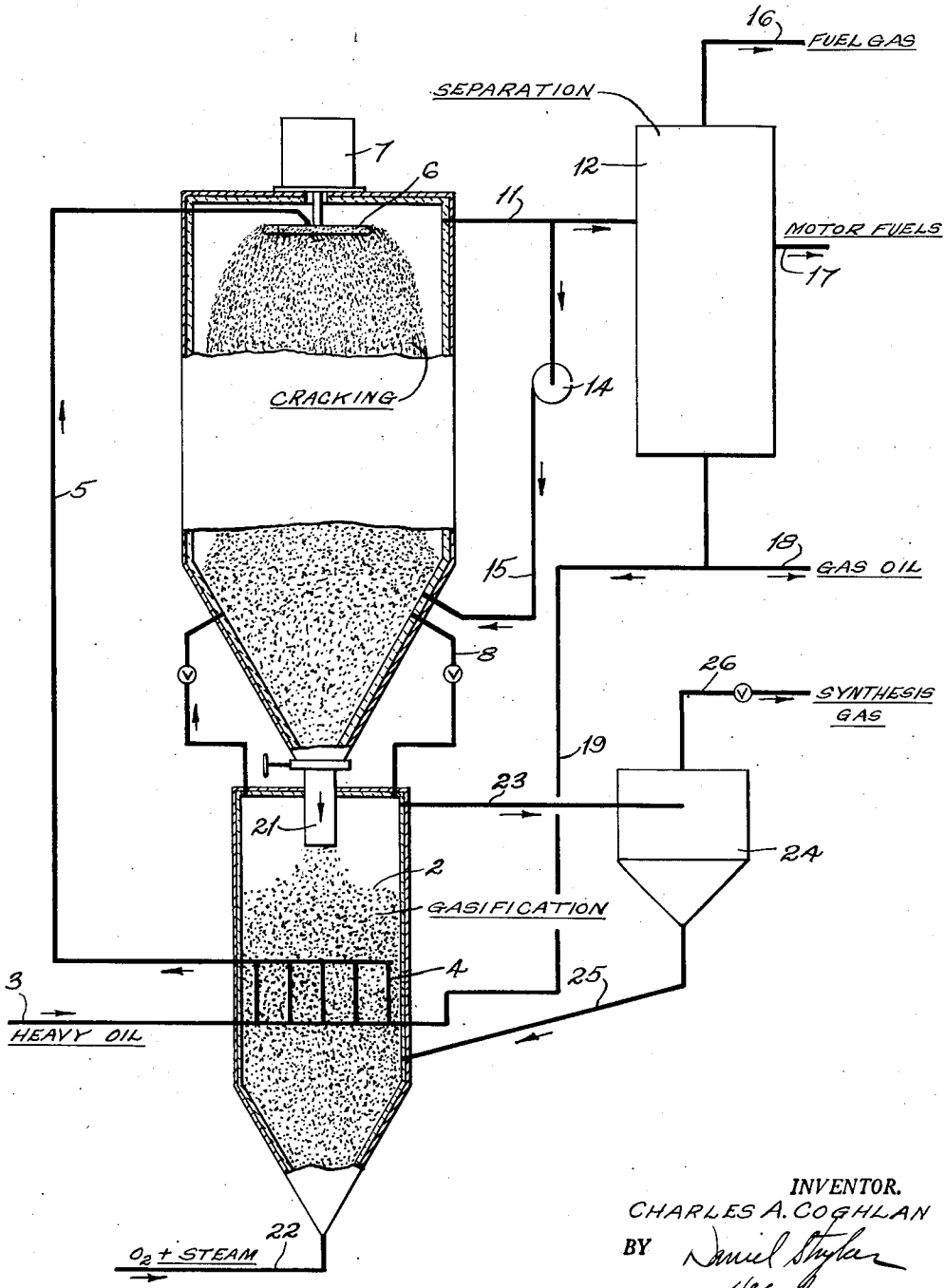
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CONVERSION OF HEAVY CARBONACEOUS OILS TO MOTOR FUELS, FUEL GAS, AND SYNTHESIS GAS

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CONVERSION OF HEAVY CARBONACEOUS OILS TO MOTOR FUELS, FUEL GAS, AND SYNTHESIS GAS

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This invention relates to a method of and apparatus for the conversion of hydrocarbon oils of low value to more valuable products. In one of its more specific aspects, this invention relates to a process for the conversion of hydrocarbon oil of relatively high molecular weight to motor fuels with the simultaneous production of granular particles of coke and the conversion of said coke to valuable gases.

The process of this invention is applicable to the treatment of hydrocarbon oils of various types and grades, such as, for example, crude residuum, gas oils and the like. The process is particularly applicable to the treatment of heavy carbonaceous oils, such as heavy reduced crude, obtained from petroleum refinery operations. The process may also be applied to the treatment of heavy oils and tars obtained from the distillation of coal. The process of the present invention provides not only valuable motor fuel hydrocarbons by thermal cracking but also fuel gas of high heating value, and a mixture of carbon monoxide and hydrogen suitable for the synthesis of hydrocarbons by the Fischer-Tropsch process. The process is particularly suitable for the production of fuel gases which may be utilized as a means of enriching manufactured fuel gases to increase the heating value of such gases. Both the method and apparatus of the invention are simple and relatively trouble-free in operation.

An important object of the present invention is to provide an improved method and apparatus for the production of motor fuels, fuel gases, and synthesis gas from heavy carbonaceous oils.

Another object is to provide an improved method for the cracking of hydrocarbon oils to produce valuable hydrocarbons and high heating value fuel gas.

Still another object of the invention is to provide such a process wherein heavy hydrocarbon oils may be utilized to advantage for production of gases of high heating value and the simultaneous production of a hydrogen-rich gas.

A further object is to provide an improved apparatus for the simultaneous production of fuel gas and synthesis gas from high molecular weight hydrocarbon feed stocks.

Other objects and advantages will be evident from the following detailed description and the accompanying drawing.

In accordance with the present invention, hydrocarbon oil is fed into a cracking zone as a spray in the form of droplets into direct contact with hot gases. The droplets of hydrocarbon oil

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are passed downwardly through the cracking zone dispersed in and countercurrent to an upwardly flowing stream of carbon oxides, hydrogen, and steam. The droplets settle slowly to the bottom of the cracking zone where the residual material is collected. In the cracking zone, the droplets of feed material are heated to a temperature sufficient to volatilize substantially all the volatilizable constituents, with accompanying cracking leaving a granular coke residue which is free flowing and highly reactive. A portion of the hydrogen and carbon monoxide is converted to methane in the cracking zone with a resulting increase in the heating value of the product gas. Some hydrogenation also takes place in the cracking zone.

The temperature within the cracking zone may range from about 800 to about 1500° F. depending upon the feed stock and desired products. Maximum yields of gasoline and gas oils are obtained at the lower temperatures within this range while the higher temperatures favor the production of low boiling olefins, such as ethylene and propylene, and aromatics. The products may include gasoline and light, medium, and heavy gas oils. Gas oil products may be used as feed stocks for catalytic cracking.

The particles of coke produced in the cracking zone are fed directly into a gasification zone, suitably of the fluid bed type, wherein the particles are reacted with steam and oxygen at relatively high temperature. The temperature within the gasification zone may range from about 1800 to about 3000° F. At least a portion of the hot gases generated in the gasification zone is passed into the cracking zone.

The cracking zone and gasification zone may be operated at any desired pressure ranging from substantially atmospheric pressure to 1000 pounds per square inch.

The hydrocarbon oil is preferably preheated prior to introduction into the cracking zone. The preheating may be carried out under the pressure at which the cracking zone is operated or at a considerably higher pressure with a pressure reduction at the point of introduction of the oil into the cracking zone. The cracking zone comprises an unobstructed reaction space wherein droplets of oil are brought into contact with the hot gases and vapors until distillation has proceeded to such an extent that the residue is substantailly non-caking. This residue is in the form of small beads or free flowing particles which may be fluidized with hot gases from the gasification zone to effect substantially complete

distillation of volatilizable constituents therefrom prior to their introduction to the gasification zone. At least a portion of the heat required for coking the hydrocarbon oil may be supplied by preheating the feed stream. The preheating may be carried out by passing the oil feed into indirect heat exchange with the products of gasification, for example, by disposing a heating coil within the gasification zone. Additional heat may be supplied to the cracking zone by the hot gases from the gasification zone.

The figure is a diagrammatic elevational view partly in cross section, illustrating the process of this invention and a preferred form of apparatus for carrying out the process.

With reference to the drawing, the apparatus comprises a cracking zone 1 and a gasification zone 2. These zones are suitably constructed with an outer cylindrical steel shell and a refractory lining as is customary for vessels of this type. A stream of oil is fed through line 3 into a heating coil 4 disposed in the gasification zone, and the preheated oil fed into the upper portion of the cracking zone through line 5. The oil feed is broken up into droplets by a rotating disk 6 driven by a motor 7. The hydrocarbon oil is fed on to the rotating disk at a point near the center and droplets of oil formed by the centrifugal force are thrown from the periphery of the disk into the cracking zone where they fall, due to the action of gravity, toward the bottom of the zone.

Hot gases from the gasification zone are introduced into the cracking zone to a point near its lower extremity through conduits 8. These gases pass upwardly through the cracking zone countercurrent to the falling droplets of oil from the spray device 6. The products of the cracking zone are hydrocarbon vapors and gases, and coke.

The hydrocarbon vapors and gases are discharged from the cracking zone through line 11 to separation apparatus 12. A portion of the vaporous effluent from the cracking zone may be recirculated by a pump 14 to the lower extremity of the cracking zone through line 15 for suspension of the droplets of liquid.

In the separation zone the desired products are recovered from the effluent of the cracking zone. As an example, the product may be separated into a fuel gas, which is withdrawn from the separation step through line 16; motor fuels, which are withdrawn through line 17, and gas oils which may be withdrawn through line 18 or recycled through line 19 for further cracking.

The residual carbon or coke from the cracking zone is discharged through conduit 21 into the gasification zone. In the gasification zone, the coke is reacted with an oxygen containing reactant gas, suitably a mixture of oxygen and steam. Commercial oxygen having a purity in excess of about 95 per cent by volume is most desirable as the source of oxygen. The reactant gas is introduced into the lower part of the gasification zone through line 22. The particles of coke may be subjected to reaction with the gas under conditions of fluidization.

The gases produced in the gasification zone in excess of the amount passed to the cracking zone through lines 8 may be discharged through line 23 to a separator 24 for removal of entrained solid particles. The separator 24 may suitably be of the cyclone type and may be incorporated within the gasification zone. In the separator 24, the solids are removed from the gas stream and returned to the gasification reactor through line 25. The resulting gases, which are suitable as feed for the synthesis of hydrocarbons or ammonia, or as a source of hydrogen or fuel gas, are discharged through line 26.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof and, therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A process for converting heavy hydrocarbon oil to hydrocarbons of lower molecular weight, fuel gas and hydrogen-containing gas, which comprises dispersing the oil in the form of droplets into the top of a reaction zone into contact with an upwardly flowing stream of hot gases comprising carbon monoxide and hydrogen under conditions of flow such that the droplets descend through said zone countercurrent to the stream of hot gases, maintaining a temperature within the range of from about 800° F. to about 1500° F. in said reaction zone to substantially completely volatilize volatilizable constituents therefrom during their downward movement whereby solid free flowing particles of coke are formed, discharging a vaporous effluent comprising hydrocarbon vapors and gases from the upper portion of said reaction zone, transferring said coke particles from the bottom of said zone into a separate gasification zone wherein they are reacted in a dense phase fluidized bed with steam and an oxygen-containing gas at a temperature within the range of from about 1800° F. to about 3000° F. under conditions such that the gas produced consists essentially of carbon monoxide and hydrogen, passing a portion of the hot gaseous product from the gasification zone into the lower portion of the reaction zone as a source of heat and reactants therefor, and discharging the remaining gaseous products of the gasification zone as a hydrogen-containing gas product.

2. A process for converting heavy hydrocarbon oil to hydrocarbons of lower molecular weight, fuel gas and hydrogen-containing gas, which comprises dispersing the oil in the form of droplets into the top of a reaction zone into contact with an upwardly flowing stream of hot gases comprising carbon monoxide and hydrogen whereby the droplets descend through said zone countercurrent to the stream of hot gases, maintaining a temperature within the range of from about 800° F. to about 1500° F. in said reaction zone, maintaining the flow of gases upwardly through said reaction zone at a rate sufficient to retard the descent of droplets therethrough to substantially completely volatilize the volatilizable constituents from said droplets during their downward movement whereby solid free-flowing particles of coke are formed, discharging a vaporous effluent comprising hydrocarbon vapors and gases from the upper portion of said reaction zone, transferring said coke particles from the bottom of said zone into a separate gasification zone wherein said coke particles are reacted in a dense phase fluidized bed at a temperature within the range of from about 1800° F. to about 3000° F. with steam and an oxygen-containing gas in proportions such that a gaseous product consisting essentially of carbon monoxide and hydrogen is produced, passing at least a portion of the hot gaseous product from the gasification zone into the lower portion of the reaction zone as a source

of heat and reactants therefor, and passing said oil in indirect heat exchange with said coke particles undergoing gasification in said dense phase fluidized bed effecting preheating of said oil prior to its introduction to said reaction zone.

3. A process for converting heavy hydrocarbon oil to hydrocarbons of lower molecular weight, fuel gas and hydrogen-containing gas, which comprises preheating the oil, dispersing the preheated oil in the form of droplets into the top of a reaction zone into contact with an upwardly flowing stream of hot gases, maintaining a temperature within the range of from about 800° F. to about 1500° F. in said reaction zone, maintaining the flow of said gases at a rate such that the descent of the droplets through said zone countercurrent to the stream of hot gases is retarded and the volatilizable constituents substantially completely volatilized therefrom during their descent whereby solid free-flowing particles of coke are formed, discharging a vaporous effluent comprising hydrocarbon vapors and gases from the upper portion of said reaction zone, reintroducing a portion of the total vaporous effluent from the reaction zone into the lower portion of the reaction zone as a source of said upwardly flowing stream of hot gases, transferring said coke particles from the bottom of said reaction zone into a separate gasification zone

wherein said coke particles are reacted in a dense phase fluidized bed at a temperature within the range of from about 1800° F. to about 3000° F. with steam and an oxygen-containing gas in proportions such that a gaseous product consisting essentially of carbon monoxide and hydrogen is produced, discharging gaseous products of the gasification zone as a hydrogen-containing gas product, and passing said oil in indirect heat exchange with said coke particles undergoing gasification in said dense phase fluidized bed thereby effecting preheating of said oil prior to its introduction to said reaction zone.

CHARLES A. COGHLAN.

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