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METHOD AND APPARATUS FOR HYDROCARBON CONVERSION

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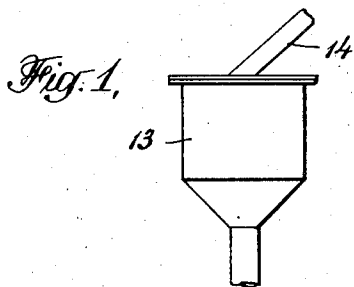
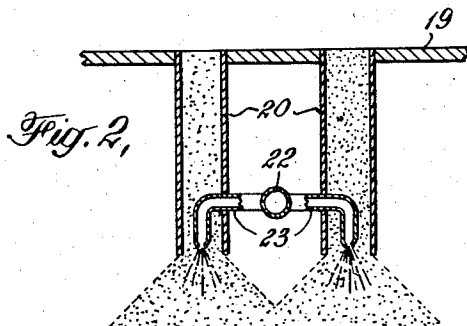
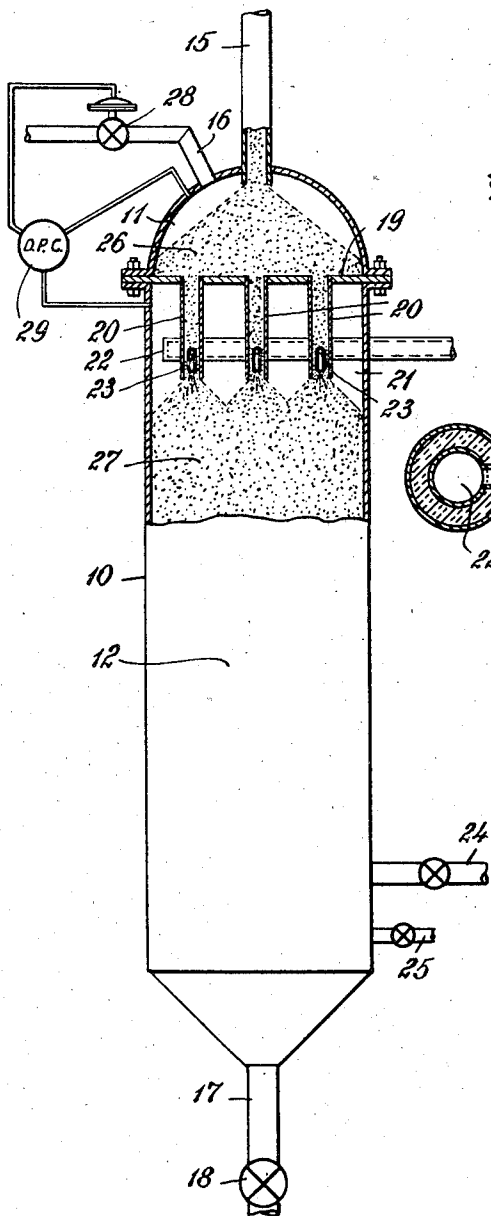


Fig. 3,

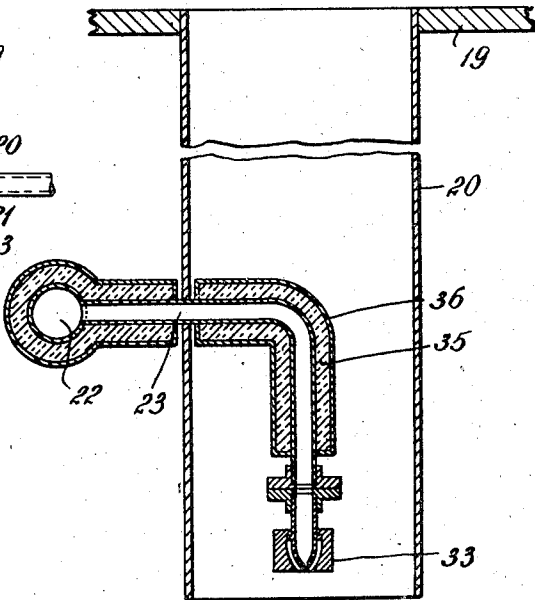
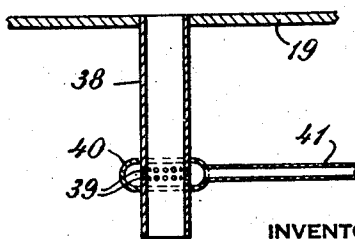


Fig. 4,



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METHOD AND APPARATUS FOR HYDRO-CARBON CONVERSION

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11 Claims. (Cl. 196—52)

1

This invention pertains to a method and apparatus for hydrocarbon conversion in the presence of a contact mass material. It is particularly concerned with a method and apparatus for conversion of a charge of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbons in the presence of a substantially compact mass of moving contact material particles. The contact material in such a process may take a number of forms such as natural clays, treated clays, bauxites, alumina or synthetic associations of silica, alumina, or silica and alumina to which small percentages of other materials such as certain metallic oxides may be added for special purposes. Such contact materials may range in particle size from about 4 to 100 mesh and may be preferably maintained for the most part between about 4 to 8 mesh.

In a recent development the conversion process has taken the form of one wherein particle form contact material is circulated at controlled elevated temperatures cyclically through a conversion zone through which it moves as a substantially compact column of downwardly moving particles and wherein it is contacted with a charge of high boiling liquid hydrocarbons to effect conversion thereof to lower boiling gaseous hydrocarbon products and through a regeneration zone wherein the contact material is subjected to a combustion supporting gas such as air acting to burn off the carbonaceous contaminant deposited upon the contact material during the hydrocarbon conversion. In such a process a major problem arises in the introduction of liquid hydrocarbon charge into the conversion zone in such a way as to permit uniform distribution of the liquid oil over the entire mass of contact material while avoiding serious coke formation on the apparatus in the vicinity of liquid introduction. For example, when a high boiling liquid petroleum fraction is introduced into the upper section of a conversion chamber onto the surface of a column of contact material particles, the liquid charge tends to channel through certain sections of the column cross-section while avoiding other sections to some extent so as to cause over-conversion of a portion of the liquid charge, under-conversion of the remaining portion and very uneven contaminant deposition on the contact mass material. Moreover, upon contacting the hot metal surfaces in the vicinity of introduction, the liquid petroleum charge tends to undergo a partial pyrolytic decomposition resulting in excessive non-condensable gas formation and excessive

2

coke deposits on the metal surfaces, which coke deposits gradually accumulate until that section of the conversion chamber becomes plugged with coke.

5 A major object of this invention is the provision of an improved method and apparatus for conversion of a charge of high boiling liquid hydrocarbons in the presence of a moving mass of contact material particles which method and apparatus avoids the above mentioned difficulties.

10 A specific object is the provision in a process for conversion of a high boiling liquid petroleum fraction to lower boiling, gasoline containing, gaseous hydrocarbons in the presence of a moving mass of contact material particles of a method and apparatus for introduction of contact material and liquid charge into the conversion zone in such a way as to insure uniform contacting of liquid and solid particles and so as to prevent serious coking of the apparatus.

15 These and other objects will become apparent from the following description of the invention. Before proceeding with said description certain terms used hereinbefore and hereinafter in describing this invention and in the claiming of this invention will be defined. The term "gaseous" as used herein is intended in a broad sense as meaning material in the gaseous phase under the particular operating conditions involved regardless of what may be the normal phase of such material at ordinary atmospheric conditions. The term "high boiling" as applied "a charge of liquid hydrocarbons" or "petroleum fractions" herein is intended as meaning that the charge of hydrocarbons or the petroleum fraction is comprised principally of material boiling above the desired average conversion temperature therefor.

20 The invention may be better understood by reference to the drawings attached hereto of which Figure 1 is an elevational view, partially in section of a conversion apparatus having incorporated therein the improvements of this invention, Figure 2 is an enlarged sectional view taken at a plane perpendicular to the plane of Figure 1 showing a section of the contact material and liquid feed means of Figure 1, and Figures 3 and 4 are sectional views showing modified forms of the invention.

25 Turning now to Figure 1, we find an elongated vessel 10 having a partition 19 across the upper section thereof dividing the vessel 10 into a seal chamber 11 within its upper section and an elongated conversion chamber 12 within the

3

lower section thereof. A supply hopper 13 having inlet chute 14 is positioned above the vessel 10 and an elongated gravity feed leg 15 extends between the supply hopper 13 and the top of seal chamber 11. An inlet pipe 16 for admission of seal gas is provided at the top of the conversion chamber. An outlet conduit 17, bearing flow control valve 18 is provided at the lower end of vessel 10 for contact material withdrawn therefrom. Depending from the partition 19 are a plurality of feed conduits 20 terminating within the upper section of chamber 12 and being uniformly distributed over the cross-sectional area thereof, a substantially solid free space 21 is provided between the lower ends of conduits 20 and the partition 19, and into the space 21 extends uniformly distributed headers of which only one member 22 is visible in Figure 1. A liquid inlet pipe 23 extends from said header to a location within the lower section of each feed conduit 20. The liquid inlet pipes are of substantially less cross-sectional area than the feed conduits and are centrally positioned within said conduits so as to direct liquid downwardly thereinto to uniformly contact the contact material flowing therethrough. The arrangement is shown in detail in Figure 2 wherein is shown a section of the partition 19, two solid feed conduits 20, liquid inlet header 22 and liquid inlet pipes 23 extending from the header 22 to a location within the lower section of each feed conduit 20. Turning again to Figure 1, an outlet 24 is provided for withdrawal of gaseous products from the lower section of the conversion chamber 12. Suitable gas-solid disengaging members (not shown) may be provided within the chamber 12 in association with the outlet 24. An inlet 25 for purge and seal gas introduction is provided in the vessel 10 below the level of outlet 24.

In operation, particle form solid contact material at a suitable conversion supporting temperature passes from supply hopper 13 through gravity feed leg 15 into the upper section of seal chamber 11 wherein is maintained a bed of contact material 26. If desired, suitable means other than that shown may be provided for introduction of contact material into seal chamber 11. The contact material then passes as a plurality of substantially compact streams through the conduits 20 onto the surface of a column of contact material 27 maintained therebelow within conversion chamber 12. Spent contact material bearing a carbonaceous contaminant is withdrawn through conduit 17 at the lower end of chamber 12 at a suitable rate controlled by valve 18 which is such as will insure maintenance of a substantially compact column of said contact material within the conversion chamber. A high boiling liquid petroleum fraction, for example, a crude residuum containing hydrocarbons boiling substantially all over about 950° F., is introduced in heated condition into manifold 22 from which it passes through inlet pipes 23 into the lower section of each of the contact material feed pipes 20. The liquid hydrocarbons uniformly contact the contact material passing through the feed conduits and the mixture is distributed uniformly over the entire cross-sectional area of the top of the column of contact material therebelow so as to insure uniform contacting of all of the liquid hydrocarbon charge and uniform contaminant deposition on all of the contact material. Any coke which may be formed in the vicinity of the liquid hydrocarbon introduction, namely, on the walls of the feed conduits 20, is

4

continuously removed by the scraping portion of the contact material particles passing through said conduits. Such coke is carried along with the contact material particles and removed in suitable regeneration vessel (not shown). Lower boiling gaseous hydrocarbon products are withdrawn from the lower section of conversion chamber 12 through outlet 24 and may be fractionated in suitable equipment of conventional type (not shown). An inert seal gas such as steam or flue gas is introduced into the seal chamber 11 through pipe 16 at a rate controlled to maintain a gaseous pressure in seal chamber 11 somewhat greater than that in conversion chamber 12. Diaphragm operated valve 28 and differential pressure controller 29 may be used to accomplish such operation. An inert purge and seal gas is also introduced into the lower section of conversion chamber 12 through inlet 25 to strip gaseous hydrocarbons from the outflowing contact material.

It is generally desirable that the liquid hydrocarbon inlet pipes be so constructed as to cause the liquid to be sprayed into each of the contact material feed conduits so as to provide the maximum uniformity of liquid contact with the contact material. Moreover, since the contact material inlet temperature is generally much higher than that of the liquid oil charge it is often desirable to insulate the liquid inlet headers and feed pipes so as to prevent overheating of the charge therein with resulting gradual coke build up along the walls of the feed pipes and nozzles. Such an improved arrangement is shown in Figure 3, wherein is shown a section of the partition or roof of the conversion chamber 19, a contact material feed conduit 20, an oil inlet header 22, a spray nozzle 33 positioned vertically and centrally within the lower section of feed conduit 20 and tubular member 23 communicating the header 22 with the upper end of spray nozzle 33. A suitable insulating material 35 encased in metal jacket 36 is provided on the header 22 and tubular member 23.

Another modification of the invention is shown in Figure 4 wherein 19 is a section of the top of a conversion chamber and 38 is one of the feed conduits depending thereinto. A plurality of orifices 39 through the conduit 38 are spaced around the periphery thereof at a level near the lower end of the conduit. A jacket 40 is connected around the outside of conduit 38 at the level of the orifices to provide a common inlet distributor space communicating with the orifices 39. A conduit 41 connects into the jacket 40 for supply of liquid charge thereto. In this modification the liquid charges sprays into the compact stream of contact material within conduit 38 all around the periphery of said stream and the scraping action of the solid particles tend to keep the orifices 39 free from coke deposits. In this modification care should be taken that the size of the orifices 39 is substantially less than that of the contact material particles employed for the operation.

It will be understood that the exact operating conditions to be employed in the process of this invention will vary from one application of the invention to another. In general an average conversion temperature within the range about 800 to 950° F. is desirable for conversion of high boiling liquid petroleum fractions. The contact material inlet temperature may fall within the range about 900° F. to 1150° F. depending upon other operating conditions and should in any

5

case be sufficiently high to supply as sensible heat the heat required for conversion of the charge of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbon products without the temperature of the contact material falling below a level at which conversion of the hydrocarbons no longer proceeds at a practical rate. While in some operations the liquid charge may be introduced without substantial preheating, it is generally preferable to heat the charge to a temperature of the order of about 600 to 850° F.

The rate of liquid hydrocarbon charge may vary from about 0.5 to 5.0 volumes of oil (measured at 60° F.) per hour per volume of contact material within the conversion zone (measured as a substantially compact mass of moving particles). The catalyst to oil ratio on the weight basis may vary from about 1.5 to 10.0 parts of catalyst per part of oil charged.

While the application of the apparatus of this invention has been specifically directed to a hydrocarbon conversion process, it will be understood that the apparatus is also applicable to many other processes involving the problem of introduction of a liquid charge into a confined contacting zone in such a way as to provide uniform distribution of liquid over the contact material. It will be understood that the specific examples of apparatus construction and operating conditions given hereinabove are intended merely as illustrative and are not to be construed as limiting the scope of this invention except as it may be limited by the following claims.

I claim:

1. In a process for conversion of a charge of high boiling liquid hydrocarbons in the presence of a substantially compact column of moving particle form solid contact mass material moving through an elongated conversion zone, the method for introduction of contact material and liquid hydrocarbon charge into said conversion zone which comprises: introducing particle form solid contact material into the upper end of said conversion zone in a plurality of confined, substantially compact streams of downwardly moving particles, said streams delivering said contact material to said column which is of substantially greater horizontal cross-sectional area than said streams, and injecting a stream of high boiling liquid hydrocarbon charge into each of said streams near the lower end thereof.

2. A process for conversion of a charge of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbon products in the presence of a moving particle form contact material which comprises: introducing said contact material at a suitable conversion supporting temperature into the upper end of a confined conversion zone onto a compact column of said contact material maintained therein as a plurality of confined, substantially compact streams of downwardly flowing particles, withdrawing contact material from the lower section of said zone at a controlled rate so as to maintain a substantially compact column of said contact material within said conversion zone, injecting heated, high boiling liquid hydrocarbon charge into each of said confined streams near the lower end thereof and withdrawing gaseous hydrocarbon products from the lower section of said zone.

3. A process for conversion of a high boiling liquid petroleum fraction to lower boiling, gasoline containing gaseous hydrocarbon products which comprises: maintaining a substantially

6

compact, confined column of downwardly moving solid catalyst particles, supplying catalyst to the upper end of said column as a plurality of confined, substantially compact vertical streams uniformly distributed over the cross-sectional area of said column, in which confined streams the catalyst moves downwardly at a substantially greater linear velocity than within said column, withdrawing catalyst from the lower end of said column at a controlled rate, injecting a heated, high boiling liquid petroleum fraction centrally and downwardly into the lower section of each of said confined streams and withdrawing gaseous, gasoline containing hydrocarbon products from the lower section of said column.

4. A process for conversion of a high boiling liquid petroleum fraction to lower boiling, gasoline containing gaseous hydrocarbon products which comprises: maintaining a substantially compact, confined column of downwardly moving solid catalyst particles, supplying catalyst to the upper end of said column as a plurality of confined, substantially compact vertical streams uniformly distributed over the cross-sectional area of said column, in which confined streams the catalyst moves downwardly at a substantially greater linear velocity than within said column, withdrawing catalyst from the lower end of said column at a controlled rate, injecting a heated, high boiling liquid petroleum fraction into each of said confined streams at a number of points around the periphery thereof at a level near the lower end thereof and withdrawing lower boiling gaseous, gasoline containing hydrocarbon products from the lower section of said column.

5. A process for conversion of a charge of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbon products in presence of a mass of moving contact material particles which comprises: introducing said contact material at a temperature sufficiently high to support said conversion without itself being cooled below a temperature suitable for hydrocarbon conversion at a practical rate into a bed of said contact material maintained in a seal zone, passing said catalyst from the bottom of said bed in said seal zone into the upper section of a conversion zone therebelow as a plurality of uniformly spaced apart, confined compact streams of downwardly flowing particles, withdrawing contact material from the lower end of said conversion zone at a rate controlled such as to maintain a substantially compact column of said contact material within said conversion zone, injecting a charge of high boiling liquid hydrocarbons at a temperature within the range about 600° F. to 850° F. into each of said confined streams of contact material near the lower end thereof, withdrawing lower boiling gaseous hydrocarbon products from the lower section of said conversion zone, introducing an inert seal gas into said conversion zone below the level of gaseous hydrocarbon withdrawal and introducing an inert seal gas into said seal zone at a rate controlled to maintain the gaseous pressure within said seal zone above that in said conversion zone.

6. In an apparatus for conversion of a charge of high boiling liquid hydrocarbons in the presence of a mass of moving contact material particles, apparatus for introducing contact material and high boiling liquid hydrocarbon charge into a substantially vertical, elongated conversion chamber which apparatus comprises: a plurality of uniformly spaced apart feed conduits depending into the upper section of said conversion chamber, at least one liquid hydrocarbon inlet

header extending into the upper section of said conversion chamber, and passage defining means for passage of liquid hydrocarbons from said header into the lower section of each of said feed conduits.

7. An apparatus for conversion of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbons in the presence of a substantially compact column of moving contact material particles which apparatus comprises: means defining a substantially vertical, elongated conversion chamber, a plurality of feed conduits extending downwardly into the upper section of said chamber, said conduits being substantially uniformly distributed across the entire cross-sectional area of said chamber, an inlet header for liquid hydrocarbon charge extending into the upper section of said chamber, passage defining members communicating said header with the interior of each of said feed conduits near the lower end of each of said conduits, an outlet conduit for contact material withdrawal from the lower end of said conversion chamber, flow throttling means associated with said outlet conduit and means to withdraw gaseous hydrocarbon products from the lower section of said conversion chamber.

8. An apparatus for conversion of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbons in the presence of a substantially compact column of moving contact material particles which apparatus comprises: means defining a substantially vertical, elongated conversion chamber, a plurality of feed conduits extending downwardly into the upper section of said chamber, said conduits being substantially uniformly distributed across the entire cross-sectional area of said chamber, inlet header means for liquid hydrocarbon charge extending into the upper section of said chamber, inlet pipes extending from said header means to a location within each of said feed conduits within the lower section thereof, said inlet pipes being open on their ends within said feed pipes, an outlet conduit for contact material withdrawal from the lower end of said conversion chamber, flow throttling means associated with said outlet conduit and means to withdraw gaseous hydrocarbon products from the lower section of said conversion chamber.

9. An apparatus for conversion of high boiling liquid hydrocarbons to lower boiling gaseous hydrocarbons in the presence of a substantially compact column of moving contact material particles which apparatus comprises: means defining a substantially vertical, elongated conversion chamber, a plurality of feed conduits extending downwardly into the upper section of said chamber, said conduits being substantially uniformly distributed across the entire cross-sectional area of said chamber, each of said feed conduits having a plurality of orifices there-through spaced around the periphery of each conduit at a level within the lower section thereof, connected around each of said conduits at the level of said orifices therein a jacket providing an enclosed distributor space communicat-

ing with said spaced holes around said conduit, inlet header means for liquid hydrocarbon charge extending into the upper section of said chamber, pipes connecting said header means into each of said jackets around said feed conduits, an outlet conduit for contact material withdrawal from the lower end of said conversion chamber, flow throttling means associated with said outlet conduit and means to withdraw gaseous hydrocarbon products from the lower section of said conversion chamber.

10. An apparatus for conversion of a high boiling liquid petroleum fraction to lower boiling gaseous hydrocarbons in the presence of a substantially compact column of moving catalyst particles which apparatus comprises: a substantially vertical, elongated vessel closed on either end, a partition across the upper section of said vessel dividing it into a seal chamber within its upper section and an elongated conversion chamber therebelow, means to admit an inert seal gas into said seal chamber, means to introduce said particle form catalyst into said seal chamber against the gaseous pressure therein, a plurality of feed conduits depending from said partition and terminating within the upper section of said conversion chamber for passage of catalyst thereinto, said conduits being uniformly distributed over the cross-sectional area of said partition and being of substantially less total cross-sectional area than said conversion chamber, a liquid spray nozzle centrally positioned and extending downwardly within the lower section of each of said feed conduits, insulated passage defining means for continuous supply of a portion of a liquid petroleum charge to the upper end of each of said spray nozzles so as to cause said liquid petroleum to be sprayed downwardly within each of said catalyst feed conduits, and means to withdraw gaseous hydrocarbon products from the lower section of said conversion chamber.

11. In a process for conversion of liquid hydrocarbons in the presence of a substantially compact column of moving particle-form solid contact material moving through an upright conversion zone, the method for introduction of contact material and liquid hydrocarbon charge to said conversion zone which comprises: introducing particle-form solid contact material into the upper section of said conversion zone in a plurality of confined, substantially compact streams of downwardly moving particles delivering onto the surface of said column, and injecting a stream of liquid hydrocarbon charge into each of said streams before it delivers onto said column.

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