

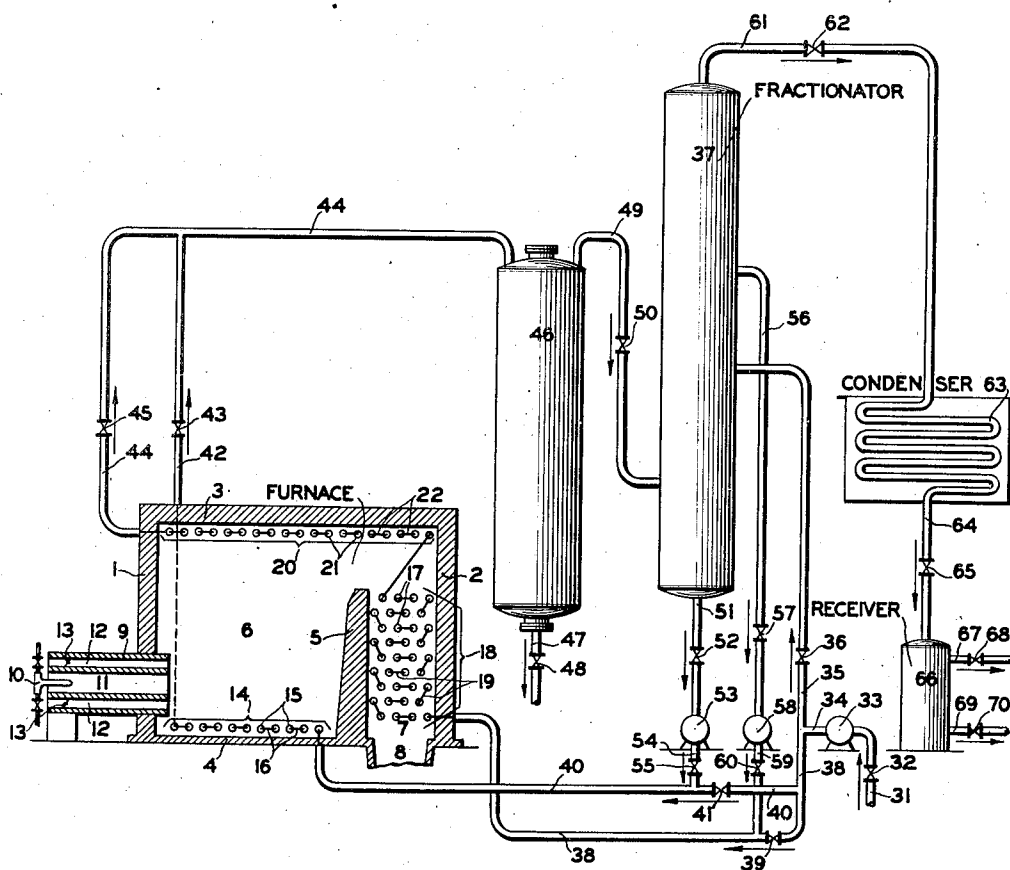
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HEATING OF FLUIDS

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HEATING OF FLUID

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1 Claim. (Cl. 196—116)

This invention relates to an improved method of heating and furnace structure for accomplishing the same, particularly adapted to heating hydrocarbon oils to the high temperatures required for their conversion, and, more particularly, is directed to an improved method and means for simultaneously heating two continuous streams of different hydrocarbon oils in the same furnace structure under conditions most suitable for the pyrolytic conversion of each.

It is well recognized that conversion time as well as the conditions of temperature and pressure employed for the conversion of hydrocarbon oils has a marked effect upon the yield and quality of the products. In general, when the production of maximum yields of good quality motor fuel is desired, relatively low boiling oils such as gas oil, pressure distillate bottoms, kerosene and kerosene distillate, naphtha, gasoline of poor anti-knock value and the like, require more prolonged conversion time than that which may be employed to best advantage in the conversion of higher boiling oils such as heavy crudes, topped crude, fuel oil, residual oil and the like. The production of coke and gas from high boiling hydrocarbon oils is minimized when they are quickly brought to the desired conversion temperature by subjecting them to high rates of heat input in order to employ a short time factor for their heat treatment while with lower boiling oils, which contain no appreciable quantities of easily cooked materials, more gradual heating is permissible and more prolonged conversion time is desirable for the production of motor fuel having high anti-knock characteristics.

When the high rates of heating necessary to obtain a short time factor are employed greatly decreased furnace efficiency ordinarily results, due to the excessively high temperature of the flue gases leaving such a furnace. With lower rates of heating and longer time factors more efficient furnace operation is obtainable, due to the ability to utilize lower flue gas temperatures.

In the present invention I take advantage of the factors above mentioned by providing for the simultaneous heating of both low boiling and high boiling oils in the same furnace structure, the high boiling oils being subjected to a high rate of heat input for a relatively short time by passing the same, preferably at relatively high velocity, through a fluid conduit situated in that portion of the furnace where the highest rates of heating are obtained while the lower boiling oil is subjected to more prolonged heating by passing the same through a fluid conduit

utilizing lower rates of heat input. In this manner the overall furnace efficiency is greatly improved as compared with a furnace utilizing only high rates of heat input and at the same time the two streams of hydrocarbon oil are each subjected to the conditions of treatment to which they are best adapted.

It will be understood that the present invention is not limited to the conversion of hydrocarbon oils but may be utilized to advantage in the heating of any fluid requiring high rates of heat transfer with a short-time factor in conjunction with the heating of another fluid, in the treatment of which lower rates of heating and a longer time factor may be safely employed. Neither is the invention, as applied to the conversion of hydrocarbon oils, limited to use in any specific type of cracking system. It is, however, particularly well adapted to use in conversion processes of the type wherein oils of different characteristics are subjected to different conversion conditions in the same system. In such cases either or both of such oils may comprise raw oil charging stock for the process or intermediate conversion products of the same cracking system or a mixture of charging stock and intermediate conversion products.

In order to more clearly illustrate the features and advantages of the present invention, particularly as applied to the conversion of hydrocarbon oils, the accompanying diagrammatic drawing is submitted, illustrating one specific type of cracking system utilizing a furnace structure and method of heating within the scope of the present invention. The drawing illustrates, diagrammatically, a side elevation of the apparatus, partially in cross-section.

Referring now to the drawing and, more particularly, to the furnace, the main furnace structure comprises end walls 1 and 2, a roof 3, a floor 4 and side walls which are not illustrated in the drawing, due to the furnace being shown in cross-section. The interior of the furnace is divided by means of bridge wall 5 into a combustion and heating zone 6 and another zone 7, heated mainly by convection, supplied with radiant and convection heat from the furnace gases passing from combustion and heating zone 6 to flue 8 and to a suitable stack (not shown). Combustion and heating zone 6 is supplied with combustible fuel, preferably by means of a plurality of firing tunnels, one of which is indicated in the drawing at 9. A burner 10 of any suitable form supplies any desired type of fuel such as oil, gas or pulverized solid fuel, preferably in admixture with a portion of 55

the air required for combustion through the central or combustion duct 11 of firing tunnel 9 to combustion and heating zone 6 and additional air for combustion may be supplied through ducts 12 located above and beneath duct 11 and controlled by dampers 13.

In the case illustrated, a single horizontal row or bank 14 of horizontally disposed tubes 15 is disposed adjacent the floor 4 of the furnace beneath firing tunnel 9. Adjacent tubes of this bank are connected at their ends in series by means of headers or return bends of any well known form (not shown), the connections between the tubes at their near ends being indicated, however, by lines 16. Tube bank 14 is supplied, primarily, with radiant heat from the combustion gases in combustion and heating zone 6 and from the hot refractory walls of the furnace and, due to its position in the furnace, a relatively high rate of heating is obtained in this portion of the fluid conduit. It will be understood that more than one row of tubes may be employed adjacent the floor of the furnace, although only one is illustrated in the drawing, but preferably not more than three such rows are employed for the heating of relatively high boiling hydrocarbon oils, in order that a high radiant heat input may be obtained and the oil quickly brought to the desired conversion temperature.

A plurality of horizontal rows of horizontally disposed tubes 17, comprising bank 18, is located within heating zone 7, adjacent tubes in each row and adjacent rows of tubes being connected in series, as indicated by the connecting lines 19 at the near end of the tubes, headers or return bends of any well known type (not shown) being employed for this purpose.

Another tube bank 20 comprising, in the case illustrated, a single horizontal row of horizontally disposed tubes 21, connected at their ends in series, as indicated by lines 22 at the near ends of the tubes, is disposed adjacent the roof 3 of the furnace. Suitable headers or return bends (not shown) are also employed for connecting the ends of adjacent tubes in bank 20. It will be understood that although the drawing illustrates only a single row of tubes in bank 20, more than one row of tubes disposed adjacent the roof of the furnace may be employed, when desired.

Tube banks 18 and 20 comprise, in the case illustrated, that portion of the fluid conduit through which the relatively low boiling oil is passed. Tube bank 20 receives radiant heat from the combustion gases and hot refractory walls of the furnace as well as convection heat from the furnace gases passing over the tubes and, normally, somewhat lower rates of heating are obtained in bank 20 as compared with those obtained in bank 14. Still lower rates of heating are obtained in tube bank 18, which is supplied with both radiant and convection heat (primarily the latter) from the furnace gases passing through this zone of the furnace. Although the temperature of the products emerging from the light oil heating coil is preferably higher than the final oil temperature obtained in the heavy oil heating coil a more gradual rate of heating and more prolonged conversion time is obtained in the light oil coil.

The invention, as employed in the specific type of furnace illustrated and described, is not limited to any particular path or direction of flow through the various tubes or tube banks of the fluid conduits except that low boiling oil is passed through tube banks 18 and 20 and high boiling oil through tube bank 14. In the case here illustrated, the

low boiling oil enters the bottom row of tubes in tube bank 18, passing upward through succeeding rows of this bank in a general direction counter-current to the flow of combustion gases through this zone, passing from the last tube in the top row of this bank to the tube of bank 20 adjacent end wall 2 of the furnace and through successive adjacent tubes in this bank, finally emerging from the tube adjacent end wall 1 of the furnace. The high boiling oil enters the tube of bank 14 nearest bridge wall 5, passing through adjacent tubes in this row in series and emerging from the tube at the opposite end of this bank most adjacent end wall 1 of the furnace.

Referring now to the entire cracking apparatus illustrated in the drawing, raw oil charging stock for the process is supplied through line 31 and valve 32 to pump 33 from which it is fed through line 34 and may pass, all or in part, either through line 35 and valve 36 into fractionator 37 or through line 38 and valve 39 into the light oil heating coil comprising tube banks 18 and 20 or from line 38 through line 40 and valve 41 into the heavy oil heating coil comprising tube bank 14. The method of supplying the charging stock to the system will, of course, depend upon its nature; being supplied to banks 18 and 20 when it is of relatively low boiling nature and to bank 14 when it is of relatively high boiling nature or, in either case, the charging stock may be supplied to fractionator 37, when desired, except in case it contains low boiling components which would contaminate the overhead stream of vaporous products removed from fractionator 37 and comprising the final light distillate product of the process. When the charging stock is of relatively wide boiling range, containing materials which it is desirable to convert in both the light oil and heavy oil coils, it is preferably supplied to fractionator 37 wherein it may be separated into low boiling and high boiling fractions, together with the reflux condensate removed from the vaporous products undergoing fractionation in this zone, the low boiling fractions being supplied to the light oil heating coil and the high boiling fractions to the heavy oil heating coil.

The high boiling oil, after being quickly heated to the desired conversion temperature in tube bank 14, is discharged therefrom, in the case illustrated, through line 42, valve 43 and line 44 into reaction chamber 46, while the low boiling oil, after being subjected to more prolonged conversion temperature, through line 44 and valve 45 also into reaction chamber 46.

Substantial superatmospheric pressure is preferably employed in both the light oil and the heavy oil heating coils, higher pressure being preferred in the light oil heating coil than that employed in the heavy oil coil, and the pressure employed in the reaction chamber may be substantially the same as that employed in the heavy oil heating coil or may be substantially reduced relative thereto.

Vaporous and liquid conversion products separate in chamber 46. The latter may be withdrawn from the lower portion of the chamber through line 47 and valve 48 to cooling and storage or to any desired further treatment or, when desired, operating conditions of the process may be so controlled that only substantially dry coke is produced as the residual product of the process, in which case this material may be allowed to accumulate in chamber 46 to be removed therefrom, in any well known manner (not shown) after the operation of the chamber is completed.

When desired, a plurality of coking chambers, similar to chamber 46, but not illustrated in the drawing, may be employed and may be operated either alternately or simultaneously.

5 Vaporous conversion products pass from the upper portion of chamber 46 through line 49 and valve 50 to fractionation in fractionator 37. The insufficiently converted components of the vapors, boiling above the range of the desired final light
10 distillate product of the process, are condensed in fractionator 37 as reflux condensate and, in the case here illustrated, the reflux condensate is separated into low boiling and high boiling fractions.

The high boiling fractions of the reflux condensate are withdrawn from the lower portion of the fractionator through line 51 and valve 52 to pump 53, by means of which they are returned through line 54, valve 55 and line 40 to the heavy oil heating coil.

20 Low boiling fractions of the reflux condensate are removed from one or a plurality of suitable intermediate points in the fractionator passing, for example, through line 56 and valve 57 to pump 58, by means of which they are returned through line 59, valve 60 and line 38 to the light oil heating coil.

Fractionated vapors of the desired end boiling point, preferably comprising materials within the boiling range of motor fuel and of good anti-knock value, are withdrawn from the upper portion of fractionator 37 through line 61 and valve 62 and are subjected to condensation and cooling in condenser 63. The resulting distillate and gas passes through line 64 and valve 65 to collection and separation in receiver 66. Uncondensable gas may be released from the receiver through line 67 and valve 68. Distillate may be withdrawn from receiver 66 through line 69 and valve 70 to storage or to any desired further treatment.
40 When desired, a regulated portion of the distillate collecting in receiver 66 may be returned, by well known means (not shown), to the upper portion of fractionator 37 to serve as a refluxing and cooling medium in this zone to assist fractionation of
45 the vapors and maintain the desired vapor outlet temperature from the fractionator, thus regulating the end boiling point of the final light distillate product of the process.

In an apparatus such as illustrated, the operating conditions of the process described may be approximately as follows: an average heat transfer rate ranging from approximately 5,500 to 8,500 B. t. u.'s per square foot, per hour may be employed in the light oil heating coil and
55 the conversion temperature employed at the outlet from this zone may range, for example, from 925 to 1050° F., or thereabouts, preferably with a superatmospheric pressure of from 200 to 800 pounds, or more, per square inch, at this

point in the system. A higher heat transfer rate of the order of 12,000 to 15,000 B. t. u.'s per square foot per hour is preferably employed in the heavy oil heating coil with a minimum velocity in this zone, based upon the volume of
5 relatively cold oil entering the coil and neglecting the increased velocity due to expansion and vaporization upon heating, of approximately 7 to 8 per feet per second. The conversion temperature employed at the outlet from the heavy
10 oil heating coil may range, for example, from 800 to 950° F., or thereabouts, and preferably a superatmospheric pressure of from 100 to 500 pounds, or thereabouts, per square inch is employed at this point in the system. Any desired
15 pressure ranging from substantially atmospheric to a superatmospheric pressure of the order of 500 pounds, or thereabouts, per square inch may be employed in the reaction chamber, the pressure in this zone being, however,
20 no greater than that employed at the outlet from the heating coil employing the lowest pressure. The pressure employed in the reaction chamber may be either substantially equilized or somewhat reduced in the succeeding fractionating, condensing and collecting portions of
25 the cracking system.

As an example of the improved operation of a cracking process, such as illustrated and above described, utilizing the features of the present
30 invention, as compared with a similar operation utilizing separate furnaces for heating the light and heavy oils and employing only high rates of heating in the furnace devoted to heating the heavy oil, the single furnace of the present
35 invention may have an overall thermal efficiency of the order of 65 to 70% as compared with an efficiency of approximately 50%, for example, in a furnace employing only high rates of heat input.
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I claim as my invention:

In the heating of hydrocarbon oils to conversion temperatures in furnaces having a radiant heat section and a convection heat section receiving combustion gases from the radiant
45 section, and the furnace fired adjacent the lower portion of the radiant heat section; the method which comprises passing a stream of relatively heavy oil at high velocity through a fluid conduit adjacent the floor of said radiant section
50 and subjecting the same therein to high rates of heating for a short period of time, and simultaneously passing a stream of lighter oil through a fluid conduit disposed partially in the convection section of the furnace and partially in the
55 upper portion of said radiant section and subjecting the same therein to lower rates of heating for a more prolonged period of time.

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