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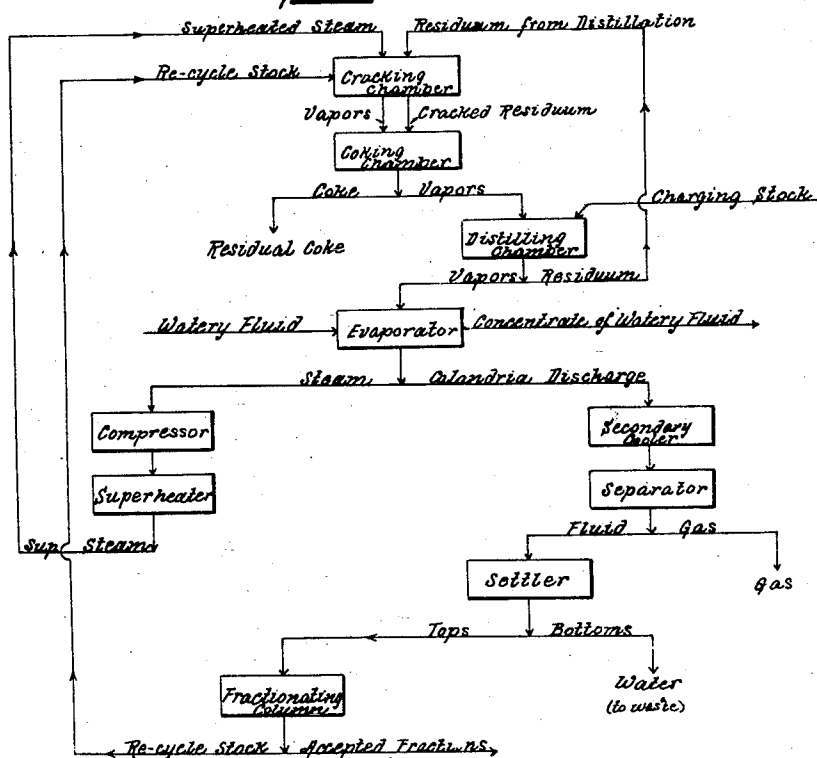
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CRACKING AND DISTILLATION OF OILS

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2 Sheets-Sheet 1

Fig. 1



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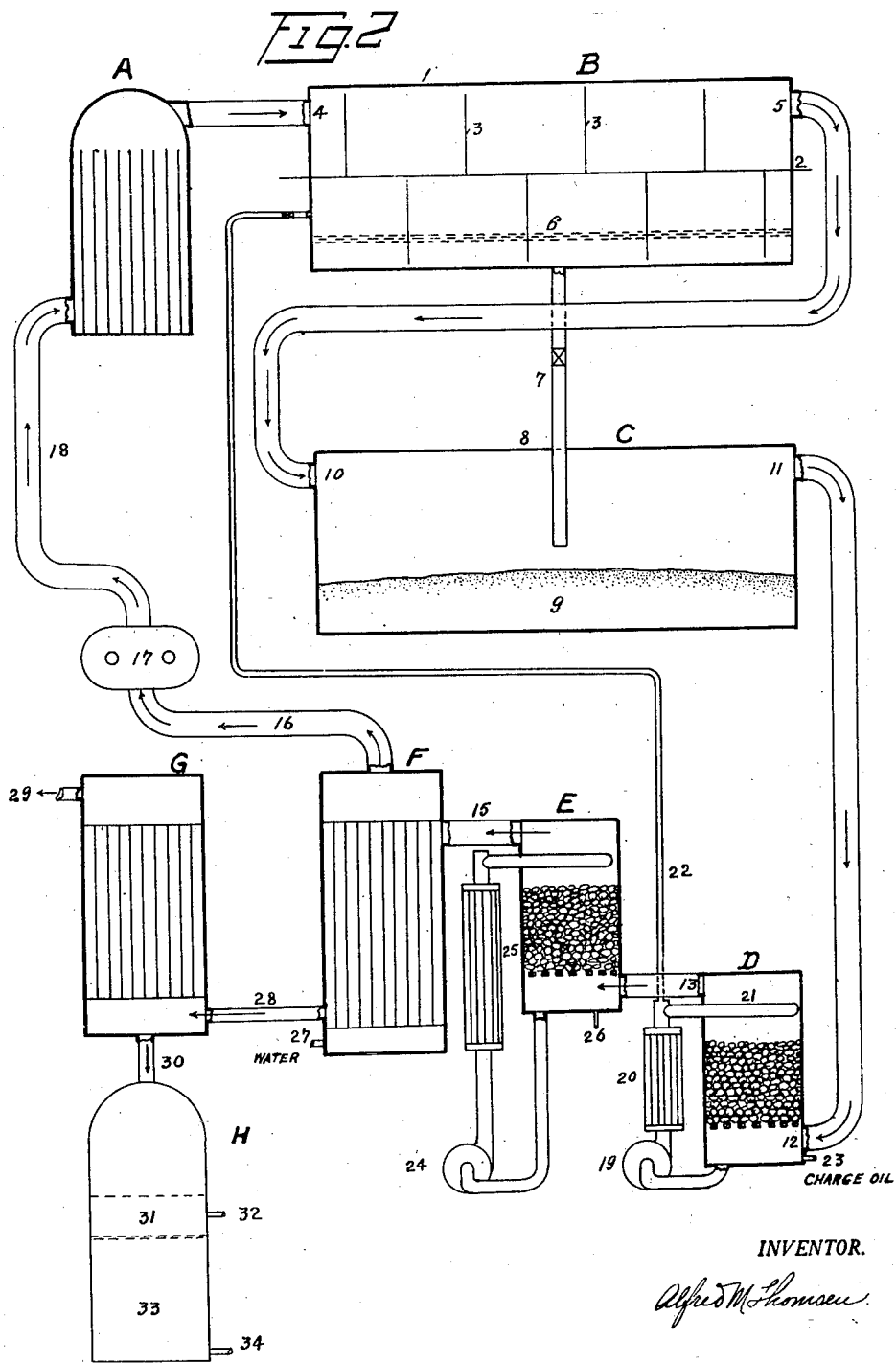
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2 Sheets-Sheet 2



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CRACKING AND DISTILLATION OF OILS

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3 Claims. (Cl. 196—61)

The peculiar advantages of cracking the high-boiling fractions of petroleum in the vapor phase, in the presence of superheated steam has long been known, particularly when the steam is used in such a large excess that it acts as the carrier of all the heat required in the reaction. The advantages are a better yield, a higher octane rating of the accepted distillate, and a very perfect elimination of sulphur.

Such being the case, it is rather strange that the commercialization of such use of superheated steam has not as yet progressed beyond the embryonic stage in the few instances where its use has been attempted on a reasonably large scale, until we scan the reason for such failures. First among these is the unfavorable heat balance of the steam carrier. With this eliminated there is no reason why such use of superheated steam can not be efficiently used. It is in the means whereby I eliminate this difficulty that my invention more particularly resides.

Without using exact figures it will be seen that from the standpoint of heat utilization the use of superheated steam is most unsound. To raise one pound of water from say 52° F. to boiling requires 160 B. t. u. To convert the water into steam requires approximately 1000 B. t. u. To superheat said steam to a temperature of say 1200° F., which is about proper, requires another 500 B. t. u., as the specific heat of steam is a little less than ½ that of water. To raise a pound of water to reaction temperature, therefore, requires close to 1700 B. t. u.

The critical temperature range for steam in the vapor phase cracking is from an initial of say 1200° F. to only 1000° F. when it becomes a very slow agent, so of this entire input of 1700 B. t. u. only about 100 B. t. u., or rather less than 6% of the total can be used in actual cracking. It is this unfortunate property of superheated steam which so much mitigates against its use. I will now describe how this difficulty can be evaded to such a degree that superheated steam becomes an acceptable means of oil cracking.

The process is best considered under two aspects, namely the use made of the sensible heat of the steam in treatment of the oil in certain steps where distillation rather than cracking is the object after its temperature is too low for the latter step; and secondly the recuperation of the latent heat of the total vapors in the form of latent heat of evaporation of water in the process of condensing same so that the oil fraction may be separated from the water fraction.

A preferred version of my process will next be given which corresponds to and is explanatory of the attached flow sheet and drawing. Considered thusly it will be seen that the process consists of 7 separate stages or steps, each of which will now be described in detail. Individ-

ually they are: A cracking stage, a coking stage, a distilling stage, an evaporating stage, a secondary cooling stage, a fractionating stage and a compressor-superheater stage. Collectively they form one process from which issues a low-boiling gasoline fraction, gas and coke as the sole products.

In the first or cracking step, steam with its full quota of superheat is admitted to the surface of a bath of oil, maintained in a state of turbulence in a cracking chamber. There are consequently two actions progressing simultaneously, namely, distillation from the surface of the comparatively cool oil and effective cracking of the vapors thus produced in the hot vapor space above the distilling oil. The relative amount of oil distilled and cracked is thus controllable by regulating the state of turbulence of the bath of oil. It should be noted that the oil operated upon is not charging stock direct, but a residuum from the third step of the process. It has, therefore, undergone a definite amount of preparation before being admitted to the cracking phase. In the drawing this step is illustrated at B, Fig. 2.

In the second or cooking stage, the residuum from the first stage is completely distilled so that coke is left as a residue. The flow sheet shows the source of heat as the total vapors from the first stage. While these are too cool to perform the cracking stage effectively they are amply hot enough to coke the residuum if same be properly exposed so as to absorb the available heat. This may be effected in any conventional manner, for instance by discharging the magma from stage 1 into shallow trays placed upon cars and run into a closed chamber. If the vapors from stage 1 now be allowed to flow through the cooking chamber, they will become cooled in accordance with the amount of oil volatilized from the trays. Simultaneously, they will become enriched with the oil vapors thus generated. In the drawing this step is represented by C, where the residual coke is represented as a solid mass upon the bottom of the coking chamber.

In the third or distilling stage, the vapors from stage 2 are further cooled by admitting them to the charging stock proper in such a manner that liquid and vapor shall be effectively commingled, thus producing distillation of the low boiling fractions. It follows that the cooled vapors drop their high boiling fractions to a very large extent and these become an integral part of the fluid which now becomes the raw material acted upon in the first stage. The cooling of the vapors in this distilling stage may be as low as 400° F. as the accepted fractions are far more volatile in the flow of superheated steam than when existing alone.

This commingling of oil and vapor may again be conducted in a variety of conventional ways but I prefer to operate as indicated in the drawing where D and E are scrubbers in which this condensing-distilling operation is effected. This will be made clear when the drawing is fully described under its proper heading.

Stage 3 is thus seen to give a flow of superheated steam, commingled with low boiling oil fractions and such permanent gas as has been produced in the various reactions leading up to this point in the process. To separate these from one another involves the necessity of condensing all the water vapor as well as the oil vapors, for as has already been pointed out these vapors are far more volatile in an atmosphere of steam than they are by themselves. In such condensation by customary means all the heat resident in such vapors as latent heat as well the sensible heat above the temperature of condensation are perforce lost in the cooling water of the condenser, and this loss is so much greater than everything else that it virtually kills the proposal to use superheated steam for the purpose of cracking. The difficulty is solved if the condensation be conducted in two stages, to wit: An evaporating stage in which the major part of this heat is converted into latent heat of volatilization of water at a lower pressure than that ruling in the mixture of oil vapor and steam that is undergoing condensation; and a secondary cooling stage in which the partially cooled products of the first stage are completely cooled.

The operation in the first condensation stage is analogous to that of the multiple effect evaporator in which steam condenses on one side of a metallic wall while the corresponding amount of water is converted into steam on the other by the expedient of maintaining the pressure slightly lower on the side where evaporation is taking place. This pressure differential may be quite small and is often as low as 4 pounds, in actual practice, nevertheless the heat transfer is excellent. Having thus abstracted the major part of the heat and converted it into steam the secondary cooling will be obvious. On the flow sheet, I have indicated this watery fluid being evaporated as entering the evaporator and leaving as a concentrate. In this manner soluble impurities in the water are eliminated or if desired, the evaporator performs its natural, normal function upon a fluid that it is desired to concentrate. To cool the vapors, to raise a corresponding amount of steam, and to perform the function of an evaporator is therefore accomplished at one and the same time. In the drawing this device, i. e., the evaporator, is represented by F.

The discharge from the calandria of the evaporator, i. e., these partially cooled fluids, is next seen on the flow sheet as entering and leaving a secondary cooler followed by a separator which discharges a mixed fluid of oil and water, and the non-condensable gas which was produced in the operation. This latter item will in general be used to heat the superheaters, which are blast furnace heating stoves used in the identical manner to superheat steam instead of to preheat the blast entering the iron furnaces. Settling finally separates the condensed water from the lighter oily products that float upon it. In the drawing, G and H, represent respectively the post condenser and the separator for condensed oils and water.

These oily products are next fractionated,

yielding an accepted product of the predetermined boiling point and higher boiling fractions that are returned to the cracking chamber as re-cycle stock. The fractionating device may be the orthodox column but I prefer to use the distilling device already indicated in the drawing. It will, therefore, consist of a series of scrubbers, each one of which is cyclically irrigated by its own condensate, each one producing a definite product, the nature of which is governed by the condensers.

Having thus traced the path of the oil from its entrance to its exit from the circuit it becomes necessary to return to the stage marked "Evaporator" on the flow sheet. The steam produced within the evaporator, corresponding to the abstraction of both sensible and latent heat from the vapors undergoing cooling, is seen as going to a compressor to increase its pressure to the required amount and then to a superheater to raise its heat to the required temperature, after which, as superheated steam it is seen as returning to the head of the flow sheet to repeat the heat cycle as before.

It has already been noted that the difference in pressure between the condensing steam and the steam produced in the evaporator by its condensation may be but a few pounds, hence it will be evident that the cost of increasing its pressure by mechanical means represents only a fraction of the cost of submitting the equivalent portion of water to evaporation.

The flow of reacting substances may also be traced upon the drawing which will now be more minutely described. A is a superheater of the orthodox blast furnace type which delivers superheated steam to the cracking chamber indicated by B. In this figure, 1 is the shell, 2 is an agitator whose blades 3, 3, keep the contained oil in a state of turbulence. The surface of the oil is indicated by 6 and the superheated steam enters by 4 and leaves by the opening 5. A valved pipe, 7, permits the still liquid residuum to be discharged to the coking chamber represented by C.

In this figure, 8 is the shell, 9 the residual coke, 10 and 11 the entrance and exit openings for the hot steam and vapors from the cracking chamber. The coke is represented simply as forming a layer upon the bottom of the chamber, but if the residuum were run into trays and those in turn upon cars then the residual coke would be obtained as cakes instead of as a single mass.

D represents a scrubber acting as a distilling-condensing device. The hot vapors enter at 12, pass upwards through a bed of pebbles acting as packing and escape by the duct 13. The pebbles are irrigated by a continuous flow of a condensate from the vapors themselves, produced by the circulation of said condensate through the pump 19 and the condenser 20, being returned as a douche by the spray pipe 21.

It is evident that the amount of such condensate is determined solely by the amount of condensation and is thus controlled by the condenser 20. The charging stock enters by the pipe 23 and commingles with the circulating condensate. A definite portion is by-passed through the pipe 22 to the cracking chamber thus constituting the material acted upon initially by the superheated steam.

In E, I have illustrated a similar device, identical with D, except that the surplus condensate leaves by the pipe 26. By means of a series of such scrubbers any desired fractionation can be obtained with the limitation presented by the

large flow of superheated steam commingled with the vapors.

When such fractionation has been completed the steam and vapors enter the evaporator, F, by the duct 15. The vapors are indicated as being outside of the evaporator tubes and the partial condensate leaves by the pipe 28. Meanwhile water for condensing purposes enters the inside of the tubes by the opening 27, and leaves as steam by the pipe 16. The necessary difference in pressure is attained by the positive pressure blower 17, which return the freshly made steam to superheater by means of the pipe 18.

G represents the post-condenser wherein the partial condensation of the evaporator is made complete. Non-condensable gases are discharged through the vent 29, and the condensate by the pipe 30, to the separator H. From this in turn, the condensed oils are discharged by the upper pipe 32, while the water leaves by the lower pipe 34. 31 and 33, respectively, indicate the layers into which the condensate naturally separates and the junction is indicated by the double dotted lines.

The salient features of my invention are thus seen to be in the field of heat conservation. The superheated steam can be manufactured in toto without the need of a boiler plant to produce the same once the operation has been started, and the residual heat residing in the vapors after the temperature has dropped too low for cracking is used progressively for coking the residuum from cracking and for "topping" the charging stock. After having passed such usage, it can still be used for raising all the steam required in the process if such be desired or as much thereof as may be wanted at the will of the operator.

While the cycle indicated on the flow sheet is an exceedingly advantageous way of combining the items above referred to I do not slavishly confine myself to this series of operations for it will be evident that the same can be widely varied along well known lines without interfering with the specific advantages conveyed by my invention. I will illustrate some such deviation in detail. It will be evident, that instead of returning the steam made in the operation of cooling the resultant vapors to the head of the circuit in which it was generated, it might with equal ease be passed on without compression to a similar unit operating under a lower pressure and this might be repeated many times. As the actual pressure under which an initial unit operates is almost optional, having but little effect on the products and that rather favorable than otherwise, it follows that the compression step might be advantageously eliminated in favor of such a series as here indicated. Such modifications I therefore consider as part of my process as well as the preferred version specifically given.

Having thus fully explained my process and shown the advantages of same over the general practice of today, I claim:

1. The method of cracking and distilling an oil which comprises: firstly, a cracking stage in which the source of heat consists of a flow of steam superheated to the requisite temperature and yielding two products, namely, a liquid residuum and superheated vapors; secondly, a coking stage wherein the products yielded under "firstly" further interact with the production of a solid residuum of coke, said coke being withdrawn from the process; thirdly, a distilling stage wherein the

steam and vapors issuing from "secondly" are further cooled by intimately commingling same with the incoming charging stock thus yielding two products, namely, a liquid portion consisting in part of the residual of the admixed oil and in part of high boiling oil fractions derived from condensing vapors, and a gaseous portion consisting of superheated steam and vapors of low boiling oil fractions, said liquid portion being transferred to the cracking stage described under "firstly" and constituting the oil acted upon therein by the superheated steam first introduced; fourthly, a condensing stage in which the steam and vapors from "thirdly" are further cooled by converting the heat resident therein, both sensible and latent, into latent heat of evaporation of water, maintained out of contact with said oil vapors and steam, at a lower pressure than that of the condensing steam, thus condensing the mixture of oil vapors and steam and simultaneously producing a new supply of steam at a lower pressure than that of the condensing vapors, said steam being then superheated, compressed and returned to the initial cracking stage described under "firstly," thus becoming the flow of superheated steam therein specified.

2. A claim similar to claim 1, with the additive step that the distilling stage as prescribed under "thirdly" be carried out by scrubbing the oil vapors and steam with a controlled and re-circulated douche of its own condensate to which the new charging stock is added.

3. The method of cracking and distilling an oil which comprises: firstly, a cracking stage in which the source of heat consists of a flow of steam superheated to the requisite temperature, admitted to the surface of a body of oil within a cracking chamber, the relative amounts of oil cracked and distilled being governed by the degree of turbulence of the body of oil, and yielding two products, namely, a liquid residuum and superheated vapors; secondly, a coking stage wherein the products yielded under "firstly" further interact with the production of a solid residuum of coke, said coke being withdrawn from the process; thirdly, a distilling stage wherein the steam and vapors issuing from "secondly" are further cooled by intimately commingling same with the incoming charging stock thus yielding two products, namely, a liquid portion consisting in part of the residual of the admixed oil and in part of high boiling oil fractions derived from condensing vapors, and a gaseous portion consisting of superheated steam and vapors of low boiling oil fractions, said liquid portion being transferred to the cracking stage described under "firstly" and constituting the oil acted upon therein by the superheated steam first introduced; fourthly, a condensing stage in which the steam and vapors from "thirdly" are further cooled by converting the heat resident therein, both sensible and latent, into latent heat of evaporation of water, maintained out of contact with said oil vapors and steam, at a lower pressure than that of the condensing steam, thus condensing the mixture of oil vapors and steam and simultaneously producing a new supply of steam at a lower pressure than that of the condensing vapors, said steam being then superheated, compressed and returned to the initial cracking stage described under "firstly," thus becoming the flow of superheated steam therein specified.

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