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PROCESS AND APPARATUS FOR THE PRODUCTION OF LOW BOILING POINT HYDROCARBONS.

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To all whom it may concern:

Be it known that I, JOHN C. BLACK, a citizen of the United States, residing at Destrehan, St. Charles Parish, Louisiana, have invented certain new and useful Improvements in a Process and Apparatus for the Production of Low Boiling Point Hydrocarbons, of which the following is a specification.

This invention relates to the manufacture of low boiling point hydrocarbons from hydrocarbons of higher boiling point and to a process and apparatus especially useful in increasing the production of so-called gasoline from relatively heavy hydrocarbons having high boiling points.

In my co-pending applications 344406 of December 12, 1919, and 492,377, of August 15, 1921, of which the present application is a continuation in part, I describe a method and apparatus for the production of low boiling point hydrocarbons from high boiling point hydrocarbons. My present invention is an improvement thereon and I am enabled to obtain an increased yield of the lower boiling point hydrocarbons from those of higher boiling point. This result is obtained by the arrangement of the heating furnace and coils and the heat control of the coils. There is also an economy in labor of operation and equipment over that required heretofore, and a large increase of capacity, all of which makes the invention useful and valuable to the art to which it relates.

To successfully operate the process it is essential to employ a pressure high enough to prevent vaporization of the hydrocarbons while undergoing decomposition or cracking and it is also essential to maintain the pressure on the carbon precipitating chamber for if the hydrocarbons are permitted to vaporize, carbonaceous material is deposited at a rapid rate and would cause fouling of the tubes, carbon precipitating chamber and other elements of the apparatus necessitating shutting down and cleaning out. By operating the process with the hydrocarbons in a liquid condition the carbonaceous material produced in cracking is in a condition easily removable due to its deposition from a liquid suspension and is not in the form usually found

in other processes but is more in the nature of an oily granular deposit easily disintegrated and purged from the apparatus. That is to say I maintain pressure from the pump throughout the system to the pressure regulating and discharge valve and by so doing I minimize the carbonaceous deposits and obtain them in an easily removable form. I have also found that cracking in the liquid phase produces low boiling point hydrocarbons of superior quality to those processes operating with the "mixed liquid vapor phase" or the "vapor phase" by producing less of the unsaturated hydrocarbons. It also produces products of better odor and color and better boiling points and produces finished gasoline approaching more nearly the quality of natural gasoline produced from crude petroleum than those processes not using high pressure. For this reason and for those previously mentioned I maintain the hydrocarbons under sufficient pressure to prevent their vaporization during the decomposition period and to hold them under such pressure until the decomposition of the hydrocarbons (at the temperature of discharge) has ceased or practically so before reducing the pressure and discharging them from the high pressure elements of the apparatus.

The pressure I prefer to use is about 70 atmospheres on the pressure side of the pressure regulating valve, this pressure insures maintaining the hydrocarbons usually employed for cracking in a liquid condition, although in some instances I have used higher pressure, and in others a lower pressure, depending on the oil under treatment.

I do not wish to limit myself to the pressure stated above as the process can be operated on pressures lower than 70 atmospheres with good results and also at a higher pressure if desired, but from a practical standpoint I prefer to operate at approximately 70 atmospheres at the terminal gauges and valves. The ingoing pressure is usually 200 pounds to 300 pounds in excess of the terminal pressure, and when this differential increases to any extent over that shown at normal operating condition it is an indication that the system is becoming fouled and should be purged of the accumulated carbonaceous material. The temperature re-

quired for the particular hydrocarbons being treated may be determined by the increase of Baumé gravity of a sample after treatment, supplemented usually by a distillation test to determine the yield of hydrocarbons boiling between certain specific temperature limits. In practice I have found that for some grades of oil the best temperature of reaction ranges from 750° F. to 850° F., while for others usually of higher Baumé gravity the temperature range may be as high as 900° F. and in some cases as high as 1000° F.

In a cracking reaction the higher the temperature with a sufficient supply of heat to prevent diminution of sensible heat and sufficient time to permit of complete reaction at that temperature; the larger will be the yield of low boiling point hydrocarbons, and the greater will be the production of carbonaceous material at any given pressure, so that in a practical commercial plant, it is necessary for the operator to choose the most efficient temperature and pressure and duration of such temperature and pressure so that as long a run as possible may be made without the necessity of cleaning out the carbonaceous accumulations consistent with a sufficient yield of low boiling point hydrocarbons to make the operation of the plant most profitable.

To perform my process I have provided a suitable apparatus, although it is understood that the process may be performed by other apparatus of different arrangement, but embodying the same fundamental principles.

For convenience in describing the process the apparatus which I prefer to employ is illustrated in the accompanying drawings in which:—

Figure 1 is a part sectional part elevational view of the apparatus.

Fig. 2 is a front elevation of the furnace showing the preferred arrangement of the furnace, and,

Fig. 3 is a pressure temperature curve showing in a diagrammatic way the change in pressure with increase of temperature of a hydrocarbon oil undergoing a cracking reaction in a vapor tension measuring apparatus.

It is an object of the invention to provide means for detecting any irregular action in the cracking coils or other part of the apparatus, the irregular action being usually caused by carbonaceous deposits therein.

One of the objects of my present invention is to heat the hydrocarbons to an increasing temperature in their progress through the tubular coils and to furnish the greater portion of the latent heat of reaction in the final coils of my apparatus where I have positive control of the temperature to the end that I may maintain therein a

uniform temperature or even a rising temperature and also to supply heat over a longer period of time at the temperature which I elect to operate at and to permit the hydrocarbons to absorb the latent heat of reaction without diminution of sensible heat, thereby bringing about the maximum cracking effect obtainable at that temperature. I have noted that when a hydrocarbon has reached a certain cracking temperature and no further heat is supplied beyond the heat ordinarily required to maintain that temperature that a diminution of temperature takes place due to the abstraction of heat from the body of the hydrocarbons and rendered latent by the endothermic reaction taking place and that the diminution of temperature reduces the rate of reaction and total production of low boiling hydrocarbons, whereas when the latent heat is supplied from an outside source an increased yield results.

I disclose two forms for the subsequent disposition and manipulation of the cracked hydrocarbons but it is to be understood that other means may be employed to process the cracked hydrocarbons after they leave the cracking zone. I may separate or fractionate the hydrocarbons by methods shown in my before mentioned applications, all of which are important to the proper operation of the complete process, and my present drawings and specification disclose a method in detail to show more clearly the separation of the desired low boiling point hydrocarbons so that one skilled in the art of oil refining would be enabled to construct and operate the apparatus from the description herewith given.

In the drawings 1 represents a furnace having therein horizontal partitions 2, 3, 4 and 5, with openings 2', 3', 4', and 5', in the partitions, and openings 6 and 6' in the furnace walls, these openings 6 and 6' having covers 7 and 7' that can be readily removed for the purpose of getting at the coils 9, 9', 10 and 10' within the furnace. Heat may be supplied to the coils in the furnace by ordinary burner tubes 6'' which may be supplied in the usual manner with oil and steam through suitable tubes having valves 6''' and 6'''. By means of these valves the heat supplied to each coil may be regulated as desired.

The coils are constructed as shown in my prior applications with the exception that they are arranged in a double series of continuous coils as shown in Fig. 2. The hydrocarbons to be cracked may be pumped by a pump 18 through the tube 31, heat exchanger 22, tube 8' and coil 8 into the series of coils 9 and 9' thence through them and downwardly through a tubular connection 12 to the series of coils 10 and 10'.

Under some conditions I may wish to pass

the oil around the heat exchanger 22. In order to do this I insert a valve 31' in the tube 31 and valve 8'' in tube 8' and connect a branch pipe 29 to the pipes 31 and 8' and insert a valve 29' in this branch pipe. Then by closing valves 31' and 8'' and opening valve 29' the oil will pass through the branch pipe 29 directly into pipe 8' without passing through the heat exchanger 22.

For convenience I insert a pyrometer 14 in the connection between the coils 9 and 10, another pyrometer 15 between the series of coils 10 and 10', and a third pyrometer 16 at the outlet of the final coil 10'.

From the coils the pressure developed by the pump 18 forces the hydrocarbons into what I denominate a "carbon precipitating chamber". This chamber is of considerably larger cross sectional area than the cross sectional area of the tubes and is intended to perform any or all of the following functions, the fundamental function being to reduce the rate of flow of the hydrocarbons after they have passed through the heating coils to facilitate the deposition of carbonaceous material produced in the cracking reaction and to deposit them in such a condition and in such a receptacle as to be easily removable from the apparatus. Another function of the "carbon precipitating chamber" is to allow the hydrocarbons therein while at a high temperature to undergo further dissociation or polymerization if the cracking reaction has not been complete in the heating coil which may be caused by inefficient operation or other causes.

To facilitate the removal of the carbonaceous material the "carbon precipitating chamber" may have detachable heads which may be conveniently removed and the "carbon precipitating chamber" purged of the carbonaceous deposits when the ordinary methods of purging hereinafter described are not effective.

To purge the apparatus of carbonaceous material in the ordinary method of purging, the valve 80' in pipe 80 is closed and the valve 86' in pipe 86 is opened whereby the oil supply to the pump 18 is shut off and a supply of water substituted for the oil, the pump is continued in operation displacing the oil in the system with water and when water appears at the purge connection 25 and valve 25' on the trap 23, then the coils and carbon precipitating chamber are sufficiently cleared of oil to permit the water and steam to be discharged from the purge connection through valve 85 on the bottom of the "carbon precipitating chamber" and the carbonaceous material is discharged with the water and steam. This is continued until the apparatus is cleared of deposits, the valve 86' is then closed and valve 80' opened and a supply of oil pumped through the appa-

ratus displacing the water with oil, the water is discharged through the purge connection 25 and valve 25' or it may be run to the slop tank through pipe 26 and valve 27', the water and oil is continued to be pumped into the "slop tank" until the stream is free from water and the oil has reached such a cracking stage that it may be discharged through valve 27'' into the "cracked oil tank" or it may be discharged through valve 36' into the fractionating tower. The fires are maintained under the heating coils during the purging operation to produce highly heated water or steam which acts as the purging agent.

There is a connecting tube 21 between the "carbon precipitating chamber" and the heat exchanger 22, this latter may conveniently be similar to the heat exchanger shown in my prior applications, the connection 21 passing through the heat exchanger and into an oil by-pass trap 23, which may comprise a tube or receptacle as shown, having therein a baffle 24, and a gauge 23' to show the pressure of oil in the trap 23, the trap 23 is preferably placed in a cooling tank 95.

The hydrocarbons when projected against the baffle 24 must pass around the same and the baffle will therefore act as a deflector to facilitate the precipitation of suspended matters not previously precipitated and such matter may be purged from the system through a tube 25 and valve 25'.

Leading from the trap 23 is a connection 26 connected to the trap a considerable distance from the bottom thereof and this connection leads through a cooler 26' to what I denominate a "control board" which constitutes a convenient means for supporting in proximity to each other the control valves 27 and 28 and gauges 30 and 30'.

The connection 26 and valve 27' leads into what I denominate a "slop tank" for receiving uncracked oil and, or, water.

Under certain operating conditions, I may wish to switch the oil supply going to the coils into the "slop tank". In order to do this I insert a connecting pipe 32 having a valve 32' therein between pipes 31 and 26. Then by opening valve 32' the oil may be passed from pump 18 or discharged back from pipe 8' through pipes 31, 32, and 26 and valve 27' to the "slop tank".

By arranging the valves 27 and 28 and gauges 30 and 30' on the "control board", an attendant may conveniently inspect these gauges and determine the condition of the apparatus and decide whether it would be desirable to increase or decrease the pressure in the system by regulation of the valve 27 or valve 36' as the case may be, or if he observes that there is an abnormal differential between the gauges 30 and 30' 130

he knows that the coils or carbon catcher or both are becoming fouled with carbonaceous material and should be purged.

The trap 23 is connected with a tower which is denominated on the drawing a "fractionating tower" by a tube 36 having a pressure regulating and discharge valve 36' therein, which permits the hydrocarbons to be delivered to the "fractionating tower."

The by-pass trap 23 has several functions as follows: When discharging into the fractionating tower through line 36 and pressure-reducing and discharge valve 36', trap 23 acts as a catcher for suspended particles of carbon and as a pressure transmitting device in conjunction with the line 26, and cooler 26' leading to the gauge 30 on the control board, valve 27 being closed when so operating.

This by-pass and connections as shown, gives the attendant an easy means of inspection and comparison of the inlet and outlet gauges 30' and 30. Or if, for any reason, it is not desired to discharge the hydrocarbons, or during purging, the water or steam into the fractionating tower, then valve 36' is closed and the main stream of hydrocarbons or water when purging, is bypassed through line 26 through the cooler 26' and discharged through the pressure regulating and discharge valve 27 into the slop tank or the cracked oil tank as may be desired. In this manner two methods of operation may be employed each independent of the other or it may be found desirable to fractionate a portion of the hydrocarbons and cool and store the balance, this may be readily carried out by the apparatus as described. The fractionating tower comprises a series of compartments 41, 42 and 43. The compartment 41 has a conical bottom for collecting the deposited residues and passing them through a tube 46 having a valve 46' therein, to what I call a "residue tank".

The compartment 41 has arranged in it just above the point where the tube 36 enters the compartment 41, a tile structure 41' made up of staggered tiles to baffle the upward passage of the hydrocarbon vapors through the tile structure and to catch the particles of oil entrained in the vapors to allow them to drop back onto the conical floor at the bottom of the compartment 41.

The vapors pass on up through the compartment 41 and through a hooded opening 50 and thence through a tile structure similar to the tile structure 41' immediately above the hooded opening. This tile structure in turn acts as a washing means for the vapors that have passed through the hooded opening 50 and have been partially condensed and absorbed on the tile surfaces due to the wetted surfaces of the tiles and to the temperature maintained in the sec-

tion 42 by the injection therein of oil through a sprinkler head 51' connected with a pump 57 by a tube 51 having a valve 51' therein. A tube 58 having a valve 58' and a trap 58'' therein opening into the compartment 42 near its bottom conducts the condensate in 42 together with the wash oil to the "supply tank".

In the "fractionating tower" above the compartment 42 may be arranged a compartment 43 having a tile structure similar in its construction and functions to that of compartment 42 but maintained at a lower temperature in order to condense out the lower boiling hydrocarbon fractions, the sprinkler head 52'' in this compartment 43 being connected to a pump 59 by a tube 52 having therein a valve 52' and the pump 59 in turn being connected to a tank which may be conveniently denominated a "heavy naphtha tank".

Connected to the lower portion of compartment 43 is a line 64 having a valve 64' and trap 64'' and connected to the "heavy naphtha tank".

Of course there may be other similar compartments in this "fractionating tower" if additional cuts or fractions are desired.

Connected to the top of the "fractionating tower" is a pipe 63 containing therein a valve 63' leading through a "condenser" and thence through a "look box" 66 and tube 65 to what may be conveniently denominated a "light naphtha tank". This pipe 63 takes from the upper part of the "fractionating tower" the uncondensed hydrocarbons not separated out in the lower compartments. The valves 46', 58', 63' and 64' are provided to permit the tower to operate under pressure if desired. The condensate from the vapors issuing from the upper compartment 43 are usually denominated "light naphtha", the mixed condensate and wash oil from the lower part of the compartment 43 heavy naphtha and from the compartment 42 is taken a grade of hydrocarbon made up of condensate and wash oil the latter being taken from the supply tank and which is returned to the supply tank together with the condensate and from the supply tank it is passed through the furnace coils to be treated.

A cooler 60 may surround the pipes 58 and 64 leading from near the bottom of the compartments 42 and 43 for cooling the condensate and the wash oils from the injection heads 52'' and 51'' before discharging them respectively into the "heavy naphtha tank" and the "supply tank".

I provide a pipe 80 having a valve 80' said pipe extending from the "supply tank" to the pump 18 with a branch pipe 81 having a valve 81' therein connecting it to the slop tank and another branch pipe 86 having a valve 86' to a "water supply" tank,

The oil "supply tank" takes its supply from the compartment 42 through pipe 58 and from an outside source of supply (not shown) through a pipe 87.

5 A cracked oil tank is provided connected with pipe 26 and valve 27".

The operation of my apparatus is apparent from the foregoing, but to briefly summarize it, the oil to be cracked is pumped
10 by pump 18 from the "supply tank" through pipe 80, thence through pipe 31 and heat exchanger 22 or through by-pass 29 to pipe 8' to the coil 8 thence through the series of coils 9 and 9' and 10 and 10'
15 in the furnace, thence to the "carbon precipitating chamber," thence through the heat exchanger to the by-pass trap 23, from the trap 23 there two flow lines, one through pipe 36 and pressure regulating valve 36' to
20 the fractionating tower, and one through pipe 26, cooler 26' and to the control board and valve 27, and discharging to the "cracked oil tank" through line 26 and valve 27", or into the "slop tank" through
25 valve 27'.

It is to be understood that the capacity of the heat exchanger 22 may be such as to cool the hydrocarbons to a degree sufficient to permit only the low boiling fractions to vaporize in the fractionating tower
30 upon release or partial release of pressure by the pressure regulating valve 36'.

It is also understood that the capacity of the cooler 26' is such as to cool the hydrocarbons discharging to the "slop tank" or
35 to the "cracked oil tank" to a degree to prevent vaporization of the lower boiling point hydrocarbons desired when the pressure is released and they are discharged into
40 said tanks. In this connection it must be understood that there are gases present due to the decomposition of the hydrocarbons that are not condensed at atmospheric temperatures and pressure and are generally
45 known as permanent gases.

In Fig. 1 of the drawings 90 and 91 show the permanent gas vents connected to the "cracked oil tank" and 92 and 93 the
50 gas vents connected to the vapor condenser connected to the fractionating tower.

The permanent gases discharged into the vents are preferably conducted to gas absorbers (not shown) to absorb out any low
55 boiling hydrocarbons that might be entrained in the gas, and the residual gases are then used as fuel under the furnaces or elsewhere if so desired.

By referring to Fig. 3 it will be observed that as heat is applied to the hydrocarbons
60 that there is a rapid rise of temperature with only a small rise in pressure as shown by the almost vertical line of the curve and that when the temperature reaches the cracking point, the vapor tension or pressure rapidly increases with a relatively small

increase of temperature although heat is continued to be applied at the same rate, thus indicating that the heat being applied to the oil is rendered latent by the endothermic reaction of cracking.

70 In my new process I so construct my apparatus that I take advantage of the phenomenon above described wherein I am enabled to furnish the latent heat of the endothermic reaction at a time when the reaction is most active and the absorption of
75 heat is at a maximum. Furthermore, I am enabled to maintain the temperature or even to increase the temperature if I so desire during the maximum cracking period, thereby obtaining the increased yield of low boiling point hydrocarbons, which is an important feature of my invention.

It will be observed from an inspection of the drawings that I have provided separate
85 coils and separate means 6" for supplying heat to each of the coils 9, 9', 10 and 10' and have provided suitable pyrometers for observation by the attendant whereby he may be governed in controlling and regulating
90 the heat supplied to the coils.

By this arrangement of coils and heat control means the temperature of the hydrocarbons may be so regulated as to bring coil
95 10 to the maximum temperature to be employed for the particular hydrocarbons under treatment, then supplying sufficient heat to coil 10' to maintain the maximum temperature of operation and to supply the heat required in the endothermic reaction and
100 by this arrangement and mode of operation, I have found that I obtain an increased yield of low boiling point hydrocarbons.

In the operation of my process I keep the hydrocarbons under sufficient pressure to
105 maintain them in the liquid phase during cracking, carbon precipitation and to the point of discharge for subsequent treatment.

The hydrocarbons are passed to the "carbon precipitating chamber", wherein their rate
110 of flow is reduced to permit of the separation of the carbonaceous material produced in the cracking reaction, which will be deposited from a liquid suspension and will be in a condition easily removed and also if the
115 reaction is incomplete in the coils, the reaction will continue in a minor degree in the "carbon precipitating chamber."

I claim as my invention:

1. In an apparatus for converting high
120 boiling point hydrocarbons into low boiling point hydrocarbons, a hydrocarbon source of supply, a furnace having a plurality of compartments, a plurality of series of coils in the upper part of the furnace, one series
125 in each compartment, a plurality of series of coils in the lower part of the furnace one series in each compartment, a connection between the series in the upper part of the furnace, a connection from one of the series in

the upper compartment of the furnace to a series in the lower compartments, a connection between the series in the lower part of the furnace, means for applying heat to each series of coils, means for regulating the supply of heat as desired for each coil, a heat indicator between the upper series and the lower series of coils, a heat indicator between the plurality of series in the lower part of the furnace and a heat indicator on the outlet of the series of coils whereby regulated amounts of heat may be supplied as desired.

2. In an apparatus for converting high boiling point hydrocarbons into low boiling point hydrocarbons, a hydrocarbon source of supply, a furnace having a plurality of compartments, a plurality of series of coils in the upper compartments of the furnace, one series in each compartment, a plurality of series of coils in the lower compartments of the furnace one series in each compartment, a connection between the series in the upper part of the furnace, a connection from one of the series in the upper part of the furnace to a series in the lower part, a connection between the series in the lower part of the furnace, means for supplying heat to each series of coils, means for regulating the supply of heat as desired for each coil, a heat indicator between the upper series and the lower series of coils, a heat indicator between the plurality of series in the lower part of the furnace, a heat indicator on the outlet of the series of coils whereby regulated amounts of heat may be supplied as desired, and a carbon precipitating chamber outside the furnace with a conduit between the final series of coils and the carbon precipitating chamber.

3. In an apparatus for converting high boiling point hydrocarbons into low boiling point hydrocarbons, a hydrocarbon source of supply, a furnace having a plurality of compartments, a plurality of series of coils in the upper compartments of the furnace, one series in each compartment, a plurality of series of coils in the lower compartments of the furnace one series in each compartment, a connection between the series in the upper part of the furnace, a connection from one of the series in the upper part of the furnace to a series in the lower part, a connection between the series in the lower part of the furnace, means for supplying heat to each series of coils, means for regulating the supply of heat as desired for each coil, a heat indicator between the upper series and the lower series of coils, a heat indicator between the plurality of series in the lower part of the furnace, a heat indicator on the outlet of the series of coils whereby regulated amounts of heat may be supplied as desired, and a carbon precipitating chamber outside the furnace with a conduit between the final series of coils and the carbon pre-

cipitating chamber, said carbon precipitating chamber having detachable heads and an outlet for the hydrocarbons.

4. In an apparatus for converting high boiling point hydrocarbons to low boiling point hydrocarbons comprising a source of supply, a pipe line connected thereto, a valve in the pipe line, a gauge also in the pipe line, a furnace, coils in the furnace connected to the pipe line for heating the hydrocarbons, a carbon precipitating chamber connected to the coils, a pipe line outlet for the carbon precipitating chamber, and an oil by-pass trap in said outlet pipe line, said by-pass trap being connected at its upper end to an outlet pipe line having therein a discharge valve for the heated hydrocarbon, the lower part of the trap having an outlet pipe line leading therefrom to a discharge tank, the pipe line leading from the supply tank to the coils and the pipe line leading from the by-pass trap to the discharge tank being arranged in proximity to each other at one point, and gauges connected with the pipe lines near this point whereby an attendant by observation of the gauges may operate said valves to regulate the pressure in the coils and the carbon precipitating chamber.

5. In an apparatus for converting high boiling point hydrocarbons to low boiling point hydrocarbons comprising a source of supply, a pump and connections thereto, heating coils and a connection between the pump and heating coils, a pressure gauge and valve in said connections, an outlet for the coils, an oil by-pass trap connected to said outlet, a blow-off discharge at the lower end thereof, an upper connection to a pressure reducing and discharge valve, a lower connection to a discharge pipe line, a pressure gauge and valve therein in proximity to the first mentioned pressure gauge and valve whereby an attendant may, by observation of the gauges so regulate the valves as to maintain the desired pressure in the coils, trap and connections as described.

6. In an apparatus for treating hydrocarbons comprising a source of supply, a control board, a furnace having a series of coils therein, a connection between the source of supply and the coils, a gauge and valve in said connections attached to said control board, an outlet for the coils, an oil by-pass trap in the outlet, and connections from the trap to a discharge, said connections leading from a point above the bottom of the trap and having therein a gauge and valve attached to the control board for the purpose described.

7. In an apparatus for treating oil, the combination of a furnace including coils, means for supplying hydrocarbons to the coils under pressure, an outlet from the coils, an oil by-pass trap in said outlet, an outlet

conduit connected to the upper portion of the trap having therein a pressure reducing valve whereby the hydrocarbons may be passed through the upper part of the trap, an outlet conduit intermediate the upper and lower portions of said trap, a cooling means for the trap, and a purging outlet from the bottom of the trap, as described.

8. In an apparatus for treating oils, the combination of a source of supply, heating coils, a carbon precipitating chamber and an oil by-pass trap, connections between the coils and carbon precipitating chamber and trap, a fractionating tower, connections between the trap and said fractionating tower, a reducing valve in said connections and means for spraying oil into the tower to meet the oil vapors after they have been discharged into the tower from the reducing valve.

9. In an apparatus for treating oils, the combination of a source of supply, a heating coil, a carbon precipitating chamber connected to the heating coil, an oil by-pass trap connected to the carbon precipitating chamber, a reducing valve connected to the trap and a fractionating tower with connections between the reducing valve and the tower and means to supply washing oil in the tower to meet the oil vapors as they ascend in the tower.

10. In an apparatus for cracking and fractionating oil comprising a means including a furnace and coils for heating the oil and delivering it under pressure to a reducing valve, a fractionating tower and connections from the reducing valve to the tower, said tower being divided into compartments, and means to supply scrubbing oil in each compartment from a supply without passing through said coils, openings between the compartments to allow the vapors delivered in the tower from said coils to rise and meet the scrubbing oil, and connections for leading away from each compartment the condensed vapors and scrubbing oil to separate storage tanks.

11. In an apparatus for converting high boiling hydrocarbons to low boiling hydrocarbons, the combination of a furnace having coils therein and a carbon precipitating chamber in series relation with the coils with connections between the coils and chamber, separate valved oil and water outlets from said chamber, an oil supply and a water supply with connections from each supply to the coils and valves in said connections whereby said sources of supply may furnish oil to said coils and carbon precipitating chamber and when desirable alternate to a supply of water to purge the coils and carbon precipitating chamber of accumulated carbonaceous material, the oil being discharged through a separate discharge from the water discharge.

12. In an apparatus for treating oils, the combination of water and oil supplies, a pump having valved connections to each source of supply, heating coils and a carbon precipitating chamber, and connections between them and between the pump and coils, said chamber having a main discharge and a blow-off discharge, said first mentioned connections having suitable valves whereby the pump may be shifted from oil to water and the oil or water forced through the coils and main discharge of the carbon precipitating chamber and water, steam and carbonaceous material discharged therefrom through the blow-off discharge.

13. In an apparatus for treating oil, a source of supply, heating coils and connections between the supply and coils, an oil by-pass trap, a discharge tank and discharge connections from the coils to the trap and from the trap to the tank, said supply connections and discharge connections having a by-pass between them with a valve therein whereby the supply of oil may be switched from the supply to the discharge connections without passing through the coils or trap.

14. In an apparatus for treating hydrocarbons, the combination of heating coils and a trap with connections between the same, said trap having its lower part water cooled, an outlet therefrom for the discharge of precipitants, and an upper and intermediate outlet for the discharge of hydrocarbon.

15. A process which consists in cracking hydrocarbons under pressure and passing them while still under pressure to a fractionating tower, reducing the pressure and fractionating under this reduced pressure, the vapors of the hydrocarbons containing various oil fractions of different specific gravity and different boiling points by subjecting the vapors to a washing, cooling and condensing action of a liquid hydrocarbon oil, separating the wash oil together with the admixed condensate from the vapor, then cooling the mixture of oils and returning a portion to the washing compartment to again act as a washing, cooling and condensing medium to separate the fractions of the vapor similar in their specific gravity and boiling points to the first said condensate whereby the wash oil maintains substantially a uniform quality, then passing the remaining uncondensed vapors to an additional washing, cooling and condensing compartment wherein the vapors are subjected to a washing and condensing action with a wash oil of lower specific gravity and lower boiling point to separate hydrocarbons from the vapors in a manner similar to that followed in the first washing compartment and separating from said vapors a condensate of lower specific gravity and lower boiling

points than the separated condensate in the first described compartment, then passing the residual uncondensed vapors to a condenser wherein the condensable vapors are liquefied, in this manner obtaining a plurality of condensates of uniform and predetermined quality.

16. The process of cracking hydrocarbons which consists in passing them through heating coils, arranged in series relation relative to each other, gradually heating the hydrocarbons by successive heating means to the maximum temperature selected for that particular oil and regulating the heating means so that said maximum temperature would be attained as the hydrocarbons enter the final coils, then passing the oils through the final coils and while so passing them maintaining substantially the said maximum temperature by supplying the hydrocarbons with sufficient heat from the final heating means to at least equal the heat that is absorbed by the hydrocarbons in the endothermic reaction of cracking and maintaining sufficient pressure upon the hydrocarbons to prevent the vaporization thereof, then reducing the pressure and vaporizing the lower boiling hydrocarbons, fractionally condensing them and returning the suitable fractions to be again subjected to treatment.

17. A process of cracking hydrocarbons which comprises forcing them through preliminary heating coils arranged in series relation relative to each other, where the hydrocarbons are heated to substantially the maximum temperature to be employed in the cracking operation, then passing them through a final heating coil wherein the temperature is maintained at the said maximum temperature and heat is supplied to the hydrocarbons to at least equal that rendered latent by the endothermic reaction of cracking, thereby subjecting the hydrocarbon to a prolonged period of heating at said maximum temperature whereby substantially maximum conversion is obtained for the temperature employed and time of reaction, then passing the hydrocarbons to a carbon precipitating chamber wherein the rate of flow of the hydrocarbons is reduced to permit of the separation of the carbonaceous material of reaction while the hydrocarbons are maintained under sufficient pressure to maintain them in a liquid state whereby the carbonaceous material is deposited in a condition easily removed, then discharging them through a pressure regulating valve into a fractionating apparatus to separate the hydrocarbons of different boiling points.

18. A process of cracking hydrocarbons which comprises forcing them through preliminary heating coils where the hydrocarbons are heated to substantially the maximum temperature to be employed in the

cracking operation, then passing them through a final heating coil wherein the heat is supplied to the hydrocarbons that is rendered latent by the endothermic reaction of cracking and sufficient heat is supplied to maintain the hydrocarbons at substantially the said maximum temperature throughout the entire coil, thereby subjecting the hydrocarbons to a prolonged period of heating at said maximum temperature, whereby substantially maximum conversion is obtained for the temperature employed and time of reaction, then passing the hydrocarbons to a carbon precipitating chamber wherein the rate of flow of the hydrocarbons is reduced to permit of the separation of the carbonaceous material of reaction while the hydrocarbons are kept under sufficient pressure to maintain them in a liquid state whereby the carbonaceous material is deposited in a condition easily removed, then passing them through a cooler to reduce their temperature to such a degree as to permit only the lower boiling point hydrocarbons to vaporize upon the release of the pressure, then condensing the vaporized fractions.

19. A process of cracking hydrocarbons which comprises forcing them through preliminary heating coils where the hydrocarbons are heated to substantially the maximum temperature to be employed in the cracking operation, then passing them through a final heating coil wherein the heat is supplied to the hydrocarbons that is rendered latent by the endothermic reaction of cracking and sufficient heat is supplied to maintain the hydrocarbons at substantially the said maximum temperature throughout the entire coil, thereby subjecting the hydrocarbons to a prolonged period of heating at said maximum temperature, whereby substantially maximum conversion is obtained for the temperature employed and time of reaction, then passing the hydrocarbons to a carbon precipitating chamber wherein the rate of flow of the hydrocarbons is reduced to permit of the separation of the carbonaceous material of reaction while the hydrocarbons are kept under sufficient pressure to maintain them in a liquid state whereby the carbonaceous material is deposited in a condition easily removed, then partially reducing the pressure to permit the lower boiling point hydrocarbons to vaporize, then fractionally condensing them to separate the hydrocarbons of different boiling points.

20. A process of cracking hydrocarbons which comprises forcing them through preliminary heating coils where the hydrocarbons are heated to substantially the maximum temperature to be employed in the cracking operation, then passing them through a final heating coil wherein the heat

is supplied to the hydrocarbons that is rendered latent by the endothermic reaction of cracking and sufficient heat is supplied to maintain the hydrocarbons at substantially the said maximum temperature throughout the entire coil, thereby subjecting the hydrocarbons to a prolonged period of heating at said maximum temperature, whereby substantially maximum conversion is obtained for the temperature employed and time of reaction, then passing the hydrocarbons to a carbon precipitating chamber wherein the rate of flow of the hydrocarbons is reduced to permit of the separation of the carbonaceous material of reaction while the hydrocarbons are kept under sufficient pressure to maintain them in a liquid state whereby the carbonaceous material is deposited in a condition easily removed, then while they are under sufficient pressure to maintain them in a liquid condition cool them to such a degree that the low boiling hydrocarbons desired are not vaporized when the pressure is reduced to substantially that of the atmosphere and discharged from the apparatus.

21. The process of cracking hydrocarbons which consists in passing them through heating coils arranged in series relation relative to each other, gradually heating the hydrocarbons to the maximum temperature selected for that particular oil and regulating the heating so that said maximum temperature would be attained as the hydrocarbons enter the final coils, then passing the oil through the final coils and while so passing it, maintaining substantially the said maximum temperature by supplying the hydrocarbons with sufficient heat to at least equal the heat that is absorbed by the hydrocarbons in the endothermic reaction of cracking and maintaining sufficient pressure upon the hydrocarbons to prevent the vaporization thereof, then reducing the pressure and discharging them into a fractionating tower wherein the lower boiling point hydrocarbons are vaporized and where the vapors containing hydrocarbons of various boiling points may be fractionated by treating the vapors with a washing, cooling and condensing hydrocarbon wash oil, separating from the vapors a fraction similar in physical properties to the wash oil, then subjecting the remaining vapors to a subsequent similar treatment whereby a fraction may be separated corresponding in physical characteristics to the wash oil employed, and then condensing the residual vapors, thereby obtaining a plurality of fractions that may be separately recovered.

22. A process of cracking hydrocarbons which comprises forcing them through preliminary heating coils where the hydrocarbons are heated to substantially the maximum temperature to be employed in the cracking operation, then passing them through a final heating coil wherein the heat is supplied to the hydrocarbons that is rendered latent by the endothermic reaction of cracking and sufficient heat is supplied to maintain the hydrocarbons at substantially the said maximum temperature throughout the entire coil, thereby subjecting the hydrocarbons to a prolonged period of heating at said maximum temperature, whereby substantially maximum conversion is obtained for the temperature employed and time of reaction, then passing the hydrocarbons to a carbon precipitating chamber wherein the rate of flow of the hydrocarbons is reduced to permit of the separation of the carbonaceous material of reaction while the hydrocarbons are kept under sufficient pressure to maintain them in a liquid state whereby the carbonaceous material is deposited in a condition easily removed, then reducing the pressure and discharging them into a fractionating tower wherein the lower boiling point hydrocarbons are vaporized and where the vapors containing hydrocarbons of various boiling points may be fractionated by treating the vapors with a washing, cooling and condensing hydrocarbon wash oil, separating from the vapors a fraction similar in physical properties to the wash oil, then subjecting the remaining vapors to a subsequent similar treatment whereby a fraction may be separated corresponding in physical characteristics to the wash oil employed, and then condensing the residual vapors, thereby obtaining a plurality of fractions that may be separately recovered.

23. A process of cracking hydrocarbons comprising heating them in continuous tubular heating coils to a temperature sufficient to crack them, heating the coils progressively to the maximum temperature to be employed, then continuing the hydrocarbons in the coil and heating the same to supply heat sufficient for the endothermic heat of reaction without diminution of temperature of the hydrocarbons, then discharging them into a carbon precipitating chamber of larger cross sectional area than the cross sectional area of the coil wherein the rate of flow of the liquid hydrocarbons is retarded, permitting the precipitation of the carbonaceous material from a liquid suspension and prolonging the time of reaction, whereby further decomposition digestion and polymerization of the hydrocarbons will result, and maintaining the hydrocarbons in the heating coils, and carbon precipitating chamber under sufficient pressure to maintain them in substantially a liquid condition and maintaining said pressure to the point of pressure reduction and discharge.

24. The continuous process of cracking hydrocarbons and periodically removing carbonaceous deposits which consists in si-

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multaneously passing the hydrocarbons through and heating them in cracking coils arranged in series relative to each other to a temperature sufficient to crack the hydrocarbons and maintaining them while thus treated under sufficient pressure to prevent their vaporization during the cracking and carbonaceous deposition period, whereby the carbonaceous deposits are in a condition easily removed, then displacing the hydrocarbons in the apparatus with water by passing the water through the apparatus in the same direction of flow as the hydrocarbons, then discharging the water and generated steam together with the residual carbonaceous materials of reaction from the apparatus whereby the various elements of the apparatus are cleared of carbonaceous deposits, then displacing the water in the apparatus with hydrocarbons and again subjecting the hydrocarbons to the cracking reaction in a cycle of operations, substantially as described.

25. The process of cracking hydrocarbons and removing carbonaceous deposits which consists in causing the hydrocarbons to pass

in streams of restricted cross section through suitable cracking coils to heat the hydrocarbons to a cracking temperature, then decreasing their rate of flow by passing them through an enlarged chamber and during this period while the temperature remains sufficiently high to crack the hydrocarbons, simultaneously maintaining them under sufficient pressure to prevent their vaporization, whereby the hydrocarbons are efficiently cracked and the carbonaceous deposits are left in a condition easily removable, then displacing the hydrocarbon in the apparatus with water and discharging the water and generated steam together with the residual carbonaceous materials of reaction from the apparatus whereby the various elements of the apparatus are cleared of carbonaceous deposits, then displacing the water in the apparatus with a fresh supply of hydrocarbons and repeating the cracking operation, substantially as described.

In testimony whereof I hereunto affix my signature.

JOHN C. BLACK.