

April 8, 1930.

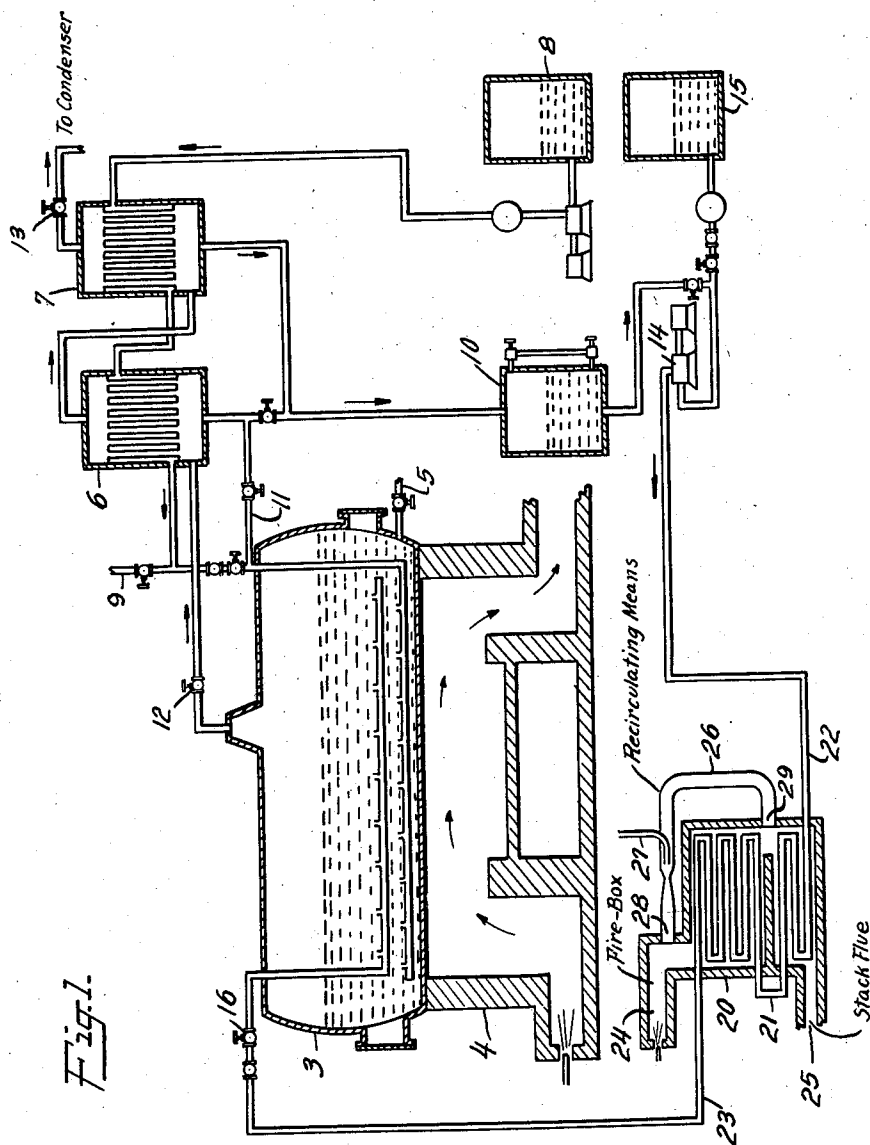
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ART OF CRACKING HYDROCARBONS

Filed May 25, 1927

2 Sheets-Sheet 1



INVENTOR

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BY

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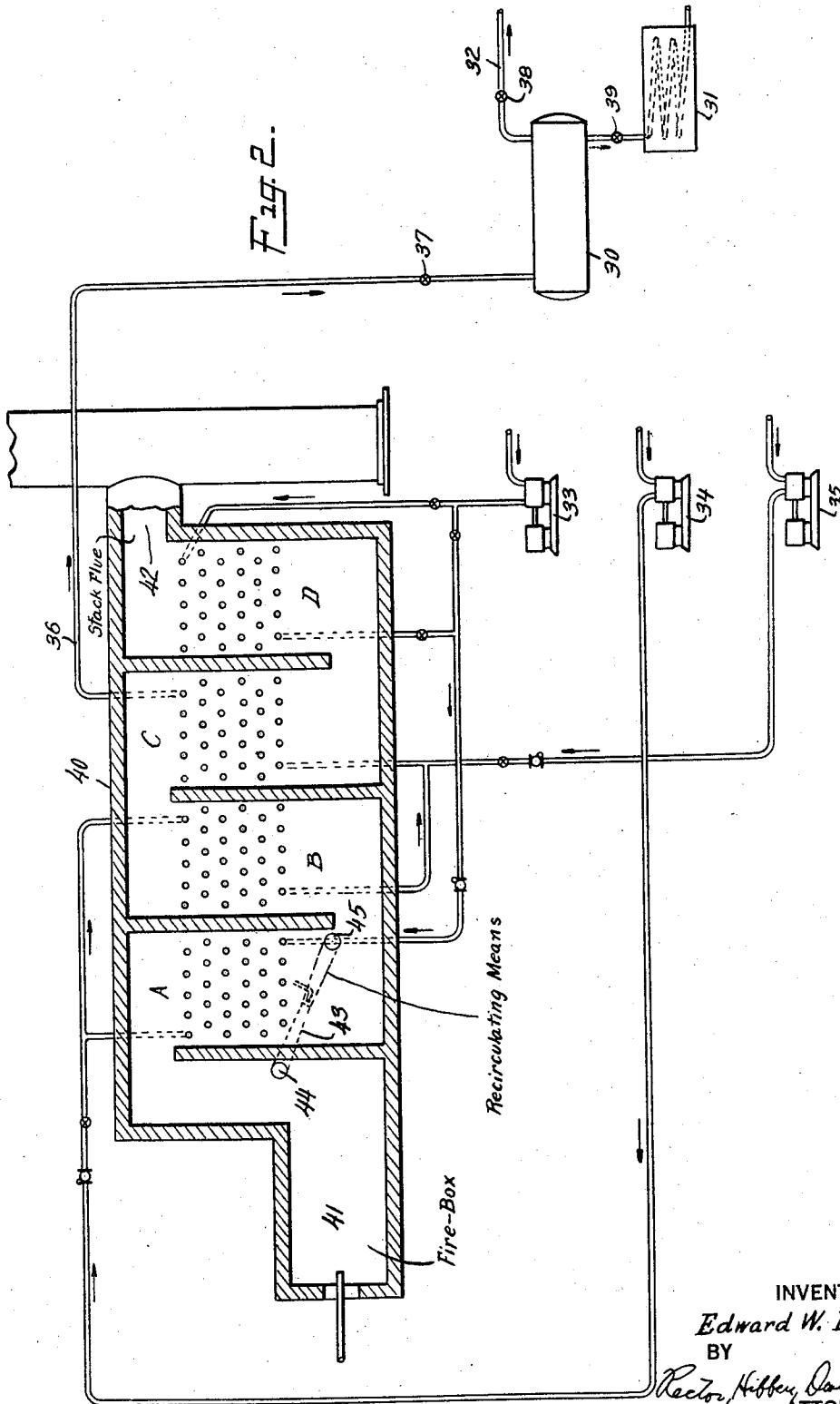
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UNITED STATES PATENT OFFICE

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ART OF CRACKING HYDROCARBONS

Application filed May 25, 1927. Serial No. 194,002.

This invention relates to improvements in the cracking of heavier and higher boiling hydrocarbon oils, such as fuel oil, gas oil and kerosene, to produce lighter and lower boiling hydrocarbon oils, such as gasoline or gasoline-containing cracked distillates. The heat for such operations is commonly supplied by passing hot products of combustion from a firebox over tubes or pipes through which the oil is circulated and in which it is heated to a cracking temperature. This invention relates particularly to improvements in supplying heat for such operations.

The products of cracking operations usually include, in addition to the desired lighter or lower boiling oils, a certain amount of pitch or tar or carbon or coke. Such pitchy or carbonaceous materials are not good conductors of heat, and to the extent that they deposit in tubes or pipes through which heat is transferred to the oil they impede heat transfer. This is objectionable not only with respect to the efficiency and the capacity of the heating apparatus, but also because it deprives the heating tubes or pipes of the protective effect of the oil absorbing heat as it passes through the heating tubes or pipes. Local overheating results with the consequent danger of burning or rupturing the tubes or pipes. The tendency toward overheating, moreover, is cumulative since local overheating tends to cause excessive local decomposition with the formation and tendency to deposit of excessive amounts of pitchy and carbonaceous materials. Such difficulties can be overcome in an advantageous way by recirculating over the heating tubes or pipes in admixture with fresh hot products of combustion a portion of the heating gases which have passed over the heating tubes or pipes. Such recirculation of a portion of the heating gases has numerous advantages. For example, the volume of heating gases passing over the heating tubes or pipes is increased and the consequent increase in velocity improves the rate and efficiency of heat transfer, the tempering action of the recirculated heating gases assists in protecting the tubes or pipes and also makes it possible to carry out combustion of the fuel used at much higher temperatures with consequent greater fuel efficiency than otherwise would be possible without danger of overheating the tubes or pipes or of local overheating, and better distribution of the heat absorption through the tubes or pipes is made possible, without decreasing but rather increasing the general efficiency of the heating operation.

However, as an increasing proportion of the heating gases which have passed over the heating tubes or pipes is recirculated thereover, there is an accompanying approach of the temperature at which the mixture of heating gases first contacts with the heating tubes or pipes and that at which it leaves the heating tubes or pipes. As an increasing proportion of the heating gases is recirculated, the temperature at which the mixture of heating gases first contacts with the heating tubes or pipes decreases and that at which it leaves the heating tubes or pipes tends to increase.

According to the present invention, the heating gases including the hot products of combustion from the firebox are passed over heating tubes or pipes through which a stream of oil undergoing cracking is circulated so that the temperature of the mixture of heating gases is progressively reduced, heating gases for recirculation over the heating tubes or pipes with which the fresh hot products of combustion from the furnace first contact are withdrawn at an intermediate point in the travel of the heating gases and at a correspondingly intermediate temperature, and the remaining heating gases are discharged only after further passage over the heating tubes or pipes and consequent further reduction in temperature. The advantages of recirculation of a portion of the heating gases which have passed over oil heating tubes or pipes and the temperature of which has been thereby reduced are secured, and at the same time a further improvement in efficiency and economy is effected by further reduction of the temperature at which the heating gases not recirculated are discharged. While the volume of heating gases passing over the heating tubes or pipes beyond the point at which a por-

tion of the heating gases are withdrawn for recirculation may not be increased, these further heating tubes or pipes are protected from overheating since the temperature at which the heating gases first contact with these further heating tubes or pipes is not greater than that of the heating gases passing over the heating tubes or pipes closer, in the passage of the heating gases, to the firebox and over which a portion of the heating gases is recirculated.

The invention will be further described in connection with the accompanying drawings which illustrate diagrammatically and conventionally, two forms of apparatus embodying the invention and adapted for carrying out the invention, but it will be understood that this further description and illustration of the invention is intended for exemplification and that the invention is not limited thereto. In the drawings, Fig. 1 illustrates the invention as applied to one form of cracking system, and Fig. 2 illustrates the invention as it is applied to another form of cracking system.

The apparatus illustrated in Fig. 1 comprises a single pass heater discharging into a shell 3. The shell 3 is arranged on a furnace setting 4 by which external heat may be supplied thereto, or the shell 3 may be heated internally only by the hot oil products discharged into it from the single pass heater. Liquid residues may be discharged from the shell 3 through connection 5. Vapors from the shell 3 pass successively through the reflux condensers 6 and 7 and from the latter to a condenser (not shown) in which the cracked distillate product is condensed. Fresh oil may be supplied to the shell 3 from tank 8. This fresh oil may be passed in heat exchanging relation with the vapors flowing through the reflux condensers 6 and 7 on its way to the shell 3, thereby being preheated and serving to cool and reflux the vapors. Additional refluxing may be effected by passing an additional amount of such fresh oil through the reflux condensers and discharging it through connection 9. Reflux condensate from the reflux condensers 6 and 7 passes to tank 10, or part of the reflux condensate from reflux condenser 6 may be returned to the shell 3 through connection 11. A super-atmospheric pressure may be maintained in the shell 3 by means of valve 12 and the reflux condensers 6 and 7 operated at atmospheric pressure or at an intermediate pressure, or the same pressure may be maintained on the shell 3 through the reflux condensers 6 and 7 by means of valve 13. Likewise, the final condenser (not shown) may be operated at the same pressure as that prevailing throughout the system, or at atmospheric pressure, or at an intermediate pressure. Reflux condensate from tank 10 is forced through the single pass heater by means of

pump 14. Additional fresh oil from tank 15 may be supplied to the single pass heater in admixture with this reflux condensate.

In operation to produce gasoline or a gasoline-containing distillate, a gas oil or heavy gas oil stock may be supplied from tank 8 and a kerosene or light gas oil stock from tank 15. The refluxing operation is regulated to condense and reflux those constituents of the vapors heavier or higher boiling than are desired in the product. A pressure up to 100 pounds per square inch or higher pressure, may be maintained in the shell 3 and oil supplied to the single pass heater under pressure just sufficient to effect discharge of the hot oil products therefrom into the shell 3, or a higher pressure may be used in the single pass heater and this pressure reduced by means of valve 16. The hot oil products may be discharged from the single pass heater at a temperature in the neighborhood of 800° F. to 1,200° F. and a temperature in the shell may be maintained in the neighborhood of 700° F. to 850° F. The charge of oil in the shell 3 may be run substantially to coke or a coke-like residue, or the operation may be conducted in a continuous manner by discharging continuously or at regular intervals tar or pitch-laden oil through connection 5.

In this apparatus, the present invention is illustrated as applied to the single pass heater. This single pass heater comprises a furnace 20 in which a number of heating tubes connected to form a continuous heating coil 21 are arranged. Oil is supplied to the heating tubes through connection 22 and the hot oil products are discharged therefrom through connection 23. The heating furnace 20 is provided with a firebox 24 and a stack flue 25, heating gases being circulated from the firebox over the oil heating tubes in the furnace of the stack flue. The firebox is provided with suitable means for burning the fuel employed to supply the heat used in the cracking operation. Before the hot products of combustion from the firebox 24 come in contact with the oil heating tubes, they are admixed with a portion of heating gases withdrawn from the heating gases circulating through the furnace at an intermediate point in their passage from the firebox to the stack flue. These recirculated heating gases have passed over a part of the oil heating tubes, and consequently are at reduced temperature, so that the fresh hot products of combustion from the firebox are tempered by admixture therewith before the mixture is contacted with the oil heating tubes. Connection 26 is provided for this recirculation of heating gases. This return connection includes a blower which may be operated by a steam jet 27, as illustrated, or by other suitable means for maintaining circulation of the returned recirculated heating gases. In place of the blower illustrated, a fan or

other suitable forcing means may be used. This recirculating connection 36 is arranged, as illustrated, at a point such that the heating gases withdrawn therethrough pass over a part but not all of the heating tubes. The remaining heating gases, not withdrawn through connection 26, continue in passage over the remaining heating tubes and are discharged, after further reduction in temperature, through stack flue 25. The oil heating tubes are thus protected, and the improvements in efficiency and economy accompanying recirculation of a portion of the heating gases are secured, the temperature of combustion in the firebox may be regulated more or less independently of the temperature conditions maintained in the heating flues, and the waste heating gases are discharged from the operation at a relatively low temperature.

The apparatus illustrated in Fig. 2 comprises a series of heating coils discharging into a vaporizing drum 30. The cracked products discharged from the heating coils into the vaporizing drum 30 are separated therein into a vapor mixture and a liquid residue, the liquid residue is discharged through a cooler 31, and the vapor mixture is discharged through connection 32 to a suitable fractionating or condensing system. Oil is forced through the heating coils by means of one or more of the pumps 33, 34 and 35. The heating coils are arranged in successive heating flues in the furnace, A, B, C and D, and the general flow of oil is successively through the heating coil in flue A then through that in flue B, and then through that in flue C, being discharged to the vaporizing drum from the last through connection 36. Before entering the heating coil in flue A, fresh oil may be passed through the heating coil in flue D. Pumps 34 and 35 are arranged to supply fresh oil at intermediate points in the passage of the oil through the heating coils. Reflux condensate or heavier or higher boiling fractions separated from the vapors discharged from the connection 32, may be supplied to one or more of the pumps 33, 34 and 35 together with fresh oil. A superatmospheric pressure may be maintained in the heating coils and regulated by means of valve 37. The vaporizing drum 30 may be operated substantially at atmospheric pressure or at a pressure intermediate that and the pressure at which the hot oil products from the heating coils are discharged through connection 36. Pressure in the vaporizing drum 30 may be maintained and regulated by means of valves 38 and 39.

In operation to produce gasoline or a gasoline-containing distillate, the gasoline character stock may be supplied to pump 33, and gas oil character stocks may be supplied to the pumps 34 and 35. The stock discharged from pump 33 may be forced directly through

the heating coil in flue A, or it may be passed or partly passed first through the heating coil in flue D, by appropriate regulation of the valves illustrated. Pressures in the neighborhood of 100 pounds to 300 pounds per square inch or higher pressures may be maintained in the heating coils. The hot oil products may be discharged from the heating coils at a temperature in the neighborhood of 700° F. to 900° F.

In this apparatus, the successive heating coils are arranged in a series of flues A, B, C and D in the heating furnace 40. This heating furnace is provided with a firebox 41 and a stack flue 42, heating gases being circulated from the firebox successively through the flues A, B, C and D, and over the heating coils therein, to the stack flue. The firebox 41 is provided with suitable means for burning the fuel employed to supply the heat used in the cracking operation. As the mixture of heating gases, including fresh hot products of combustion from the firebox, flow through the successive flues in the heating furnace, its temperature is progressively reduced. Before the fresh hot products of combustion from the firebox 41 come in contact with the heating coil in flue A, they are admixed with a portion of the heating gases which have passed through flue A the temperature of which has been accordingly lowered by the heat absorbed in the heating coil therein. The connection 43 is provided for effecting this recirculation of heating gases which have passed over the heating coil in flue A. This return connection includes suitable forcing means as previously described. The recirculated heating gases are discharged through outlet 44 where they mix with the fresh hot products of combustion from the firebox before the latter contact with the heating coil in flue A. These recirculated heating gases are withdrawn adjacent the connection between flue A and flue B, through the inlet 45 to the return connection. The remaining heating gases then pass in succession over the heating coils in flue B, in flue C and in flue D, finally being discharged through the stack flue at a temperature much lower than that at which they escape from flue A or enter flue B.

I claim:

1. In cracking hydrocarbon oils in operations in which a flowing stream of oil is heated to a cracking temperature by heat exchange with hot products of combustion from a firebox in which fuel is burned, the improvement which comprises passing a stream of oil through a heating conduit and passing heating gases including hot products of combustion from a firebox in heat exchanging relation therewith whereby the oil is heated to a cracking temperature and the temperature of the heating gases is progressively reduced, withdrawing a portion of the heating gases from an intermediate point in the passage of

the heating gases over the heating conduit at an intermediate temperature, recycling such withdrawn heating gases over the heating conduit in admixture with fresh hot products of combustion from the firebox, and discharging the remaining portion of the heating gases after further passage over the heating conduit and at a lower temperature than that at which the recycled heating gases are withdrawn.

2. In apparatus for cracking hydrocarbon oils, a heating furnace having a firebox and a stack flue and heating flues connecting the firebox with the stack flue, oil heating tubes arranged in said heating flues and means and connections for circulating oil there through, a return flue communicating at one end with said heating flues at a point intermediate the positions of said oil heating tubes nearest the firebox and those nearest the stack flue and at the other end with a heating flue nearer the firebox, and forcing means in said return flue for recirculating through said flue nearer the firebox heating gases withdrawn from the heating flues at said intermediate points.

In testimony whereof, I have subscribed my name.

EDWARD W. ISOM.