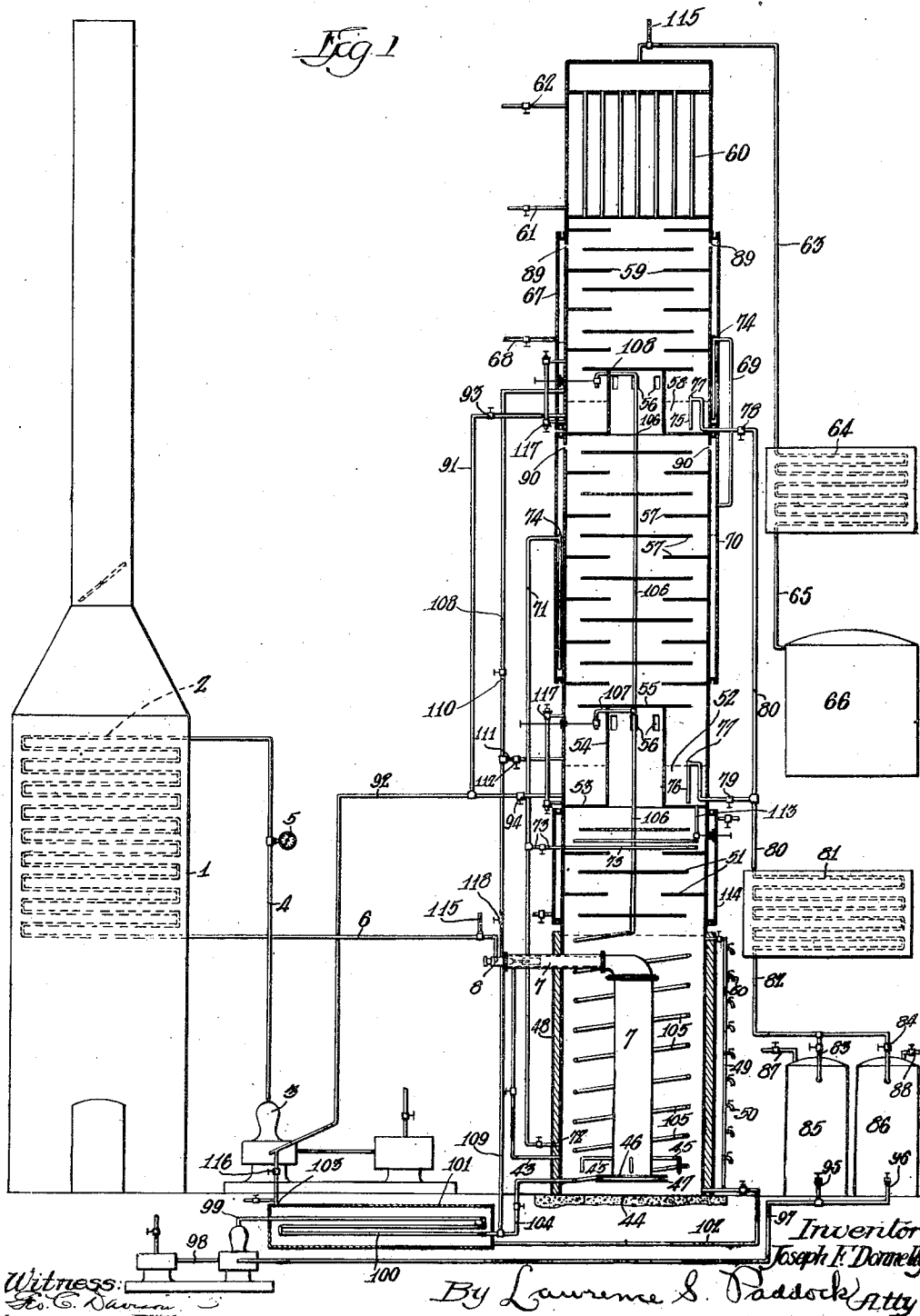


J. F. DONNELLY

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed April 24, 1926

3 Sheets-Sheet 1



May 8, 1934.

J. F. DONNELLY

1,957,946

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed April 24, 1926

3 Sheets-Sheet 2

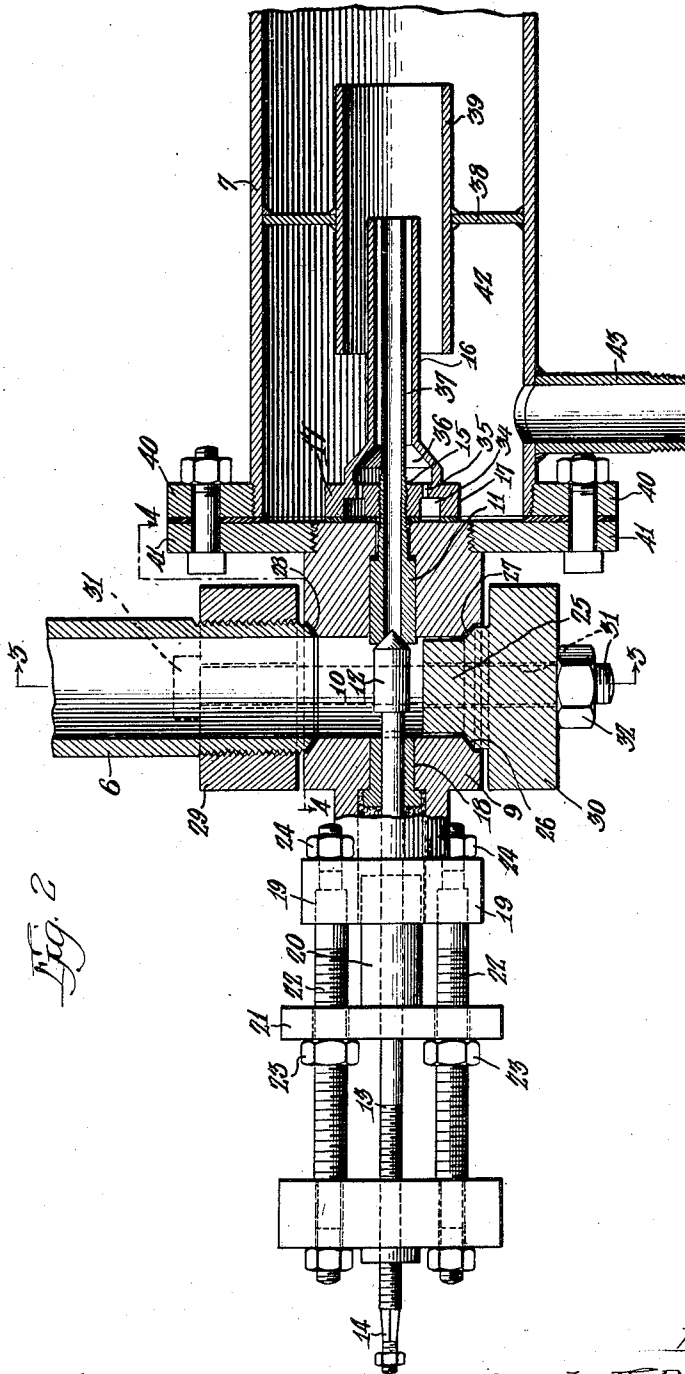


Fig. 2

Witness:
Ed. Duran

Inventor
Joseph F. Donnelly
By Lawrence S. Paddock
Att'y

May 8, 1934.

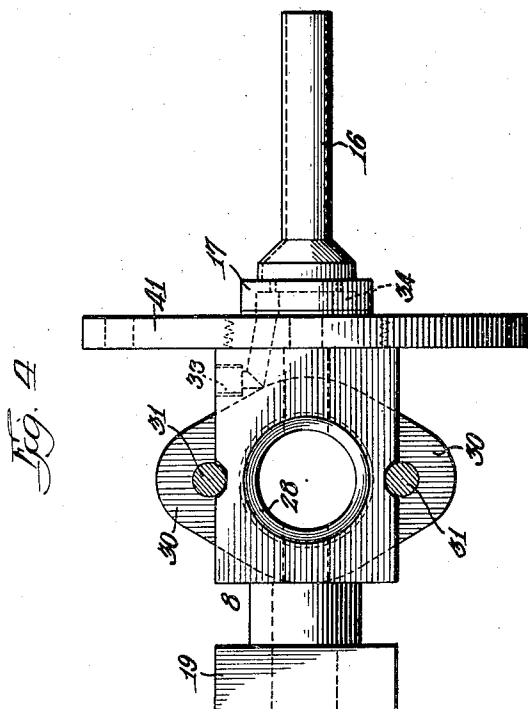
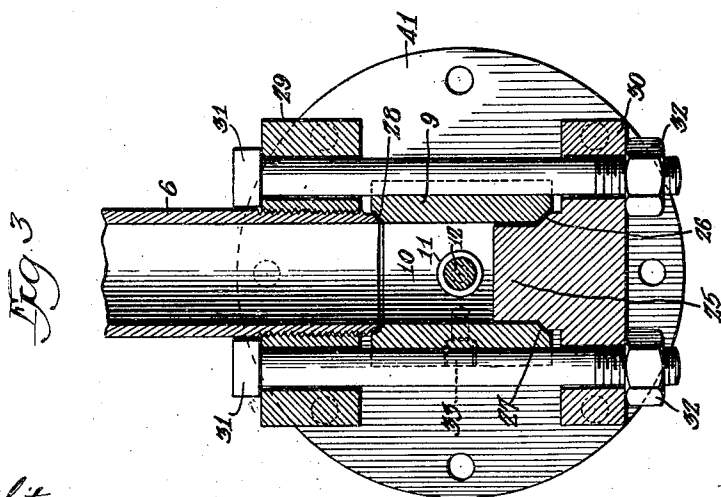
J. F. DONNELLY

1,957,946

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed April 24, 1926

3 Sheets-Sheet 3



Witness:

Ed. C. Green

Inventor:

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UNITED STATES PATENT OFFICE

1,957,946

PROCESS FOR THE CONVERSION OF
HYDROCARBON OILSJoseph F. Donnelly, Lemont, Ill., assignor to
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corporation of Nevada

Application April 24, 1926, Serial No. 104,365

12 Claims. (Cl. 196—58)

This invention relates to a process for the conversion of heavy hydrocarbon oils into lighter hydrocarbon oils, and the present application is a continuation as to common subject matter of my co-pending application (Serial 751,250 filed Nov. 21, 1924, which has matured into Patent No. 1,712,789). The apparatus disclosed in this application is the subject matter of a copending application Serial No. 104,364, filed April 24, 1926.

It is an object of my invention to effect the conversion of the heavier oils in such a manner that the final products possess chemical characteristics more nearly approximating those of the natural hydrocarbon oils than have heretofore been produced by cracking processes.

Another object is to effect the production of the desired lighter end products without reducing the heavier products of conversion to the form of solid end products such as hard carbon or coke.

Another object is to separate the residue from the products which it is desired to subject to the conversion cycle, and keep the residue in liquid solution by adding thereto lighter solvent oils in such quantity as will prevent the residue from being reduced to solid end products such as free carbon or coke.

Another object is to establish such physical condition of operation that the formation of hard carbon and coke in the apparatus is avoided.

Another object is to prevent excessive decomposition of the heavier constituents which constitute marketable products, such as fuel oils, lubricating oils and waxes, while at the same time permitting such dissociation as is necessary to effect the production of the desired lighter products.

Another object is to utilize the heat of the reaction products to distill a mass of crude oil in such a manner that the products of distillation from said crude oil intermingle with the products of the cracking reaction and undergo treatment in the cycle of operation therewith.

A further object is to control the temperature of the zones of fractional condensation by a heat interchange between the vapors it is desired to condense and the cooler crude oil.

A further object is to blend selected lighter fractions of the crude oil, which are separated by fractional distillation with the fresh oil and selected condensates of the cracking reaction to form the makeup of the cycle oil.

A further object is to maintain the oil in the heating step of the cycle of treatment under a temperature and pressure for such a length of time that the cracking reaction is carried up to the point of a rapid formation of solid end prod-

ucts, such as carbon and coke and forthwith checking the cracking reaction.

Other objects and advantages of my process will appear hereinafter.

In order to render my invention clear, reference is had to the accompanying drawings in which I disclose a preferred means of carrying out my process.

In the drawings Fig. 1 is an elevation partly in cross section of an apparatus for carrying out my process.

Fig. 2 is a side elevation partly in cross section, showing a portion of the expansion chamber and fluid-controlling valve of the apparatus.

Fig. 3 is a section taken on line 3—3 on Fig. 2.

Fig. 4 is a plan view taken on line 4—4 on Fig. 2, showing the valve body and connected nozzles.

1 is a pipe still having a continuous coil of pipe 2 therein in which the oil to be heated is subjected to the heating step of the cycle of treatment. A pump 3 supplies the oil to the coil 2 through a connected pipe 4. A gauge 5 indicates the pressure on the oil in said pipe. The heated oil is delivered from the coil 2 through a connected pipe 6 to an expansion chamber 7. A fluid-controlling valve 8 is located between the pipe 6 and the expansion chamber 7. The valve 8 is the subject of my co-pending application Serial #83,545 filed Jan. 25, 1926. The valve 8 is provided with a body member 9 having a chamber 10 therein, to which is connected the pipe 6. A tubular member 11 forms the outlet from the chamber 10. The member 11 has a valve seat thereon at its inner end, upon which operates a valve head 12, which is actuated by a stem 13 adapted to receive an operating member at 14. The tubular member 11 extends through the body member 9 a portion thereof being threaded as shown at 15. Surrounding the projecting end of the member 11 is a tubular jacket 16 having an enlarged portion 17 thereon, which is threaded on the threaded portion of the member 11 and abuts the body member 9 of the valve 8. The enlarged portion 17 thus acts as a locking member to firmly hold the tubular member 11 in operative position in the body 9 of the valve 8. A bushing 18 surrounds the stem 13 and forms a closure member between the chamber 10 and the packing chamber of a packing box 19, which is an integral extension of the body 9. The packing box 19 is provided with a compression member 20. The compression member 20 is provided with a flange 21 through which pass a pair of pillar posts 22 which are threaded as shown and carry nuts 23 which bear against the flange 21

and hold the compression member 20 in the desired adjusted position against the packing in the packing box 19. The pillar posts 22 are removably attached to a packing box 19 and are held in place therein by nuts 24. By removing the nuts 24 the entire mechanism attached to the pillar posts 22, including the valve head 12 and stem 13, may be removed from the body 9 as a unit. The chamber 10 in the body member is formed by a transverse bore which is closed at one end by a closure member 25 having a seat 26 thereon which contacts with a seat 27 on the body member 9. A gasket may be interposed between the seats 26 and 27, as shown. The end of the pipe 6 is formed so as to mate with the annular seat 28 on the body member 9 at the opposite end of the bore forming the chamber 10. A flange 29 is attached to the pipe 6 and the closure member 25 is formed with a flange 30. Bolts 31 pass through openings in the flanges 29 and 30 and are provided with nuts 32. By means of these bolts and nuts the pipe 6 and the closure member 25 are drawn toward each other, thereby holding them firmly in fluid tight contact with the body member 9. The body member 9 has a passage 33 therein leading to an annular recess 34 in the enlarged portion 17 of the member 16. Passages 35 lead from the annular recess 34 into a chamber 36, which opens into the annular space 37 between the member 11 and the jacket 16. The expansion chamber 7 is provided with a partition 38 in the center of which is mounted a tubular member 39. The tubular member 39 extends over a portion of the jacket 16 and member 11, as shown in Fig. 2. The expansion chamber 7 is provided with a flange 40 which is bolted to a flange 41 secured to the body member 9. By this construction a chamber 42 is formed in the expansion chamber 7 between the partition 38 and flange 41. Attached to the expansion chamber 7 and leading into the chamber 42 is an oil conducting pipe 43 which leads to the base of a tower 44. In the present form of apparatus the expansion chamber 7 is formed with a restricted portion which passes through the wall of the tower 44 and an enlarged portion which is located within the base of the tower 44 and extends to a point near the bottom thereof, as clearly shown in Fig. 1. The chamber 7 is provided with a series of outlet pipes 45 at the lower ends thereof, which have downwardly extending ends. The lower end of the chamber 7 is provided with a flange 46 to which is attached a plate 47, so positioned with respect to the flange 47 as to leave a space therebetween so as to form a circular outlet at right angles to the chamber 7. The discharge of the streams of fluid through the annular outlet and downwardly extending ends of the pipes 45 is caused by this construction to meet at right angles, thereby preventing a surging action which would arise by reason of the discharging streams of fluid striking against the side walls of the tower.

The tower 44 is constructed so as to provide a series of zones of decreasing temperature adapted to subject the vapors therein to fractional condensation and provide a distilling section in the base thereof. The products of conversion are first passed into the base of the tower 44 which is normally filled to the desired level with residue oil. The level of the liquid in the base is indicated by a dotted line on Fig. 1. A jacket of heat insulating material 48, surrounds the base of the tower and is co-extensive with the level of the liquid in said base. The level of the liquid

in the base is determined by a gauge 49 which is provided with a series of try-cocks 50. A series of condensing baffle plates 51 are located above the liquid in the base. The vapors which pass the baffles 51 pass upwardly through a trap 52 which is composed of an annular plate 53, having a central opening therethrough, over which a drum 54 is mounted. A plate 55 closes the upper end of the drum 54. The drum 54 is provided with a series of openings 56 through which the uncondensed vapors pass into a second zone of lower temperature within the tower. Within this second zone is mounted a series of condensing baffle plates 57. From this second zone the uncondensed vapors pass into a third zone of lower temperature through a trap 58 similar in construction to the trap 52. Within this third zone is located a series of condensing baffle plates 59. Above the baffle plates 59 is located a tubular condenser 60 which is provided with a supply of cooling water through an inlet pipe 61. A water outlet pipe is provided at 62. The uncondensed vapors which pass through the condenser 60 are conducted through a pipe 63 to a coil in a cooling box 64 and from thence through a pipe 65 into a rundown tank 66. The condensates which are delivered to the tank 66 constitute a final end product such as gasoline.

For the purpose of treating crude oil simultaneously with the cracked products a heat interchange is caused to take place between the cracked products and crude oil in such a manner that the crude oil acts as a temperature regulator for the zones of reactional condensation and at same time is subjected to fractional distillation. The liquid and vaporous products of the fractional distillation of the crude oil are caused to blend with the liquid and vaporous products of the cracking reaction and undergo treatment with them. To this end I have provided a jacket 67 around the shell of the tower opposite the location of the third zone of lower temperature into which I introduce crude oil through a pipe 68. The level of the crude oil is allowed to rise to a predetermined height in the jacket 67, which is determined by an overflow pipe 69 which leads to a jacket 70 around the shell of the tower opposite the location of the second zone of lower temperature. The level of the oil in the jacket 70 is determined by an overflow pipe 71 which leads to the base of the tower at 72 and also through a branch pipe 73 into the vapor space above the liquid in said base. The overflow pipes 69 and 71 are provided with downwardly extending legs as shown, and also with vents at 74 to prevent siphonic action. Overflow pipes 75 and 76 provided with vents 77 are connected to traps 58 and 52 and are provided with control valves 78 and 79. These overflow pipes discharge into a common pipe 80, which leads to a coil in a cooling box 81, from whence a pipe 82 leads to branch pipes 83 and 84, discharging into tanks 85 and 86. The tanks 85 and 86 are provided with auxiliary inlets 87 and 88 by which the tanks may be supplied with oil from an outside source when desired. The upper portion of jackets 67 and 70 constitute vapor spaces in which collect the vapors from the heated oil in said jackets. The vapors thus produced are permitted to pass from the jackets 67 and 70 into the interior of the tower through openings 89 and 90 in the walls of the tower. These vapors blend with the vapors of the cracking reaction and undergo treatment therewith.

The temperature of the third zone is main-

tained at such a degree that the condensates which collect in the trap 58 are of the kerosene series. The temperature maintained in the second zone is such that the condensates collected in the trap 52 answer to the specifications of gas oil. The first zone including the base is maintained at such a temperature that the oil collected therein answers to the specifications of fuel oil. It will be understood that while I have designated oils such as gasoline, kerosene, gas oil and fuel oil, as produced in the several zones mentioned, other fractions may be produced when desired by suitable regulation of the temperature in said zones.

When it is desired to use a kerosene as the cracking stock the cycle oil is drawn from the trap 58 by the pipe 91, which connects with the pipe 92 leading to the inlet of the pump 3. The pipe 91 has a valve 93 therein. Pipe 92 leads to the trap 52 and has a valve 94 therein. When operating on kerosene as a cracking stock, the valve 93 in pipe 91 is open, and the valve 94 in pipe 92 is closed. At this time the valve 78 in pipe 75 is closed, and the valve 79 in pipe 76 is open. A control valve in the branch pipe 83 is closed at this time and a control valve in the branch pipe 84 is open, allowing the gas oil from trap 52 to pass into the tank 86.

When it is desired to operate on gas oil as a cracking stock the cycle oil is drawn from trap 52 by way of pipe 92 and is fed to the inlet of pump 3. When operating in this manner the valve 93 in pipe 91 is closed, and the valve 94 in pipe 92 is open. At the same time valve 79 in pipe 76 is closed, and valve 78 in pipe 75 is open. Also the control valve in branch pipe 84 is closed and the control valve in branch pipe 83 is open, allowing the kerosene from trap 58 to pass to the tank 85. Separate valve controlled outlets 95 and 96 lead from the tanks 85 and 86 which connect with the pipe 97 leading to the inlet of a pump 98. A pipe 99 connects the outlet of the pump 98 with a coil 100, located in a receptacle 101, through which flows the hot residue oil from the base of the tower 44 by way of a pipe 102. The receptacle 101 is provided with an outlet 103. From the coil 100 the oil, which has been pre-heated by a heat interchange with the hot residue oil from the base of the tower, flows through a valve controlled pipe 104 into a coil 105 located in the base of the tower 44 where it absorbs heat from the residue oil in the base of the tower. From the coil 105 heated oil passes upwardly through a pipe 106, from which it may discharge through a valve controlled branch pipe 107 into the trap 52 or through a valve controlled branch pipe 108 into the trap 58. Leading from the pipe 104 is a pipe 109 having a control valve 110 therein and connected to said pipe 109 is a branch pipe 111 having a control valve 112 therein. The oil leaving the coil 100 may be wholly or partially passed through the pipe 109 or wholly or partially passed through the pipe 104 by a regulation of the controlling valves in these pipes. By regulating valve 110 in pipe 109 and valve 112 in branch pipe 111 the oil from pipe 109 may be passed either into the trap 58 or the trap 52. When kerosene is being used as a cracking stock it may be drawn from the tank 85 and supplied to the pump 98 which forces it through the pipe 109 into the trap 58, at which time the valve 110 is open and the valve 112 is closed. When the gas oil is being used as a cracking stock it may be drawn from the tank 86 and supplied to the pump 98, which forces it through

the pipe 109 into the trap 52, at which time the valve 112 will be open and the valve 110 closed.

In practice the apparatus is so proportioned as to extract from the crude oil treated sufficient cracking stock such as kerosene or gas oil to supply the cracking operation. If, due to certain conditions of operation or the nature of the crude oil treated, it is found that the necessary amount of cracking stock may not be extracted from the crude being treated, the necessary additional amount of such cracking stock may be drawn from the tanks 85 and 86 which are furnished with an auxiliary supply through the inlets 87 and 88.

A valve controlled outlet pipe 113 is connected to the trap 52 which allows a regulated quantity of the condensates to flow from the trap 52 into the base of the tower where they first come in contact with the vapors rising from the oil in the base and then descend in the cascade fashion over the plates 51 and finally blend with the oil in the base, acting as a temperature regulator and also as a solvent to keep the residue oil in the base from being reduced to a condition whereby solid end products are formed, such as coke and free carbon. The temperature of these condensates and rising vapors may be further controlled by a cooling jacket 114, which may be furnished with cooling water or other cooling agent such as oil if desired. The jacket 114 is provided with inlet and outlet piping for the cooling agent, as shown. The temperature of the residue oil is further controlled by the heat interchange taking place between the residue oil in the base and the oil passing through the coil 105. Temperature indicators, such as thermometers or thermocouples 115, are placed in position where it is desirable to obtain a temperature reading. A valve controlled by-pass 116 is provided for use when starting up the operation, whereby the oil from the base may be circulated through the heating coil 2 of the still 1 and back to the base until the normal operating temperature is obtained.

In starting the operation the cracking stock may be drawn from either of the tanks 85 or 86 by the pump 98 and fed through the coil 100 and either or both of the pipes 104 or 109 into the traps 52 and 58, from which it is fed through the pipes 91 and 92 into the inlet of the pump 3 which forces the oil through the heating coil and pipe 6 into the expansion chamber 7, from whence it is delivered into the base of the tower 44 and fills the same up to the desired level, as indicated by the dotted line in Fig. 1. The level in the base may be determined at any time by the gauge 49. During this preliminary filling operation the valves 78 and 79 in pipes 75 and 76 are closed. When the desired level of the oil in the apparatus as indicated by the dotted lines in Fig. 1, is reached the circulation of the oil from the tanks 85 and 86, as the case may be, is discontinued and the valve in the by-pass 116 is opened. The oil in the base is then passed by way of pipe 102 receptacle 101 and by-pass 116 to the inlet of the pump 3, by which it is passed through the coil 2 and pipe 6 to the expansion chamber 7, from which it enters the base. During this preliminary circulation to and from the base, as described, the furnace in pipe still 1 is in operation applying heat to the oil as it passes through the coil 2. When the oil in the system has reached its normal operating temperature the valve and the by-pass 116 is closed, and thereafter during normal operation the supply to the pump 3 is drawn from the traps

52 and 58, as the case may be. Liquid level gauges 117 are provided as shown, which indicate the liquid level in the traps 52 and 58.

The oil leaving the pipe 6, at approximately 900° F. under the regulation of the controlling valve 8, passes through the tubular member 11, and is released at the outer end thereof into the tubular member 39 where it enters a zone of lower pressure and forms an expanding fluid jet in the outer portion of the member 39. This jet action creates a suction on the oil in the chamber 42 drawing it into the tubular member 39 and discharging it with the heated expanding oil, into the expansion chamber 7. The oil delivered from the chamber 42 is cooler than the heated oil discharged from the tubular member 11 which is at a cracking temperature and acts to check the cracking reaction of the heated oil which is discharged into expansion chamber 7 in such a manner that the cracking reaction does not proceed beyond the limits where a further cracking reaction would be productive of solid end products, such as free carbon and coke. The cracking reaction is also checked in this manner before total decomposition is effected in the marketable products such as the lubricating and wax constituents thereof. I found that lubricating oils and waxes are formed in the zone of lower pressure synthetically by polymerization. In order to protect the oil in the chamber 42 from having direct contact with the heated tubular member 11, steam is fed through a pipe 118 into the passage 33 and recess 34, from whence it flows through the passage 35 into the chamber 36 and annular space 37 between the tubular jacket 16 and the tubular member 11. In this manner solid deposits of carbon or coke on the tubular member 11, which might otherwise be caused by local overheating, are avoided. The steam will also assist thereafter in the fractional distillation. The cooler oil from the chamber 42 will, in addition to checking the cracking reaction within the chamber 7, act to control the amount of vaporization effected therein, and thereby retain a larger proportion of the highly volatile oils in the liquid form and also reduce the tendency toward the formation of gases. The lighter oils, which are thus kept in the liquid phase, have a solvent action, which also acts to prevent the formation of solid end products. The temperature of the residue oil is maintained at such a point as to prevent total decomposition therein with the consequent formation of solid end products. The lighter oils also act to keep the heavier hydrocarbon constituents in liquid solution. In addition, solvent oil may also be drawn from the trap 52 and passed into the residue oil in the base by means of the valve controlled pipe 113. The crude oil, which is supplied through pipe 68 into the jacket 67, is stripped of its lighter fractions by vaporization which pass into the tower through the openings 89 and blend with the vapors passing into the condenser 60. The remaining fractions of the crude then pass through the overflow pipe 69 into the jacket 70 wherein a further distillation at a higher temperature takes place, the vapors thus produced in the jackets 70 passing through the openings 90 into the tower and blending with the vapors passing through the openings 56 into the zone above the trap 58, wherein the kerosene fractions are extracted. The unvaporized oil in the jacket 70 passes through the overflow 71 and may be led through either or both of the valve controlled pipes 72

and 73 into the base of the tower, whereby such oil may be directly blended with the residue oil in the base through the pipe 72 or passed in heat interchanging contact with the vapors arising from the residue oil through the pipe 73. The gas oil fractions of the oil thus introduced into the base from the jacket 70, are vaporized and blended with the vapors passing through the openings 56 in the trap 52 into the zone above the trap 52, wherein the gas oil fractions are condensed.

In carrying out my process in a typical run on a characteristic Mid-Continent gas oil of the following specifications—Baumé gravity 34° initial boiling point 405° F.—maximum boiling point 780° F., a single pass through the coil 2 of the cracking stock resulted in a product having an initial boiling point of 75° F. and contained fractions vaporizing between 75° F. and 374° F. as tested by the Bureau of Mines method. This result was obtained without the formation of a deposit of solid end products, such as free carbon and coke. The pressure carried on the heating coil 2 throughout the run was 1050 pounds per square inch, and the temperature at the delivery end of the coil 2 was 890° F. By careful tests I have determined that the percentage of conversion of the heavy oils into lighter oils may be carried to 20 per cent and upwards without formation of solid end products such as free carbon and coke. It will be understood, however, that these percentages may vary with oils of different characteristics.

From the foregoing description it will be seen that my process provides a method of combined topping and cracking, wherein the vaporization incident to the topping is effected by heat interchange with the heated products of the cracking reaction and the vapors of the topping reaction undergo fractional condensation with the vapors of the cracking reaction. The cracking stock is made up in part of freshly produced clean condensates of the vapors of the cracking reaction, and also freshly produced oil extracted from the crude oil by fractional distillation and condensation, which is effected simultaneously with and jointly treated with the products of the cracking reaction. It will be seen that the cracking stock, which is recycled to the action of the heating step of the cycle is not intermingled with the residue oil and therefore constitutes what is known as "clean stock" which is particularly adapted to a cracking reaction, wherein it is desired to avoid formation of solid end products.

It is within the scope of my invention to check the dissociation of the heated oil either before or after vaporization or simultaneously therewith. The checking of the dissociation by reduction in temperature may take place upon the introduction of the heated oil into the base of the tower 44 upon coming in contact with the cooler oil in said base, in which case the prior step of cooling may be omitted. The temperature of the oil in the base would, under these circumstances, be controlled so as to accomplish the functions of checking the dissociation of the heavy oil and also the prevention of the formation of solid end products such as coke, from the oil in said base. The control of the temperature of the oil in the base of the tower is also such as will cause those fractions to be vaporized which form the desired condensates for the re-cycle oil which must be of a definite nature to permit of successful treatment in the heating step of the cycle of treatment. When the prior cooling step is omitted the heated oil may be carried under pressure directly up to its introduction

into the cooler oil in the base of the tower where the pressure is released and expansion occurs.

I claim:

1. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, simultaneously introducing a regulated quantity of relatively cooler hydrocarbon oil into said heated oil, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, introducing a separate mass of relatively heavy hydro-carbon oil into said mass of cooler oil, subjecting the vaporized and uncondensed products to fractional condensation, introducing a portion of the condensates of said fractional condensation into said mixture of cooler oil and separate mass of relatively heavy hydro-carbon oil, mixing a mass of fresh oil with a separate portion of the condensates of said fractional condensation and subjecting the mixture of fresh oil and condensates to the heating step of the cycle of treatment.

2. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products formed in said zone into a mass of cooler oil, introducing a separate mass of relatively heavy hydro-carbon oil into said mass of cooler oil, subjecting the vaporized and uncondensed products thus formed to fractional condensation, introducing a portion of the condensates of said fractional condensation into the mixture of said cooler oil and separate mass of relatively heavy hydro-carbon oil, preheating a mass of fresh oil by heat interchange with said mixture of cooler oil, condensates and separate mass of relatively heavy hydro-carbon oil, mixing said mass of preheated fresh oil with a separate portion of the condensates of said fractional condensation and subjecting said mixture of preheated fresh oil and condensates to the heating step of the cycle of treatment.

3. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, simultaneously introducing a regulated quantity of relatively cooler hydrocarbon oil into said heated oil, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by heat interchange with a separated fresh mass of crude oil so as to cause vaporization of the lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone so as to undergo treatment therewith, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series so as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter fractions thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature, so as to undergo treatment therewith, and passing the unvaporized fractions of said crude oil into heat interchanging relation with a zone of relatively higher temperature than the second named zone of said series of zones.

ing the lighter fractions thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith and passing the unvaporized fractions of said crude oil into heat interchanging mixture with said vaporized and uncondensed products separated from said cooler oil in a zone of relatively higher temperature than the second named zone of said series of zones.

4. A process for the conversion of hydrocarbon oils which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, simultaneously introducing a regulated quantity of relatively cooler hydrocarbon oil into said heated oil, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by heat interchange with a separated fresh mass of crude oil so as to cause vaporization of the lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone so as to undergo treatment therewith, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series so as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter fractions thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature, so as to undergo treatment therewith, and passing the unvaporized fractions of said crude oil into heat interchanging mixture with said vaporized and uncondensed products separated from said cooler oil and directly with said cooler oil in a zone of relatively higher temperature than the second named zone of said series of zones.

5. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, simultaneously introducing a regulated quantity of relatively cooler hydrocarbon oil into said heated oil, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of one of said zones by heat interchange with a separated fresh mass of crude oil in such a manner as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of said series so as to undergo treatment therewith, and subjecting the condensates from said zone to the cracking step of the cycle of treatment.

6. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-

carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil in such a manner as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as to undergo treatment therewith, subjecting the condensates from said zone of relatively low temperature to the cracking step of the cycle of treatment, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith, and removing the condensates from said zone of relatively higher temperature as an intermediate product.

7. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil so as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as to undergo treatment therewith, removing the condensates from said zone of relatively low temperature as an intermediate product, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith, and subjecting the condensates from said zone of relatively higher temperature to the cracking step of the cycle of treatment.

8. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil so

as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as to undergo treatment therewith, mixing a fresh mass of oil with the condensates from said zone of relatively low temperature, subjecting the mixture thus formed to the cracking step of the cycle of treatment, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith and removing the condensates from said zone of relatively higher temperature as an intermediate product.

9. A process for the conversion of hydro-carbon oils which consists in heating a mass of relatively heavy hydro-carbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil so as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as to undergo treatment therewith, removing the condensates from said zone of relatively low temperature as an intermediate product, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith, mixing a fresh mass of oil with the condensates from said zone of relatively higher temperature and subjecting the mixture thus formed to the cracking step of the cycle of treatment.

10. A process for the conversion of hydro-carbon oils which consists of heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperatures, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil so as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as

to undergo treatment therewith, preheating a fresh mass of oil by a heat interchange with said mass of oil cooler than said products and mixing it with the condensates from said zone of relatively low temperature, subjecting the mixture thus formed to the cracking step of the cycle of treatment, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into a heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith and removing the condensates from said zone of relatively higher temperature as an intermediate product.

11. A process for the conversion of hydrocarbon oils which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure, introducing the products thus formed in said zone into a mass of hydro-carbon oil cooler than said products, subjecting the vaporized and uncondensed products thus formed to fractional condensation in a series of zones of decreasing temperature, controlling the temperature of a zone of said series having a relatively low temperature by a heat interchange with a separate mass of crude oil so as to cause vaporization of lighter constituents thereof, mixing said vaporized lighter constituents with the vapors undergoing condensation in said zone of relatively low temperature so as to undergo treatment therewith, removing the condensates from said zone of relatively low tem-

perature as an intermediate product, passing the unvaporized fractions of said crude oil from said zone of relatively low temperature into heat interchanging relation with a zone of relatively higher temperature of said series in such a manner as to control the temperature thereof and vaporize lighter constituents of said unvaporized fractions of said crude oil, mixing the lighter constituents thus vaporized with the vapors undergoing condensation in said zone of relatively higher temperature so as to undergo treatment therewith, preheating a fresh mass of oil by heat interchange with said mass of oil cooler than said products and mixing it with the condensates from said zone of relatively higher temperature and subjecting the mixture thus formed to the cracking step of the cycle of treatment.

12. A process for the conversion of hydrocarbon oils which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature between 700 and 1000° F. under a pressure from 600 to 2000 pounds per square inch for a sufficient length of time to convert in a single exposure to said temperature and pressure 20 percent and upwards into lighter oil, forthwith checking the dissociation of said heated oil by reducing the temperature thereof in such a manner as to inhibit the formation of free carbon therein, introducing the products of conversion into a mass of oil cooler than said products, subjecting the uncondensed and vaporized products thus formed to fractional condensation, returning a portion of the condensates of said fractional condensation to said mass of cooler oil, mixing a mass of fresh oil with a separate portion of said condensates and subjecting said mixture of fresh oil and condensates to the heating step of the cycle of treatment.

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