March 23, 1926. 1,577,871

G. L. PRICHARD ET AL

PROCESS OF CONTINUOUS CATALYTIC DISTILLATION

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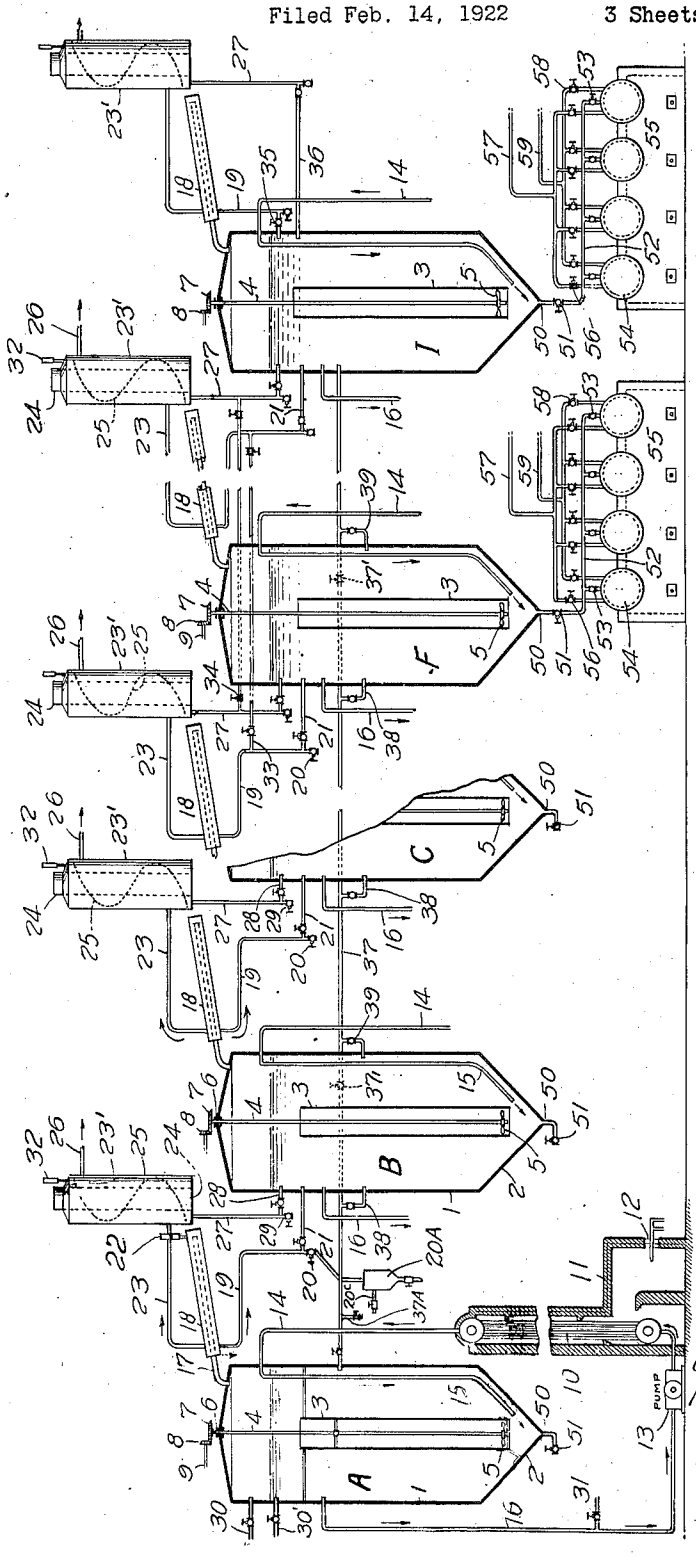


Fig. 1.

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Fig. 2.

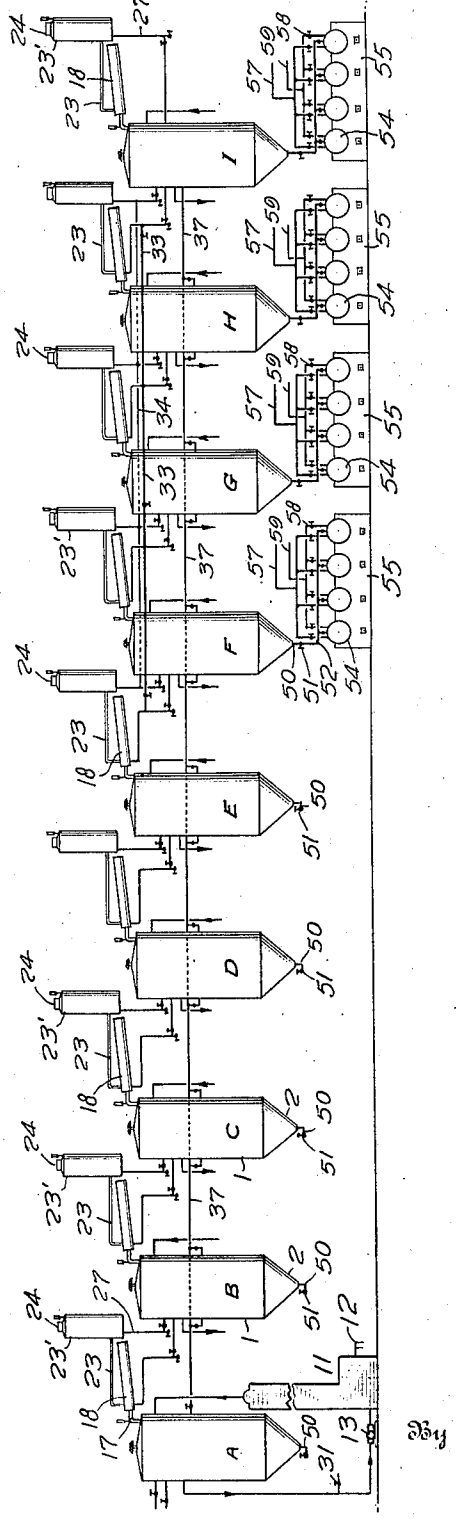
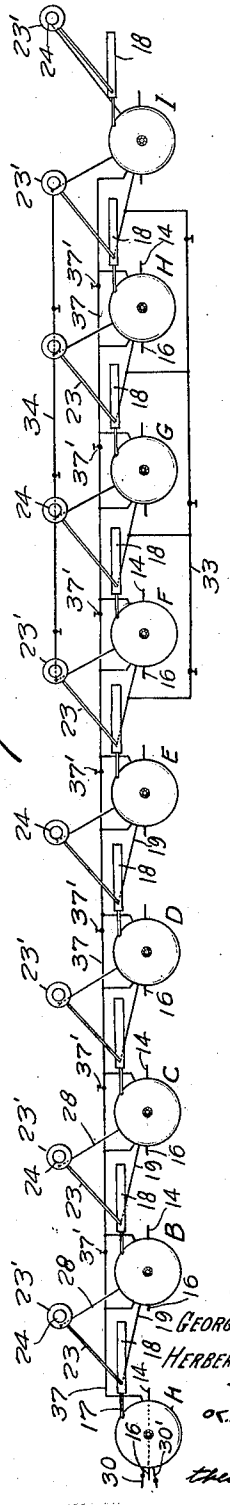


Fig. 3.



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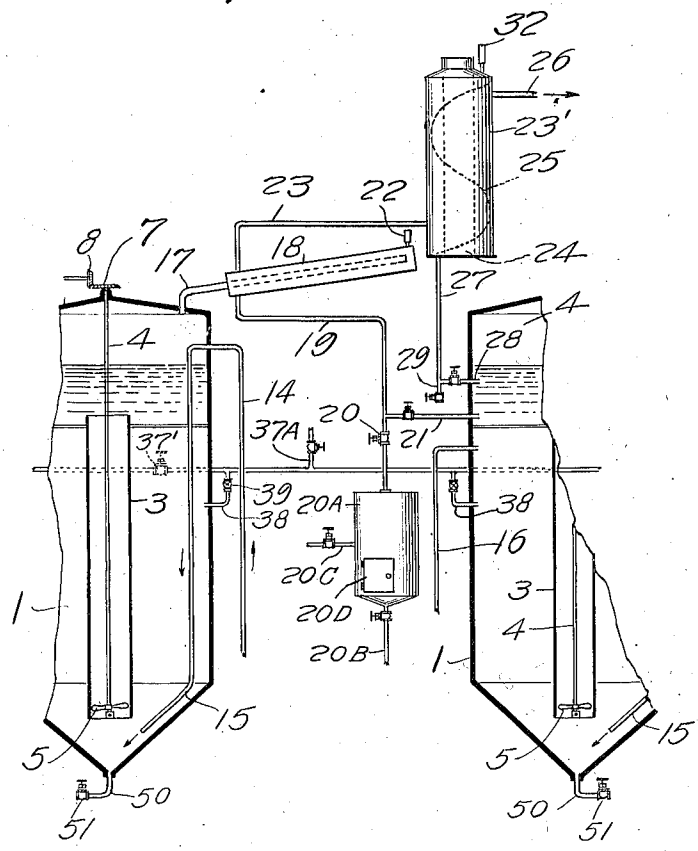
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PROCESS OF CONTINUOUS CATALYTIC DISTILLATION

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Fig. 4.



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UNITED STATES PATENT OFFICE.

GEORGE L. PRICHARD AND HERBERT HENDERSON, OF PORT ARTHUR, TEXAS, ASSIGNORS TO GULF REFINING COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF TEXAS.

PROCESS OF CONTINUOUS CATALYTIC DISTILLATION.

Application filed February 14, 1922. Serial No. 536,503.

To all whom it may concern:

Be it known that we, GEORGE L. PRICHARD and HERBERT HENDERSON, citizens of the United States, and residents of Port Arthur, in the county of Jefferson and State of Texas, have invented certain new and useful Improvements in Processes of Continuous Catalytic Distillation, of which the following is a specification.

This invention relates to processes of continuous catalytic distillation and it comprises distilling higher boiling hydrocarbons such as gas oil and the like in the presence of a catalytic chemical such as anhydrous aluminum chlorid advantageously at progressively rising temperatures and under certain conditions ensuring the maximum yield of lower boiling hydrocarbons with a maximum utilization of heat units and with economy in time; all as more fully hereinafter set forth and as claimed.

In the distillation of higher boiling hydrocarbons with catalytic chemicals, such as aluminum chlorid, the aluminum chlorid is mixed with a higher boiling oil and the mixture is brought to distillation temperature, usually in the case of gas oil, to a temperature around 500 to 550° F. In practice, the vapors from the stills are allowed to pass to one or more air or other cooled condensers which serve not only to condense the higher boiling oils vaporized, but also the aluminum chlorid and the aluminum chlorid combinations with the oil. The condensates in the condensers are usually back-trapped to the still, from which they come and the vapors of lower boiling oils, such as gasoline, are allowed to flow from the air cooled condensers to final or water cooled condensers and thence to stock. At temperatures not substantially above 350° F. the aluminum chlorid and its combinations with higher boiling oils condense and thus can be back-trapped to the stills, while the vapors of lower boiling hydrocarbons mostly of the nature of gasoline will not condense at such temperature and therefore flow onward to the final or the water-cooled condensers.

We have found in actual operation, that the vapors reaching the preliminary or air-cooled condensers in distillation processes such as described, not only contain aluminum chlorid, to which reference has been made, but also contain considerable quantities of lower boiling oils, which are condensed and returned. In other words, the back-trapping of the aluminum chlorid and its hydrocarbon compounds under the conditions noted, also results in back-trapping to the stills, lower boiling hydrocarbons, very much like gasoline, and such as kerosene and the like. In being back-trapped, the lower boiling hydrocarbons must necessarily be again heated, since they have undergone cooling and condensation in the preliminary condensers, and this is disadvantageous because there is a tendency for aluminum chlorid to perform what we call the "reverse" action, and convert lower boiling hydrocarbons into higher boiling hydrocarbons. Aluminum chlorid has the power not only of building up, but of breaking down hydrocarbons.

Among other objects of our invention is the provision of ways and means for utilization of lower temperatures (with consequent less resultant deterioration of the aluminum chlorid) and consumption of less heat units than is possible by hitherto known processes; and the provision of a distillation system whereby all the aluminum chlorid is utilized for the breaking down reaction rather than the building reaction, and whereby products with narrow range between their initial and end boiling points may be easily and economically secured.

Other objects of the invention will hereinafter appear.

In the accompanying drawing showing one form of apparatus capable of performing our process:

Figure 1 is a segmental view partly in section and partly in elevation of our distillation plant;

Figure 2 is a diagrammatic view showing the different vapor lines, condensers, etc.; and

Figure 3 is a top plan view of the diagrammatic showing of Figure 2;

Fig. 4 is a diagrammatic view, partly in section showing two adjacent stills.

Referring to the drawings and particularly Figure 1, we have shown a plurality of stills lettered A to I inclusive, stills D, E, G and H being omitted for clarity of presentation. The diagrammatic views of Figures 2 and 3 show all the stills. Each still comprises the tank 1 having the conical shaped bottom or sump 2, and an interior

draft tube 3, provided with the enclosed shaft 4 having the propeller 5 at the lower end thereof and passing through the stuffing box 6 at the top of the still. Each shaft has the beveled gear 7 meshing with the pinion 8 on shaft 9 driven from a source of power (not shown). Since aluminum chlorid tends to settle and form an underlying layer under the body of oil undergoing distillation, this stirring means is particularly advantageous. The apparatus described results in a circulation upwardly in the tube and downwardly around the outside thereof. The conical shaped bottom or sump 2 provides a settling basin for the exhausted or partially exhausted sludge of oil and aluminum chlorid which may be withdrawn continuously or from time to time as the exigencies of any particular case demand.

In the embodiment shown, the higher boiling oil is heated in the tubular boiler like arrangement 10, mounted in the furnace 11, provided with the oil or oil and gas burner 12 and is set by means of pump 13 through line 14 to the still, preferably, to a point near the bottom thereof by pipe 15 extending toward the lower end of the still. The higher boiling oil in admixture with aluminum chlorid is removed from the still by line 16 and sent to the heater 10 by means of the pump 13. This provides for a continuous circulation of the oil and mixture in the still 1 and not only assists in the stirring but is particularly advantageous in preventing localized heating of the still with consequent baking on of aluminum chlorid and coky residue. The circulating system is not specifically herein claimed, it forming part of our application, Serial No. 516,596, filed November 21, 1921, matured into Patent No. 1,476,219.

Each still is provided with the vapor line 17 leading to the trap 18, which comprises a sleeve or envelope sealed at both ends with the vapor line terminating short of the far end. Condensates in this trap flow by line 19 either to still B or to another point of disposition and use through the line 20, the valve on line 21 leading to still B being open and the valve on line 20 being closed in the first instance, and vice versa. This condensate from the trap 18 will contain relatively large quantities of aluminum chlorid and aluminum chlorid hydrocarbon compounds, together with some relatively lower boiling oils and higher boiling oils. The condensate taken from line 20 may be filtered through ordinary filtering apparatus such as the tank 20^A containing filtering material and having outlet 20^B for filtered oil, outlet 20^C for aluminum chlorid and closure 20^D for placing and removing the filtering medium. The aluminum chlorid thus recovered is sent to any one of the stills or disposed of in any other way, while the oil separated may be fractionated in a well understood way or may be sent to another still. The trap 18 is provided with thermometer 22 for observation of temperature. Leading from the trap 18 is the vapor line 23 terminating in an air cooled condenser of special design. This condenser 23′ is annular in cross section and is provided with the preferably central flue or air space 24 for the purposes of insuring maximum cooling surfaces. The vapors from line 23 pass in the annular space against the spiral baffle 25 and thence out of the vapor line 26 to final or water cooled condensers (not shown). Condensates in the air cooled condenser described flow by line 27 either to the still B through line 28 or to other points of use through line 29, the valve on these two last mentioned lines being adjusted depending upon the disposition of such condensates. The aluminum chlorid may be fed into still A through the line 30 or 30′, and this is best done by heating oil and aluminum chlorid and pumping it through said line, or the mixture of oil and aluminum chlorid may be admitted to the line 16 through line 31 and sent to the furnace 10.

The other stills in the series are similar in construction to the still described and are provided with the traps, condensers and other appurtenances as well as with the heating device illustrated. Of course, any other heating device or any other process of heating may be employed. It is advantageous to provide thermometers 32 for each of the air cooled condensers.

From the apparatus and operation described, it will be noted that the condensate from the trap 18 goes either to the next succeeding still or may be removed for other disposition. However, when a plurality of stills are used, at some point in the system, it is advantageous to send this heavy condensate to a still further along in the system. This may be accomplished through the construction shown beginning at still F. The line 19, leading from the trap 18, may be provided with a branch 33 tapping into any one of the succeeding stills and the line 27 from the preliminary air cooled condensers may be provided with a line 34 leading to any one of the succeeding stills. For purposes of illustration, we have shown these lines 33 and 34 leading to the last still I in series, but it is to be understood that they may lead to any one of a number of stills between F and I. This construction may be used for all of the stills.

The last still in the series, represented by I, may be provided with return back-trap lines 35 and 36 leading respectively from the trap 18 and the air cooled condenser 23′; back to the still.

The arrangement described permits opera-

tion in many different ways. Occasion may arise for transferring the oil and possibly the oil in admixture with aluminum chlorid from any one still to another in the series and in order that we may accomplish this result, we provide what we call a continuous oil main 37 tapping all the stills. This main is provided with branches 38 and 39 at each still. For instance, the contents of stills A or a portion thereof may be sent to any one or more of the succeeding stills and the contents of still B or any portion thereof may be likewise transferred to one or more of the succeeding stills.

With the apparatus in operation as described, the most highly active aluminum chlorid may be used in the first still A, with the relatively higher boiling hydrocarbon and the used aluminum chlorid trapped from the traps 18 and condenser 23′ may be used on lower boiling hydrocarbons in still B and so on, with the possibility of changing the specific character of the oil in any one of the stills through the oil main 37, described.

As the trapped aluminum chlorid gradually loses its activity, fresh aluminum chlorid may be added to any of the stills through the line 30 or through the line 31 leading to the heating apparatus. As the aluminum chlorid passes from still to still it gradually loses its activity so that particularly in the last few stills of the series it may be in a condition where it is masked, so to speak with carbon or coke, which has been formed. We therefore provide means for recovering the aluminum chlorid, particularly from the last four stills in the series, although we, of course, may use the recovery apparatus, to be described, with any of the stills.

The recovery apparatus shown in Figure 1 may be of the type described and claimed in our copending application, Serial No. 518,197, filed November 28, 1921.

Leading from the sump of the still is the pipe 50 suitably valved as at 51 and such pipe communicates with the main 52, having valved branches 53 leading to retorts 54 mounted in the furnaces 55. Vapors of hydrocarbon first distilled off from these residues may go by lines 56 to the pipe 57 leading to a condenser (not shown) or to one or more of the stills and the volatilized aluminum chlorid resulting from further heating to a higher temperature may go by lines 58 to pipe 59 leading to an aluminum chlorid condensing apparatus (not shown) from which the aluminum chlorid may be pumped to inlet 30 of the still A and inlet 31 of the still A or the preheating apparatus. In some cases aluminum chlorid vapors may be sent direct to a still.

According to a specific embodiment of our invention high boiling oil is charged by a pump 13 through the heater 10 into still A. High boiling point oil such as gas oil or the like and aluminum chlorid mixed therewith is charged into the still A through line 30. Pump 13 withdraws oil from still A through line 16 and discharges it through heater 10 into the bottom of still A through line 14. The vapors pass from still A through vapor line 17 and the still is controlled by thermometer 22 placed in line 17. That is to say, the degree of heat in the preheater is regulated in accordance with the temperature of the vapors at this point. The vapors then pass through the trap 18 and around the pipe located therein. The aluminum chlorid sludge is trapped from the bottom of this trap 18 through pipe 19 and by opening the valves on line 21 the mixture of aluminum chlorid and oil is trapped to still B. If it is desired to trap the mixture out at this point valve on line 21 is closed and valve on line 20 is opened, thus trapping the mixture out to a recovery plant or through a filtering device as previously described. This mixture of aluminum chlorid sludge may be trapped off after it has passed through any still down the line.

The vapors from this trap 18 pass through vapor line 23 into the dephlegmator tower or air cooled condenser 23′ and the vapors from this dephlegmator pass through line 26 to a final or water cooled condenser (not shown).

The heavy oil and aluminum chlorid sludge from this dephlegmator 23′ are trapped through line 27 into the second still B or, if found desirable, they may be trapped out either to a filter and recovery plant or direct to the recovery plant through valved line 29, the valves on these lines being suitably regulated as will be well understood. The higher boiling condensed hydrocarbons and the aluminum chlorid are separated and then either or both sent to any one of the succeeding stills through the main 37.

Oil main 37 is connected to all the stills so that the oil can when occasion requires be equalized throughout the entire battery. When run through a still—still B for example—the valve 37′ in line 37 is closed and valve 38 opened, allowing the oil to flow to one side of the still and valve in line 39 is opened allowing the oil to flow from the still back into the equalizing line 37. If a still is cut out of the line for repairs or for any other purpose, valve 37′ is opened and valves on lines 38 and 39 are closed, allowing the oil to flow directly past the still.

Back trap lines 19 and 27 are also connected, so that the sludge from the trap or dephlegmator from still E may trap into still G, by-passing still F. This arrangement, of course, may be adopted for any of the stills in the series. In other words,

the arrangement is such that any one still or any group of stills in the battery may be cut out, either as regards the flow of oil or as regards trapping arrangements. The trap lines may be cut out entirely and recovering of the residue resorted to.

The last group of stills in the battery commencing with F is equipped with a battery of batch retorts or stills referred to as a recovery apparatus. The sludge is drawn from the still through line 50 to any one of the recovery apparatuses or retorts 54, and the oil vapors driven off are conducted through lines 56 and 57 to a condenser (not shown). After all the oil vapors have been driven off, the valves on line 56 are closed, and valves on lines 58 are opened, thus allowing the volatilized and recovered aluminum chlorid vapors to pass through line 59 to the condenser (not shown) from whence the aluminum chlorid may be pumped back to still A.

If found desirable all the sludge may be trapped off from any one of the condensers by closing valve in line 21 and opening valve in line 20, also by closing valve in line 28 and opening valve in 29, thus trapping the sludge from this point to the batch still or retorts 54; and a certain amount of fresh aluminum chlorid may be charged into the high boiling point oil in line 37 through pipe 37A (Fig. 4) to make up the supply.

It will be seen that in operation all the vapors and oil that come over from any individual still unit may be taken out; that is, the vapors consisting of low boiling point oil vapors, high boiling point oil vapors and aluminum chlorid may be removed. The low boiling point vapors, after passing through the aluminum chlorid trap 18 and dephlegmator 23', go to the final condensing coil. The high boiling point oil vapors and the aluminum chlorid are either trapped to the next succeeding still in line or are trapped out and the high boiling point oil and aluminum chlorid (or aluminum chlorid sludge) are filtered through any filtering medium found best. We may use canvas or asbestos paper if the filtration is done hot, in which case the high boiling point oil which passes through the filtering medium may be trapped into the next still line or may be sent to storage to be used over again or for some other purpose. The aluminum chlorid remaining on the filtering medium is either trapped into the next succeeding still in line or is drawn off to a recovery plant.

If the battery of stills is run continuous, trapping from the first to the second, second to third, and so on, at some point down the line of stills, (at F, for instance), the aluminum chlorid sludge would be spent or practically spent and may be recovered in the manner described, or the last still may be run to dryness.

In one mode of operation, still A may be run with a vapor temperature in the vapor line of approximately 150° F. as indicated by thermometer 22. The vapor temperature in the vapor line of the last still, or still I, may be run as high as 500° F., with the temperatures in the vapor lines of the stills in between gradually stepping up and ranging from 150° F. for still A to 500° F. for still 1. The temperatures of the mixtures in the stills are determined by the vapor temperatures. This permits of greater production of low boiling point oils because we are able to keep each individual still at a uniform temperature.

In prior practice, the still is heated to a gradual increasing temperature and where fresh aluminum chlorid is charged the temperature is lowered temporarily because there is sudden production of lower boiling point oil. We are not confronted with this difficulty.

Of course, the temperature to which the oil in any still must be heated to insure converting action of the aluminum chlorid on the oil, depends upon the nature of the distillate or the higher boiling oil in the particularly still, and since these distillates may be constantly changed not only by the character of the condensates sent to them from the trap and dephlegmators, but also by the introduction of fresh oil either continuously or from time to time, it is difficult to state the exact temperature necessary to run each still. In a general way, the oil in the first still, gas oil, for instance, in admixture with aluminum chlorid may be heated to about 350° to 400° F. and the mixture in the last still may be heated from 500° to 600° F., with a gradual rise in temperature from the second to the eighth still in the series. The highly active aluminum chlorid in the first still under the temperatures noted will produce considerable gasoline and large quantities of partially converted and saturated higher boiling oil. These in going to the second still are acted upon by the aluminum chlorid which has already exercised some of its converting action, and unless new aluminum chlorid is supplied to the second still, the temperature therein should be slightly in excess of the temperature in the first still, and so on down the series. Since we provide individual heating plants for each still the temperatures can be easily regulated, and, as stated, they are best determined by observation of temperature of the vapors, either in the first trap or at the highest point in the vapor line leading from the dephlegmator. In the embodiment shown the traps and dephlegmators are air cooled, their temperatures and their consequential condensation power depending not only upon atmospheric conditions, but upon the volume of

vapors in them at any given time; and the volume of these vapors, or the rate of distillation, in other words, may be controlled by the heating plants furnishing hot oil to the still or the converting chambers.

It is possible with the arrangement described to produce continuous flow of good gasoline vapor from the dephlegmators all along the series while refluxing from still to still through the traps and dephlegmators the condensates including aluminum chlorid; and when the exigencies of any particular case demand, hydrocarbons having somewhat higher boiling points than gasoline, but lower boiling points than the oil undergoing distillation, may be trapped out along the line, filtered free of aluminum chlorid or distilled.

We have secured gasoline from the vapor line of the dephlegmator having end boiling point as low as 300° F. and we have secured from the traps and dephlegmators condensate having end boiling point as low as 400° F. and 450° F. By proper manipulation this may be done anywhere along the line. This is advantageous where it is undesirable to send to a succeeding still hydrocarbon having boiling points higher than gasoline, but lower than the boiling point of the initial oil used, because the product so produced is of a sweet saturated character although it has been produced from higher boiling point hydrocarbons, and there is no necessity of again submitting it to the action of the aluminum chlorid.

By running the stills continuously as described, each still contains the aluminum chlorid in a more uniform state of activity or exhaustion as the case may be. For example, fresh aluminum chlorid is charged into still A and the still may be run at the rate of two-tenths gallons of distillate per pound aluminum chlorid charged and the aluminum chlorid sludge trapped into another still. This aluminum chlorid sludge upon being trapped into the second still does the further work of two-tenths gallons per pound of the chlorid making the total work it has done through this stage four-tenths gallons of distillate per pound and so on down the line. The aluminum chlorid which is trapped from the eighth still to the ninth still has done the work of one and sixth-tenth gallons per pound of aluminum chlorid charged. These figures are used simply by way of explanation.

By removing the condensates from the traps and dephlegmators, as described, we are enabled to obtain good, sweet, saturated kerosene, and other hydrocarbons having narrow ranges between their initial and end boiling points, while continuously producing sweet, saturated gasoline, and lower boiling hydrocarbons with similarily narrow ranges between their end and initial boiling points.

Referring to the diagrammatic showing of Figures 2 and 3, the operation is the same as described wth regard to Figure 1, and these diagrammatic showings are self-explanatory.

What we claim is:—

1. The process of producing lower boiling hydrocarbon from higher boiling hydrocarbons which comprises distilling a body of higher boiling hydrocarbons in the presence of a catalytic chemical of the nature of aluminum chlorid condensing vapors of higher boiling hydrocarbons and the catalytic chemical, maintaining a second body of higher boiling hydrocarbon and the catalytic chemical undergoing distillation, delivering said condensate to said second body, and delivering for final condensation vapors of lower boiling hydrocarbon produced in the first distillation.

2. The process of catalytic distillation which comprises maintaining a series of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each distillation and delivering the condensates from each such distillation to a succeeding body in the series, while separately and finally condensing vapors of lower boiling hydrocarbons from each such body.

3. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons having boiling points higher than that of gasoline and preliminarily condensing the catalytic chemical from each such distillation, while separately collecting and condensing vapors of gasoline formed and delivering the condensed kerosene and higher boiling hydrocarbons together with such catalytic chemical from each such body undergoing distillation to a succeeding body undergoing distillation.

4. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the higher boiling hydrocarbon condensates and catalytic chemical from each other and returning one of them to a succeeding body undergoing distillation.

5. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the higher boiling hydrocarbon condensates and catalytic chemical from each other by filtration and returning one of them to a succeeding body undergoing distillation.

6. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the higher boiling hydrocarbon condensates and catalytic chemical from each other and returning the higher boiling hydrocarbon condensates to a succeeding body undergoing distillation.

7. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the higher boiling hydrocarbon condensates and catalytic chemical from each other by filtration and returning the higher boiling hydrocarbon condensates to a succeeding body undergoing distillation.

8. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbons and catalytic chemical from one of said condensation stages to a succeeding body undergoing distillation.

9. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from all of said stages of said condensation to a succeeding body undergoing distillation.

10. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from one of said stages of condensation to a succeeding body undergoing distillation, and separating the mixture of higher boiling hydrocarbon condensates and catalytic chemical from another of said stages of such condensation from each other.

11. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from one of said stages of condensation to a succeeding body undergoing distillation, and separating the higher boiling hydrocarbon condensates and catalytic chemical from one of said stages of condensation from each other and returning one of the so separated products to one of said bodies other than the one from which it was derived.

12. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from one of said stages of condensation to a succeeding body undergoing distillation, and separating the higher boiling hydrocarbon condensates and catalytic chemical from another of said stages of condensation from each other and returning the higher boiling hydrocarbon so separated to one of said bodies other than the one from which it was derived.

13. The process of catalytic distillation, which comprises maintaining a plurality of

bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from one of said stages of condensation to a succeeding body undergoing distillation, and separating the higher boiling hydrocarbon condensates and catalytic chemical from another of said stages of condensation from each other by filtration and returning one of the separated products to one of said bodies other than the one from which it was derived.

14. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation in a plurality of stages, while separately collecting and condensing vapors of lower boiling hydrocarbon formed and delivering the condensate of higher boiling hydrocarbon and catalytic chemical from one of said stages of condensation to a succeeding body undergoing distillation, and separating the higher boiling hydrocarbon condensates and catalytic chemical from another of said stages of condensation from each other by filtration and returning the higher boiling hydrocarbon so separated to one of said bodies other than the one from which it was derived.

15. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbon and the catalytic chemical from each such distillation, while separating, collecting and condensing vapors of lower boiling hydrocarbon formed, and delivering the condensed higher boiling hydrocarbon and catalytic chemical from each such distillation to a succeeding body undergoing distillation while supplying liquid higher boiling hydrocarbon from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

16. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbons and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each such distillation while separately collecting and condensing vapors of lower boiling hydrocarbons formed and delivering the condensed higher boiling hydrocarbon and catalytic chemical from each such distillation to a succeeding body undergoing distillation while supplying liquid higher boiling hydrocarbon and catalytic chemical from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

17. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the condensed higher boiling hydrocarbons and the catalytic chemical from each other delivering one of them to a succeeding body undergoing distillation and supplying liquid higher boiling hydrocarbons from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

18. The process of catalytic distillation, which comprises maintaining a plurality of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the condensed higher boiling hydrocarbons and the catalytic chemical from each other, delivering one of them to a succeeding body undergoing distillation while supplying liquid higher boiling hydrocarbon and catalytic chemical from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

19. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the condensed higher boling hydrocarbons and catalytic chemical from each other, delivering the condensed higher boiling hydrocarbon to a succeeding body undergoing distillation and supplying liquid higher boiling hydrocarbon from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

20. The process of catalytic distillation which comprises maintaining a plurality of bodies of hydrocarbon and catalytic chem-

ical of the nature of aluminum chlorid at distillation temperatures, preliminarily condensing higher boiling hydrocarbons and catalytic chemical from each such distillation, while separately collecting and condensing vapors of lower boiling hydrocarbons formed, separating the condensed higher boiling hydrocarbons and catalytic chemical from each other, delivering the condensed higher boiling hydrocarbon to a succeeding body undergoing distillation and supplying liquid higher boiling hydrocarbons and catalytic chemical from one of the bodies undergoing distillation to another of the bodies undergoing distillation.

21. The process of catalytic distillation which comprises maintaining a series of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, the temperature of each body being higher than the temperature of the one preceding it in the series, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each distillation and delivering the condensates from each such distillation to a body in the series maintained at a temperature higher than the temperature of the body from which said condensates were derived, while separately and finally condensing vapors of lower boiling hydrocarbons from each such body.

22. The process of catalytic distillation which comprises maintaining a series of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, the temperature of each body being higher than the temperature of the one preceding it in the series, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each distillation and delivering the condensates from each such distillation to a body in the series maintained at a temperature higher than the temperature of the body from which said condensates were derived, separately and finally condensing vapors of lower boiling hydrocarbons from each body, and supplying higher boiling hydrocarbon from one of the bodies to another of the bodies maintained at a higher temperature.

23. The process of catalytic distillation which comprises maintaining a series of bodies of hydrocarbon and catalytic chemical of the nature of aluminum chlorid at distillation temperatures, the temperature of each body being higher than the temperature of the one preceding it in the series, preliminarily condensing higher boiling hydrocarbons and the catalytic chemical from each distillation and delivering the condensates from each such distillation to a body in the series maintained at a temperature higher than the temperature of the body from which said condensates were derived, separately and finally condensing vapors of lower boiling hydrocarbons from each body, and supplying liquid higher boiling hydrocarbon and catalytic chemical from one of the bodies to another of the bodies maintained at a higher temperature.

In testimony whereof we have hereunto signed our names at Port Arthur, Texas, this 9th day of February, 1922.

GEORGE L. PRICHARD.
HERBERT HENDERSON.