Feb. 8, 1955 A. H. SCHUTTE 2,701,788

COKING OF HYDROCARBONS

Filed March 10, 1951

Fig. 1.

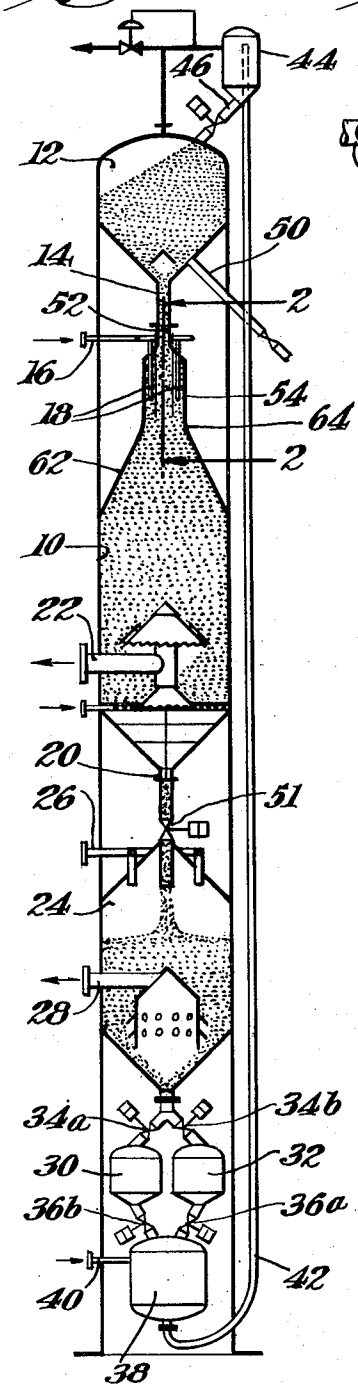


Fig. 2.

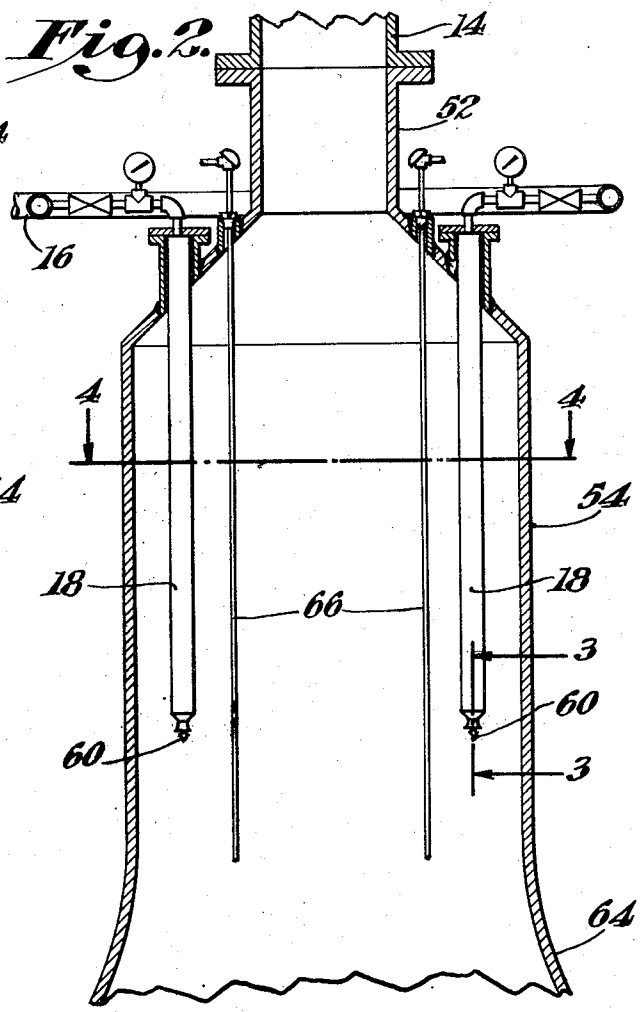


Fig. 3.

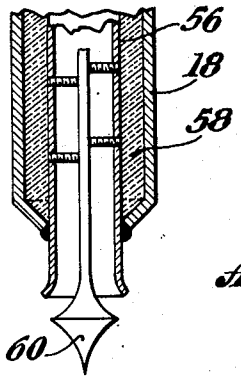
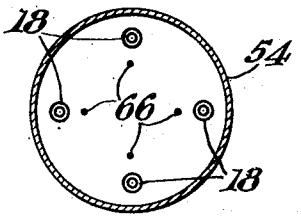


Fig. 4.



INVENTOR
August Henry Schutte
Nathaniel Ely
ATTORNEY

United States Patent Office 2,701,788 Patented Feb. 8, 1955

2,701,788

COKING OF HYDROCARBONS

August H. Schutte, Hastings on Hudson, N. Y., assignor to The Lummus Company, New York, N. Y., a corporation of Delaware

Application March 10, 1951, Serial No. 214,947

4 Claims. (Cl. 202—14)

This invention relates to improvements in the conversion of hydrocarbons and more particularly to an improved method and apparatus for applying heavy liquid hydrocarbons to a continuously moving gravity packed column of granular particles whereby uniform wetting is accomplished. It is an improvement on my prior Patent 2,482,140 and is a specific manner of applying the liquid charge in a process as disclosed in copending application Serial No. 3,747, filed January 22, 1948, now Patent No. 2,561,334, of which I am a co-inventor.

It has been pointed out that the use of moving columns of gravity packed granular material serve as an excellent heat transfer medium for carrying out various physical and chemical conversions. Such systems can be and are being used for catalytic reactions particularly in vapor phase operations. The liquid phase operation raises a further complication however, for it is indispensible to most reactions that a uniform charge be given a uniform heat treatment. It is important that deviations from the average temperature at any one region be avoided and every effort is made to have the contact material move through the reaction zone at a uniform rate. My present invention pertains to the uniform distribution of the liquid charge to the respective particles. In a companion application Serial No. 214,948, filed March 10, 1951, now Patent No. 2,658,031, I have provided method and means for the uniform flow of the particles which is of course vital to the reaction as well as the reheating of the particles.

The attached drawing is an illustrative embodiment of my invention and in such drawing:

Fig. 1 is a diagrammatic view of a complete reactor-regenerator-elevator unit.

Fig. 2 is a central vertical section through the upper part of a reaction chamber.

Fig. 3 is a vertical cross section on the line 3—3 of Fig. 2 showing the end of a feed conduit.

Fig. 4 is a central cross sectional view through the top section of the reaction chamber taken substantially on the line 4—4 of Fig. 2 to show the orientation of the nozzles.

The continuous coking cycle in accordance with the invention disclosed in the application Serial No. 3,747 above noted, includes a pre-heating of granular petroleum coke particles as ultimately made in the system, such particles being fed to a reactor **10** from hopper **12** by gravity through line **14**. The heavy hydrocarbon charge primarily in liquid phase is applied to this hot coke by feeding the liquid through conduit **16** to one or more feed nozzles **18** which distribute the oil on the coke before it reaches the main body of the reactor **10**. The reactor **10** is preferably of such depth and the particles contain sufficient heat so that the applied liquid will go to dryness before the particles are drawn off at **20**. At least five and as much as forty minutes coke travel time may be necessary between the feed injection and coke drawoff points based on several factors hereinafter described, in order that the coke may be removed in a dry unagglomerated condition. The hydrocarbon vapors are removed at **22**.

In order to supply the heat requirement in the reactor the coke particles are passed through a reheater **24** in which the particles may be suitably heated by fuel gas and air entering at **26** or by partial combustion. The coke is usually heated therein to about 1000° F. to 1050° F. The products of combustion are removed at **28**.

The reheated coke particles are next passed alternatively

through pressure drums **30** and **32** suitably controlled by inlet valves **34***a* and **34***b* and by outlet valves **36***a* and **36***b* and thence into the blow case **38**. By suitable controls not shown, a minimum particle level can be maintained in blow case **38** and with the application of a gas or steam lifting medium through line **40**, a constant flow of particles can be obtained through lift line **42**. Discharge is into vapor separator **44** from which the heated particles continuously flow by gravity into hopper **12** through line **46** to complete the cycle.

It will be understood that various flow control elements, valves and regulators will be used. In general, a circulation of one hundred tons per hour of granular coke of from 40 mesh to ½ inch average particle size will be sufficient to reduce about 1000 barrels per day of a 10° API reduced crude having a Conradson carbon content of 13%. The net make of coke will be drawn off at **50** or other suitable location. Flow control through the unit is preferably accomplished by a suitable valve **51** below the reactor **10**.

A particular feature of my present invention is the manner of applying the heavy liquid hydrocarbon to the coke particles. With particular reference to Fig. 2, the solids inlet nozzle **52** communicates with a reduced diameter mixing zone **54** of the reactor **10**. The liquid feed from distributor **16** is introduced into this section by one or more feed conduits or down pipes **18** which are retractable for any desired maintenance. Preferably they carry insulation as indicated by **58** for the internal conduit **56** as shown in Fig. 3.

As specifically shown in Fig. 2 and serving as a major feature of my invention, I extend the feed conduits **18** to a point above the lower end of the mixing zone **54** so that the mixture of liquid and vapors resulting from the initial contact of the oil and the coke must pass down through a certain depth of gravity packed small cross section bed before entering the relatively large cross section reactor **10**.

Since the oil is usually charged to the mixing zone at about 650 to 850° F. and the circulating coke may be at a temperature of 950 to 1100° F., upon initial contact, vaporization and rapid cracking occur. It has been found that if the resulting foam of unvaporized oil and vapors is forced to take a pressure drop of at least 20" of water in passing down through the restricted column of coke below the feed point, uniform contact and uniform wetting of the coke particles are assured since the vapor-liquid mixture is forced to travel through all the bed void passages in this lower section of the mixing zone. Passage of oil vapors upwards through coke feed line **14** must be prevented, of course, by so adjusting the differential pressure between the top hopper **12** and the mixing zone that a downward flow of inert gas or steam is obtained in the coke feed pipe **14**. Since the feed leg **14** and the mixing zone **54** are completely filled with coke no spaces are present, the walls of which are not scrubbed by flowing coke particles. This effectively eliminates coke formations on anything but the coke particles and this is an important feature of this invention and a departure from the prior art.

The feed pipe **56** is preferably fitted with a tip **60** that is suitably fitted with respect to the end of the pipe so that the liquid will flow downwardly and laterally into the coke column passing the feed point. The tip **60** is not designed to give appreciable pressure drop since it is only necessary to introduce the oil in a reasonably uniform fashion. The mixing is done by pressure drop through the mixing bed and not by atomization or dispersion of the oil feed at the point of entry.

Below the end of the reduced diameter portion **54**, I provide a transition cone **62** that extends to the wall of the reactor **10**. This should be at an angle of at least 45° or steeper than the normal flow angle of the particles and preferably, I make the angle of the cone with a vertical of about 30° to assure a continuous flow of particles and scrubbing action along the wall to prevent coke from forming in the wetted zone. At the junction of the cone **62** with the reduced diameter mixing chamber piece **54**, the wall is preferably gently curved, as at **64** to avoid sudden changes in flow direction.

I find it desirable in a commercial installation to pro-

vide for temperature readings at the individual liquid feed entries as a check on the uniformity of mixing in the various sections of the mixing zone. For this purpose I provide vertical thermowells 66 into which the customary thermo-couples may be inserted. These are conveniently placed adjacent to and below the discharge point of each liquid feed pipe.

It will thus appear that I obtain unusual success in uniformly wetting the coke particles with the liquid oil and vapors with a relatively rapid movement of the initially dry coke past the feed points. The reaction may then most effectively take place at a slower column movement as controlled by the valve 51 until dryness of coke is again achieved whereafter the dry coke is effectively moved at the higher velocities through the seal pipe connections, valves, and other restricted orifices. In the past, I have successfully operated with a bed velocity in the reactor section of about one foot per minute and a proportionately higher velocity in the restricted inlet conduit past the feed points.

While I have shown and described a preferred form of embodiment of my invention I am aware that modifications may be made thereto which are within the scope and spirit thereof and of the claims appended hereinafter.

I claim:

1. In a continuous process for converting heavy reduced crude to dry coke and hydrocarbon vapors by application in a reaction zone of the charge in liquid form to a continuously moving columnar mass of gravity packed granular particles of heat carrying material which contain all the necessary heat at a temperature above the desired reaction temperature to carry out the reaction, the improvement which comprises; passing the particles through an inlet conduit of less cross section than the reaction zone and through a confined transition zone into the upper part of the reaction zone; applying the liquid charge to the particles while they are passing through the conduit, such application being at such a point above the outlet of the conduit to the reaction zone that the gravity packed particles offer a substantial pressure drop on the resulting foam of unvaporized oil and vapors in the inlet conduit; passing the particles from the inlet conduit in a completely wetted condition into the reaction zone, and maintaining the rate of change of diameter less than the normal flow angle of the particles whereby no free vapor space exists above the point of liquid discharge.

2. A process as claimed in claim 1 in which the density of packing, the diameter and length of the inlet conduit and the positioning of the liquid discharge nozzle establishes a calculated pressure drop on the vapors equal to at least 20 inches of water.

3. A reactor for converting heavy liquid hydrocarbons into vaporous products and coke deposits on discrete particles of granular material forming a gravity packed, free flowing bed, said reactor having a reduced diameter mixing zone at the upper part thereof, said mixing zone having a particle inlet at the upper part, a liquid feed pipe extending into said mixing zone and having a liquid discharge tip completely surrounded by the particles whereby the particles are wetted as they pass the tip and the tip is scrubbed of coke formation by the moving particles, said mixing zone having a length such that a substantial pressure drop will be established by the vapors in passing out of the mixing zone, said reactor having a reaction zone of substantially greater horizontal cross section than said mixing conduit, and a transition cone between the mixing zone and the reaction zone, said cone having a side wall which is steeper than the normal flow angle of the particles and flow control means below the reaction zone whereby all parts thereof and of the transition zone are continuously scrubbed by the particles and there is no free surface for formation of coke.

4. A reactor for hydrocarbon oils wherein the oil in liquid form is applied directly to granular moving contact material at a temperature above the desired reaction temperature to vaporize the oil, and the vapors are further contacted at conversion temperatures with the continuously moving contact material, said reactor comprising a reduced diameter mixing zone at the upper part thereof, said mixing zone having a hot contact material receiving inlet, a liquid hydrocarbon inlet within the mixing zone, the contact material passing said liquid inlet as the contact material moves downwardly through the mixing zone, said mixing zone being effectively closed to upward flow of vapors, an enlarged reaction zone below said mixing zone, a transition member between the mixing zone and the reaction zone, said transition member and mixing zone and reaction zone having no space unscrubbed by contact with contact material in its flow downward into the reaction zone, and vapor removal channels near the bottom of the reaction zone whereby the flow of vapor is cocurrent with the contact material to the vapor removal channels, said liquid hydrocarbon inlet being disposed in the path of the contact material where the relative velocity of the contact particles are uniformly wetted prior to their lateral movement into the enlarged horizontal area of the reaction zone.

References Cited in the file of this patent

UNITED STATES PATENTS

1,920,840	Chouinard et al.	Aug. 1, 1933
2,008,834	Marchant	July 23, 1935
2,089,304	Stein	Aug. 10, 1937
2,432,344	Sinclair	Dec. 9, 1947
2,432,962	Bergstrom	Dec. 16, 1947
2,482,138	Schutte	Sept. 20, 1949
2,482,140	Schutte	Sept. 20, 1949
2,494,695	Fisher	Jan. 17, 1950
2,511,813	Lockwood	June 13, 1950
2,541,693	Frevel et al.	Feb. 13, 1951
2,543,070	Shabaker	Feb. 27, 1951
2,561,420	Schutte	July 24, 1951
2,568,239	Lonngren	Sept. 18, 1951
2,600,078	Schutte	June 10, 1952