Sept. 19, 1933. F. W. SULLIVAN, JR 1,927,074

ELECTROTHERMAL OIL TREATMENT

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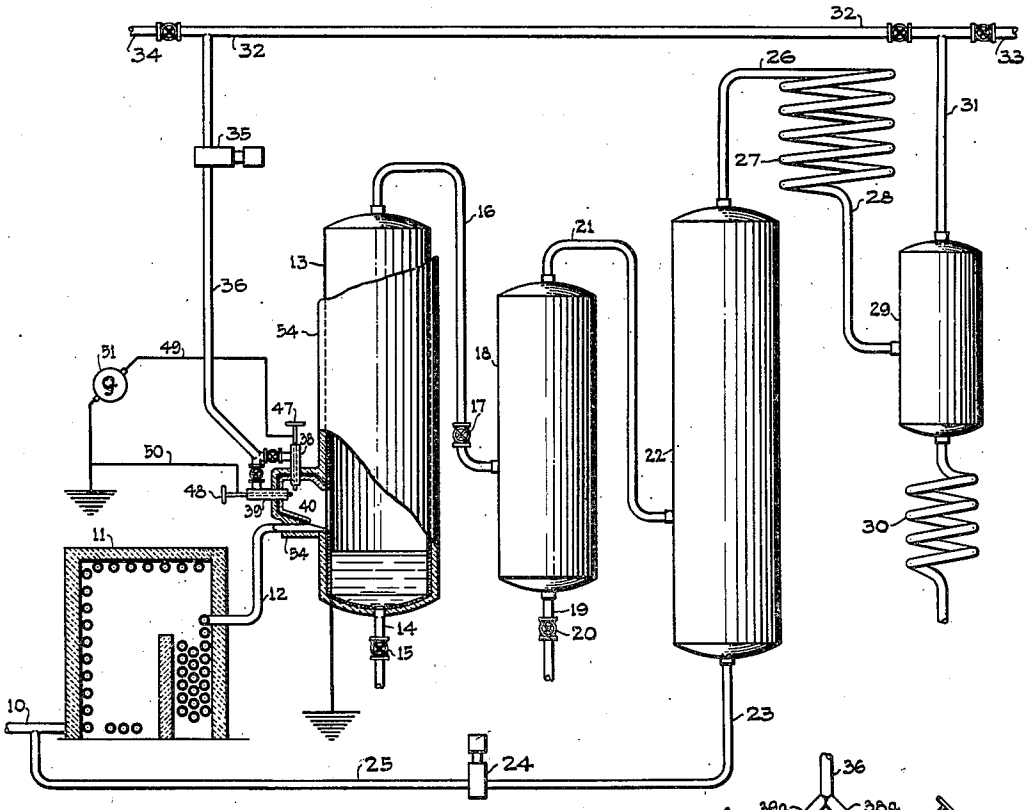

Fig. 1

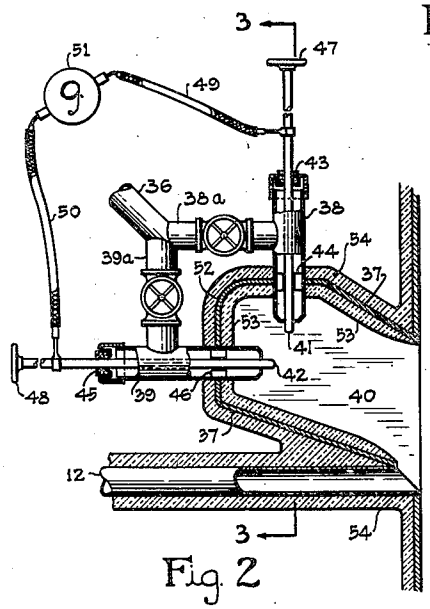

Fig. 2

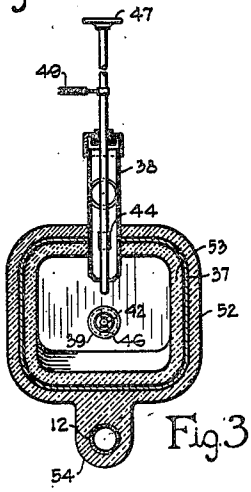

Fig. 3

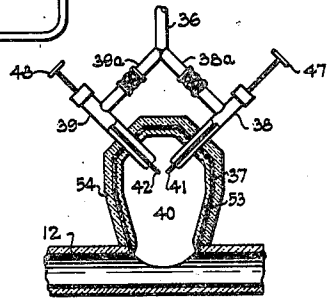

Fig. 4

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ELECTROTHERMAL OIL TREATMENT

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11 Claims. (Cl. 196—66)

This invention relates to an electrothermal prcoess for treating oils and it pertains more particularly to an improved method and means for converting heavy petroleum hydrocarbons into lighter hydrocarbons, such as gasoline.

The object of my invention is to provide a system whereby the yield of gasoline from high boiling petroleum hydrocarbons may be increased and the yield of tar and gases may be decreased, thus increasing the efficiency of the cracking process. A further object is to provide an improved method and means for supplying the last increment of heat into petroleum hydrocarbons in a cracking process so that the heater may be operated at lower temperatures and the factor of safety thereby increased. A further object is to electrically activate hydrocarbon gases whereby they may be chemically combined or utilized by heavy hydrocarbons in a cracking process for the production of light oils, such as gasoline. A further object is to provide an improved stable, high antiknock gasoline. Other objects will be apparent from the following detailed description.

In practicing my invention I pass residual gases from a cracking process through an electrical arc whereby they are heated to a temperature of between 1200 and 1500° F. and partly converted into activated hydrogen. The temperature in the arc is, of course, 3000 to 7000° F. and at these temperatures the hydrogen-containing gases are broken down and partially converted into activated hydrogen. A sufficient volume of gas is usually introduced around the electrodes, however, to maintain a temperature in chamber 40 of about 1500° F. I inject these hot activated gases into hydrocarbons entering the soaking drum of the cracking system. The temperature of the hydrocarbons is thereby raised from about 800 to 925° F. The tendency to form tar or coke is reduced by the presence of the activated hydrogen which is obtained from the waste gases of the system. The invention will be more clearly understood from the description of a preferred embodiment which is illustrated in the accompanying drawing wherein—

Figure 1 is a diagrammatic elevation partly in section of my improved system,

Figure 2 is a detailed section showing a preferred form of an electric arc heater,

Figure 3 is a section taken along the lines 3—3 of Figure 2.

Figure 4 is a horizontal section of another embodiment of my improved electric arc heater.

The cracking system generally is along the lines of commercial vapor phase cracking units now in use. The heavy petroleum hydrocarbons which may be gas oil, naphtha bottoms, reduced crude, or other charging stock is introduced by pipe 10 into the tubes of pipe still 11. The exact routing of the oil through the pipe still forms no part of the present invention and it is only essential that the oil be heated to a temperature of about 850° F. without material coke deposition and without too great a pressure drop. The last part of the pipe still heating is conveniently accomplished in the top tubes of the convection section from which the hot hydrocarbons are conducted by pipe 12 into the base of soaking drum 13.

The soaking drum, which is well insulated, is normally operated under a pressure of about 300 pounds. At its base I provide a tar draw-off pipe 14 containing a suitable valve 15. Vapors from the top of the soaking drum are withdrawn through pipe 16, passed through reducing valve 17 and introduced into preliminary fractionating tower 18 which is equipped with suitable baffles, cooling coils, etc. A light tar is drawn from the base of this tower through pipe 19 and valve 20. Gases and vapors are conducted by pipe 21 from the top of tower 18 to rectifier 22 which is also equipped with suitable bubble plates, cooling means, reflux means, stripping means, etc. The heavy ends from the base of tower 22 are withdrawn through pipe 23, pump 24, and pipe 25 which leads back to the pipe still. This "cycle stock" is diagrammatically shown entering the pipe still with fresh feed, but it is understood that cycle stock may be introduced into the pipe still at any suitable point, preferably where the temperature of the oil in the coils is equal to the temperature of the cycle stock.

Light hydrocarbon gases and vapors leaving the top of tower 22 by pipe 26 are partially condensed in coil 27 and are introduced by pipe 28 into separator 29, condensate being withdrawn through cooling coil 30 and the uncondensed gases being discharged from the top of the separator through pipe 31. The residual gases in pipe 31 contain some methane and ethane, hydrogen, light olefins, etc., the mixture being similar to what is ordinarily termed refinery gases. These gases are conducted by pipe 32 to arc heater 37 so that they can be further utilized in the manufacture of gasoline.

In order to prevent a large amount of gas from accumulating in the system I provide a discharge pipe 33 for bleeding out small amounts of gases when their volume is unduly increased. On the other hand, it may be desirable to add refinery

gases from other parts of the plant or to inject hydrogen into the system through pipe 34. These gases, which contain hydrogen in the free or combined state, are compressed by compressor 35 and introduced by means of pipe 36 into electric arc heater 37. The gas is preferably divided and introduced into the heater by means of two inlet nozzles 38 and 39, the amount of gas in each nozzle being regulated by valves in the respective connecting arms 38A and 39A. Both nozzles terminate in a chamber 40 and are arranged with their discharge ends relatively close together and at an angle to each other. Tungsten electrodes 41 and 42 extend through the respective nozzles. Electrode 41 is insulated from nozzle 38 by packing material 43 and separator 44, both of which are composed of suitable insulating material. Likewise, electrode 42 is insulated from nozzle 39 by means of packing material 45 and separator 46. Electrode 41 may be moved inwardly or outwardly by means of regulating handle 47 and electrode 42 may be similarly regulated by handle 48. These electrodes are connected by conductors 49 and 50 to a suitable power source 51 which is designed to operate at voltages of from 220 to 440 and to deliver sufficient current to heat the gases to about 1200–1500° F. and to activate the hydrogen. In the accompanying drawing, the electrode mounting and the nozzles have been shown more or less diagrammatically, but it is understood that any suitable means may be used whereby these nozzles may withstand cracking pressures and whereby the electrodes may be insulated from the sides of the nozzles.

The structure of the arc chamber will be best understood by reference to Figures 2 and 3. A high temperature alloy steel chamber 52 is welded to the side of the soaking drum 13 adjacent the discharge of pipe 12. It is protected on its inner side by a refractory material 53, such as fire clay, and it is protected on its outside by suitable insulating material 54, which insulating material also surrounds the soaking drum and hot pipes. The chamber preferably opens directly into the soaking drum and is disposed at a slight angle to pipe 12. I may, however, use the modification shown in Figure 4, wherein the chamber is mounted directly above pipe 12 and does not directly communicate with the soaking drum.

The operation of my invention is as follows: The charging stock introduced by pipe 10 is heated to a temperature of about 850° F. in pipe still 11 and is then discharged through pipe 12 into soaking drum 13 at a pressure of about 150–300 pounds. In order that the soaking drum may operate under vapor phase conditions I prefer to increase the temperature of the charging stock to 925° F. It is difficult to obtain these temperatures in a pipe heater because even high temperature alloy tubes often fail at these temperatures and pressures. I reduce the danger and facilitate the operation of the heater by supplying the last increment of heat by means of electrode heater 37.

Refinery gases from pipe 36 are fed into chamber 40 around electrodes 41 and 42, so that the gases act as a cooling medium therefor. The arc is adjusted to give a current sufficient to heat the hydrogen containing gases to a temperature of about 1200 to 1500° F. so that the mixture of these gases with heated charging stock may give a resultant temperature of about 925° F. or above. It should be noted that the charging stock does not pass directly through the arc or in close enough proximity thereto to become decomposed. At least a part of the hydrocarbon gases which are introduced around the electrodes are decomposed in the arc to form hydrogen, small amounts of free carbon and acetylene. Under these conditions part of the hydrogen is activated and/or converted into atomic hydrogen. This electrically activated hydrogen is unusually effective in converting the hot charging stock into gasoline and in minimizing the formation of coke. I do not limit myself to any theory or explanation of these phenomena, but it appears that the introduction of electrically activated gases and hydrogen into the hydrocarbon vapors undergoing thermal dissociation prevents polymerization and formation of coke and undesirable tarry residues.

The carbon produced in the arc and the small amount of heavy tar which may form in soaking drum 13 are periodically or continuously withdrawn therefrom through pipe 14. The light reaction products pass through expansion valve 17 into fractionating or rectifier towers 18 and 22. Light tar from pipe 19 may, in some cases, be recirculated through the system as cycle stock or it may be withdrawn for other purposes. Fractionating tower 22 is preferably at about atmospheric pressure so that both the cycle stock from this tower and the gases from separating chamber 29 must be compressed before they are reintroduced into the system.

The apparatus illustrated in Figures 1 to 3 is advantageous from the standpoint of carbon deposition because the turbulent action of the hot gases tends to sweep this deposit into the soaking drum where it is suspended in heavy tar and withdrawn. The modification in Figure 4 may be employed in a coil cracking system wherein sufficient soaking of the vapors is provided by additional insulated pipe coils usually employing large diameter pipes.

While I have described in detail a preferred embodiment of my invention it is to be understood that I do not limit myself to said details except as defined by the following claims.

I claim:

1. In apparatus of the class described for converting heavy hydrocarbons into gasoline by the combined process of pyrolitic cracking and destructive hydrogenation, a pipe still for heating charging stock to above 800° F., an electric arc heater for heating hydrogen containing gases to a temperature of about 1200 to 1500° F., and means for mixing said heated gases with said heated charging stock whereby a resulting temperature of about 925° is obtained.

2. In apparatus of the class described for converting heavy hydrocarbons into gasoline, an insulated soaking drum adapted to withstand a pressure of about 150–300 pounds per square inch, a pipe heater for elevating the temperature of said hydrocarbons, an electric arc heater for adding the last increment of heat thereto, means for passing hydrogen-containing gases through said arc heater and means for subsequently mixing said gases with said heated heavy hydrocarbons and for introducing them into said soaking drum.

3. In apparatus of the class described for converting heavy hydrocarbons into gasoline, an insulated soaking drum adapted to withstand high pressures, means for heating said heavy hydrocarbons and introducing them into said soaking drum, means for separately recovering heavy hydrocarbons, light hydrocarbons and hydrogen-containing gases from the products of said soaking drum, an electric arc, means for passing a

portion of said hydrogen-containing gases through said electric arc, and means for subsequently mixing said gases with the heated heavy hydrocarbons entering said soaking drum.

4. In apparatus of the class described for converting heavy hydrocarbons into gasoline, means for heating said hydrocarbons to cracking temperature, a passage conduit leading from said heating means, an arc chamber adjacent to said discharge conduit and communicating therewith, arc electrodes in said chamber, means for mounting said electrodes whereby at least one of them is insulated from the system and from the other electrodes, and means for introducing a hydrogen-containing gas into said chamber to regulate the temperature thereof and to combine with the heated hydrocarbons adjacent thereto.

5. In apparatus of the class described for converting heavy hydrocarbons into gasoline, a reaction drum, an arc chamber adjacent thereto and communicating therewith, arc electrodes in said chamber, means for introducing a hydrogen-containing gas into said arc chamber for cooling said arc electrodes, regulating the temperature in said chambers and finally regulating the temperature in said reaction drum.

6. In apparatus of the class described, a reaction chamber, an arc electrode adjacent to said chamber and communicating therewith at a point spaced from the bottom thereof, means for withdrawing liquids and liquid suspensions from the bottom of said chamber, means for removing gases and vapors from the top of said chamber, means for introducing a heated hydrocarbon into said chamber, and means for introducing a hydrocarbon gas into said arc chamber so that the carbon which is formed by the arc may be suspended in heated petroleum liquid and withdrawn from the base of said chamber.

7. In apparatus of the class described, an arc chamber, two nozzles extending into said arc chamber and inclined toward each other whereby the gases from said nozzles impinge in said arc chamber, arc electrodes extending through said nozzles, means for insulating at least one arc electrode from the other and from the system, and means for introducing gases in regulated amounts into said nozzles whereby the gases flow around said electrodes to cool the same and whereby the gases impinge at the point of the arc so that the reaction products of the arc are swept therefrom.

8. In apparatus of the class described, a conduit, an arc chamber adjacent said conduit, arc electrodes in said chamber, means for introducing a cooling gas around said electrodes whereby part of said gases are heated in the arc to a temperature of 3000 to 7000° F. and the temperature in the chamber is maintained at about 1200 to 1500° F., the gases from the arc chamber being introduced into said conduit to regulate the temperature of liquids flowing therein.

9. The combination of claim 8 wherein heated hydrocarbons are in said conduit and hydrocarbon gas is passed through said arc chamber so that a part of the hydrocarbon gas will be converted into activated hydrogen which, on introduction into the conduit, elevates the temperature thereof and reacts therewith.

10. In apparatus of the class described, a pipe still, a soaking drum, means for passing a hydrocarbon oil through said pipe still and introducing it into said soaking drum, an electric arc adjacent said conduit and communicating therewith, means for removing liquids and liquid suspensions from the base of said soaking drum, means for separating gasoline and hydrocarbon gases from the reaction products of the soaking drum, and means for returning said hydrocarbon gases to said soaking drum through said arc.

11. The method of converting heavy hydrocarbons into gasoline which comprises heating said hydrocarbon to a temperature of about 800° F. in a closed conduit, heating a light hydrocarbon gas in an electric arc whereby it is decomposed, activated and is raised to a high temperature, and combining the hot reaction products of the electric arc with the heated hydrocarbon in the conduit so that the temperature of the hydrocarbon in the conduit is raised to about 925° F. and the reaction products of the arc combine with the heated hydrocarbon.

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