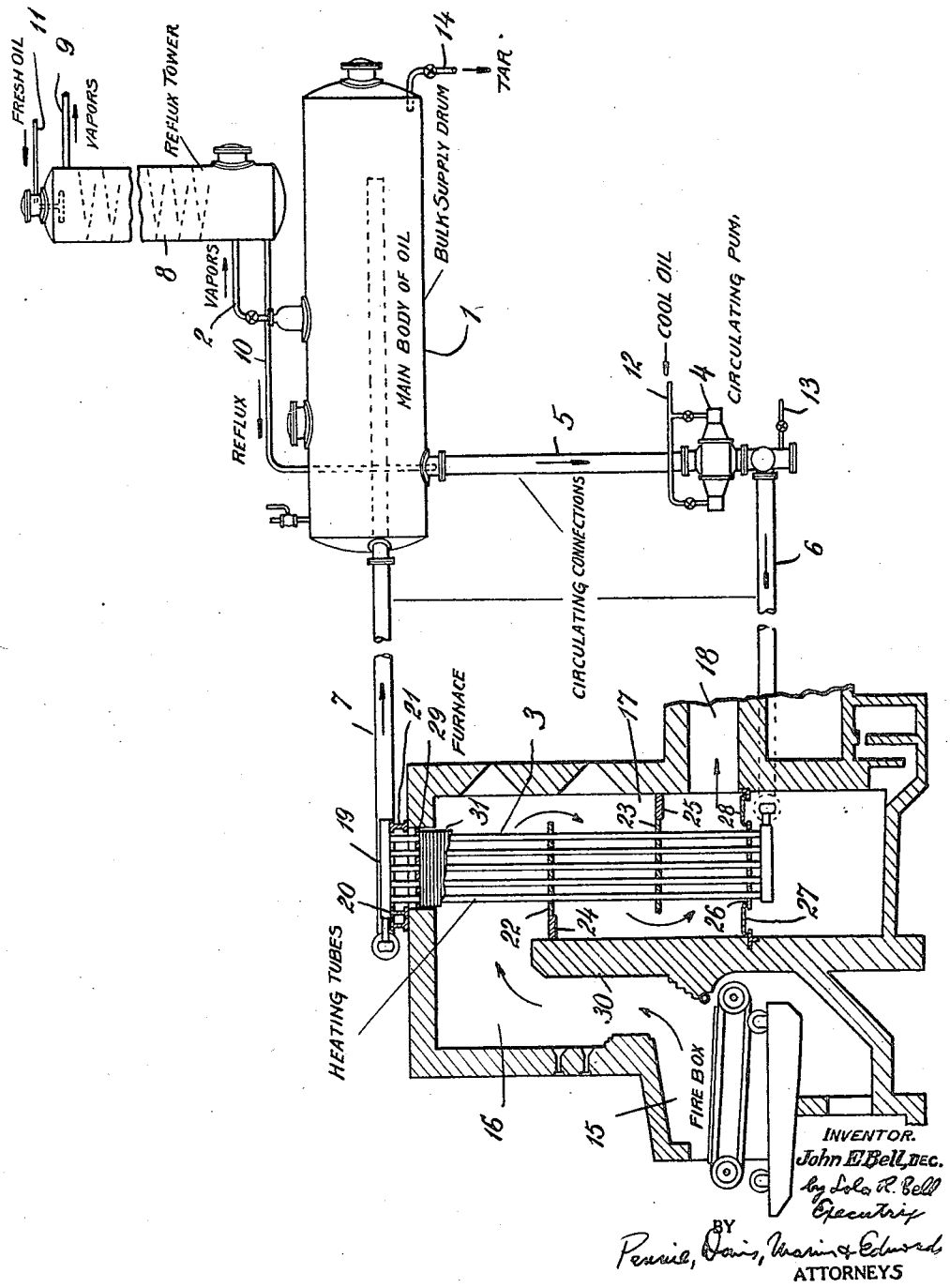
Oct. 23, 1928. 1,688,325

J. E. BELL

ART OF CRACKING HYDROCARBONS

Filed Jan. 22, 1925



Patented Oct. 23, 1928. 1,688,325

UNITED STATES PATENT OFFICE.

JOHN E. BELL, DECEASED, LATE OF BROOKLYN, NEW YORK, BY LOLA R. BELL, EXECUTRIX, OF BROOKLYN, NEW YORK, ASSIGNOR TO SINCLAIR REFINING COMPANY, OF NEW YORK, N. Y., A CORPORATION OF MAINE.

ART OF CRACKING HYDROCARBONS.

Application filed January 22, 1925. Serial No 3,985.

This invention relates to improvements in processes for cracking heavier hydrocarbon oils to produce lighter hydrocarbon oils. This application is in part a continuation of an application filed May 13, 1921, Serial No. 469,127.

More particularly this invention relates to improvements in the operation of pressure stills of the general character described and illustrated in Patent No. 1,285,200, granted to the Sinclair Refining Company November 19, 1918, on the application of Edward W. Isom. In such pressure stills the main body of oil being cracked is confined in a bulk supply drum provided with means for the escape of vapors of the cracked oil, the body of oil is heated by circulating oil from the bulk supply drum through a battery of externally heated tubes located in a suitable furnace, the battery of heating tubes is vertically arranged and connected at top and bottom to the bulk supply drum, and the bottom connection to the heating tubes includes a pump for forcing circulation of the oil. The oil is circulated from the bulk supply drum to the lower end of the heating tubes and thence upwardly through the heating tubes and back to the bulk supply drum from the upper end of the heating tubes.

The cracking of petroleum hydrocarbon oils, such as gas oil, is accompanied by a separation of carbon and fixed gas, the amount of which is a function of the temperature and increases very rapidly as the temperature necessary to effect the cracking reaction is exceeded. In the usual practice of cracking oils, temperatures in the neighborhood of from about 700 to 800° F. are employed. To impart this temperature to the oil in the heating tubes in the type of still above referred to a high temperature of the heating gases is necessary. For efficient operation it is desirable to extract from the heating gases the largest possible proportion of the heat contained therein but at the same time it is desirable to avoid excessive temperatures in any region of the battery of heating tubes in order to minimize separation of carbon therein. If carbon separates upon the heating tubes which are subjected to the high temperatures of the heating gases it forms a coating which tends to insulate the surface on which the carbon is deposited from the cooling effect of the circulating oil, aggravating the tendency of this particular region to become overheated with the development of hot spots and consequent danger of rupture of the wall of the heating tubes at such point or points. To avoid such dangers, it is necessary to shut down the still for the purpose of cleaning the heating tubes from time to time.

To promote the economy and efficiency of the cracking operation it is desirable in carrying out the operation in stills of this character to distribute the heat absorption as equally as possible through the battery of heating tubes, or at least to avoid excessive heating in any region and to provide for effective heat absorption throughout the battery of heating tubes. The heating gases are at their maximum temperature when they first contact with the heating tubes and the temperature of the heating gases declines as they circulate over the heating tubes and as their heat is absorbed by the oil circulating through the heating tubes. If the heat absorptive capacity of the heating tubes is uniform throughout the battery, considerably the greater part of the heat of the heating gases is absorbed by the tubes, or the parts of the tubes, with which the heating gases first contact with the result that this region of the heating tube battery is subjected to severe overheating while that part of the battery of tubes with which the heating gases later contact does not receive as much heat as desirable. If the front tubes, or those nearest the first-box of the furnace, are exposed to direct radiation from the furnace an additional amount of heat is imparted to these tubes by direct radiation. As a consequence, the heating tubes with which the heating gases first contact or those exposed to direct radiation from the fire-box of the furnace are subjected to such extreme conditions as to require more or less frequent renewal.

According to the present invention, the oil is circulated from the bulk supply drum to the lower end of the vertically arranged tubes in the furnace, thence upwardly through the heating tubes, and back to the bulk supply drum from the upper end of the heating tubes; and the heating gases from the fire-box are circulated first over the upper end of the heating tubes and thence downwardly over the heating tubes.

The oil circulating through the heating tubes and the heating gases circulating over

the heating tubes are thus brought into heat exchanging relation in counter-current flow; the heating gases at maximum temperature are first brought into heat exchanging relation with the hot oil as it is leaving the upper end of the heating tubes and the heating gases as they give up their heat are passed downwardly over the heating tubes to the lower end of the heating tubes where the oil entering from the bulk supply drum is first brought into heat exchanging relation with the heating gases at the lower temperature at which they leave the furnace, and the oil from the bulk supply drum is first brought into heat exchanging relation with the heating gases at their minimum temperature in the furnace and as the oil is circulated upwardly through the heating tubes it is finally brought into heat exchanging relation with the heating gases at their maximum temperature and the oil reaches the upper end of the heating tubes at its maximum temperature. The oil is thus heated to the cracking temperature as it flows upwardly through the heating tubes and reaches the maximum cracking temperature as it leaves the upper end of the heating tubes, the final input of heat for the cracking reaction being effected in the upper end of the heating tubes where the heating gases at maximum temperature are brought into heat exchanging relation with the circulating oil. In the heating tubes there is no resting place for precipitated carbon and the oil is progressively heated in the direction of its flow. The cracking reaction is started in the heating tubes and the cracking reaction continues, and the major part of the cracking reaction occurs, in the bulk supply drum into which the oil is discharged from the heating tubes at its maximum temperature.

In this way the absorption of heat in the battery of heating tubes is made more uniform, the heating of the oil being distributed more equally throughout the heating tubes, and carbon deposit upon the heating surfaces of the tubes is avoided or minimized, both by the improved uniformity of the heating operation and by bringing the oil to the maximum cracking temperature as it leaves the heating tubes. The circulating oil protects the heating tubes by absorbing heat as it flows upwardly therethrough and the progressive heating of the oil assists and promotes the upward circulation through the heating tubes.

The uniformity of the heat absorption in the battery of heating tubes may be further promoted by progressively increasing the velocity of flow of the heating gases over the heating tubes of the pressure still as the temperature of the heating gases decreases. With increased velocities more effective heat transfer can be obtained and a certain compensation for the decreasing temperature of the heating gases thus effected. The uniformity of the heat absorption by the heating tubes may also be promoted by shielding the heating tubes from direct radiation from the fire-box supplying the heating gases. Where the initial heating surfaces are not so protected, a relatively large proportion of the heat from the fire-box may be transmitted to the initial heating surfaces by direct radiation from the fire-box with consequent overheating of these surfaces, but by shielding the heating tubes from direct radiation the heating tubes are protected and this radiant heat is made available, in large part, as sensible heat in the heating gases. By reducing the temperatures to which the initial heating surfaces are exposed where coal is used as fuel, there is also less accumulation thereon of slag which is contained in the products of combustion from coal and which at extreme temperatures is in a molten condition.

The process of the invention may be carried out in a still in which the circulation is maintained by thermosiphonic action. The process of the invention, however, is of special value and application in connection with the operation of pressure stills of the general character referred to in which the circulation is maintained and promoted by mechanical forcing means such as a pump. By means of a pump, an increased rapidity of circulation can be maintained, the increased velocity of flow of the oil through the heating tubes improving the heat transfer to the oil and also further protecting the tubes by the more rapid absorption of the heat in the rapidly circulating oil. Due to the more uniform heating of the heating tubes, the oil may be circulated therethrough at an increased rate, this increased circulation of oil further protecting the tubes and increasing their heat absorptive capacity as has been described, and at the same time the more rapid circulation of the oil and the increased heat absorption thus effected enable an increased input of heat to the oil promoting the cracking reaction and increasing the capacity and efficiency of the cracking still.

The process of the invention will be further described in connection with the accompanying drawing which illustrates an apparatus particularly adapted for carrying out the process of the invention. It is to be understood, however, that this specific disclosure is for the purpose of exemplification only and that the scope of the invention is defined in the following claims in which I have endeavored to distinguish it from the prior art so far as known to me without, however, relinquishing or abandoning any portion or feature thereof.

The drawing diagrammatically illustrates, in elevation and partly in section, a pressure still adapted for carrying out the process of the invention, the furnace structure being

shown in vertical section and the remainder of the still being shown, somewhat conventionally, in elevation.

The pressure still illustrated is of the general character described and illustrated in Patent No. 1,285,200 previously referred to. It comprises a bulk supply drum 1 adapted to contain the main body of oil being cracked, a vapor line 2 for the escape of the vapors of the cracked oil, a battery of heating tubes 3 arranged in a furnace, a circulating pump 4, and circulating connections 5, 6 and 7 connecting successively the bulk supply drum, the circulating pump, the lower end of the heating tubes, the upper end of the heating tubes and the bulk supply drum. The vapors escaping from the bulk supply drum to the vapor line 2 may be passed through a reflux tower 8 in which they may be subjected to direct contact with fresh oil charged to the still. The vapors from the reflux tower escape through vapor line 9 to a condenser and receiver. The pressure may be regulated between the reflux tower and the condenser or beyond the condenser. From the reflux tower, reflux, and admixed fresh oil if fresh oil is introduced into the reflux tower, are returned to the still through connection 10. Fresh oil may be introduced into the upper end of the reflux tower through connection 11. Cool fresh oil may be supplied to the bearings of the circulating pump through connection 12 to cool and protect the same. A connection 13 is provided for pumping out and initially charging the still. A connection 14 is arranged for withdrawing tar from the still during the operation thereof.

The furnace structure comprises a fire-box 15 which may be of any usual or approved construction furnishing the required amount of heat, an uptake 16, a downtake heating flue 17 and a stack flue 18. The battery of oil heating tubes 3 is suspended vertically in the heating flue 17, the upper header 19 thereof being supported upon I beams 20 and 21 on top of the furnace. The heated products of combustion descending the heating flue 17 are caused to circulate back and forth over the heating tubes by means of baffles 22 and 23. These baffles are supported by the tubes and cooperate with partitions 24 and 25 respectively to cause the heating gases to circulate back and forth over the heating tubes. The lower end of the heating flue is closed by a partition or floor 26 arranged somewhat above the lower end of the heating tubes and supported thereby, this partition or floor cooperating with partitions 27 and 28 to close the lower end of the heating flue completely. The upper end of the heating flue is closed by partition 29 arranged in the opening in the top of the furnace through which the heating tubes depend, this partition being supported by the heating tubes. The heating tubes 3 of the battery are thus suspended from their upper end and are free to expand and contract with changes of temperature. The battery of heating tubes may likewise be removed as a unit through the opening in the top of the furnace for the purpose of inspection or repair.

The distance between the baffle 22 and the top of the heating flue is greater than the distance between the baffles 22 and 23 and this latter distance in turn is greater than the distance between the baffles 23 and the bottom of the heating flue so that the velocity of the heating gases is progressively increased through the successive passes in the heating flue as the temperature of the heating gases falls, thereby compensating to a greater or less extent for the decreased heating effect of the heating gases as their temperature declines. The front tubes of the battery of heating tubes are prevented from receiving an undue amount of heat by direct radiation from the fire-box 15 by provision of the bridge wall 30 and the elongated throat or uptake 16, the bridge wall acting as a screen to cut off direct radiation from the fire-box to the heating tubes. The term firebox is used in the usual manner in this application to include the part of the furnace setting in which the fuel and gaseous products generated therefrom are burned. The heating tubes of the battery may also be provided with heat absorbing elements of suitable character, shown conventionally at 31. Such heating elements present a materially increased surface of contact and enable a materially increased amount of heat to be transferred to the oil with the result that the oil can be circulated at a more rapid rate without decrease of the heat absorption, further assisting in protecting the tubes and increasing the capacity of the pressure still.

In carrying out the process of the present invention in the apparatus illustrated, the oil is circulated from the bulk supply drum 1 by means of the circulating pump 4 to the lower end of the heating tubes 3 and thence upwardly therethrough and back to the bulk supply drum from the upper end of the heating tubes. The circulation is assisted by the progressive heating of the oil as it flows upwardly through the heating tubes. The hot products of combustion rising from the fire-box 15 are first brought in contact with the upper end of the heating tubes and then circulate back and forth over the heating tubes downwardly to the stack flue 18. The heat in the hot products of combustion is thus effectively utilized, the cooler oil entering the lower end of the heating tubes from the bulk supply drum being first brought into heat exchanging relation with the products of combustion which have been cooled by their passage through the heating flue and the oil circulating upwardly through the heating tubes is given its ultimate temperature by heat exchange with the prod-

ucts of combustion as they rise from the fire-box in the upper end of the heating tubes from which the oil is discharged and with which the hot products of combustion initially contact. The back and forth circulation of the products of combustion over the heating tubes also assists in promoting uniform distribution of the heat absorption. The bridge wall 30 cuts off direct radiation from the fire-box to the heating tubes, avoiding overheating of the front tubes of the battery from this cause, and the velocity of the products of combustion as they pass downwardly through the heating flue and as their temperature decreases due to absorption of heat of the circulating oil is increased by the progressive decrease in the area of the passage through which the heating gases circulate.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. The improvement in the operation of externally heated pressure stills for cracking hydrocarbon oils, which comprises circulating oil from a bulk supply drum to the lower end of vertically arranged heating tubes and thence upwardly through the heating tubes and back to the bulk supply drum from the upper end of the heating tubes, heating the oil to the cracking temperature in the heating tubes by passing heating gases first in contact with the upper end of the heating tubes and then downwardly over the heating tubes and progressively increasing the velocity of flow of the heating gases as their temperature declines, whereby uniform distribution of the heat absorption is promoted and the oil is brought to the maximum cracking temperature as it leaves the heating tubes and is discharged to the bulk supply drum.

2. The improvement in the operation of externally heated pressure stills for cracking hydrocarbon oils, which comprises circulating oil from a bulk supply drum to the lower end of vertically arranged heating tubes and thence upwardly through the heating tubes and back to the bulk supply drum from the upper end of the heating tubes, heating the oil to the cracking temperature in the heating tubes by passing hot products of combustion from a fire-box first in contact with the upper end of the heating tubes and thence downwardly over the heating tubes, and preventing direct radiation from the fire-box to all parts of the heating tubes, whereby uniform distribution of the heat absorption is promoted and the oil is brought to the maximum cracking temperature as it leaves the upper end of the heating tubes and is discharged to the bulk supply drum.

3. The improvement in the operation of externally heated pressure stills for cracking hydrocarbon oils which comprises mechanically circulating oil, from a bulk supply drum to the lower end of vertically arranged heating tubes and thence upwardly through the heating tubes and back to the bulk supply drum from the upper end of the heating tubes, heating the oil to the cracking temperature in the heating tubes by passing heating gases in contact with the upper end of the heating tubes and thence downwardly over the heating tubes and progressively increasing the velocity of flow of the heating gases as their temperature declines, whereby uniform distribution of the heat absorption is promoted and the oil is brought to a maximum cracking temperature as it leaves the heating tubes and is discharged to the bulk supply drum.

4. The improvement in the operation of externally heated pressure stills for cracking hydrocarbon oils, which comprises circulating oil from a bulk supply drum to the lower end of vertically arranged heating tubes and back to the bulk supply drum from the upper end of the heating tubes, heating the oil to the cracking temperature in the heating tubes by passing heating gases first in contact with the upper end of the heating tubes and then downwardly over the heating tubes, progressively increasing the velocity of flow of the heating gases as their temperature declines, and preventing direct radiation from the fire-box to all parts of the heating tubes, whereby uniform distribution of the heat absorption is promoted and the oil is brought to the maximum cracking temperature as it leaves the upper end of the heating tubes and is discharged to the bulk supply drum.

In testimony whereof I affix my signature.

LOLA R. BELL,

Executrix of the Last Will and Testament of John E. Bell, Deceased.