cause atomized droplets and impinged droplets to settle in said second section as liquid; recycling a portion of settled liquid from said second section as oil emitted in said second spray and recovering a remaining portion thereof; withdrawing settled liquid from said first section and then introducing the liquid thus withdrawn at its existing temperature into direct communication with a section of said distillation zone downstream from said first section, thereby flashing a portion of the withdrawn settled liquid; condensing vapors from the last said flash vaporization and recovering condensate thus formed, and recovering condensate and residual liquid from the last said flash distillation as products of the process.

13. The process of claim 12 wherein settled liquid is withdrawn from said first section and then introduced at its existing temperature into a distillation zone external to the first said distillation zone, maintained in direct communication with a downstream section of the first said distillation zone.

14. The process of claim 12 wherein the absolute pressure within said first distillation zone is maintained within the limits of 0.01 and 18 mm. Hg, wherein said oil residuum is introduced into said first distillation zone at a temperature within the limits of 600 and 900° F., wherein the temperature of said second oil spray is not more than 30° F. above the temperature of vapors contacted therewith, and wherein the temperature of oil sprays in said third and fourth sections is from 3 to 500° F. below that of vapors contacted therewith.

15. The process of claim 12 wherein said hydrocarbon oil residuum introduced into said first section is in the form of droplets having radii of curvature within the limits of 0.001 and 0.01 microns.

16. The process of claim 12 wherein the pressure drop across said first distillation zone is within the limits of 2 and 20 mm. Hg.

17. A process for the vacuum distillation of a hydrocarbon oil residuum comprising passing such an oil in an upstream direction into a first and upstream-most section of a distillation zone, maintained under subatmospheric pressure, as a first spray under flashing conditions so as to vaporize a portion of said oil; said first section containing a major proportion of vapors present in said distillation zone and thereby operating at a higher pressure than that at any downstream point in said distillation zone; a portion of unvaporized oil settling in said first section and a remaining portion being entrained in vapors therein as droplets; passing vapors and droplets entrained therein from said first section into a second section of said distillation zone, downstream and adjacent said first section, against a flow in said second section of atomized and impinging oil droplets emitted as a second oil spray; said atomized sprayed droplets in said second section having a momentum at least as great and a temperature at least as high as that of entrained droplets in vapor contacted therewith so as to cause atomized droplets and impinged droplets to settle in said second section as liquid; recycling a portion of said liquid from said second section as oil emitted in said second spray and recovering a remaining portion thereof; passing vapors free from entrained liquid from said second section into a third section of said distillation zone adjacent said second section against a flow in said third section of atomized oil droplets emitted as a third oil spray at a temperature maintained so as to substantially completely condense vapors from said second section on said third oil spray and as separate droplets, said third oil spray having a momentum at least as high as that of entrained condensate in said third section so as to cause condensate to settle in said third section as liquid; passing a portion of settled liquid from said third section as said third oil spray and recoverng a remaining portion thereof; applying vacuum to said distillation zone at a point in direct communication with said third section; withdrawing settled liquid from said first section and then introducing the withdrawn liquid at its existing temperature as a fourth spray into a fifth section, in said distillation zone, opposite-most from said first section, thereby flashing a portion of the withdrawn settled liquid in said fifth section; a portion of unvaporized oil in said fifth section settling in said fifth section and a remaining portion being entrained in vapors therein as droplets; passing vapors and droplets entrained therein from said fifth section into a fourth section of said distillation zone intermediate and adjacent said third and fifth sections, against a flow in said fourth section of atomized and impinging oil droplets emitted as a fifth oil spray; said atomized sprayed droplets in said fourth section having a momentum at least as great and a temperature at least as high as the momentum and temperature respectively of entrained droplets in vapor contacted therewith so as to cause atomized droplets and impinged droplets to settle in said fourth section as liquid; recycling a portion of settled liquid from said fourth section as oil emitted in said fifth spray and recovering a remaining portion thereof; passing vapors free from entrained liquid from said fourth section into said third section against a flow in said third section of atomized oil droplets emitted as a sixth oil spray at a temperature maintained so as to substantially completely condense vapors from said fourth section on said sixth oil spray and as separate droplets; said sixth oil spray having a momentum at least as high as that of entrained condensate in said third sec-

tion so as to cause condensate to settle in said third section as liquid; passing a portion of settled liquid from said third section as said sixth oil spray and recovering a remaining portion thereof, and recovering settled liquid from said fifth section.

18. The process of claim 17 wherein the temperature of said second oil spray is from 15 to 30° F. above that of vapors contacted therewith, wherein the temperature of each oil spray in said third section is from 3 to 500° F. below that of the vapors contacted therewith, and wherein the temperature of said fifth oil spray is from 15 to 30° F. above that of vapors contacted therewith.

19. A process for the vacuum distillation of a residual hydrocarbon oil, comprising passing such an oil into a first and upstream-most section of a distillation zone maintained under subatmospheric pressure, as a first spray directed upstream towards a coalescing surface, under flashing conditions so as to vaporize a portion of said oil; applying vacuum to said distillation zone at a point downstream from said first section to maintain said subatmospheric pressure; said first section containing a major proportion of vapors present in said distillation zone and operating at a higher pressure than that at any downstream point in said distillation zone; recovering liquid from said section, settled therein as described here after, and introducing a portion of same as a second spray into said first section at a point downstream from said first spray, and in a direction toward said coalescing surface thereby causing droplets from said second spray to impinge unvaporized droplets entrained in vapor formed by said flash vaporization; maintaining momentum of droplets sprayed from said second spray at least as great as that of said entrained liquid droplets so as to cause total unvaporized liquid in said first section to settle therein as the above described settled liquid; condensing resulting vapor free from entrained liquid and recovering condensate thus formed; withdrawing a remaining portion of settled liquid from said first section and then introducing the liquid thus withdrawn at its existing temperature into direct communication with a section of said distillation zone downstream from said first section, thereby flashing a portion of the withdrawn settled liquid; condensing vapors from the last said flash vaporization and recovering condensate thus formed, and recovering condensate and residual liquid from the last flash vaporization as products of the process.

20. A vacuum distillation chamber comprising an elongated shell; a first conduit extending into a first end section of said shell; a first baffle transversely disposed across said shell and terminating said first end section said baffle being adapted to permit flow of vapor through said baffle substantially across the entire cross-section of said chamber and then only along a tortuous path; a second conduit extending into said shell; a first spray means in said shell, adapted to emit spray substantially uniformly across the entire cross-section of said shell, intermediate said first baffle and the end of a second shell end section, connected to said second conduit and directed toward said first baffle; a second baffle transversely disposed across said shell and disposed intermediate said first baffle and the end of said second shell end section; a third conduit extending into said shell; a second spray means in said shell intermediate said second baffle and the end of said second shell end section connected with said third conduit and directed toward said second baffle; a third baffle transversely disposed across said shell and disposed intermediate said second baffle and the end of said second shell end section; vacuum producing mean external to said shell in direct communication with the interior thereof at a point intermediate said third baffle and the end of second shell end section; and outlet conduit means in said shell connected with each of said end sections, and with intermediate shell sections defined by said baffiles.

21. A vacuum distillation chamber comprising an elongated shell; a first conduit extending into a first end section of said shell; a first baffle section transversely disposed across said shell and terminating said first end section, said baffle section being adapted to permit flow of vapor through said baffle section substantially uniformly across the entire cross-section of said shell and then only along a tortuous path; a second baffle section intermediate said first baffle section and a second shell end section, transversely disposed across said shell; a second conduit extending into said shell; a spray means in said shell, adapted to emit spray substantially uniformly across the entire cross-section of said shell, intermediate said second baffle section and the end of said second end shell section, connected with said second conduit, and directed toward said second baffle section; vacuum producing means external to said shell in communication with the interior of said shell at a point intermediate said spray means and the end of said second section of said shell; and conduit outlet means in each of said end sections and in said shell section intermediate said first and second baffle sections.

22. A vacuum distillation chamber comprising a closed elongated shell; a first conduit extending into a first end section of said shell; a first baffle section in said shell transversely disposed across same and terminating the said first end section; said first baffle section being adapted to permit flow of vapor through said baffle section substantially across the entire cross-section of said shell and then only along a tortuous path; a second conduit extending into a second end section of said shell; a second baffle section in said shell intermediate said first baffle section and the end of said second end section, transversely diposed across said shell and terminating aid second section; a third section in said shell intermediate said end sections; a third conduit extending into said third shell section; a fourth conduit extending into said third shell section; a first spray means in said third section connected with said third conduit and directed toward said first baffle section, said first spray means being adapted to emit spray substantially uniformly across the entire cross-section of said shell; a second spray means in said third shell section intermediate said first spray mean and said second baffle, connected with said fourth conduit and directed toward said second baffle section; vacuum producing means external to said shell in direct communication with the interior of said third shell section; and outlet conduit means in each of said shell sections.

23. In the apparatus of claim 22 a third baffle section intermediate the end of said first conduit and said first baffle section and transversely closing said shell; and a fourth baffle section intermediate the end of said second conduit and said second baffle section, and transversely closing said shell.

24. A process for the vacuum distillation of a residual oil, comprising maintaining an elongated distillation zone under sub-atmospheric pressure and passing such an oil into a first and upstream-most section of said distillation zone under flashing conditions so as to vaporize a portion of said oil; unvaporized oil settling in said first section; passing vapor from said first section through a baffle into a second and adjacent section of said distillation zone against a flow therein of atomized oil droplets emitted as an oil spray maintained at a temperature lower than that of vapors contacted therewith to condense at least a portion of said vapor on said oil spray and as separate oil droplets, said atomized droplets from said oil spray having a momentum at least as high as that of condensate entrained in said section, whereby condensate is caused to settle in said section; passing any uncondensed vapors from said second section through a baffle into a third section in said distillation zone and therein cooling same to form condensate, and recovering liquid from said first section and from at least one of said second and third sections of said distillation zone as products of the process.

25. A process for the vacuum distillation of a residual oil, comprising maintaining an elongated distillation zone under sub-atmospheric pressure and passing such an oil into a first and upstream-most section of said distillation

zone under flashing conditions so as to vaporize a portion of said oil; unvaporized oil settling in said first section; passing vapor containing entrained liquid from said first section through a baffle into and through a second and adjacent section of said distillation zone, whereby at least a portion of said entrained liquid settles in said second section; passing vapors from said second section through a baffle into a third section of said distillation zone against a flow therein of atomized oil droplets emitted as an oil spray maintained at a temperature lower than that of vapors contacted therewith so as to condense substantially all of said vapor on said oil spray and as separate droplets, said atomized droplets from said oil spray having a momentum at least as high as that of condensate entrained in said third section, whereby total condensate is caused to settle in said third section; and recovering liquid from said first, second and third sections of said distillation zone, as products of the process.

26. A process for the vacuum distillation of an oil, comprising applying vacuum to a first and central section of a closed elongated distillation zone; passing oil feed into a second section of said distillation zone adjacent said central section, under flashing conditions so as to vaporize a portion of said oil, unvaporized oil settling in said second section; passing oil feed into a third section of said distillation zone adjacent said central section, under flashing conditions so as to vaporize a portion of the last said oil, unvaporized oil settling in said third section; passing vapors from said second section through a first baffle into said central section against a first spray of atomized oil droplets maintained at a temperature lower than that of vapors contacted therewith so as to cause condensation of said vapor contacted therewith; said first oil spray having a momentum at least as high as that of condensate formed in contact therewith so as to cause condensate thus formed, and entrained, to settle in said central section; passing vapors from said third section through a second baffle into said central section against a second spray of atomized oil droplets therein maintained at a temperature lower than that of vapors contacted therewith so as to cause condensation of said vapors therewith; said second oil spray having a momentum at least as high as that of condensate formed in contact therewith so as to cause condensate thus formed, and entrained, to settle in said central section; and recovering liquid from each of said first, second and third sections of said distillation zone as products of the process.

27. The process of claim 26 wherein said vapors, passed from each of said second and third sections through a baffle are respectively passed first into adjacent fourth and fifth sections of said distillation zone and then through a baffle into said first section.

28. The process of claim 27 wherein vapors in each of said fourth and fifth sections of said distillation zone are passed against a flow of atomized oil droplets maintained at a lower temperature so as to cause partial condensation of said vapors contacted therewith, said oil droplets having a momentum at least as high as that of condensate formed in contact therewith so as to cause condensate thus formed, and entrained, to settle in each of said fourth and fifth sections; and recovering liquid from each of said fourth and fifth sections as products of the process.

29. In the vacuum distillation of a heavy oil, the improvement comprising introducing liquid charge stock into a distillation zone, under flash conditions providing for vaporization of a portion of said charge to form vapors containing entrained liquid droplets, in a direction opposite to the direction of vapor flow therein and against a liquid coalescing surface, under conditions causing vapors emitted toward said surface to suddenly change their direction of flow subsequent to contacting said surface, whereby separation of unvaporized and vaporized portions of charge is facilitated and entrainment of liquid in the vapor form is minimized by coalescence of unvaporized liquid droplets on said coalescing surface, and draining coalesced liquid from said surface and collecting liquid so drained below said coalescing surface.

30. Apparatus comprising a closed elongated distillation chamber; conduit means for admitting distillable material into an end portion of said chamber predetermined as the upstream end of said chamber; baffle means transversely disposed across said chamber, said baffle means being adapted to permit flow of vapor through said baffle means substantially across the entire cross-section of said chamber and then only along a tortuous path; spray means in said chamber positioned beyond said baffle means adapted to emit spray substantially uniformly across the entire cross-section of said chamber in contact with vapor flowing downstream in said chamber; vacuum producing means in communication with the interior of said chamber positioned beyond said spray means; and outlet conduit means connected with said chamber and positioned upstream from said baffle means for withdrawal of fluid therefrom.

31. In a horizontal flash vaporization section of a vacuum distillation chamber, a wire mat vertically disposed in one end of a closed portion of said flash section and an oil inlet conduit extending into said flash section and terminating in a direction toward said wire mat and toward said end portion and a vapor outlet at the other end of said chamber.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,901,425 August 25, 1959

Paul M. Waddill

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 27, line 19, strike out "first" and insert the same before "distillable" in line 20; column 28, line 17, before "least" strike out "at"; line 64, for "setcions" read -- sections --; line 65, for "communiaction" read -- communication --; column 30, line 44, for "recoverng" read -- recovering --; column 31, line 25, for "here after," read -- hereafter, --; line 67, for "mean" read -- means --; column 32, line 30, for "aid" read -- said --; line 39, for "mean" read -- means --; column 34, line 22, after "admitting" insert -- a --.

Signed and sealed this 8th day of March 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents