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2,436,938

METHOD OF PRODUCING MOTOR FUEL

Filed Feb. 22, 1945

2 Sheets-Sheet 1

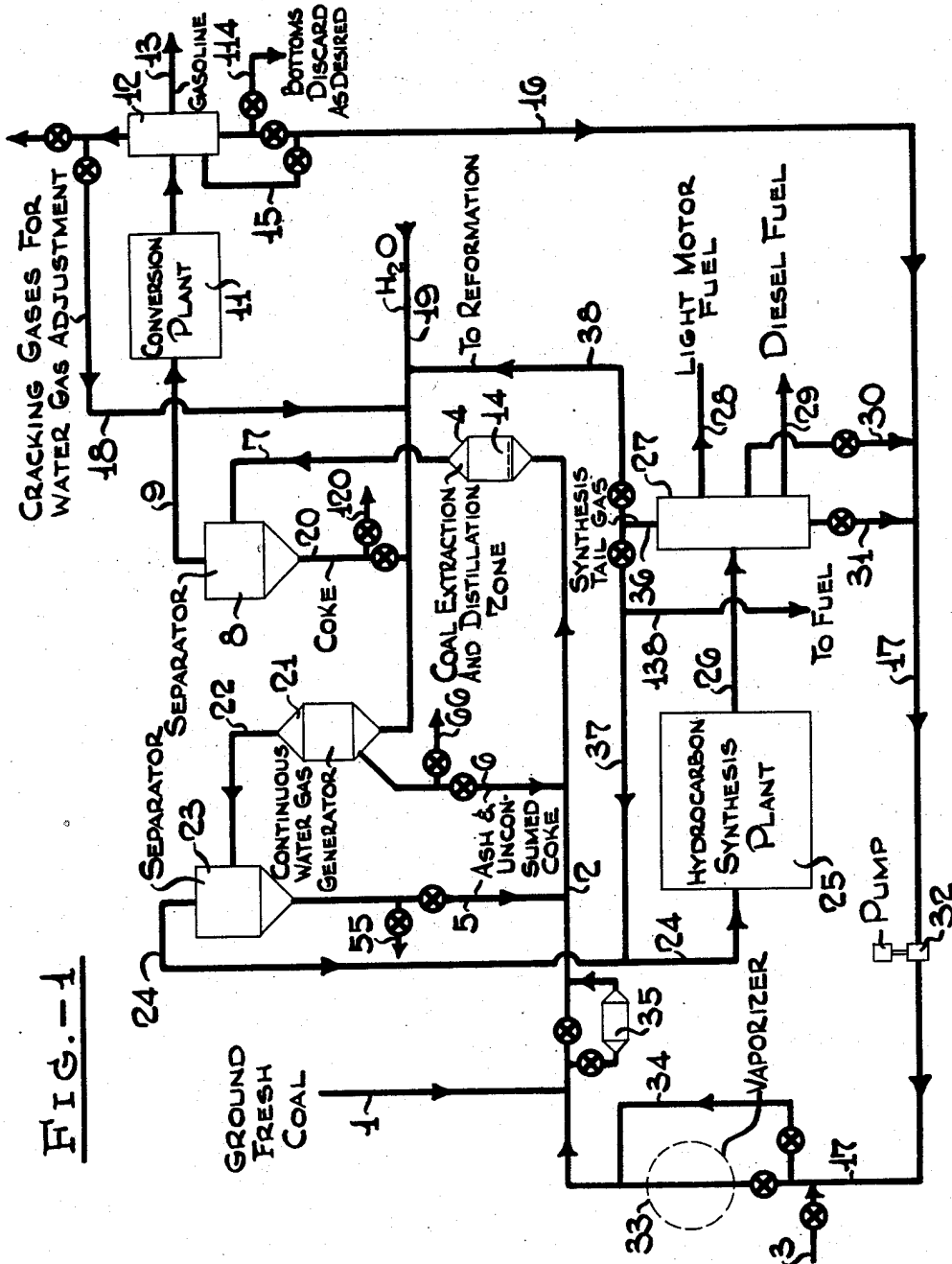


FIG. - 1

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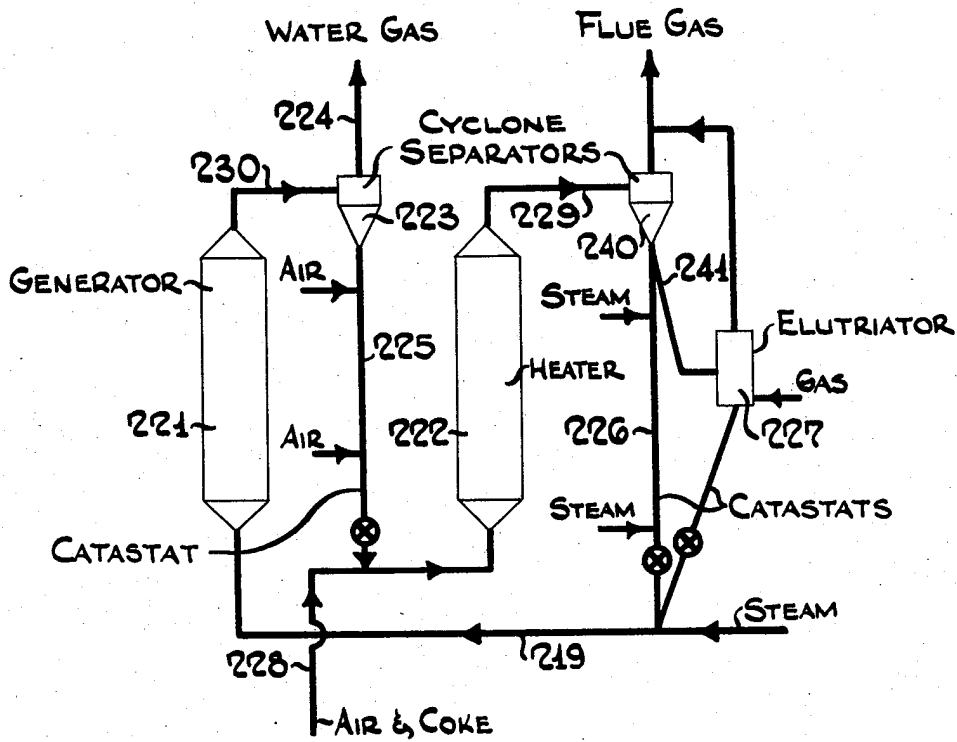


FIG.-2

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UNITED STATES PATENT OFFICE

2,436,938

METHOD OF PRODUCING MOTOR FUEL

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Application February 22, 1945, Serial No. 579,300

13 Claims. (Cl. 196—56)

1

The present invention relates to the production of liquid motor fuels from solid carbonaceous materials. More particularly, the present invention relates to improvements in the production of liquid motor fuels, such as gasoline, from solid carbonaceous materials containing volatile hydrocarbon constituents, such as coal, lignite, oil shale, and certain cellulosic materials, by subjecting the starting material to a distillation-extraction treatment in the presence of a hydrocarbon oil of suitable boiling characteristics and recovering liquid motor fuels from the distillate obtained.

Heretofore, solid carbonaceous materials have been distilled in the presence of hydrocarbon oils of natural petroleum origin. When such a petroleum oil having boiling characteristics approximating those of the volatile constituents of the solid material is used, a better conduction of heat and an increased yield of light hydrocarbon products are secured as compared with dry distillation processes or operations involving the use of higher boiling mineral oils. At the same time the mineral oil is partially converted into lower boiling products with further increased yields of valuable low boiling hydrocarbon oils. The use of such mineral oils also reduces to some extent the amount of pitch and tar in the distillates obtained which for this reason represent an improved charging stock for subsequent cracking and reforming operations.

However, the use of hydrocarbon oils of natural petroleum origin in the distillation of solid carbonaceous materials involves serious difficulties. The distillates still contain substantial amounts of pitch and tar unless the distillation is limited to the recovery of light to medium boiling oils leaving valuable heavier constituents in the residue and thus unavoidable for the production of motor fuels. Pitch and tar are materials of relatively low hydrogen content; they are formed from the solid carbonaceous materials when subjected to distillation. Hydrocarbon oils of natural petroleum origin, due to their normally naphthenic character, have a strong solvent power for pitches and tars. When the carbonaceous materials mixed with such natural petroleum oils are distilled close to dryness, substantial amounts of pitches and tars are carried into the distillate. This results in increased coke formation and premature catalyst deactivation in case the distillates are subjected to modern cracking and reforming processes for the production of high octane motor fuels.

Furthermore, the use of a hydrocarbon oil of

2

natural petroleum origin involves the charging of from 5 to 10 times as much oil as is recovered from the coal or other carbonaceous material. As a result, the operation normally has to be carried out in conjunction with petroleum refining operations of 5 to 10 times the magnitude of the distillation-extraction operation and obviously does not constitute a method of obtaining liquid fuels from coal or other solid carbonaceous materials when and where supplies of natural petroleum oils are not available.

Our invention provides an improved method whereby these difficulties may be overcome.

The main object of our invention, therefore, relates to improvements in the utilization of solid carbonaceous materials, such as coal, lignite, oil shale, and the like, for the economic production of maximum quantities of high octane motor fuels by distillation-extraction of the solid materials.

Another object of our invention is the production of a maximum amount of liquid distillate substantially free of coke-forming pitches and tars by distillation-extraction of solid carbonaceous materials of the type specified in the presence of a minimum amount of suitable hydrocarbon oils.

A more specific object of our invention is to provide a continuous process of converting solid carbonaceous materials of the type specified into maximum quantities of liquid hydrocarbon oils of the motor fuel boiling range by a distillation-extraction method which is independent of extraneous sources of liquid hydrocarbon oils.

These and other objects of our invention are accomplished in general by using in the distillation-extraction of solid carbonaceous materials containing volatile hydrocarbon constituents an acyclic type hydrocarbon oil, preferably a predominantly paraffinic oil, having an end boiling point similar to that of said volatile constituents, and preferably a synthetic hydrocarbon oil of that character which may be obtained by subjecting the distillation residue to a water gas reaction with steam, obtaining a carbon monoxide-hydrogen synthesis gas mixture from the water gas and synthesizing liquid hydrocarbons from this gas according to well-known catalytic methods. Because of the absence of aromatics and naphthenes in the synthetic oil used in the distillation-extraction, a smaller amount of oil than heretofore used, for instance, a quantity not substantially greater than the quantity of volatile oils contained in the solid material, may be employed; the total oil may also be made up in part of oil obtained in the extraction process or from any

conversion thereof. The synthetic oils are free of pitches and tars and we have found that when using these oils the pitch and tar of the solid material are either retained by the distillation residue or converted into lower boiling, non-coking oils so that the process yields a substantially pitch- and tar-free distillate of considerably reduced coking tendency.

Other objects and advantages of our invention will appear from the following more detailed description and claims.

In the accompanying drawing, Fig. 1 illustrates diagrammatically by means of a flowplan a preferred embodiment of our invention, and Fig. 2 similarly illustrates a preferred modification of our water gas generation step.

Referring now in detail to Fig. 1, fresh ground coal, of which any type but anthracite may be used, including peat, lignite brown coal, bituminous coal, etc., enters the present system through line 1 by any suitable means (not shown), for instance, by means of a screw feeder in communication with a suitable supply hopper. The coal is discharged into line 2 and mixed therein with a hydrocarbon oil predominantly paraffinic, with an initial boiling point of about 300° to 400° F., and having an end boiling point of not higher than 700° to 800° F. Where other solid carbonaceous materials are charged, this end boiling point may be somewhat higher or lower, best operation being obtained when it is about the same as the end point of the volatile constituents to be extracted from the carbonaceous material. This oil is normally produced in a later stage of the process and supplied through recycle line 17 to the mixing zone of line 2, as will appear hereafter in more detail. During the starting period of the process, any extraneous hydrocarbon oil having the specified boiling characteristics may be introduced into the mixing zone of line 2 through supply line 3. The coal and/or oil supplied to line 2 may be preheated, if desired, sufficiently beyond the initial boiling point of the oil so that the mixture of coal and oil consists at least to a substantial part of a suspension of powdered coal in oil vapor. The relative proportions of coal and oil in this mixture are maintained at about 1 lb. of coal per 0.2 to 1 lb. of oil. If sufficient oil is vaporized at this point to suspend the solid material, operation may be in the lower range of the proportions given, e. g., 0.3 to 0.5 lb. of oil per 1 lb. of coal; if nearly all the oil remains liquid at this point, the greater amount of oil is required, e. g., 0.6 to 0.8 lb. of oil per 1 lb. of coal, but the treating time may be reduced in the latter case. The mixture of coal and oil is passed from line 2 into the distillation-extraction zone 4, where it is maintained at a temperature of the order of 700° to 800° F. for a sufficient length of time to secure substantially complete vaporization of the oil and the volatile constituents of the coal. Heat for this reaction may be supplied by charging recycled coke and/or ash obtained at a high temperature of, for instance, 1600° to 1800° F. in a later stage of the process through either or both of lines 5 and 6 into line 2. If desired, the reaction may be carried out in a vessel designed to transmit heat through the retaining walls to the reaction zone. Such equipment may consist of a tube-like furnace if continuous operation is required or it may involve the use of a drum-type retort. If heat supply through the walls of the distillation-extraction chamber is contemplated, the heat required may be supplied by direct firing or may be obtained by indirect heat transfer with

the gas generated at temperatures as high as 1600° to 1800° F. in the water gas reactor to be described hereafter in more detail. One or more of the above methods of retorting may be used in the same system.

As indicated before, the oil may be present in line 2 either in the liquid or in the vapor phase. However this may be, the oil is completely vaporized in zone 4 to form therein a suspension of powdered coal in oil vapors. In order to secure optimum heat conduction and a proper time of residence of the powdered coal in zone 4, the vapor velocity and the particle size of the coal in zone 4 may be so controlled as to cause the phenomenon of "hindered settling" and the formation of a dense suspension of powdered coal in the oil vapor. This is accomplished in known manner by maintaining vapor velocities in zone 4 of ½ to 10 ft. per second, preferably ¾ to 3 ft. per second, and coal particle sizes of from 50 to 400 mesh. To aid in the distribution of the entering gas suspension, a perforated member 14 may be disposed near the bottom of distillation-extraction zone 4. The average residence time of the powdered coal in zone 4 may range from 3 to 30 minutes, a longer treating period giving somewhat greater per cent extraction.

A suspension of coked distillation residue in a mixture of oil vapors and vaporous volatile constituents from the coal is continuously withdrawn overhead from zone 4 and passed through line 7 into a vapor solid separator 8, which may be of any suitable known design, such as a cyclone separator, a Cottrell precipitator, or the like. Alternatively, the functions of vessels 4 and 8 may be carried out in a single vessel, in accordance with improvements in the fluid solids technique known to the art.

From separator 8 hydrocarbon vapors are taken overhead and passed through line 9 to a gasoline recovering plant which may comprise a conversion plant 11 and a fractionating column 12. In conversion plant 11 the distillate vapors may be subjected to thermal or catalytic cracking to increase the yield of high octane motor fuels. It should be understood, however, that any other desired refining treatment, such as thermal or catalytic reforming, may follow or take the place of the cracking treatment in plant 11. The cracked and/or reformed distillate is fractionated in column 12 into a gasoline fraction withdrawn and passed to storage through line 13 and a bottom fraction which may be either withdrawn for further treatment or otherwise disposed of through line 14, recycled to column 12 through line 15, or recycled through lines 16 and 17 to the mixing zone of line 2 to furnish at least a portion of the hydrocarbon oil used in the distillation-extraction zone. Normally gaseous products are withdrawn overhead from column 12 and may be either discarded or passed through line 18 into line 19 which carries steam and oxygen for purposes described below.

Returning now to separator 8, coked distillation residue is withdrawn downwardly through line 20 and introduced into line 19 carrying steam and oxygen and, if desired, gaseous products from the conversion plant to form a coke-in-gas suspension which is conveyed into water gas generating plant 21 where the coke and any hydrocarbon gases present are converted into water gas consisting of carbon monoxide and hydrogen. The production of water gas in plant 21 may be carried out in cyclic fashion with intermediate reheating of the coke in which case the addition

5

of oxygen or oxygen-bearing gases is not required. It is ordinarily more desirable, however, to maintain continuous operation, in which case a water gas generator of the well-known Winkler type requiring addition of oxygen may be used. The coke may be charged to the steam-oxygen mixture by any known means but direct charging from separator 8 makes use of the excess heat from the distillation-extraction step.

The production of water gas in generator 21 takes place at temperatures of the order of 1600° to 2500° F. Steady operation of a Winkler type generator does not involve carry-over of a large proportion of solid material in the gases manufactured. It is ordinarily necessary, however, to provide some means of separating fly ash or the like from the water gas. The generator may therefore consist of a reaction and a separation zone, the first of which may partially carry out the functions of the latter to varying degrees. Thus, incomplete conversion of the coke will allow the withdrawal of unconverted coke directly from the reactor body at a high temperature and its use as a heating medium in the distillation-extraction step. This material will ordinarily be at a temperature of the order of 1600° to 2500° F. and will therefore provide relatively large amounts of sensible heat in being cooled to the outlet temperature of about 800° F. of the distillation-extraction zone. Such hot unconverted coke may therefore be withdrawn from plant 21 downwardly through line 6 and passed into line 2 carrying the suspension of coal in hydrocarbon oil described before. Alternatively, if plant 21 is operated under such conditions as to bring all unconverted solids overhead from the gas generator, the unconverted solids to be used as a heating material of the coal-in-oil suspension may be withdrawn, while suspended in the water gas formed, through line 22, passed into separator 23 which may be of similar design as separator 8, separated therein from the water gas and passed from the bottom of separator 23 through line 5 to the coal-in-oil suspension in line 2. In either case, provision should be made for the purging of some of the solid material in order to prevent ash from building up in the system. For this purpose lines 5 and 6 are provided with purging outlets 55 and 66. Preferably, the water gas generation is carried out under such conditions that sufficient unconverted solids may be withdrawn through line 6 to supply heat for the distillation-extraction step, while the water gas generated is taken overhead through line 22 in which, if desired, waste heat equipment, such as waste heat boilers, economizers, etc., may be inserted. This arrangement has the advantage that separator 23 may be designed for considerably lower temperatures than exist in the generator. The conditions may be so controlled that the solid material separated in separator 23 consists exclusively of ash which may then be removed as a whole from the system.

It may not be desirable to subject all of the coke produced in the distillation-extraction step to a conversion into water gas. In this case part of the coke removed from separator 8 through line 20 may be taken out through line 120 to be fired in a boiler furnace or other furnace equipped for using powdered solid fuel. If this material is used directly, substantial preheat is available. Other uses of the coke not subjected to the water gas reaction are possible, especially if a drum-type retort is used in the distillation-extraction step in which case the coke may be obtained in

6

lump form. An alternative method of converting the coke distillation residue into water gas will be described below in connection with Fig. 2 of the drawing.

Returning now to separator 23, the carbon monoxide mixture is withdrawn through line 24 and passed to the hydrocarbon synthesis plant 25 which is operated to produce maximum yields of normally liquid hydrocarbons by any of various known methods. For example, the reaction may be conducted at substantially atmospheric or moderately elevated pressures up to 150 lbs. per sq. in. gauge with catalyst containing metallic cobalt, iron, nickel or copper, which may be in admixture with promoters such as oxides of chromium, zinc, aluminum, magnesium and the rare earth metals and which may be deposited on carriers, such as kieselguhr and pumice, and synthetic gels, such as hydrated silica and/or alumina. Optimum synthesis gas composition will range from 0.5 to 2.5 volumes of hydrogen per volume of carbon monoxide, depending on synthesis catalyst and conditions. For instance, with cobalt catalyst, synthesis gas is supplied preferably in a ratio of about 1 mol of carbon monoxide to 2 moles of hydrogen, the proper carbon monoxide-hydrogen ratio being obtained by a proper adjustment of the amount of normally gaseous reaction products supplied together with the steam through line 19 to the water gas generator 21. The carbon monoxide-hydrogen ratio realizable from steam reformation of these gases differs from that obtained from the steam-coke reaction alone and depends on their content of lower hydrocarbon gases, hydrogen, carbon monoxide, carbon dioxide, etc., and the amount available, thus providing a convenient means of adjusting the carbon monoxide-hydrogen ratio by controlling the supply of gaseous products to the water gas generator. The synthesis gas of proper composition is reacted in synthesis plant 25 at temperatures maintained between 350° and 430° F. with catalysts containing compounds of cobalt and magnesia and between 550° and 650° F. with catalysts containing iron. Synthesis plant 25 may be operated with good results using the fluid catalyst technique.

The synthetic hydrocarbon products leave synthesis plant 25 through line 26 to enter fractionating column 27 where they are fractionated into light motor fuel withdrawn through line 28, Diesel fuel withdrawn through line 29, and a heavier fraction having an end boiling point of about 700° to 800° F. and the paraffinicity characteristics required for the oil used to suspend the fresh coal charged to line 2; this latter fraction is withdrawn from column 27 through line 30 and/or 31 and recycled through line 17 carrying pump 32 to mixing line 2. Synthesis tail gas is taken overhead from column 27 through line 36 and either recycled through lines 37 and 24 to hydrocarbon synthesis plant 25 or passed through line 38 into the steam feed line 19 for the water gas generator 21 to assist in the adjustment of the proper ratio of carbon monoxide and hydrogen in the water gas used for the hydrocarbon synthesis. It will be understood that an amount of gas must be purged from the hydrocarbon synthesis plant circulating system to avoid build-up of inerts therein. This may be done conveniently by withdrawing tail gas through line 138 for use as fuel, as indicated on the drawing.

If desired, a vaporizer 33 may be provided in line 17 to vaporize oil charged to mixing line 2 when it is desired to suspend the fresh coal in

7

vaporized oil. As indicated above, however, it is not necessary to provide a vaporizer in line 17 inasmuch as the highly heated solid material from the water gas generator may be added through lines 5 and 6 to the suspension of coal in the liquid oil in a manner similar to that disclosed in the United States Patent No. 2,309,034, issued January 19, 1943, to Frank T. Barr, where the introduction of hot solid materials into water for the vaporization thereof is described. In this case it may be advisable to feed the fresh coal into line 2 at a point subsequent to the confluence of either line 5 or line 6 with line 2, depending on which of these lines is used for the supply of hot solids from the water gas generator 21.

Depending on the type of coal charged, the exact characteristics of the oil recycled, etc., for instance, where coal of low volatile but high bitumen content is used and the oil employed is in some degree aromatic as, for instance, when a large portion of the recycle oil is supplied from the conversion plant through line 16, improved results may be obtained by charging the fresh coal to oil in the liquid state without preliminary vaporization. This may be accomplished by carrying out the process as shown on the flow-plan, using bypass line 34 and feeding fresh coal ahead of the point of entrance of lines 5 and/or 6 into line 2. It may also be desirable to provide time for soaking the coal in the oil at temperatures at which at least a portion of the oil will remain in the liquid state. This may be accomplished by providing soaking space between charging conduits 1 and 5 (or 6, depending on which is used), as indicated at 35. Close and effective control of the soaking time-temperature-fractional vaporization relation may be obtained by introducing the recycled temperature-control material from water gas generator 21 in a controlled fashion through a multiplicity of charging conduits similar to 5 (or 6), with soaking zones similar to that indicated at 35, following each charging point.

Solids supply lines 1, 5 and 6 may be aerated standpipes as they are commonly used for the supply of solids in the fluid solids technique. As aeration gases, flue gas may be used for line 1, water gas for lines 5 and 6, or steam for any or all of lines 1, 5 and 6. However, some adaptation of the process may make other means of solids introduction more desirable. For instance, with limited vaporization at the confluence of lines 1 and 2, a screw conveyor, lock hopper or other means of positive pressure introduction may be of greater advantage.

In case it is desired to supply the heat for the distillation-extraction step through the retaining walls of the distillation-extraction chamber 4, the supply of temperature-control material from water gas generator 21 through lines 5 (or 6) is dispensed with and the fresh coal suspended in the recycled oil is passed through a heating coil (not shown), fired in such a manner as will give the desired soaking time temperature-fractional vaporization relation. In any case, the final temperature is carried to approximately 800° F., which is the temperature at which the recycled oil and all volatile constituents to be extracted from the coal are completely distilled off. This temperature may be somewhat higher or lower, depending on the character of the solid carbonaceous material charged.

It is normally not desirable to carry the distillation-extraction of the coal to a temperature greatly exceeding about 800° F. in order to avoid the extraction and formation of undesirable

8

pitches, tars and other liquid, but viscous, strongly unsaturated materials which are refractory to cracking. However, it is one of the advantages of our invention that the distillation-extraction may be carried out at considerably higher final distillation-extraction temperatures without producing an undesirably high proportion of tar, pitch, and the like. This favorable effect is due to the extreme paraffinicity characteristic of the synthetic hydrocarbon oils used as the extracting oil. As a result, considerably more cracking may be carried out in the distillation-extraction step and a lighter oil containing a larger proportion of motor or aviation fuel may be produced directly from the unit. The cracking step described in connection with conversion plant 11 may therefore be considerably reduced in magnitude or may, depending on the distribution of products desired, be dispensed with entirely.

If, however, it is desired to reduce the boiling range of the distillate from the distillation-extraction zone considerably, the distillate may be subjected to cracking in plant 11 to produce additional amounts of gasoline, as outlined before. It may be desirable to fractionate the distillate before cracking or the entire distillate stream may be cracked. In either case, considerable saving results when the distillate is charged from separator 8 at a temperature of approximately 800° F. directly to the conversion unit 11 without intervening cooling or condensation.

The synthesis and/or conversion steps in plants 25 and 11, respectively, may be operated under conditions approaching as nearly as possible those which will give an amount and composition of normally gaseous products which are required for an optimum modification of the composition of the water gas suitable for the hydrocarbon synthesis.

Fig. 2 of the drawing illustrates an alternative method of converting the powdered coked distillation residue into water gas by application of the fluid solids technique in plant 21 of Fig. 1. As indicated in Fig. 2, the water gas plant may comprise a water gas generator 221 and a coke-burning heater 222, as well as cyclone separators 223 and 240, standpipes 225 and 226 and elutriator 227. Powdered coke from separator 8 in Fig. 1 may be mixed with air to form a suspension which is passed through line 228 into heater 222, where the coke is heated by combustion to reaction temperatures of 1700° to 3000° F. The suspension of coke in combustion gases is withdrawn overhead from heater 222 and passed through line 229 into cyclone separator 240 where the flue gases are removed from the hot coke at about the outlet temperature of the regenerator. Flue gases are withdrawn overhead from separator 240 while powdered hot coke is passed downwardly through standpipe 226, fluidized with steam as indicated, and introduced into steam supply pipe 219, corresponding to line 19 in Fig. 1. The suspension of hot coke in steam is passed through line 219 into reactor 221 under the pressure of standpipe 226 to produce desired amounts of water gas at reaction temperatures of the order of 1500° to 2500° F. A suspension of unconverted coke in water gas is withdrawn overhead from reactor 221 and passed through line 230 into cyclone separator 223, which corresponds to cyclone separator 23 in Fig. 1, and from which water gas is withdrawn overhead through line 224, corresponding to line 24 of Fig. 1. Pow-

dered coke cooled by the water gas reaction is passed downwardly from separator 223 into standpipe 225, fluidized with air as indicated, and from there into coke and air feed line 228 to supply the hydrostatic pressure required for the upward flow in heater 222. Part of the hot coke from separator 240 may be bypassed through line 241 to elutriator 227 to remove the very fine powdered ash which is formed in the burning of the coke. Part of the hot solids from either separator 223 or 240 is withdrawn fluidized with steam and charged to the extraction step in accordance with the operation described in connection with Fig. 1, lines 5, 6 and 2, and its modifications.

The heating in the heater 222 may take place by means of burning of the carbon or by means of hot flue gases or the combustion of combustible gases in the heater in the presence of the coke. Normally gaseous products from the conversion and synthesis plants may be introduced through line 219, as outlined in connection with Fig. 1, to control the ratio of carbon monoxide and hydrogen in the water gas produced.

In a water gas plant operating on this principle, a desirable modification, known to the art, comprises combination of the functions of generator 221 and separator 223 in a single vessel, and similar combination of heater 222 and separator 240.

The process of our invention described above affords an efficient method of producing liquid motor fuels, such as gasoline, from solid carbonaceous materials, such as coal, by a distillation-extraction treatment without the use of extraneous sources for the extracting oil, wherein higher temperatures may be employed in the distillation-extraction step with resulting increased yields of motor fuel range distillation products and considerable reduction of the pitch and tar content in the distillate from the distillation-extraction step. For example, if a ton of powdered coal of high-volatile bituminous rank were used in our process, we may obtain a net yield of 0.4 barrel of gasoline per ton of coal by mere fractionation of the distillation-extraction distillate and 0.8 barrel of gasoline per ton of coal by further converting said distillate in conversion zone 11. The distillate from the distillation-extraction step would contain as little as 1% of heavy unsaturated constituents such as tar and pitch. If, on the other hand, a hydrocarbon oil of natural petroleum origin, such as a Coastal gas oil, were used in the distillation-extraction step, the gasoline content of the distillation-extraction step would amount to 0.4 barrel of gasoline per ton of coal, but would be increased by subsequent conversion of the distillate by only 0.5 barrel of gasoline per ton of coal. The quantity of tar and pitch in the distillate amounts in that case to approximately 5 to 10%, a proportion which seriously interferes with economic subsequent thermal or catalytic conversion of the distillate. It will be understood that these net yields cover products directly from coal only, and are over and above the yields which would be obtained by processing the extracting oil as described but without charging coal. A large quantity of oil is also available from the synthesis plant, so that the overall yield of synthetic oils is in the neighborhood of 3 barrels per ton of coal, no other raw material being required.

Depending on the coal used to charge the system, the temperatures and other conditions

employed for best results may vary to a certain extent but may easily be determined by preliminary tests. However, good results will be obtained when the directions given herein are closely followed by experienced operators.

Numerous modifications of our invention falling within the spirit thereof will occur to those skilled in the art.

We claim:

1. A continuous method of producing liquid motor fuels from coal which comprises continuously suspending powdered coal in a hydrocarbon oil being essentially free of cyclic hydrocarbons and having an end boiling point of between about 700° and 800° F. in a mixing zone to obtain a suspension containing substantially more than 50% by weight of coal, continuously conveying said suspension to a distillation-extraction zone, maintaining in said distillation-extraction zone conditions of residence time and temperatures not exceeding about 700° to 800° F. adapted to cause substantial removal of the volatile constituents from said coal, continuously separating distillate from coked residue, continuously withdrawing coked residue from said distillation-extraction zone, reacting at least a portion of said coked residue with steam to produce water gas, recovering from said water gas a mixture of carbon monoxide and hydrogen suitable for the catalytic synthesis of liquid hydrocarbons therefrom, reacting said mixture in contact with a synthesis catalyst to obtain a synthetic hydrocarbon oil, recovering from said synthetic hydrocarbon oil a fraction being essentially free of cyclic hydrocarbons and having an end boiling point similar to that of the first-mentioned hydrocarbon oil, continuously recycling said fraction to said mixing zone and recovering liquid motor fuels from said distillate.

2. The method of claim 1 in which a portion of the coked residue subjected to the action of steam is passed without intermediate cooling to said distillation extraction zone to supply at least a part of the heat required for said distillation-extraction.

3. The method of claim 1 in which said distillate is subjected to cracking to increase the amount of hydrocarbons boiling within the motor fuel range recoverable therefrom.

4. The method of claim 1 in which normally gaseous hydrocarbons formed in the process are at least in part passed to the water gas production step to be converted into carbon monoxide and hydrogen.

5. The method of claim 1 which is conducted in such a manner as will produce normally gaseous products adequate in amount and composition for controlling said water gas reaction so as to yield carbon monoxide and hydrogen in the approximate molar ratio of 1:2.

6. The method of claim 1 in which a dense fluidized suspension of solid carbonaceous material is maintained in said distillation-extraction zone.

7. The method of claim 1 in which said steam is reacted with said coked residue in the form of a dense fluidized suspension of coked residue in steam and gaseous reaction products.

8. The method of claim 1 in which the hydrocarbon oil in said mixing zone is present at least to a substantial part in the vapor phase.

9. The method of claim 1 in which the hydrocarbon oil in said mixing zone is present at least to a predominant part in the liquid phase.

10. The method of claim 1 in which said syn-

11

thetic hydrocarbon oil is fractionated into said fraction to be recycled and fractions boiling within the motor fuel range to recover additional amounts of liquid motor fuel.

11. The method of claim 1 in which said suspension is passed through a soaking zone prior to its entry into said distillation-extraction zone.

12. A continuous method of producing liquid motor fuels from solid carbonaceous materials which comprises mixing finely divided carbonaceous solids with a hydrocarbon oil essentially free of cyclic hydrocarbons, conducting the mixture continuously into a soaking zone, retaining the mixture in said soaking zone for a time sufficient to permit solution of at least a portion of the soluble constituents of said solids in said oil, adding to said mixture a controlled amount of hot finely divided solids to raise the temperature of said mixture to distillation temperature, conducting the resultant mixture to a distillation zone, distilling volatile constituents from said mixture in said distillation zone, removing a suspension of solids in product vapors from said distillation zone, separating said product vapors from said suspended solids prior to condensation of said product vapors, condensing product vapors and recovering condensed products.

13. The method of claim 12 in which the

12

amount and temperature of said added hot finely divided solids are sufficient to heat said mixture to a temperature not exceeding about 700° to 800° F.

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