March 2, 1943. P. E. KUHL 2,312,719

CRACKING PROCESS

Filed Nov. 1, 1938 3 Sheets-Sheet 1

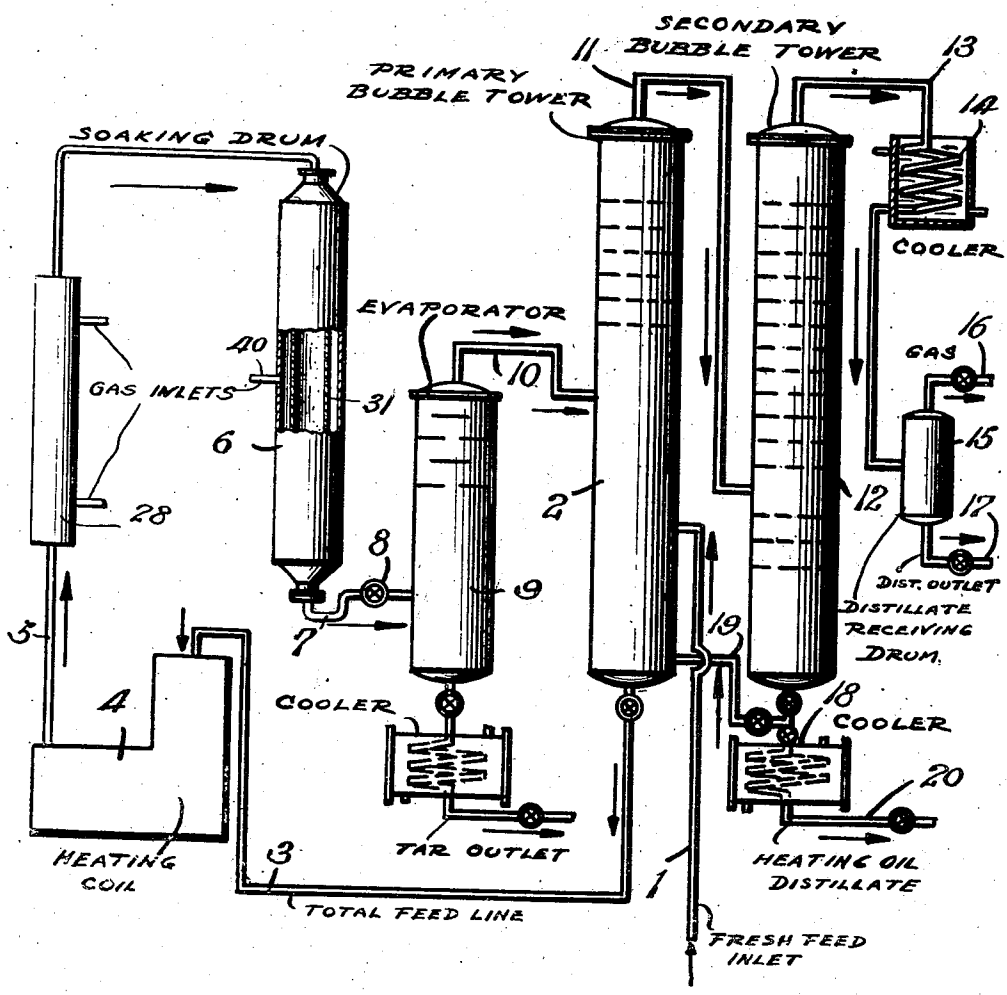


Fig. 1

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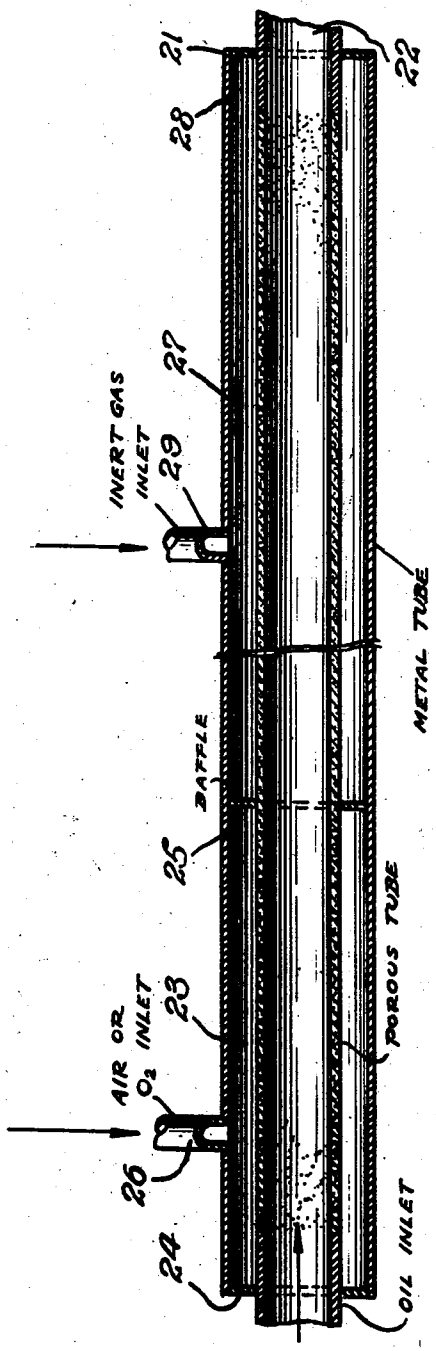


Fig. - 2

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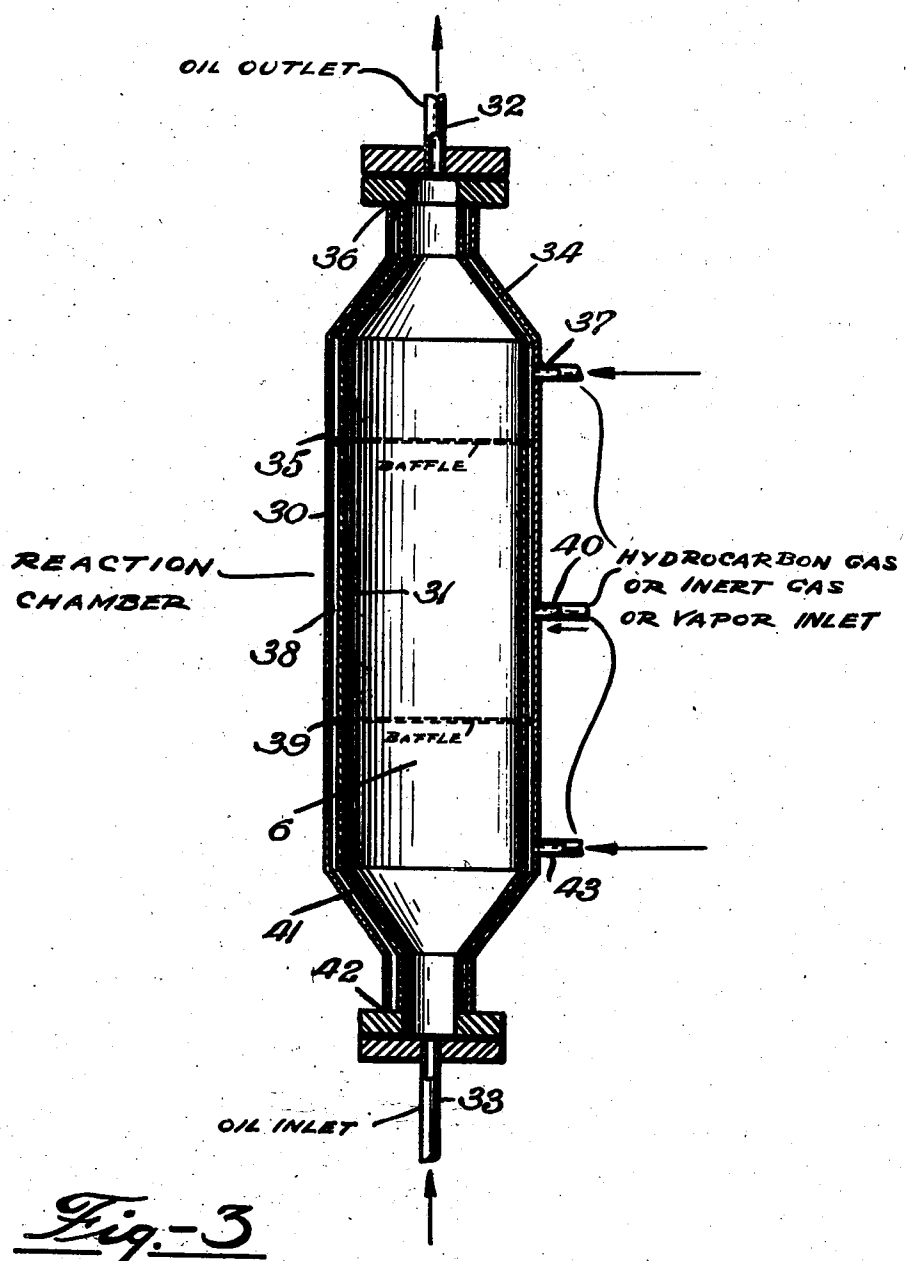


Fig.-3

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UNITED STATES PATENT OFFICE

2,312,719

CRACKING PROCESS

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Application November 1, 1938, Serial No. 238,138

2 Claims. (Cl. 196—65)

The present invention relates to the conversion of relatively high boiling petroleum hydrocarbons into relatively low boiling petroleum hydrocarbons. The invention is particularly directed to a method and apparatus of securing in a commercial operation temperatures higher than have previously been secured and is also directed to a method of avoiding deleterious coke formations. The invention is directed to the use of tubular porous linings in the heating tubes and in the reaction chamber of petroleum cracking equipment.

It is well known in the art to convert relatively high boiling petroleum hydrocarbons into more desirable products of relatively lower boiling range. In these processes, the feed material is subjected to various temperatures and pressure conditions for various time periods which are usually measured in terms of yield per unit throughput, hereinafter termed "conversion per pass." These various variable factors are optimumly adjusted to secure the desired yield and depend upon the particular feed material being treated, as well as upon the yields and quality of products desired. In these processes, it has been found that when processing heavy feed stocks such as reduced crude, the ultimate yield of gasoline can be substantially increased by increasing the conversion per pass. A gasoline of higher octane number is also secured. However, it has not been possible to increase the conversion per pass to any substantial extent, due to the fact that as conversion per pass increases an increased amount of coke formation occurs, necessitating closing down the equipment for cleaning. The formation of coke usually occurs upon the surfaces of the reaction chambers and in the tubes in which the petroleum oil is raised to cracking temperatures. Various attempts have been made to rectify these conditions, as for example, by operating in the so-called up-flow manner in which the reaction products flow upwardly through the reaction chamber or soaking drum. These methods have not been entirely successful in eliminating coke formations and, as pointed out above, this factor limits the extent to which the conversion per pass may be raised, and also the extent to which the temperature of the oil may be raised by indirect heating. Thus the disadvantages of these limitations may be readily understood when it is considered that higher yields and a more economical operation are secured by cracking hydrocarbons at temperatures in excess of those which can now be tolerated when heating indirectly as is the present practice. The process of my invention overcomes these difficulties and carries out a cracking operation at temperatures in excess of those now permitted. By the present process it is also possible to substantially increase the conversion per pass and thus substantially increase the ultimate yield of gasoline.

The process comprises subjecting petroleum hydrocarbons to suitable cracking conditions in a manner that the petroleum hydrocarbons are not in contact with metallic surfaces. In accordance with the present process, petroleum hydrocarbons are passed through a porous lining disposed within a metallic shell. Sufficient pressure is maintained in the area between the metallic shell and the porous lining to force an inert gas or an oxygen-containing gas through said lining thereby maintaining between the petroleum hydrocarbons and the porous lining substantially a gaseous wall. By operating in the present manner, it is possible to further increase the temperatures of the hydrocarbons by injecting an oxygen-containing gas into the same, thus raising their temperature by direct heating. It is also possible to prevent undue coke formation, as for example, in the soaking drum, by forcing an inert gas through the porous lining in order to maintain a gaseous wall between the petroleum hydrocarbons and the drum.

The invention may be readily understood by reference to the attached drawings showing modifications of the same. Figure 1 shows a diagrammatical flow plan of a normal cracking operation. Figure 2 is a sketch demonstrating a suitable construction of a tube to be employed, while Figure 3 shows a satisfactory construction of a soaking drum within the scope of the present invention.

Referring specifically to the drawings, Figure 1 is a diagrammatical flow plan of a typical cracking operation. For purposes of description it is assumed that the fresh feed is a gas oil fraction boiling in the range from about 400° F. to 700° F. In this operation fresh feed is introduced by means of feed line 1 into the bottom of primary

bubble tower 2. The feed together with cycle oil is withdrawn from the bottom of primary bubble tower 2 and introduced into furnace 4 by means of line 3. Furnace 4 is so designed so as to secure optimum heat transfer as the feed stock flows through tubes in the sections and to bring the oil up to cracking temperatures. The total feed is led from furnace 4 through line 5 into soaking drum or reaction chamber 6 which permits additional time under cracking conditions. The oil is withdrawn from reaction drum 6 through line 7 and the pressure reduced by valve 8. The cracked products pass into evaporator 9 from the bottom of which tar or fuel oil of the desired gravity is removed. The vapors pass overhead from evaporator 9 through line 10 into primary bubble tower 2. Cycle stock accumulates in the bottom of primary bubble tower 2 and vapors pass overhead through line 11 into a secondary bubble tower 12. The temperature at the top of tower 12 is controlled so as to produce an overhead distillate of the desired end point which is removed by line 13 and condensed in cooler 14. The gas is separated from the distillate in distillate drum 15 and removed by means of line 17. The distillate is removed by means of line 16. Heating oil may be withdrawn from the bottom of tower 12 through line 18 and may be recycled if desired through line 19 or withdrawn through line 20.

Figure 2 is a detailed drawing of line or tube 5. It is to be understood that any number of tubes may be employed in any manner desirable, as for example, in order to secure parallel or parallel series flow. The tube consists of a main tube wall 21 and an inner tube 22. Inner tube 22 is pervious to gases. The exit products from the furnace after being heated to the optimum temperature by any of the conventional methods are then passed longitudinally through the inner tube 22. Oxygen containing gas is introduced into the area 23 between the tube walls 21 and 22 and between baffles 24 and 25 by means of gas inlet 26. Sufficient pressure is maintained in the area 23 to cause the gas in this area to flow at the optimum rate into the inner tube 22. If desirable, inert gas may be introduced into area 27 between the tube walls 21 and 22 and baffles 25 and 28 by means of inlet 29.

Figure 3 describes in detail reaction chamber or soaking drum 6. This drum consists of an outer wall 30 and an inner wall 31. The oil is introduced into the reaction drum 6 by means of line 33 and withdrawn by means of line 32. The inner wall 31 is pervious to gases. Hydrocarbon gas, inert gas or oxygen-containing gas is introduced into area 34 between walls 30 and 31 and baffles 35 and 36 by means of line 37. Oxygen containing gas is introduced into area 41 between walls 30 and 31 and baffles 39 and 42 by means of line 43. In a similar manner a suitable inert or oxygen-containing gas may be introduced into area 38 by means of line 40. It is understood that inert gas, hydrocarbon gas or oxygen-containing gas may be employed depending upon whether it is desired to simply prevent coking or also to raise the temperature by direct oxidation of a part of the hydrocarbons.

The process of the present invention pre-heats a feed oil to its maximum temperature now permitted by indirect heating methods, as for example, in heating coil 4. The oil is then withdrawn at this temperature and introduced into tube 22. Oxygen-containing gas is introduced into section 23 by means of line 26 and maintained at a sufficiently high pressure so as to force the gas into tube 22, thus securing internal combustion and raising the temperature considerably above the temperature previously secured by indirect heating. Inert gas is introduced into area 27 by means of line 29 and maintained at a sufficient pressure so as to cause the gas to flow through the pervious tube walls 22 and maintain a gas lining along the side walls, thus preventing undesirable and deleterious coke formation. In a similar manner the oil is introduced into soaking drum 6 into which inert gas is maintained between the pervious wall 31 and the outer wall 30. Sufficient pressure is maintained in the respective areas 34, 38, and 41 to overcome the liquid head in said drum and to cause the gas to flow through the pervious wall, thereby maintaining a gas lining between the hydrocarbon products and the wall, thus preventing coke formation. The tubes and reaction chamber of the present invention are preferably used together. However either the tube or the reaction chamber may be employed in the absence of the other.

The amount of oxygen-containing gas introduced into the pervious tube will at least be sufficient to prevent a temperature drop between the heating coil and the soaking drum. In general, sufficient oxygen-containing gas is introduced to raise the temperature of the oil from about 10° F. to 50° F. It is preferred to introduce sufficient oxygen-containing gas to raise the temperature of the oil at least 30° above the temperature at which it is withdrawn from the heating coil.

In order to further illustrate the invention, the following examples are given which should not be construed to restrict the same in any manner whatsoever.

Example 1

Gas oil boiling in the range from 400° F. to 700° F. is heated to about 650° F. to 700° F. as it enters the furnace. The feed material passes through the furnace in which it is heated to a temperature of about 915° F. to 925° F. After leaving the heater the total feed enters the reaction chamber or soaking drum which is maintained at a pressure of from 650 lbs. to 850 lbs. per square inch. The oil is released from the bottom of this reaction chamber into an evaporator which is maintained at about 100 lbs. pressure and at about 785° F. to 800° F. Part of the feed material which enters the evaporator remains in the liquid state and is withdrawn from the unit as cracking coil tar which has a gravity of about 9° to 10° A. P. I. The vapors leave the top of the evaporator at about 765° F. and flow through suitable heat exchange equipment and then pass into the primary tower where the heavier fractions condense and drop into the accumulator section at the bottom of the tower to form part of the total feed. The temperature of the vapors leaving the top of the primary tower is maintained at about 525° F. to 550° F. These vapors pass into the secondary tower where heavier fractions condense to form a light cycle stock. The lighter boiling fractions having an end point of 400° F. are taken overhead.

The temperature of the total feed leaving the furnace and the temperature maintained in the reaction chamber were limited by the fact that if higher temperatures were employed or if the conversion per pass were increased, undue coke formation would occur. By carrying out the above process in accordance with the present invention, it is possible to increase the temperature of reaction from about 920° F. to 940° F., and to

increase the conversion per pass from about 28% to 32% and thus to increase the yield of gasoline from about 7000 gallons per hour to 8000 gallons per hour.

The improved results secured when cracking gas oil and operating in accordance with the present invention may be summarized as follows:

	Gas oil normal operation temp. limited by coke formations	Temperature permitted by use of pervious linings
Temperature °F	920	940
Total feed converted to gasoline per cent	28	32
Ultimate yield gasoline do	63	61.5
Gasoline gallons per hour	7000	8000
O. N. gasoline	71.0	72.5

Furthermore, by operating in accordance with the process of the present invention, coke formation would be prevented, thus increasing the efficiency of the equipment and materially decreasing operating costs.

The invention may be readily applied in the cracking of any petroleum stock. However it is particularly desirable in the cracking of residual stocks as for example reduced crudes.

The improvements secured when cracking reduced crude in accordance with the present process may be readily seen by the following data summarizing reduced crude cracking operations.

	Reduced crude normal operation temp. limited by coke formation	Temperature permitted by use of pervious linings
Temperature °F	890	920
Total feed converted to gasoline per cent	11.5	20
Ultimate yield gasoline do	26.5	29.5
Gasoline gallons/hour	2880	5000
O. N. gasoline	65.5	66.0

From the above data it may be seen yields were increased by approximately 75% and the octane number of the product was higher.

Conditions and methods of flow may be widely varied in the process of my invention. Temperatures and pressures may be varied to secure optimum cracking results. For example, the soaker may be either upflowing or downflowing and tube 5 may be either a single tube or may be a series of tubes in parallel.

If relatively low temperatures are desired, it may be desirable to employ merely the lined soaking drum and to dispense with the lined heating tubes. It also may be desirable to employ the lined heating tubes in the absence of the soaking drum of the present invention. The particular construction of the soaking drum and heating tubes may also be varied widely. It is, of course, necessary to employ a complete lining which is preferably similar to the construction of the tube or soaking drum. The area in which the inert gases or oxygen-containing gases are injected may be any optimum volume with regard to cost of construction and desirable strength of the equipment The process of my invention is not to be limited by any theories or mode of operation, but only by the following claims in which it is intended to claim all novelty insofar as the prior art permits.

I claim:

1. Process of thermal cracking petroleum hydrocarbons, comprising raising said hydrocarbons to cracking conditions by passing the same through non-porous metallic tubes in a furnace, removing the petroleum hydrocarbons from said furnace and passing the same longitudinally through a porous lining situated within a non-porous metallic tube, maintaining an oxygen-containing gas between said non-porous metallic tube and the porous lining under sufficient pressure to force said gas through the porous lining into the petroleum hydrocarbons thereby raising the temperature of the same, withdrawing the hydrocarbons and passing the same through a porous lining situated within a non-porous metallic drum in which an inert gas is maintained within the area between the non-porous metallic drum and the porous lining of said non-porous metallic drum under sufficient pressure to force said inert gas through the porous lining, thereby maintaining an inert gas wall between said petroleum hydrocarbons and said porous lining.

2. Process in accordance with claim 1 in which sufficient oxygen is introduced into the porous lining to raise the temperature of the oil from 10° F. to 50° F.

PAUL E. KUHL.