

Dec. 31, 1929.

J. E. BELL

1,741,275

PROCESS OF FRACTIONATING VAPORS FROM PRESSURE STILLS AND THE LIKE

Filed March 24, 1924

3 Sheets-Sheet 1

Fig. 1,

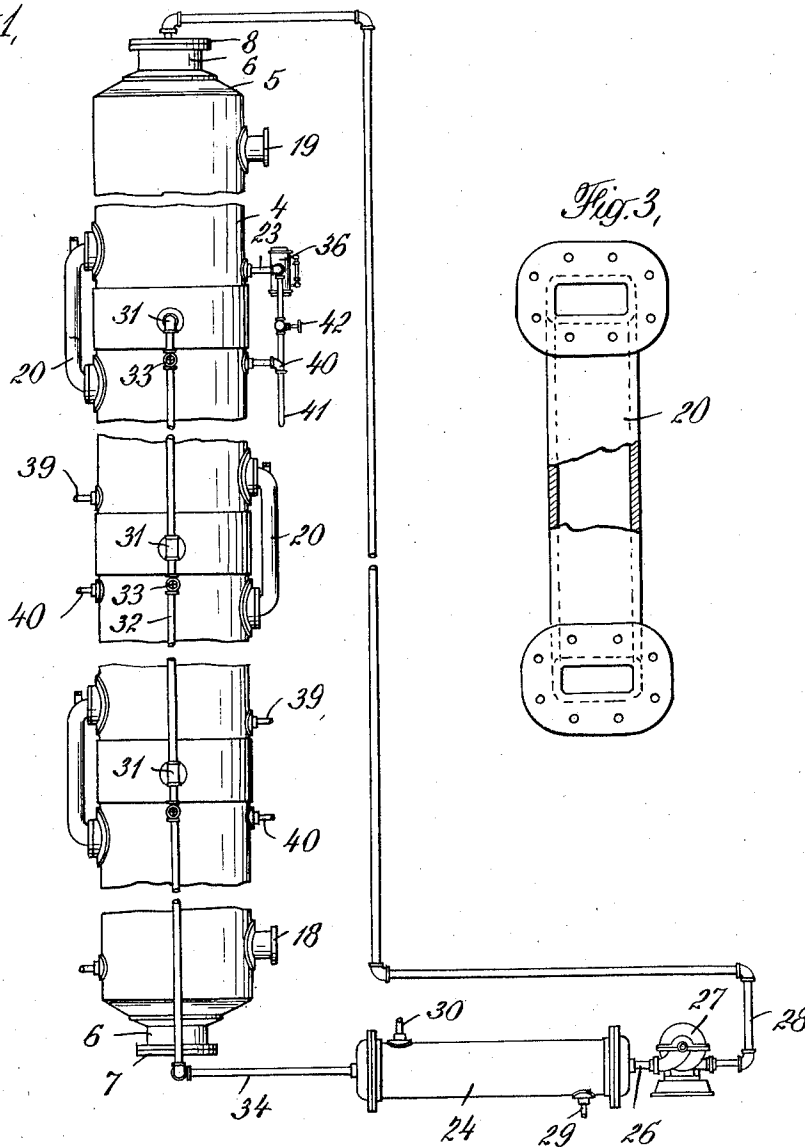
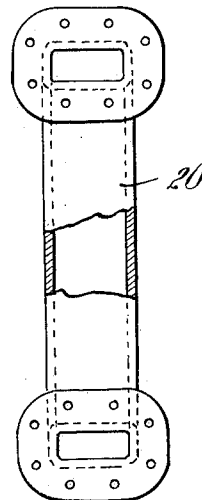


Fig. 3,



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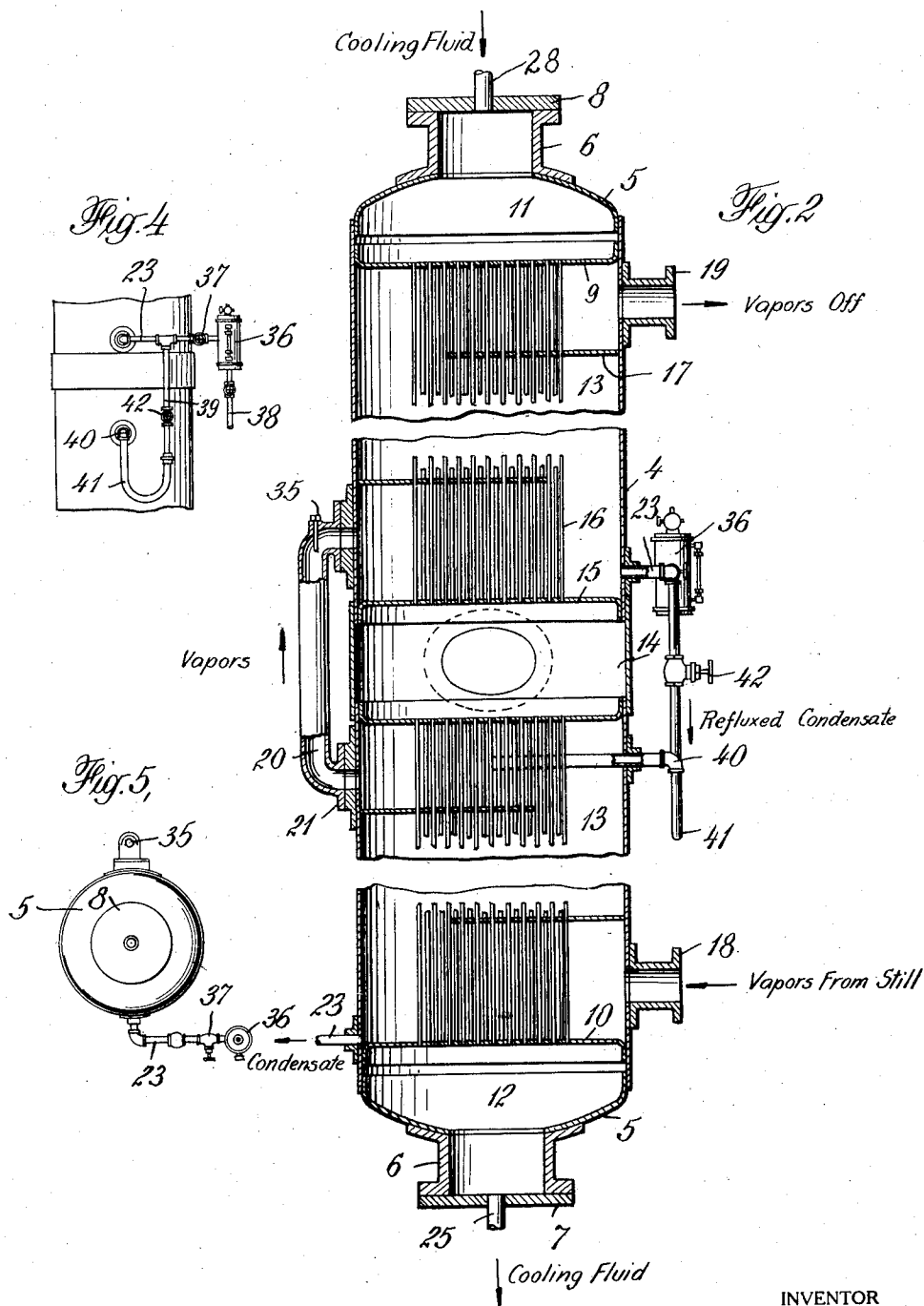
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

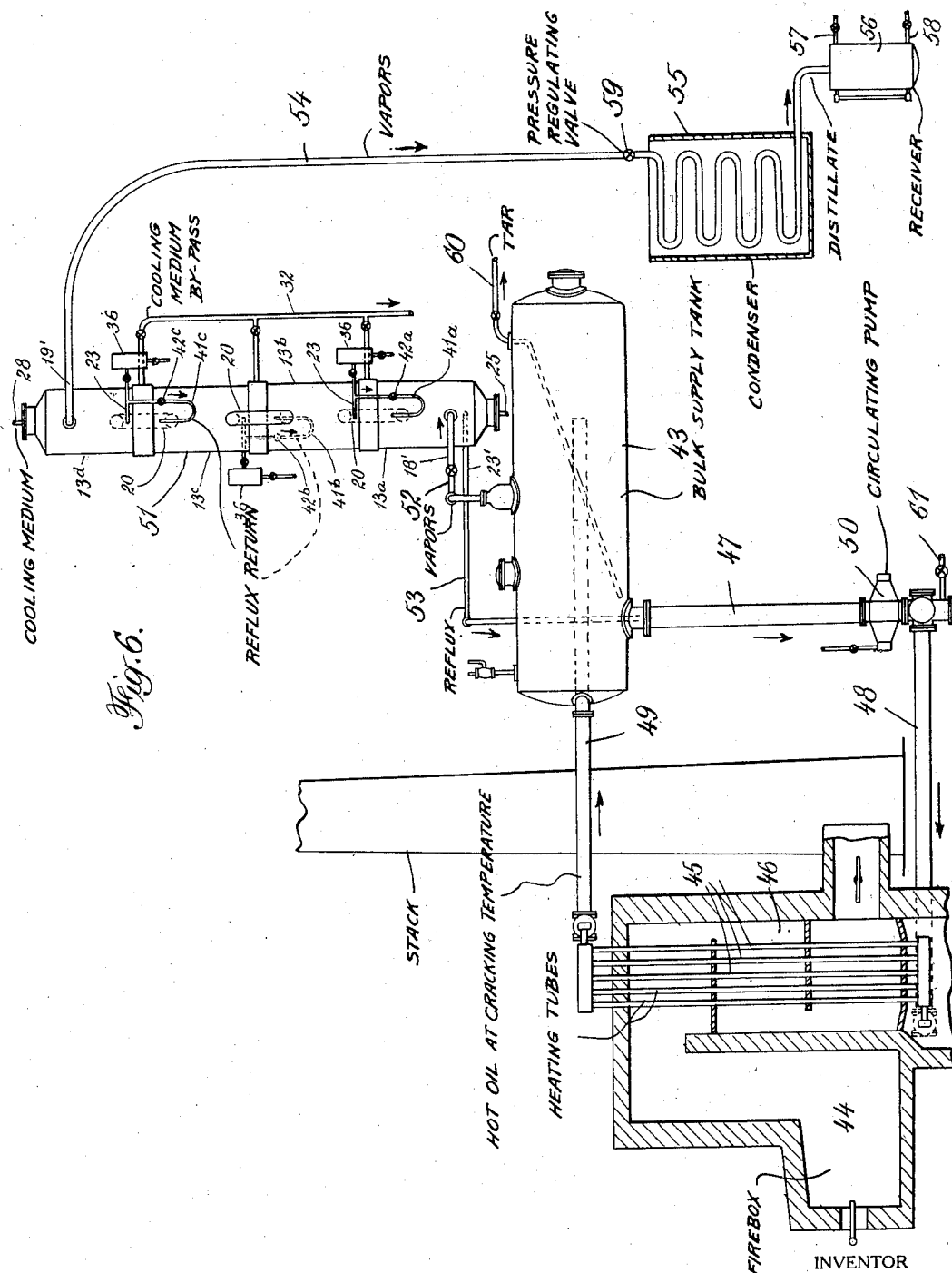


Fig. 6.

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PROCESS OF FRACTIONATING VAPORS FROM PRESSURE STILLS AND THE LIKE

Application filed March 24, 1924. Serial No. 701,396.

This invention relates to an improved method of fractionating vapors, particularly the vapors from pressure stills, and involves an improved method of fractionally condensing the vapors whereby accurate fractionation is obtained directly.

The invention relates particularly to improvements in the operation of fractionating towers employed in conjunction with pressure stills for cracking hydrocarbon oils of higher boiling point such as gas oils and the like to form more volatile or lighter hydrocarbon oils such as those which constitute commercial gasoline or pressure distillate.

In cracking hydrocarbon oils by distillation under pressure, the crude pressure distillate from the pressure still contains, in addition to the lighter hydrocarbons suitable as components of gasoline, hydrocarbons of the kerosene group and others even heavier. It has heretofore been necessary to subject the crude condensate from the pressure still to redistillation to fractionate it into merchantable products and to separate out the heavier hydrocarbons.

One of the objects of the present invention is to partially or entirely dispense with this redistillation by fractionally condensing the vapors as they come from the pressure still, separating the heavier components from the lighter components and separately condensing them.

According to this invention the vapors from the pressure still are passed successively through a series of separate vapor condensing chambers maintained at progressively lower temperatures and a regulated part of the condensate from condensing chambers at lower temperature is refluxed into condensing chambers of higher temperature. The condensing surfaces in the successive chambers are maintained at progressively lower temperatures so that the heaviest vapors are condensed in the first chamber entered by the vapors, the next heaviest vapors in the next chamber entered, and so on. By refluxing a part of the condensate from condensing chambers at lower temperature into condensing chambers at higher tem-

perature, the refluxed condensate assists in effecting condensation and is subjected to re-fractionation, and by regulation of the amount of condensate so refluxed, the fractional condensation in the condensing chambers into which the reflux condensate is introduced is controlled.

According to this invention, the accuracy of the fractionation is further promoted by maintaining a low temperature differential between the condensing surfaces and the vapors undergoing condensation thereon. As the temperature of the condensing surface approaches the critical temperature of the vapor to be condensed the more accurate is the fractionation, and it is desirable, for close fractionation, that the condensing surfaces be maintained at temperatures just below the critical temperatures of the respective vapors to be condensed. Practically, however, it is necessary to sacrifice, to a certain extent, accuracy or definiteness in cut because of the large number of compounds of different gravity in the vapors to be condensed and the increased extent of condensing surface necessary where a lower temperature differential is maintained.

In carrying out the improved process of the present invention, it is advantageous to maintain a differential of less than 25° F. Between the temperature of the cooling fluid circulating over the condensing surfaces and the temperature of the vapors undergoing condensation thereon, the temperature of the condensing surface being somewhere intermediate the temperatures of the cooling medium and the vapors respectively. The temperature differential of 25° F. between the cooling medium entering each condensing chamber and the vapors leaving the same chamber is substantially maintained throughout the condensing chambers of the series. The temperature differential may be lower, say 10° F. for example, with corresponding increase in the size of the apparatus if the same number and character of cuts are to be made. For example, to condense all of the vapors from the pressure still in the fractional condenser, including the gasoline fraction, with a temperature differential of 25°

F., assuming the vapors from the pressure still have a temperature of about 530° F. when they reach the fractional condenser, the cooling medium for cooling and condensing the vapors would enter at a temperature of about 65° F. and leave at a temperature of about 505° F. By increasing the flow of the cooling medium, or by decreasing its initial temperature, greater condensation can be achieved, but at the expense of the accuracy of the cuts obtained.

According to the present invention, a regulated part of the condensate from condensing chambers at lower temperature is refluxed into the condensing chambers of next higher temperature to increase the efficiency of separation and to control the fractional condensation. The condensate refluxed from a cooler chamber to a hotter chamber is mainly re-vaporized in the hotter chamber, only a small fraction of heavy components which have been carried over with the lighter vapors remaining behind in liquid form in the hotter chamber. The refluxed condensate is thus subjected to refractionation; and condensation, within the chamber into which the refluxed condensate is introduced in regulated amount, is controlled by the cooling effect of the introduced liquid condensate and the vaporization thereof. All or a part of the condensate from certain of the chambers may be reintroduced into the preceding chamber at higher temperature, and, in some cases, it may be desirable to by-pass a part of the refluxed condensate about the next preceding chamber and introduce it into the succeeding chamber at still higher temperature.

The series of separate condensing chambers in which the vapors are fractionally condensed may be arranged in vertically superposed position in the form of a tower, the vapors undergoing fractional condensation entering at the bottom of the tower and leaving from the top thereof. The condensing surfaces preferably constitute tubes disposed within the condensing chambers and through which the cooling fluid flows. Any cooling fluid, stable at the temperatures to which it is subjected, may be employed, but I find it advantageous to use a suitable oil, and to constantly recirculate it through the tower counter current to the flow of vapors there-through, through a cooler to absorb the heat from the oil, and back to the tower by means of a suitable pump. That regulated part of the condensate refluxed from each of the superposed chambers to the chamber at next higher temperature may be returned by gravity to the next lower condensing section in the tower.

The invention will be further described in connection with a pressure still of the general type described and illustrated in Patent No. 1,285,200 granted to the Sinclair Re-

fining Company, November 19, 1918, on the application of Edward W. Isom, but it will be understood that the invention is of more general application, although it is of particular value in connection with a pressure cracking still of this type.

In the accompanying drawings, I have shown certain forms of apparatus in which the process of the invention can be practised and the invention will be further described in connection therewith. It is to be understood, however, that these specific illustrations and description are for the purpose of exemplification and that the scope of the invention is defined in the following claim, in which I have endeavored to distinguish it from the prior art, without, however, relinquishing or abandoning any portion or feature thereof.

In the accompanying drawings,

Fig. 1 is a side elevation of a fractionating tower adapted for the practice of the process of the invention,

Fig. 2 is a fragmentary axial longitudinal sectional view of the same on an enlarged scale,

Figs. 3 and 4 are elevations partly in section showing detail,

Fig. 5 is a horizontal section showing a detail, and

Fig. 6 represents in elevation and partly in section a fractionating tower of the type shown in Fig. 1 in conjunction with a pressure still and a final condenser.

Each part is identified by the same reference character wherever it occurs in the separate figures.

Referring to the drawings, the fractionating condensing tower comprises a cylindrical shell 4 closed by end plates 5, each of which is provided with a hand-hole fitting 6. The hand-holes are normally closed by plates 7 and 8. Slightly spaced from the end plate 5 at each end of the tower are header sheets, 9 and 10, said sheets forming with the adjacent end plates inlet and outlet chambers, 11 and 12, for the cooling fluid as will presently appear. The space between the header sheets is divided into a plurality of vapor condensing chambers 13, shown as four in number although the number may be varied and is dependent upon the number of cuts desired. Between adjacent vapor condensing chambers are chambers 14 for the cooling fluid formed by header sheets 15 on opposite sides thereof and the wall of the cylindrical tower. The header sheets are successively connected by batteries of tubes 16 extending through the respective vapor condensing chambers whereby the cooling fluid may flow the length of the tower through the cooling fluid chambers and these tubes. The vapor chambers are provided with suitable baffle plates 17, fitting loosely about the cooling tubes 16, to provide a circuitous circulation for the vapors

therethrough in order that they may be more thoroughly brought in contact or heat exchanging relation with the cooling tubes.

The lowermost of the vapor condensing chambers is provided with an inlet port 18 for the entrance of the vapors and the uppermost condensing chamber with a vapor outlet 19. Tubular connections 20 are provided to conduct the vapors or such portion thereof as remains uncondensed from each vapor chamber, except the topmost, to the vapor condensing chamber next above. As best shown in Figs. 2 and 3, this connection is formed of rectangular tubing, the end flanges of which are secured in any suitable manner to the cylindrical wall of the tower above and below the intermediate cooling fluid chambers, the point of connection to the upper vapor condensing chamber being sufficiently above the header sheets forming the bottom of that chamber to allow for the collection of liquid condensate therein.

Where oil is employed as the cooling fluid, it is preferably circulated downwardly through the tower and is drawn off through the bottom, cooled, and returned to the top of the tower. For this purpose, a cooler 24 is connected by a pipe 25 to cover plate 7 of the lower manhole 6, the other end of the cooler being connected by a pipe 26 to circulating pump 27 by which the oil is forced through pipe 28 to the top of the tower. The cooler 24 is not illustrated in detail since it may be of the usual tubular construction, the inlet for the water or other fluid for cooling the oil being shown at 29 and the outlet therefor at 30 of Fig. 1. In order to supplement the control of the gravities of the several cuts effected in the respective vapor condensing chambers by regulated refluxing of the condensate separately collected in each chamber, connections are provided for controlling and distributing the flow of cooling fluid through the respective batteries of pipes in the vapor condensing chambers. For this purpose, each of the intermediate cooling fluid chambers 14 is provided with an outlet 31, these outlets being connected to a common by-pass pipe 32 provided with hand-valves 33 and connected by pipe 34 to the cooler. By means of this by-pass pipe, more or less of the cooling fluid may be by-passed through any of the condensing chambers except the first or it may be carried from any of the cooling fluid chambers directly to the cooler. Thermometer wells 35 are provided in the connections 20 for observation of the temperature in each of the vapor connections.

Each condensing chamber near its bottom and below the level of the vapor connection thereto, has a draw-off pipe 23, which is provided at 36 with a gauge glass to indicate the level of the condensate in the chamber, and a valve 37 for shutting off the draw-off and controlling the passage of condensate there-

through. A pipe 38 connected to the gauge glass receptacle extends to a cooler or storage tank. A branch connection 39 leads from the draw-off 23 of each condensing chamber, except the lowermost, to the top of the next lower condensing chamber at 40, a trap being formed in said pipe at 41 and a valve located therein at 42. A regulated part of the condensate from each condensing chamber is refluxed through this connection to the next lower and hotter condensing chamber where it is revaporized and returned for further treatment, the amount of reflux so introduced into the next lower and hotter chamber being controlled by valve 42. The stream of condensate entering the top of condensing chamber from pipe 39 spreads over the topmost baffle therein, and, the holes in the baffle through which the cooling tubes extend being somewhat larger than the latter, forms films on the tubes until vaporized being thus effectively subjected to the temperature of the tubes. The refluxed condensate is thus in effect redistilled and refractionated securing a more definite cut while at the same time effecting a regulated condensation of the vapors of the chamber into which it is introduced.

The pressure still illustrated in Fig. 6 is made up of the bulk supply tank 43 located away from the heating furnace 44, the vertical heating tubes 45 arranged in the heating flue 46 of the furnace, and circulating pipes 47, 48 and 49 connecting the lower and upper ends of the vertical tubes, respectively, with the bulk supply tank and a circulating pump 50 for circulating the oil from the bulk supply tank through the vertical tubes and back through the bulk supply tank. Arranged above the bulk supply tank is the fractionating tower 51, the lowermost vapor condensing chamber of which is connected with the vapor dome of the bulk supply tank through the vapor line 52. A return reflux line 53 leads from the lowermost vapor chamber back to the bulk supply tank. The vapors from the top condensing chamber in the fractionating tower escape through the vapor line 54 to the condenser 55 where the vapors are condensed and collected in the receiver 56 from which the uncondensed vapors and gases are drawn off through the connection 57 and the liquid condensate through the connection 58. The pressure may be regulated and reduced by means of a regulating valve 59 between the fractionating tower and the condenser, or by the valves in the connections 57 and 58 located beyond the receiver. A continuous tar draw-off is shown at 60 and a pumping-out line for discharging the still is shown at 61.

The fractionating tower 51, illustrated in Fig. 6, is of the construction shown in somewhat more detail in the preceding figures, and is provided with four vapor condensing chambers. The cooling fluid, at appropriate

temperature, is introduced into the upper cooling fluid compartment in the tower through connection 28, passed downwardly through the cooling tubes and intermediate cooling compartments in the tower, and removed through connection 25. The hot vapors from the pressure still, through connection 52, enter the hottest and lowermost vapor condensing chamber through connection 18' and pass upwardly through the successive vapor condensing chambers, maintained at progressively lower temperature, undergoing partial condensation in each condensing chamber. The uncondensed vapors and gases from the uppermost and coolest vapor condensing chamber in the tower pass to the final condenser through connections 19' and 54. The heaviest vapors are condensed in the lowermost and hottest chamber 13^a, the next heaviest vapors in the next chamber 13^b, and the progressively lighter fractions in the successive chambers 13^c and 13^d, the condensate in each chamber being separately collected in the lower part of that chamber. The liquid condensate collecting in the lowermost chamber 13^a, is returned to the pressure still through connection 23'. A regulated part of the condensate collecting in each of the chambers, 13^b, 13^c and 13^d, is refluxed into the next lower and next hotter chamber through the connections 41^a, 41^b and 41^c respectively, the amount of condensate so returned being controlled in each case by valves 42^a, 42^b and 42^c respectively. That part of the condensate collecting in each chamber which is not refluxed into the preceding chamber is withdrawn through the receptacles 36.

In carrying out the process of the invention, in conjunction with the pressure distillation of relatively heavy hydrocarbon oils for the production of gasoline, the gasoline fraction may be condensed in a separate condenser, as illustrated in Fig. 6, or the gasoline fraction may be condensed in one or more of the upper sections of the tower. Where the gasoline fraction is condensed in the fractionating tower, the gasoline may be condensed in the upper two chambers and the kerosene and heavier fractions condensed in the two lower chambers. Where the gasoline fraction is separately condensed, the fraction condensed in the hottest section, 13^a, contains substantially no gasoline or kerosene and may be returned to the still directly or put in heavier stock. The fractions condensed in the succeeding three chambers are of a kerosene character and may be marketed as such or the different fractions may be blended with each other or with other stock in a variety of ways according to the specific composition desired. If no kerosene is desired, the tower may be operated with a smaller drop in temperature of the cooling medium in the tower. The heavier kerosene character fractions may be returned to the

still with the condensate from the hottest condensing chamber by refluxing all of the condensate from the second, or from the second and third chambers, 13^b and 13^c, into the preceding chamber.

It will thus be seen that this invention provides an improved method of operation of pressure stills and an improved method for fractionating and condensing vapors therefrom whereby the vapors can be divided into cuts or fractions as desired, the division between the several cuts being definite and under the operator's control thus dispensing, in whole or in part, with the operation of redistillation. It will further be seen that the invention provides an improved method of operation of pressure stills in which the vapors from the still are subjected to a plurality of successive refluxing operations.

I claim:

The improvement in the operation of pressure stills which comprises distilling oil under pressure at a cracking temperature, passing the vapors therefrom successively through a series of separate condensing chambers under substantially the pressure prevailing in the still, passing a cooling fluid through the condensing chambers counter-current to the vapors and in indirect heat exchanging relation with the vapors therein, separately collecting the condensate in each of the chambers, controlling the condensation in the condensing chambers by refluxing part of the condensate from chambers at lower temperatures to chambers at next higher temperature, separately controlling the condensation in the chambers by by-passing regulated portions of the cooling fluid around the chambers, and returning the condensate from at least one of said condensing chambers directly to the pressure still.

In testimony whereof I affix my signature.

JOHN E. BELL.