Nov. 16, 1954 D. D. MacLAREN 2,694,672

REFORMING OF HYDROCARBONS

Filed Oct. 27, 1950 2 Sheets-Sheet 1

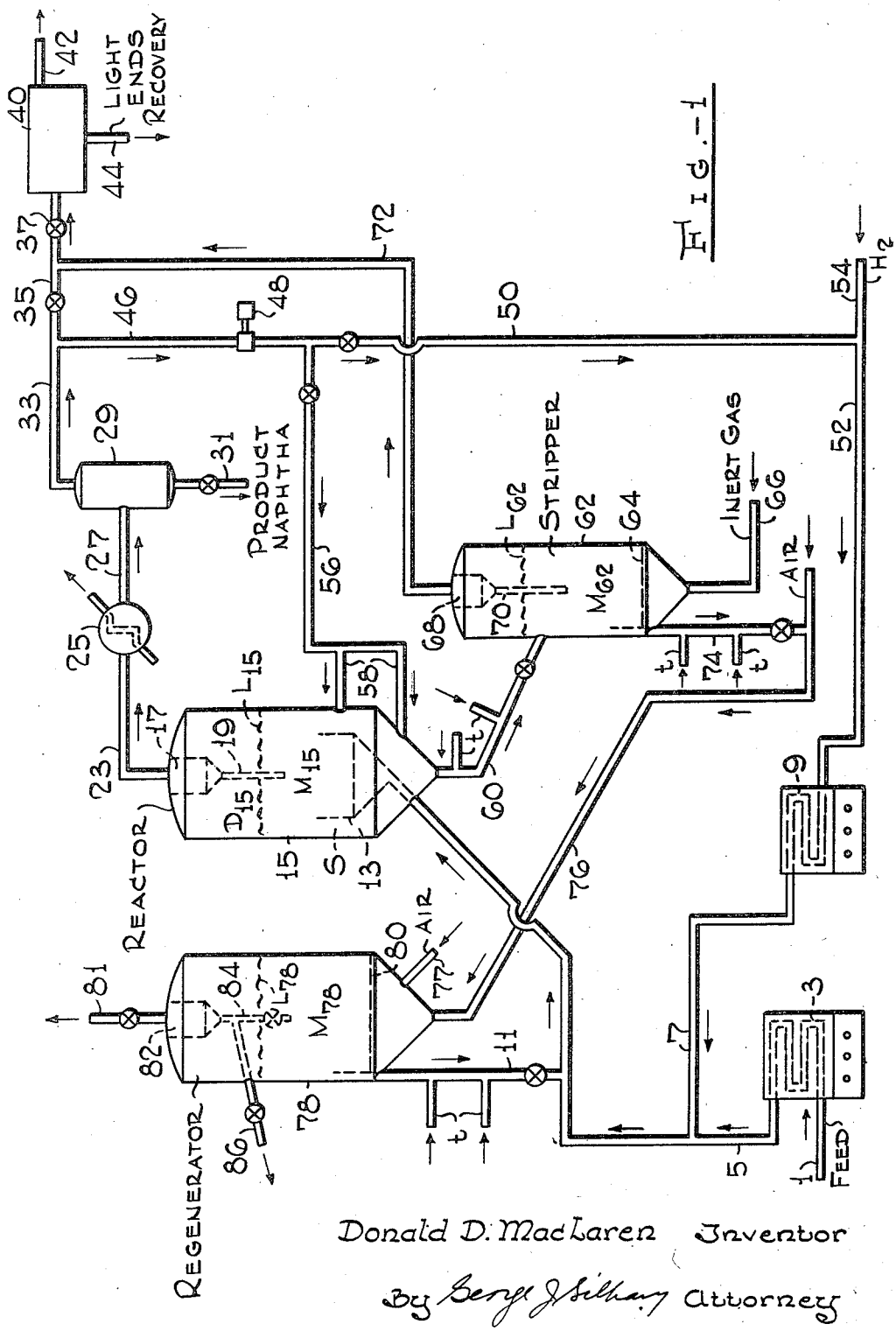


FIG. 1

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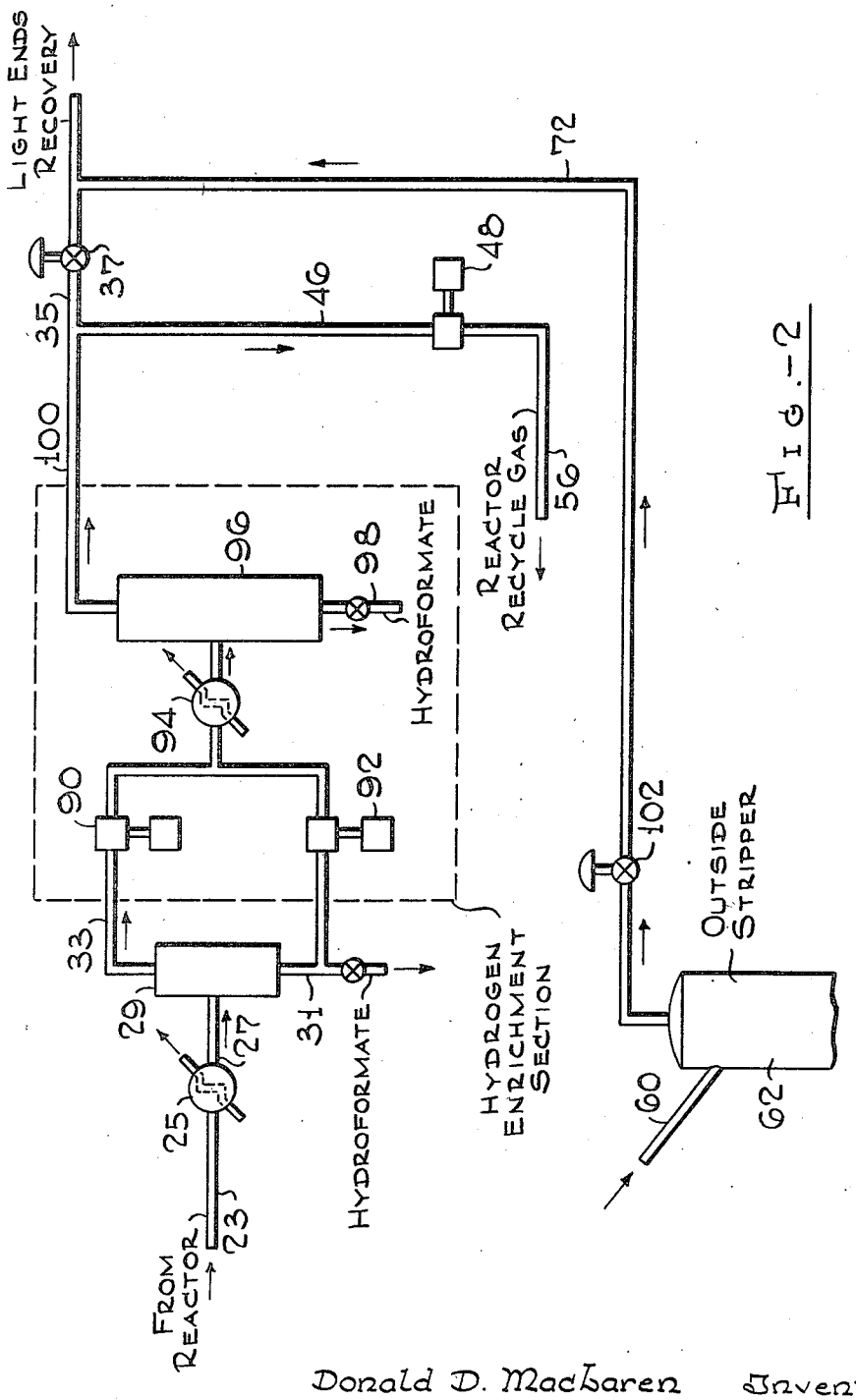


FIG. -2

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2,694,672

REFORMING OF HYDROCARBONS

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This invention relates to the reforming of naphtha in the presence of a catalyst which circulates in a continuous manner through the reforming zone and pertains more particularly to a method and apparatus for removing hydrocarbons and gas entrained in the catalyst withdrawn from the reforming zone. The invention finds particular application to hydroforming processes in which light gas rich in hydrogen produced during the reforming process is recycled to the reforming zone.

It has heretofore been proposed to reform naphtha fractions in the presence of a recycled tail gas containing from 40 to 70 or more percent of free hydrogen but under such conditions that there is no net consumption of hydrogen during the treatment. This process is commonly known as "hydroforming." This term, as used hereinafter, refers to a catalytic operation carried out in the presence of a reformnig catalyst such as a sixth group metal oxide supported on active alumina and in the presence of hydrogen, the principal chemical reaction involving the dehydrogenation of hydrocarbons accompanied by certain side reactions, such as isomerization, cyclization, cracking, polymerization, etc.

The present invention is particularly applicable to what is known as the fluid hydroforming process wherein finely divided catalyst maintained in fluid condition by admixture with gas is continuously circulated through a hydroforming zone and thereafter through a heating or regeneration zone. In the heating and regeneration zones the catalyst is heated by the combustion of carbonaceous deposits to a temperature substantially higher than that maintained in the reaction zone. When carrying out the process in this manner substantially all the heat required can be supplied by hot regenerated catalyst circulated at a relatively rapid rate from the regenerator to the reactor. It is particularly important in this type of operation to treat the spent catalyst with a stripping or purging gas prior to regeneration to recover valuable products, particularly hydrocarbons adsorbed on or associated with the catalyst withdrawn from the reactor under relatively high pressures and also to avoid burning of such products in the regenerator with a resultant undesirable increase in the amount of heat liberated therein without an equivalent increase in the removal of carbonaceous deposits from the catalyst.

It has previously been proposed to treat the catalyst withdrawn from the reforming zone with a portion of the tail gas from the process to avoid diluting the reaction products with extraneous gas. This practice, however, results in the transfer of a substantial amount of hydrogen and light hydrocarbons (C_1–C_5) to the regenerator where they are burned along with the carbon deposits formed on the catalyst during the reforming treatment. This not only reduces the carbon burning capacity of the regenerator but uses up a substantial amount of hydrogen. The latter may, in turn, reduce the hydrogen content of the recycle gas returned to the reactor to a point where the recycle gas must be enriched with hydrogen.

It has also been proposed to strip the catalyst withdrawn from the reforming zone with steam but it has been found that steam has an adverse effect on the activity of the catalyst. The use of inert stripping gases, such as flue gas, nitrogen, etc. is, therefore, desirable and has been suggested heretofore. However, prior art systems providing for the use of inert stripping gases of this type involve serious drawbacks. Recovery of the valuable hydrocarbons removed from the catalyst by the

stripping gases is indispensable economically in commercial operation. Most of the known processes combine the stripping zone effluent with the effluent of the hydroforming zone so as to utilize the main product recovery system for the recovery of the stripped hydrocarbons. However, this type of operation causes an undue dilution of the reactor recycle gas with the inert stripping gas which cannot be separated from the recycle gas by commercially practical means. This dilution so considerably reduces the hydrogen concentration of the recycle gas that substantial proportions of extraneous hydrogen must be supplied to the recycle gas to maintain the same at the desired 40–70% hydrogen concentration. It has, therefore, been suggested either to provide separate hydrocarbon recovery equipment for the stripping zone effluent or to use the latter as a fuel. Either procedure involves obvious disadvantages for the economics of the process. The present invention overcomes this difficulty.

It is, therefore, the principal object of the present invention to provide improved means permitting the use of inert stripping gases in a fluid type catalytic hydroforming process with full recovery of the stripped hydrocarbons and without dilution of the recycle gas stream with inert stripping gases.

Other objects and advantages will appear from the description of the invention given below wherein reference will be made to the accompanying drawing in which

Figure 1 is a semi-diagrammatic illustration of a system adapted to carry out an embodiment of the invention; and

Figure 2 is a similar illustration of a portion of the system of Figure 1 modified to carry out another embodiment of the invention.

In accordance with the present invention, the catalyst withdrawn from the hydroforming zone is passed to a separate stripping zone and stripped therein with an inert, essentially non-combustible gas such as flue gas, nitrogen, etc., preferably in the fluidized state. The gasiform effluent of the stripping zone is combined with the main product gas stream from which normally liquid products have been previously removed by condensation, the stripper effluent entering this product gas stream at a point subsequent to the withdrawal therefrom of the recycle gas stream but prior to the entry of the main product gas stream into the equipment normally provided for the recovery of light ends. When so operating, inert gases may be used for stripping without diluting the recycle gas stream and without the requirement of additional recovery equipment for a complete recovery of the hydrocarbons stripped off the catalyst.

In accordance with the preferred embodiment of the invention, the spent catalyst is subjected to a two stage stripping treatment. In a first stripping stage the catalyst used in the hydroforming reaction is stripped with a portion of the recycle gas streams to remove the heaviest hydrocarbons adhering to the catalyst. The gasiform effluent from this stage may be combined with the main product stream at any desired point prior to liquid product recovery. Conventional internal stripping means arranged within, and discharging their gaseous effluent into the hydroforming zone may be used in this stage. In the sceond stripping stage, the catalyst freed of relatively heavy hydrocarbons in the first stage is further stripped with inert gas to remove adhering light ends and hydrogen entrained in the first stripping stage. The gaseous effluent from this second stage is passed to the main product gas stream from which the recycle stream has been previously branched off and the mixture is supplied to conventional light ends recovery equipment. The catalyst so treated is free of valuable entrained materials, such as hydrocarbons and hydrogen, and may be passed on to the regeneration zone for reheating and burning of its carbonaceous deposits in any manner known per se.

The process of the invention may be carried out at any elevated pressure suitable for hydroforming without requiring additional equipment for pressure control. In some cases, it may be desirable to increase the hydrogen concentration of the recycle gas by reducing

its hydrocarbon content for which purpose the pressure on the liquid product recovery system may be increased. The process of the invention may be readily adapted to this type of operation by merely providing an additional pressure control valve between the inert gas stripper and the point of entry of its effluent into the product gas stream. The invention may also be applied to single stage stripping with inert gas, in which case suitable equipment may be provided for the recovery of relatively heavy hydrocarbons from the stripper effluent.

From the foregoing it will be appreciated that the present invention permits the use of inert stripping gases to remove valuable combustibles from the hydroforming catalyst to be regenerated, without the disadvantages inherent in conventional operation, which means that the invention has made possible for the first time the use of inert stripping gases in commercial fluid type hydroforming operations. The significance of this development becomes apparent from a comparison of recycle gas with inert gas as the stripping medium.

As indicated above, entrainment of the hydrogen-rich stripping gas from the reactor stripper to the regenerator is particularly significant in high pressure, high circulation rate fluid hydroforming operations. The magnitude of this entrainment is shown by the experimental data tabulated below illustrating the effect on product yields at about 950° F., 200 p. s. i. g. pressure and at a fluidized catalyst to oil weight ratio of 6 corresponding to 0.4 hr. catalyst residence time when using reactor recycle gas as compared to equivalent proportions of inert gas as the stripping medium, under otherwise substantially equal conditions.

Stripping Medium	Reactor Recycle Gas	Inert Gas	Differences
Yields on Fresh Feed:			
C_4/430° F. Gasoline, Vol. Percent	77.7	78.1	+0.4
Coke, Wt. Percent	5.4	4.3	−1.1
Dry Gas, Wt. Percent	9.6	10.8	+1.2
Hydrogen, s. c. f./Bbl.	465	595	+130

It will be noted that at these conditions the effect of inert gas stripping is not only to reduce regeneration load by eliminating the burning of hydrocarbons and hydrogen (1.1 wt. per cent coke equivalent of hydrocarbons and 130 s. c. f./bbl. hydrogen, respectively), but also to increase the gasoline yield (0.4 volume per cent) because of the C_4 and heavier hydrocarbons carried over to the regenerator in the case of recycle gas stripping. Thus, effective stripping with inert gas as it is made possible by the present invention is seen to be extremely important.

Having set forth its object and general nature, the invention will be best understood from the subsequent more detailed description of specific embodiments illustrated in the drawing. Referring now to Figure 1, the system shown therein essentially comprises a hydroforming reactor **15**, a catalyst regenerator **78** and a catalyst stripper **62**, the function and coaction of which will be presently described.

In operation, a naphtha feed of, say about 200° to 430° F. boiling range, which may contain about 30–50% of naphthenes is supplied to the system through line **1** and may be passed through a fired coil **3** to be vaporized and heated therein to temperatures of about 500°–1000° F. The preheated vapors leave coil **3** at a pressure of about 100–500 p. s. i. g. via line **5** which receives from line **7** a gas rich in hydrogen, consisting essentially of recycle gas and containing about 40–70% of hydrogen, the remainder being low molecular weight hydrocarbons of 1–4 carbon atoms per molecule. This gas, obtained as will appear hereinafter, is preheated in fired coil **9** so as to enter line **5** at a temperature of about 900°–1000° F., and in amounts of about 500–5,000, preferably about 1,000–3,000, standard cubic feet of gas per barrel of naphtha feed.

The mixture of naphtha vapors and gas flowing through line **5** is supplied via standpipe **11** with regenerated and stripped hot subdivided hydroforming catalyst which may have a fluidizable average particle size of about 40–80 microns and a temperature of about 950°–1250° F. as a result of the regenerating treatment to be described later on. The catalyst may be any one of those known to catalyze the hydroforming reaction, such as oxides of molybdenum, chromium or tungsten on a carrier such as activated alumina, zinc aluminate spinel and the like, preferably molybdenum oxide on activated alumina; it may be added to line **5** in amounts of about 0.5 to 7 lbs. of catalyst per lb. of naphtha fed. A dilute suspension of catalyst in vapors and gases is formed in line **5** and passed at a reaction temperature of preferably about 900°–1000° F. to a lower portion of a conical feeding device **13** arranged in the conical bottom portion of a substantially cylindrical hydroforming reactor **15** designed for fluid solids operation. As shown in the drawing, a free space S is provided between the walls of feeding device **13** and those of reactor **15** for stripping purposes as will appear more clearly hereinafter. Reactor **15** is so dimensioned that at the prevailing flow conditions a relatively dense highly turbulent mass M_{15} forms therein, fluidized by the upflowing gases and vapors to resemble a boiling liquid separated by an interface or level L_{15} from an overlying dilute phase D_{15}. Linear superficial vapor velocities of about 0.3–3 ft. per second are normally suitable for this purpose. Reaction conditions in reactor **15** may include temperatures of about 900°–1000° F., pressures of about 100–500 p. s. i. g. and vapor-solids contact times corresponding to a space velocity of about 0.1 to 1.0 lbs. of oil per hour per lb. of catalyst.

Reaction vapors and gases containing some entrained catalyst are withdrawn overhead from level L_{15} and may be passed through conventional gas-solids separation means, such as cyclone separator **17**, from which separated catalyst may be returned to mass M_{15} via line **19**. The gasiform effluent now substantially free of entrained solids is passed through line **23** to a cooler or condenser **25** wherein it is cooled to substantially room temperature and most of the normally liquid products are condensed. The cooled effluent then may be passed via line **27** to a gas-liquid separator **29** from which liquid hydroformate may be recovered via line **31** and passed to suitable work-up equipment including fractionation and filtration equipment to remove entrained solids, etc. (not shown).

The gasiform overhead from separator **29** containing about 40–70% of hydrogen and 30–60% of low molecular weight hydrocarbons may be withdrawn via line **33**. The portion of the gas not required for recycle may be passed via line **35** directly to light ends recovery system **40**, if desired after pressure release through pressure control valve **37**. System **40** may comprise conventional liquid absorption and/or solid adsorption facilities, etc. Tail gas consisting essentially of C_1—C_3 hydrocarbons, hydrogen and inert stripping gas introduced as will appear later on, may be vented or passed to any suitable use via line **42**. Light hydrocarbons, mainly C_3—C_5 compounds may be recovered via line **44**.

The remainder of the gasiform effluent in line **33**, which is not passed to line **35** is fed to line **46** to be circulated by pump **48** as recycle gas. Most of this recycle gas is passed via line **50** and **52** to preheater **9** and line **7** to supply hydrogen to the process as described above. If desired, fresh hydrogen may be supplied to the system via line **54**. A proportion of the recycle gas in line **46**, amounting to about 20 to 300 c. f. of recycle gas at stripper conditions per 1000 lbs. of catalyst may be branched off through line **56** and supplied through one or more lines **58** to space S of reactor **15** for stripping purposes, preferably after reheating to about 800° to 1000° F. in heat exchange with hot reactor or regenerator effluent in any conventional manner (not illustrated). Subdivided catalyst from mass M_{15} drops continuously into space S wherein it is stripped and maintained in a dense readily flowing state by the stripping gas supplied through lines **58**, stripping gas and stripped vapors entering reactor **15** to be withdrawn together with the reaction products as described above.

Catalyst which is substantially free of relatively high boiling hydrocarbons, but which contains carbonaceous materials deposited in the course of the reaction as well as hydrogen and light hydrocarbons entrained from the stripping gas in space S, is withdrawn under the pseudo-hydrostatic pressure of mass M_{15} via line **60** substantially at the rate at which catalyst is supplied via line **5** to reactor **15**. Line **60**, which may have the form of a conventional standpipe aerated and further stripped through one or more taps *t* with small amounts of recycle gas or the like, feeds into a separate stripper **62** which has the form of a vertical substantially cylindrical

vessel provided in its bottom portion with a gas distributing means, such as a perforated plate or grid **64**. An inert gas, such as flue gas, nitrogen or the like, at temperatures in the range of about 400° to 1000° F. is supplied from line **66** through grid **64** to the lower portion of stripper **62** in amounts of about 20 to 300 c. f. at stripping conditions per 1000 lbs. of catalyst circulated. Stripper **62** is so dimensioned that, at the flow conditions indicated, a fluidized mass M_{62} having an upper level L_{62} is formed in stripper **62** substantially as described with reference to mass M_{15} of reactor **15**. At these conditions the catalyst in stripper **62** may be substantially completely freed of adhering or occluded hydrocarbons and hydrogen within residence times which need not substantially exceed about 30 minutes and which normally may be maintained within the approximate range of 1–20 minutes. A mixture of stripping gas and stripped constituents passes upwardly from level L_{62} through gas-solids separation means, such as cyclone **68** from which separated catalyst may be returned via dip-pipe **70** to mass M_{62}. The gaseous stripper effluent now substantially free of entrained solids is passed via line **72** to line **35** to be mixed therein with the gasiform effluent of separator **29** at a point downstream of the recycle gas take-off line **46**. In this manner, the hydrocarbon content of the stripper effluent may be recovered in light ends recovery system **40** together with light product hydrocarbons from line **33** without dilution of the recycle gas stream in line **46** with inert stripping gas.

Returning now to stripper **62**, the catalyst stripped of volatile combustibles may be withdrawn at a temperature of about 800°–1000° F. under the pseudohydrostatic pressure of mass M_{62} via standpipe or the like **74** and suspended in line **76** in air supplied to line **76** at atmospheric temperature. Additional air to establish amounts sufficient to burn off most of the carbonaceous deposits and adsorbed hydrogen, and to account for the normal oxidation reduction cycle of the catalyst is added via line **77**. About 1 to 15 c. f. of air per lb. of catalyst circulated is normally sufficient for this purpose. The catalyst-in-air suspension so formed is passed to the conical bottom of regenerator **78** provided with distributing means, such as grid plate **80**. Regenerator **78** is so designed that a fluidized mass M_{78} hasing a level L_{78} is formed therein in a manner similar to that described with reference to masses M_{15} and M_{62}. Sufficient catalyst residence time is provided in regenerator **78** for the desired degree of combustion and to reheat the catalyst to about 950°–1250° F. Flue gases containing entrained solids are withdrawn through line **81** via cyclone **82** from which separated catalyst may be returned to mass M_{78} via dip-pipe **84** or discarded via line **86**. The hot flue gases may be used as stripping medium in stripper **62** and to preheat process fluids in any conventional manner. Make-up catalyst may be supplied together with the naphtha feed in any conventional manner.

Regenerated catalyst is withdrawn substantially at the temperature and under the pseudohydrostatic pressure of mass M_{78} through standpipe **11** to be supplied to line **5** as described above. Small amounts of a stripping medium, such as recycle gas or product tail gas, are supplied to standpipe **11** via one or more taps *t* to aerate the solids and displace occluded air and flue gas therefrom.

As pointed out above, in certain fluid hydroforming operations where the amount of hydrogen produced is not sufficient to maintain the hydrogen concentration of the recycle gas at the desired value, some form of enriching system may be added to increase the hydrogen concentration by removing more of the heavier hydrocarbons from the overhead vapor stream. The present invention may be used in a system of this nature, as shown in Figure 2 in a simplified manner. Figure 2 shows chiefly portions of the product recovery system used in combination with the process of the invention, most of the elements common to the systems of Figures 1 and 2 and not essential for a proper understanding of Figure 2 having been omitted for the sake of simplicity. Such common elements as appear in both figures have been identified by like reference numerals.

Referring now to Figure 2, the product effluent from reactor **15** passing through lines **23** and **27** and condenser **25** to separator **29** is treated in the latter substantially at the pressure of reactor **15** as described with reference to Figure 1. However, the gasiform effluent in line **33** and a portion, say about 20 to 70%, of the liquid products in line **31** are compressed in pressure boosters **90** and **92**, respectively, to a pressure of about 200 to 500 p. s. i. g. and passed via cooler **94** to a high pressure separator **96** maintained at a temperature of about 60° to 100° F. Additional liquid product may be recovered via line **98** while gasiform effluent is passed via lines **100** and **35** provided with pressure control valve **37** to the light ends recovery system **40** of Figure 1. The recycle gas stream which is branched off line **100** via line **46** at a point upstream of control valve **37** is now substantially leaner in hydrocarbons and accordingly richer in H_2 as compared with the recycle stream of Figure 1. The gaseous effluent of stripper **62** is withdrawn via line **72** which is now provided with a pressure control valve **102** because reactor **15** and stripper **62** may be at a pressure different from that in line **100**. For the same reason, line **72** now feeds into line **35** at a point downstream of control valve **37**. In all other respects, operation of the system of Figure 2 is identical with that of Figure 1 described above.

Both systems illustrated in the drawing may be operated without the first stage internal stripper S described above. In this case, system **40** will preferably contain suitable equipment for the recovery of relatively high boiling hydrocarbons, such as suitable condensers, gas-liquid separators, absorbers, etc. Other modification of the system illustrated will appear to those skilled in the art without deviating from the spirit of the invention.

The above description and exemplary operations have served to illustrate specific embodiments of the invention but are not intended to be limited in scope.

What is claimed is:

1. In the process of continuously hydroforming naphthas in the presence of a fluidized hydroforming catalyst circulating between a fluid-type hydroforming zone and a fluid type catalyst regeneration zone for the combustion of carbon on the catalyst, wherein the product effluent of said hydroforming zone is separated into normally liquid products and a gas stream, a substantial portion of said gas stream is branched off and recycled to said hydroforming zone and the remaining tail-gas portion of said gas stream is supplied to a light ends recovery zone, the improvement which comprises stripping said catalyst circulating from said hydroforming zone to said regenerating zone in a separate stripping zone with an inert essentially non-combustible stripping gas selected from the group consisting of flue gas and nitrogen to remove volatile and gaseous combustibles from said catalyst prior to its entry into said regeneration zone, withdrawing a mixture of said inert stripping gas and volatile combustibles from said stripping zone and adding said mixture to said tail-gas stream at a point subsequent to the branching-off of said recycled gas portion and prior to said light ends recovery zone, whereby said recycled gas stream and said hydroforming zone are kept entirely free of said inert stripping gas.

2. The process of claim 1 in which said inert gas comprises flue gas.

3. The process of claim 1 in which said inert gas comprises nitrogen.

4. The process of claim 1 in which said catalyst is maintained in said stripping zone in the form of a dense turbulent solids mass fluidized by said inert gas.

5. The process of claim 1 in which said hydroforming zone is maintained at a pressure of about 100–500 p. s. i. g. and said catalyst is circulated between said hydroforming and regeneration zones at a relatively high rate within the range of about 0.5–7 lbs. of catalyst per lb. of naphtha fed to said hydroforming zone.

6. In the process of continuously hydroforming naphthas in the presence of a fluidized hydroforming catalyst circulating between a fluid-type hydroforming zone and a fluid-type catalyst regeneration zone for the combustion of carbon on the catalyst, wherein the product effluent of said hydroforming zone is separated into normally liquid products and a gas stream, a substantial portion of said gas stream is branched off and recycled to said hydroforming zone and the remaining tail-gas portion of said gas stream is supplied to a light ends recovery zone, the improvement which comprises stripping the catalyst withdrawn from said hydroforming zone in a first stripping zone with a portion of said branched-off recycle gas to remove relatively high boiling volatile

combustibles from said catalyst, further stripping said stripped catalyst in a separate second stripping zone with an inert essentially non-combustible stripping gas selected from the group consisting of flue gas and nitrogen to remove relatively low boiling and gaseous combustibles including combustible constituents of said recycle stripping gas from said catalyst prior to its entry into said regeneration zone, withdrawing a mixture of said inert stripping gas and removed gaseous combustibles from said second stripping zone and adding said mixture to said tail-gas stream at a point subsequent to the branching-off of said recycle gas stream and prior to said light ends recovery zone, whereby said recycled gas stream and said hydroforming zone are kept entirely free of said inert stripping gas.

7. The process of claim 6 in which a mixture of recycle stripping gas and relatively high boiling combustibles is withdrawn from said first stripping zone and said last-named mixture is combined with said product effluent prior to said separating into normally liquid products and a gas stream.

8. The process of claim 6 in which said catalyst is maintained in said second stripping zone in the form of a dense turbulent mass fluidized by said inert gas.

9. In the process of continuously hydroforming naphthas at elevated hydroforming temperatures and pressures in the presence of fluidized hydroforming catalyst circulating between a fluid-type hydroforming zone and a fluid type catalyst regeneration zone for the combustion of carbon on the catalyst, wherein the product effluent of said hydroforming zone is separated into normally liquid products and a gas stream, a substantial portion of said gas stream is branched off and recycled to said hydroforming zone and the remaining tail-gas portion of said gas stream is supplied to a light ends recovery system, the improvement which comprises stripping the catalyst withdrawn from said hydroforming zone in a first stripping zone substantially at said temperatures and pressures with a portion of said recycle gas to remove relatively high boiling volatile combustibles from said catalyst, withdrawing a mixture of recycle gas and relatively high boiling combustibles from said first stripping zone, combining said mixture with said product effluent prior to said separating into normally liquid products and a gas stream, further stripping said stripped catalyst in a separate second stripping zone with an inert essentially non-combustible stripping gas selected from the group consisting of flue gas and nitrogen to remove relatively low boiling volatile and gaseous combustibles from said catalyst prior to its entry into said regeneration zone, maintaining said catalyst in said second stripping zone in the form of a dense turbulent solids mass fluidized by said inert gas, withdrawing a mixture of said inert gas and removed low boiling and gaseous combustibles from said second stripping zone, and adding said last named mixture to said tail-gas stream at a point subsequent to the branching off of said recycled portion and prior to said light ends recovery zone.

10. The process of claim 9 in which said catalyst has a residence time in said second stripping zone of about 1–20 minutes.

11. The process of claim 9 in which at least a substantial portion of said gas stream prior to said branching-off of said recycled gas is further separated at a pressure of about 200–500 p. s. i. g. into products liquid at said last-named pressure at about 60°–100° F. and a secondary gas stream, said recycled gas being branched off said secondary gas stream and the remainder of said secondary gas stream being passed as the tail-gas to said light ends recovery zone.

12. In the process of continuously hydroforming naphthas in the presence of a fluidized hydroforming catalyst circulating between a fluid-type hydroforming zone and a fluid-type catalyst regeneration zone for the combustion of carbon on the catalyst, wherein the product effluent of said hydroforming zone is subjected to a separation into liquid products and a gas stream, a substantial portion of said gas stream is branched off and recycled to said hydroforming zone and the remaining tail-gas portion of said gas stream is supplied to a light ends recovery zone, the improvement which comprises carrying out at least a portion of said separation at an elevated pressure to condense substantial amounts of normally vaporous hydrocarbon products and to render said gas stream relatively rich in hydrogen and relatively lean in hydrocarbons, stripping said catalyst circulating from said hydroforming zone to said regeneration zone in a separate stripping zone with an inert essentially non-combustible stripping gas selected from the group consisting of flue gas and nitrogen to remove volatile and gaseous combustibles from said catalyst prior to its entry into said regeneration zone, withdrawing a mixture of said inert stripping gas and volatile gaseous combustibles from said stripping zone and adding said mixture to said tail-gas stream at a point subsequent to the branching-off of said recycled portion and prior to said light ends recovery zone.

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