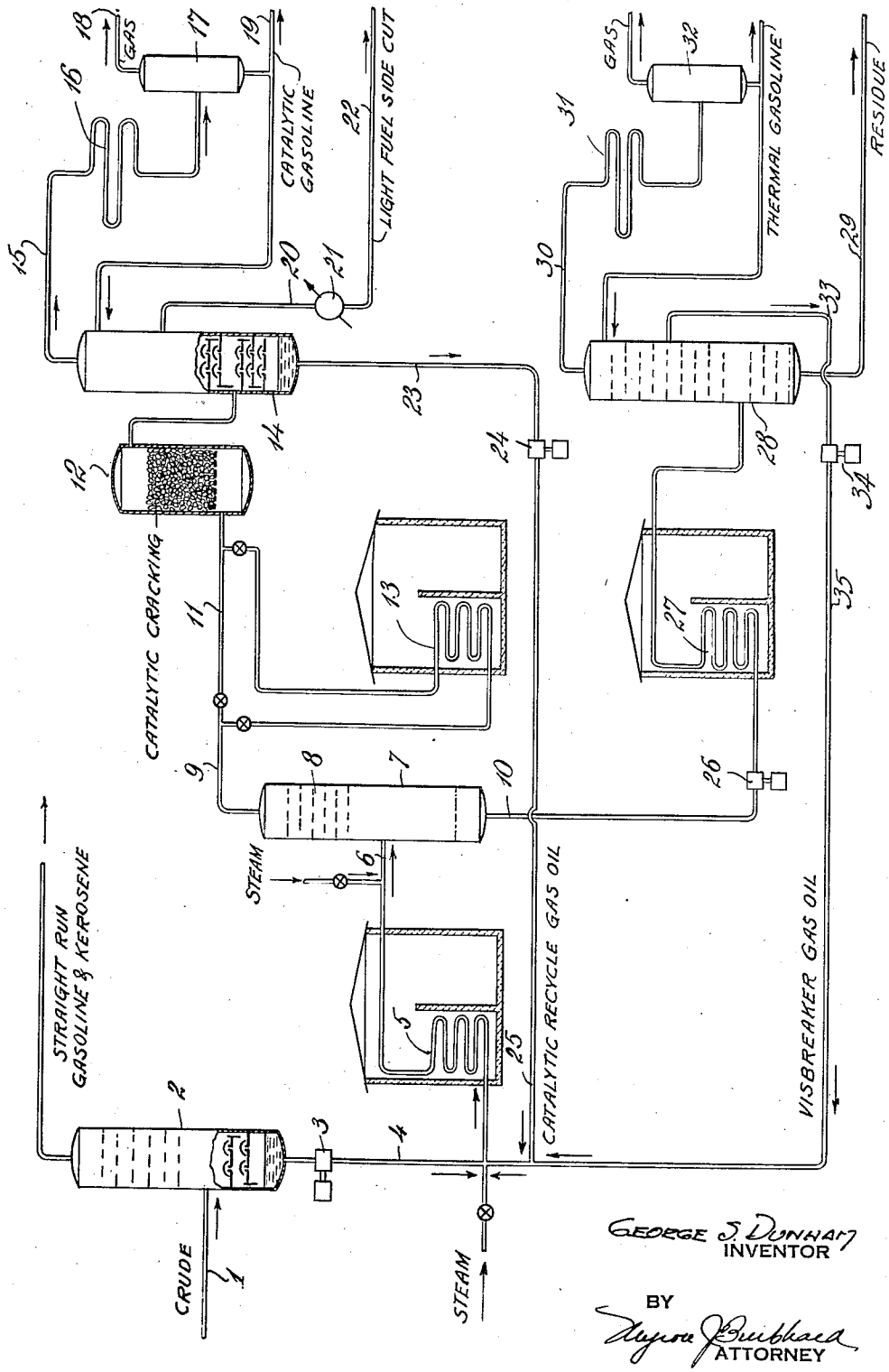
April 24, 1945. G. S. DUNHAM 2,374,338

CONVERSION OF HYDROCARBONS

Filed Aug. 9, 1941



GEORGE S. DUNHAM
INVENTOR

BY

ATTORNEY

Patented Apr. 24, 1945

2,374,338

UNITED STATES PATENT OFFICE

2,374,338

CONVERSION OF HYDROCARBONS

George S. Dunham, Merion, Pa., assignor to Socony-Vacuum Oil Company, Incorporated, New York, N. Y., a corporation of New York

Application August 9, 1941, Serial No. 406,102

6 Claims. (Cl. 196—52)

This invention has to do with the conversion of hydrocarbons by vapor phase cracking in the presence of a contact mass capable of catalyzing conversion of gas oil to gasoline. It is particularly concerned with the proper preparation of charging stocks for such processes.

Several important characteristics must be possessed by such charging stocks. The most important one, probably, is that they should contain no substantial amount of material boiling above about 700° F. since such material tends to lay down coke upon the cracking catalyst far in excess of that which is deposited by normal cracking of lower boiling charge constituents. A further quality requirement is that the charge be free, if possible, from materials already within the gasoline boiling range, since such materials, in this process, are merely so much inert gas, which blanket the effectiveness of a proportionate amount of the catalyst without usually giving rise to any offsetting benefits.

For maximum economy of operation it becomes necessary to prepare a maximum amount of charge from crude. This requirement runs contrary in many ways to the properties desired in the optimum charge stocks. The presently disclosed process is the result of extensive commercial study and experience with previously proposed processes, and is believed to be that one most desirable for the usual crudes of mixed base or similar types in that it most completely meets the requirements of high recovery of charge from crude while maintaining high quality of such charge.

In order to readily understand the process of this invention, reference is now made to the drawing attached hereto, the single figure of which shows the operation in diagram form.

In this drawing crude oil is seen entering at pipe 1 and the usual distillation operation for the removal of straight run gasoline and kerosene is indicated by columnar still 2. The reduced crude so produced, containing all of the gas oil, is forwarded by pump 3 and pipe 4 through heater coil 5 and discharged through pipe 6 into vaporizer 7. Vaporizer 7, which is preferably equipped with some form of entrainment separator as indicated at 8, and which may even take the form of a fairly competent vaporizer-fractionator, serves to deliver through pipe 9, as an overhead product, a vapor having no substantial portion boiling above about 700° F. and to separate therefrom all materials heavier than this desired charge, such heavier materials constituting a vaporizer tar to be withdrawn through pipe 10.

Overhead vapor from pipe 9 may be passed directly through pipe 11 to a catalytic cracking operation indicated by vessel 12, or these vapors may be superheated by passage through coil heater 13. The choice here depends somewhat upon the nature of the crude, some crudes requiring vaporizer operation at temperatures too low for proper catalytic cracking, but many permitting vaporizer operation at temperatures sufficiently high for direct passage to the catalytic cracking step.

The catalytic cracking step indicated at 12 may be the catalytic cracking process disclosed in the various patents of Eugene Houdry and associates or any similar one wherein gas oil is converted to gasoline in the presence of a contact mass of generally clay-like character. In case the process of Houdry is used, it is to be understood that the single catalyst case shown at 12 is merely indicative, since a commercial process of bed-in-place type must utilize several catalyst chambers to permit of cutting one from the system for regeneration at periodic intervals.

From the catalytic cracking operation the vapors pass to fractionator 14, therein to be separated into an overhead product delivered through pipe 15 and condenser 16 to receiver 17 from which gas is discharged at 18 and catalytically cracked gasoline at 19. At a point on the side of tower 14 it is usual to take a side cut of gas oil, commercially designated as light fuel oil, which is withdrawn by pipe 20, cooled in 21 and disposed of through 22. From the bottom of fractionator 14 there is withdrawn through pipe 23 a recycle stock, constituting all material emergent from catalytic cracking heavier than gasoline except that material removed as a side cut at 20. Even this removal is optional, subject to commercial demands, and the whole of the material heavier than gasoline may be withdrawn, if desired, through 23. The material withdrawn through 23 is forced by pump 24 through pipe 25 to join the reduced crude flowing through coil heater 5.

Referring now to vaporizer 7, the vaporizer tar collected therein and withdrawn through pipe 10 is forced by pump 26 through coil heater 27 and there subjected to viscosity breaking conditions suitably chosen for the conversion of a maximum of material into a boiling range suitable for the catalytic cracking charge with a minimum conversion to materials within the gasoline boiling range. The transfer line stream from the operation is delivered into vaporizer-fractionator 28 (two separate chambers may be used if desired), wherein all material of boiling point too high for

catalytic cracking charge is collected and removed from the system through pipe 29. From the top of 28, there is withdrawn, through pipe 30, as a vapor, the gasoline and lighter products of viscosity breaking to be condensed in 31 and passed to receiver 32. Condensates, constituting all viscosity breaking products heavier than gasoline and boiling sufficiently low to be suitable for catalytic cracking charge are withdrawn through pipe 33 and forced by pump 34 to pass through pipe 35 and join the reduced crude and recycle stock being passed through heater coil 5.

This invention has several novel features. One major feature is the use of catalytic cracking recycle stock in the vaporizing of charge from reduced crude. It has generally been the impression heretofore that catalytic "recycle" stocks were not amenable to retreatment in the operation from which they were derived. It has been found that not only may they be so used, but that when so used, if they are heated together with the reduced crude prior to its separation into charge stock and primary tar, that greatly enhanced ease and cleanliness of separation could be had. A second feature of importance is the separation and rejection from the system, without passage through the catalyst of thermal cracked gasoline originating from viscosity breaking. A third feature is that due to the carrying capability of the gas oil from recycle and the gas oil from viscosity breaking introduced into the reduced crude distillation step as well as the volume of such products, that distillation step can be conducted in a manner suitable for the production of desirable charging stock entirely without the formation of thermally cracked products. Further since those products are reintroduced at temperatures not greatly below their condensation temperature, the heat load for the distillation step is not unduly increased by their presence.

As an example of the operation of this system, the following results, as obtained upon a Mid-Continent crude of about 36–38° A. P. I. gravity are cited. Of one hundred barrels of crude originally charged to the crude stripping step, about 60 barrels of reduced crude were withdrawn and passed to the reduced crude distillation step. Passing therethrough in company with 40 barrels of catalytic recycle stock and 7 barrels of viscosity breaker gas oil to give a furnace charge of 107 barrels per hundred barrels of crude, and heated to a temperature of about 840° F. at 20 pounds gauge p. s. i. transfer line pressure, in the presence of steam to the amount of 10% by weight on charge to case, there were separated in the primary vaporizer 80 barrels of charge for catalytic cracking and 27 barrels of primary tar, each per hundred barrels of crude oil. The 80 barrels passed to catalytic cracking of the bed-in-place Houdry type at a temperature of about 825° F. gave rise to 20.0 barrels of catalytically cracked gasoline, 6½ barrels of gas, coke, and loss, 13½ barrels of light fuel oil side cut and 40 barrels of catalytic recycle stock, all per hundred barrels of crude. The 27 barrels passing to viscosity breaking at temperatures of 880–920° F. and transfer line pressures of around 250 pounds gauge p. s. i. gave 7 barrels of gasoline, gas, and loss, 7 barrels of viscosity breaker gas oil and 13 barrels of viscosity breaker tar, all per hundred barrels of crude.

From these figures it is quite evident that the process is not only highly able to produce increased amounts of more desirable charging stock from a given reduced crude, but is also capable of giving better than usual results in catalytic cracking.

I claim:

1. That method for the conversion of hydrocarbons comprising removing from a crude oil all materials lighter than gas oil, heating the reduced crude in the presence of a substantial proportion of added gas oil and vaporizing to separate gas oil vapors suitable for vapor phase catalytic cracking from heavier material, this distillation being practiced without conversion of charge material to thermally cracked gasoline, said added gas oil being present in an amount sufficient to substantially alter the distillation characteristics of the heater charge, withdrawing the heavier material as vaporizer tar, passing the vapors from the vaporizer to and through a catalytic vapor phase conversion in the presence of a contact mass capable of catalyzing the cracking of gas oil to gasoline, separating the effluent vapors from catalytic cracking into gasoline and materials heavier than gasoline, withdrawing catalytically cracked gasoline from the system, returning at least a portion of catalytic effluent material heavier than gasoline to the reduced crude distillation as a portion of the added gas oil present therein, passing the vaporizer tar from reduced crude distillation to and through a viscosity breaking operation operated to convert a maximum of tar to gas oil suitable as catalytic cracking stock while converting a minimum to thermally cracked gasoline, separating vis-breaker effluent into thermally cracked gasoline, gas oil and vis-breaker tar, withdrawing thermally cracked gasoline and vis-breaker tar from the system and adding the vis-breaker gas oil to the reduced crude prior to distillation thereof.

2. That method of preparing a charge stock in vapor form for conversion in the presence of a contact mass, which charge stock is substantially free from material boiling above about 700° F. and also from thermally cracked gasoline boiling range material and naturally occurring gasoline boiling range material which comprises subjecting a topped crude to heating without thermal cracking in the presence of substantial quantities of a recycle gas oil and a visbreaker gas oil, said added gas oil being present in an amount sufficient to substantially alter the distillation characteristics of the heater charge, to form a liquid residue and the desired vaporous charge stock, subjecting said charge stock while still in vapor form to conversion in the presence of a contact mass and separating unconverted material from the products of such conversion to form the said recycle gas oil, subjecting the liquid residue to thermal cracking under conditions adjusted to produce a maximum of cracking to gas oil and a minimum of cracking to gasoline, separating the visbreaker gas oil so produced from the products of this thermal cracking, and combining the recycle gas oil, the visbreaker gas oil, and the topped crude to form the charge for the first named distillation step.

3. A process for the conversion of hydrocarbons to gasoline by vapor phase catalytic cracking, comprising removing from a crude oil all materials lighter than gas oil, adding to said retained crude oil which includes the gas oil an amount of gas oil derived from a catalytic cracking process equal to at least 50% by volume of said crude gas oil, heating the mixture in the presence of steam, separating the mixture into gas oil vapor suitable for vapor phase catalytic cracking and heavier material, withdrawing the heavier mate-

rial as vaporizer tar, passing the gas oil vapors to and through a catalytic vapor phase conversion in the presence of a contact mass capable of catalyzing the cracking of the gas oil to gasoline, separating the vapors from said catalytic cracking into gasoline and materials heavier than gasoline, withdrawing catalytically cracked gasoline from the system, returning at least a portion of the material resulting from the catalytic cracking which is heavier than gasoline, to mix with incoming reduced crude oil, passing the vaporizer tar to and through a viscosity breaking operation operated to convert a maximum of tar to gas oil while converting a minimum to thermally cracked gasoline, separating the results of the viscosity breaker process into thermally cracked gasoline, viscosity breaker gas oil and viscosity breaker tar, withdrawing thermally cracked gasoline and viscosity breaker tar from the system and adding the viscosity breaker gas oil to mix with the reduced crude oil.

4. A process for the conversion of hydrocarbons to gasoline by vapor phase catalytic cracking, comprising removing from a crude oil all materials lighter than gas oil, adding to said retained crude oil which includes the gas oil, an amount of gas oil derived from a catalytic cracking process equal to at least 50% by volume of said crude gas oil, and an amount of gas oil derived from a viscosity breaking process equal to at least 5% by volume of said crude gas oil, heating the mixture in the presence of steam, separating the mixture into gas oil vapor suitable for vapor phase catalytic cracking and heavier material, withdrawing the heavier material as vaporizer tar, passing the gas oil vapors to and through a catalytic vapor phase conversion step in the presence of a contact mass capable of catalyzing the cracking of the gas oil to gasoline, separating the vapors from said catalytic cracking into gasoline and materials heavier than gasoline, withdrawing catalytically cracked gasoline from the system, returning at least a portion of the material resulting from the catalytic cracking which is heavier than gasoline, to mix with incoming reduced crude oil, passing the vaporizer tar to and through a viscosity breaking operation operated to convert a maximum of tar to gas oil while converting a minimum to thermally cracked gasoline, separating the results of the viscosity breaker process into thermally cracked gasoline, viscosity breaker gas oil and viscosity breaker tar, withdrawing thermally cracked gasoline and viscosity breaker tar from the system and adding the viscosity breaker gas oil to mix with the reduced crude oil.

5. A process for the conversion of hydrocarbons to gasoline by vapor phase catalytic cracking, comprising removing from a crude oil all materials lighter than gas oil, adding to said retained crude oil which includes the gas oil, an amount of gas oil derived from a catalytic cracking process, heating the mixture to a temperature in excess of 800° F. but less than 900° F. in the presence of steam, separating the mixture into gas oil vapor suitable for vapor phase catalytic cracking and heavier material, withdrawing the heavier material as vaporizer tar, passing the gas oil vapors to and through a catalytic vapor phase conversion step at a temperature of about 825° F. in the presence of a contact mass capable of catalyzing the cracking of the gas oil to gasoline, separating the vapors from said catalytic cracking into gasoline and materials heavier than gasoline, withdrawing catalytically cracked gasoline from the system, returning at least a portion of the material resulting from the catalytic cracking which is heavier than gasoline, to mix with incoming reduced crude oil, passing the vaporizer tar to and through a viscosity breaking operation at a temperature in the range from 880°–928° F. operated to convert a maximum of tar to gas oil while converting a minimum to thermally cracked gasoline, separating the results of the viscosity breaker process into thermally cracked gasoline, viscosity breaker gas oil and viscosity breaker tar, withdrawing thermally cracked gasoline and viscosity breaker tar from the system and adding the viscosity breaker gas oil to mix with the reduced crude oil.

6. A process for the conversion of hydrocarbons to gasoline by vapor phase catalytic cracking, comprising removing from a crude oil all materials lighter than gas oil, adding to said retained crude oil which includes the gas oil, an amount of gas oil derived from a catalytic cracking process equal to at least 50% by volume of said crude gas oil, and an amount of gas oil derived from a viscosity breaking process equal to at least 5% by volume of said crude gas oil, heating the mixture to a temperature in excess of 800° F. but less than 900° F. in the presence of steam, separating the mixture into gas oil vapor suitable for vapor phase catalytic cracking and heavier material, withdrawing the heavier material as vaporizer tar, passing the gas oil vapors to and through a catalytic vapor phase conversion step in the presence of a contact mass capable of catalyzing the cracking of the gas oil to gasoline, separating the vapors from said catalytic cracking into gasoline and materials heavier than gasoline, withdrawing catalytically cracked gasoline from the system, returning at least a portion of the material resulting from the catalytic cracking which is heavier than gasoline, to mix with incoming reduced crude oil, passing the vaporizer tar to and through a viscosity breaking operation operated to convert a maximum of tar to gas oil while converting a minimum to thermally cracked gasoline, separating the results of the viscosity breaker process into thermally cracked gasoline, viscosity breaker gas oil and viscosity breaker tar, withdrawing thermally cracked gasoline and viscosity breaker tar from the system and adding the viscosity breaker gas oil to mix with the reduced crude oil.

GEORGE S. DUNHAM.