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PROCESS OF CONVERTING HIGHER BOILING POINT HYDROCARBON OILS INTO LOWER
BOILING POINT HYDROCARBON OILS.

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1,374,858.

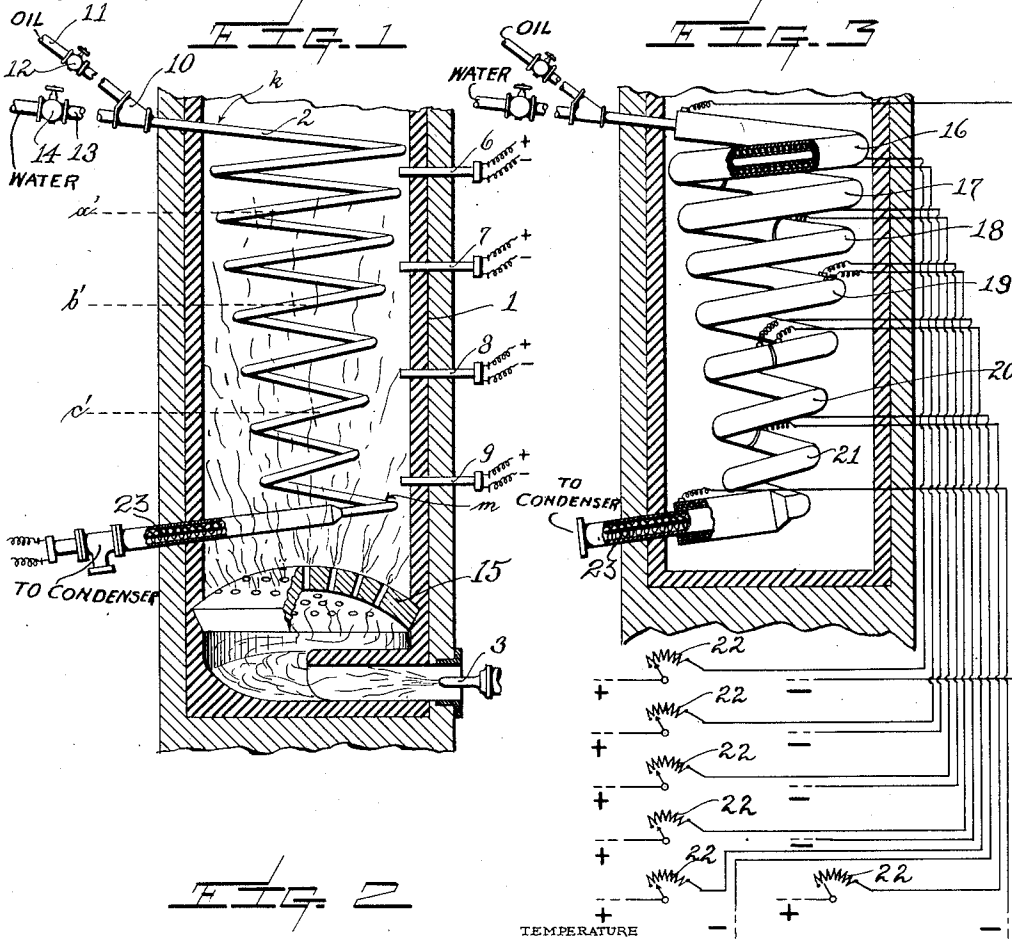
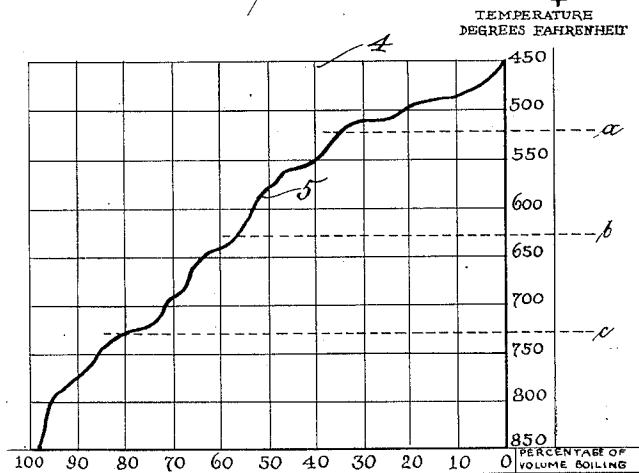


FIG. 2



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PROCESS OF CONVERTING HIGHER-BOILING-POINT HYDROCARBON OILS INTO LOWER-BOILING-POINT HYDROCARBON OILS.

1,374,858.

Specification of Letters Patent.

Patented Apr. 12, 1921.

Application filed July 3, 1920. Serial No. 393,893.

To all whom it may concern:

Be it known that I, WILLIAM MONEY-PENNY McCOMB, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in a Process of Converting Higher-Boiling-Point Hydrocarbon Oils into Lower-Boiling-Point Hydrocarbon Oils, of which the following is a specification.

This invention relates to a new and improved process of converting heavy liquid hydrocarbons or liquid hydrocarbons of higher boiling point into lighter hydrocarbons or hydrocarbons of a lower boiling point. One of the objects of the invention is to provide a process that yields a maximum quantity of liquid recovery with a minimum of fixed gas and a minimum of carbon loss from a given quantity of material treated.

Another object of the invention is to provide a process of the above character wherein conversion of the heavy hydrocarbon oils into lighter or lower boiling point hydrocarbon products is carried on in a tubular vessel or chamber, preferably in the form of a sinuously formed coil, so constructed and so related to a source or sources of heat, that the temperature of the material being treated at a point adjacent the inlet end of the coil approximates the initial boiling point of said material, and the temperature of the material within the coil at a point adjacent to the hottest or cracking section or zone of the coil approximates the end or highest boiling point of the volatilizable elements of the material being treated, the temperature of the intermediate points of the coil increasing approximately in the same ratio with respect to the total intervening length of said coil as the boiling point temperatures of the hydrocarbon oil increase in ordinary fractional distillation of a sample of the oil under treatment throughout the successive portions of its boiling point range.

A further object of the invention is to provide means for determining the precise form and length of the coil for treating or converting hydrocarbon oils of known characteristics, as well as the proportion of water to be introduced into said coil with said hydrocarbon oil, in accordance with my improved process, and the relation of the

source or sources of heat to said coil and various parts or sections thereof.

Other objects and aims of the invention more or less specific than those referred to above, will be in part obvious and in part pointed out in the course of the following description of the steps and the relation of each step to one or more of the others thereof employed in carrying out my process, and the scope of protection contemplated will be indicated in the appended claims.

In the accompanying drawing, I have shown diagrammatically two forms of apparatus I have found practicable for use in carrying out my improved process.

Figure 1 is a schematic view in vertical section showing my improved tubular coil or vessel in elevation, as well as its relation and the relation of its associated parts, to a source of heat.

Fig. 2 illustrates a scaled boiling point curve of the particular material which the apparatus is designed to treat; and

Fig. 3 is a view similar to Fig. 1, but showing a different mode of applying heat to the tubular coil or vessel employed in carrying out my process.

At this point it may be noted that heretofore in the art of oil conversion there has been little or no attempt made to determine in advance by scientific principles and by the employment of scientific methods, the particular form of the converting coil or vessel, and its relation to the source or sources of heat, so as to provide a process for carrying on a systematic and continually progressive volatilization of the material in conversion, and at the same time to carry on the work of heat saturation of the constituent molecules, so that immediately upon their introduction to the cracking temperature they will be most nearly in condition for dissociation and subsequent re-association into the lighter boiling point products.

Referring now to the drawings, wherein I illustrate an apparatus for carrying on the process, and by means of which I largely eliminate the difficulties heretofore existing, and obtain, among others, the various objects hereinbefore set forth, and wherein similar reference characters refer to similar parts, the reference numeral 1 denotes the wall of a furnace such as may be employed in carrying out my process, and 2 denotes

the tubular vessel or coil which is intended to be suitably supported and properly located within the furnace above a source of heat shown herein as consisting of a burner 3.

5 Referring now to the method I adopt in arriving at the particular shape of tubular vessel or coil adapted to carry on my improved process, I first determine by ordinary methods the boiling point characteristics of the given class of liquid hydrocarbon oils to be treated. This I accomplish by 10 carrying on fractional distillation operations upon several samples of the class of oils to be treated. Having determined the boiling point characteristics of the oil as 15 aforesaid, I next plot in a suitable manner a diagram to scale showing as coördinates the several average boiling points and the percentages of the materials that vaporize at each particular temperature. Such average or composite boiling point curve shows 20 the average proportionate quantity of such material that boils at the various temperature within such boiling point range, that is to say, between the initial boiling point and 25 the dry end or final boiling point. For example, and as shown in the chart or scale 4, shown in Fig. 2, an oil distillate having an approximate boiling point range between 30 450° F. and 850° F. 32° Baumé, gravity is to be converted into lower boiling point hydrocarbon products. In this case samples of the hydrocarbon oils to be treated are submitted for boiling point determinations and 35 from the several determinations a curve at scale such as shown at 5 is plotted, which curve represents the average boiling point characteristics of the several tested samples.

The tubular coil or vessel 2, when turned 40 on a radius of approximately 15 inches I have found most convenient and efficient in commercial operation. In some classes of oils it may prove of advantage to have the foldings of the coiled tubular vessel made 45 of conical formation from the top downward to the last turn of the coil before its exit from the furnace, such as is herein shown, in order to secure a particularly even progressive increase in the distribution of 50 heat from the inlet to the outlet of said coil.

In the treatment of a hydrocarbon oil having boiling point characteristics of the one hereinbefore set forth, I have found 55 that a coil formed of tubing of 1½ inches internal diameter, and in length approximately 100 feet to be best suited for the carrying out of my process. The coil is also formed with a gradually increasing pitch from the top to the bottom thereof, and the various intermediate portions from 60 the top to the bottom of the coil are proportionate in length to the ascertained, and charted and scaled boiling point curve, for I have discovered that a certain relationship 65 ship exists between the boiling point char-

acteristics of hydrocarbon oils and the required time of contact of said oils with the progressively heated surfaces of the coil or tubular vessel, which relationship is shown 70 by the boiling point curve of the hydrocarbon oil under treatment, whereby without premature cracking and resultant carbon loss, the constituents of such are heated progressively in accordance with the boiling 75 points and carried in the presence of the water vapors to the point where dissociation and subsequent re-sociation takes place with the maximum production of the materials sought to be produced.

I preferably locate the burner in the lower 80 portion of the furnace below the coil so that a gradually diminishing temperature is obtained within the furnace from the bottom to the top thereof, the height of the furnace the disposition of the coil therein, and 85 the quantity of heat supplied from the burner being such that the temperature within the coil at the top thereof approximating the initial boiling point of the material under treatment, the temperature of 90 the material within the coil at a point adjacent the hottest or cracking point or zone of the coil approximating the end or highest boiling point of the volatilizable elements of the material being treated and the 95 temperature of the intermediate points of the coil increasing from the coolest part or zone at the top of the furnace approximately in the same ratio with respect to the total intervening length of said coil as the 100 boiling point temperatures of the hydrocarbon oil increase in ordinary fractional distillation as determined by a sample of the oil under treatment throughout the successive portions of its boiling point range. 105

For purposes of illustration Fig. 1 represents the furnace in which is located the coil, as above described. It will be noted that the boiling point curve shown in Fig. 2 has 110 been divided into four equal parts as defined by dotted lines *a*, *b*, and *c*, which correspond to the dotted lines *a'*, *b'*, and *c'*, which divide the length of the coil into four sections between the point *k* on said coil 115 and *m* on said coil. It will be understood that in practice the actual heating zones of the coil correspond to the actual boiling points and their proportions as developed by the boiling point curve; it being understood that the source of heat is of such intensity and capacity and is so positioned in 120 the furnace that the desired temperatures will be at all times maintained in the furnace to heat the different sections of the coil to correspond with the heat requirements as evidenced by the predetermined 125 boiling point curve of the liquid under treatment.

Located in each of the zones of the furnace is a heat registering device, the same 130

in the present instance being constituted by a thermo-couple, said thermo-couple being indicated at 6, 7, 8 and 9. It will be understood that in actual practice such a number of these thermo-couples will be provided as is necessary to aid in the determination and regulation of the heat at various localities in the furnace.

The hydrocarbon oil is fed under pressure into the upper end of the tubular vessel or coil 2, through a fitting 10, by means of the conduit 11, valved as at 12, whereby the required amount of raw material to be fed into the coil may be regulated. The water necessary to carry on the process, as herein-after described, is fed into said coil through the fitting 10, by means of the conduit 13, valved as at 14, whereby the amount of water to be let into the coil may be regulated. The proportion of the quantity of water to the material under conversion to be fed into the coil is determined on the basis of the specific heat of the hydrocarbon oil to be converted, and such quantity is determined by a calorimeter test of such oil, which test is made by taking a sufficient quantity of representative samples of the material under treatment, and testing the same in a calorimeter with benzoic acid, or some other fuel of known heat value, the specific heats being reckoned with the water as unity.

The quantity of water fed in conjunction with the oil bears such proportion to the oil, based upon the specific heat of the oil as above determined, so as to furnish a quantity of water sufficient to absorb or take up approximately one-third of the radiant heat from the radiant inner surface of the coil in the journey of the material in conversion from the inlet to the outlet of the tubular vessel or coil. In actual practice in the carrying out of my process in the coil herein referred to, I employ approximately seven parts of water to twenty-two parts of oil of the class herein referred to, both the water and oil of course are forced into the coil with sufficient pressures to overcome the internal pressure of the coil, which ordinarily amounts to between 90 and 100 pounds. The valves 12 and 14, which are preferably needle valves, regulate to a nicety the proportionate amount of water and oil let into the coil. The water and oil are of course both pre-heated by any suitable means to approximately the boiling point of the earliest boiling point constituent of the oil, although I prefer to utilize the means disclosed in my Patent No. 1,337,144.

The volatilized constituents of the material under conversion are discharged from the coil through a chamber having therein a body of high specific heat, as described in said prior patent such for instance as nickel chromium or molybdenum, which is shown

at 23, in which chamber dissociation and re-association of the molecules take place, whereby lower boiling point products are formed. These products are condensed and subsequently taken care of in the manner shown and described in my aforesaid prior patent.

Referring now to Fig. 3 of the drawings, I have shown therein a different method of heating the tubular vessel or coil. In this embodiment of my invention I have positioned upon said tubular coil or vessel a plurality of independent electrically heated units indicated at 16, 17, 18, 19, 20 and 21, each of which heating units is connected with a source of electric current supply as indicated in the drawings, suitable rheostatic devices 22 being provided, whereby the temperature of each unit and the relations of the temperatures of all the units may be regulated. In this embodiment of my invention suitable heat measuring devices will be employed in the zones defined by the several heating units whereby the temperature of the various parts of the coil may be ascertained.

Where I have used the term "boiling point" in referring to the material under conversion when the same is present in the tubular vessel or coil, it is understood of course that I do not contemplate the boiling points of the constituents of the hydrocarbon oil at the atmospheric pressure but rather to their boiling points as they are in the pressure of the coil, which boiling points are of course much higher by reason of the said pressure, but which, of course, bear a definite relation to their boiling points at atmospheric pressure.

By the terms "end boiling point" or "highest boiling point constituent" is meant the highest boiling points of the material in conversion, it being understood that in certain classes of hydrocarbon oils it is not practicable to volatilize all of the material, for it is well known that in all heavy hydrocarbon oils there is a dry end point consisting of carbon in the form of coke or asphaltic bodies.

It will be understood, therefore, that the heating means illustrated in the present drawings are for illustrative purposes only, and that in the carrying out of my process other heating means may be employed, whereby the required heat is distributed to the various points of the coil to correspond with the boiling points of the constituent compounds as they reach their volatilization temperatures in their travel from the inlet to the outlet of the coil.

I have found in the successful operation of my improved process that an exceedingly large proportion of the lighter or lower boiling point hydrocarbon oil is obtained from a given quantity of raw material, with a very small production of fixed gas and carbon

loss. I have also found that a considerable quantity of heat is conserved with a consequent saving of fuel inasmuch as just the right amount of heat is employed as is necessary to successively volatilize the constituents of the hydrocarbon oil. My process is therefore both efficient and economical.

I realize that many changes can be made in the carrying out of my process without departing from the essentials of my invention, and it is to be understood that the matter contained in the above description and shown in the accompanying drawing shall be interpreted as illustrative only and not in a limiting sense.

Having thus described my invention, and the manner in which the same is performed, what I claim as new and desire to secure by Letters Patent is:

1. A method of converting relatively heavy hydrocarbon oils into hydrocarbon oils of lower boiling points, which consists in passing a mixture of such heavy hydrocarbon oils together with a smaller percentage of steam through a heated tubular vessel or coil of progressively increasing temperatures from its inlet to its outlet ends, the temperature of the oil therein at a point adjacent the inlet end of the coil approximating the initial boiling point of the oil under treatment and the temperature of the oil therein at a point near the outlet end approximating the end boiling point of the oil under treatment, the temperature of the intermediate points of the oil in the coil increasing approximately in the same ratio with respect to the total intervening length of the coil under consideration as the boiling point temperatures of the oil increase in ordinary fractional distillation of a sample of the oil under treatment throughout the successive positions of its boiling point range.

2. A method of converting relatively heavy hydrocarbon oils into hydrocarbon oils of lower boiling points, which consists in providing a tubular vessel or coil and locating the same in a furnace, providing a burner under the said coil, passing a mixture of said hydrocarbon oils together with steam through said coil, the form of the coil and its relation to the heater being such that the material passing through the coil is subjected to progressively increasing temperatures from the inlet to the outlet ends of said coil, the temperature of the oil therein at a point adjacent the inlet end of the coil approximating the initial boiling point of the oil under treatment, and the temperature of the oil therein at a point adjacent the outlet end, approximating the end boiling point of the oil under treatment, and the temperature of the oil at the intermediate points in the coil increasing approximately in the same ratio through the total intervening length of

the coil as the boiling point temperatures of the oil increase in ordinary fractional distillation of a sample of the oil under treatment throughout the successive temperatures of its boiling point range.

3. The herein described process of converting relatively heavy hydrocarbon oils into hydrocarbon oils of lower boiling points, which consists in fractionally distilling a sample of the oil under treatment throughout the successive temperatures of its boiling point range, plotting a boiling point curve of said sample, providing a furnace, providing a tubular vessel or coil in said furnace, providing a burner under said coil, passing said hydrocarbon oil in the presence of water vapors through said tubular vessel or coil toward said burner, so relating said coil and said burner with the temperature of the oil therein that the temperature at a point adjacent the inlet end of the coil approximates the initial boiling point of the oil under treatment as shown by said boiling point curve, and the temperature of the oil therein at a point near the outlet end approximates the temperatures of the end boiling point of the oil under treatment as shown by said boiling point curve, the temperature of the oil at intermediate points of the coil increasing approximately in the same ratio with respect to the total intervening length of the coil under consideration, as is indicated by said boiling point curve.

4. The process of converting heavy liquid hydrocarbons into lighter hydrocarbons, which consists in first determining the constituents of the said heavy liquid hydrocarbons and establishing their boiling points and proportions, passing said material to be treated with water vapor through a tubular vessel located in a furnace, and in its passage therethrough subjecting it to the action of a progressive heat beginning with approximately the temperature of the boiling point of the lowest boiling point constituent compound and ending with the temperature of the boiling point of the highest boiling constituent compound in conversion, the tubular vessel being so proportioned and the speed of feed being such that the time of exposure in each progressive heat zone shall be in proportion to the quantity of material being volatilized in such zone.

5. The herein described process of converting higher boiling point hydrocarbon oils into lower boiling point hydrocarbon oils, which consists in determining the boiling points or volatilization characteristics of the material to be treated, providing a scale wherein the elements of temperature and quantity are coördinates, laying out upon said scale the boiling point curve of the material to be treated, passing a mixture of said material and water vapor through a

tubular vessel or coil and so selectively and progressively heating the different portions of the oil in said coil within the limits of the boiling point range of the oil under conversion that the various constituents of the material in conversion will be successively volatilized at points in the length of said coil predetermined in accordance with the boiling point curve of said material in conversion.

6. The herein described process of converting higher boiling point hydrocarbon oils into lower boiling point hydrocarbon oils, which consists in ascertaining the volatilization characteristics of the material to be treated and from the coördination of said volatilization characteristics determining and plotting at scale the boiling point curve of said material, passing the said material mixed with water vapor through a tubular vessel or coil, supplying heat for said coil to progressively heat the material being treated so that the temperature of the oil therein at a point adjacent the inlet end

of the coil approximates the initial boiling point of the oil under treatment and the temperature of the oil therein at a point near the outlet end approximates the end boiling point of the oil under treatment, the temperature of the intermediate points of the oil in the coil increasing approximately in the same ratio with respect to the total intervening length of the coil under consideration as the boiling point temperatures of the oil increase in ordinary fractional distillation of a sample of the oil under treatment throughout the successive positions of its boiling point range, leading the material in conversion through a higher heated zone in the presence of a metallic body of high specific heat and then condensing the resultant product.

In testimony whereof, I affix my signature in the presence of two witnesses.

WILLIAM M. McCOMB.

Witnesses:

EMMA WEINBERG,

IRVING A. HAME.