

Sept. 27, 1960

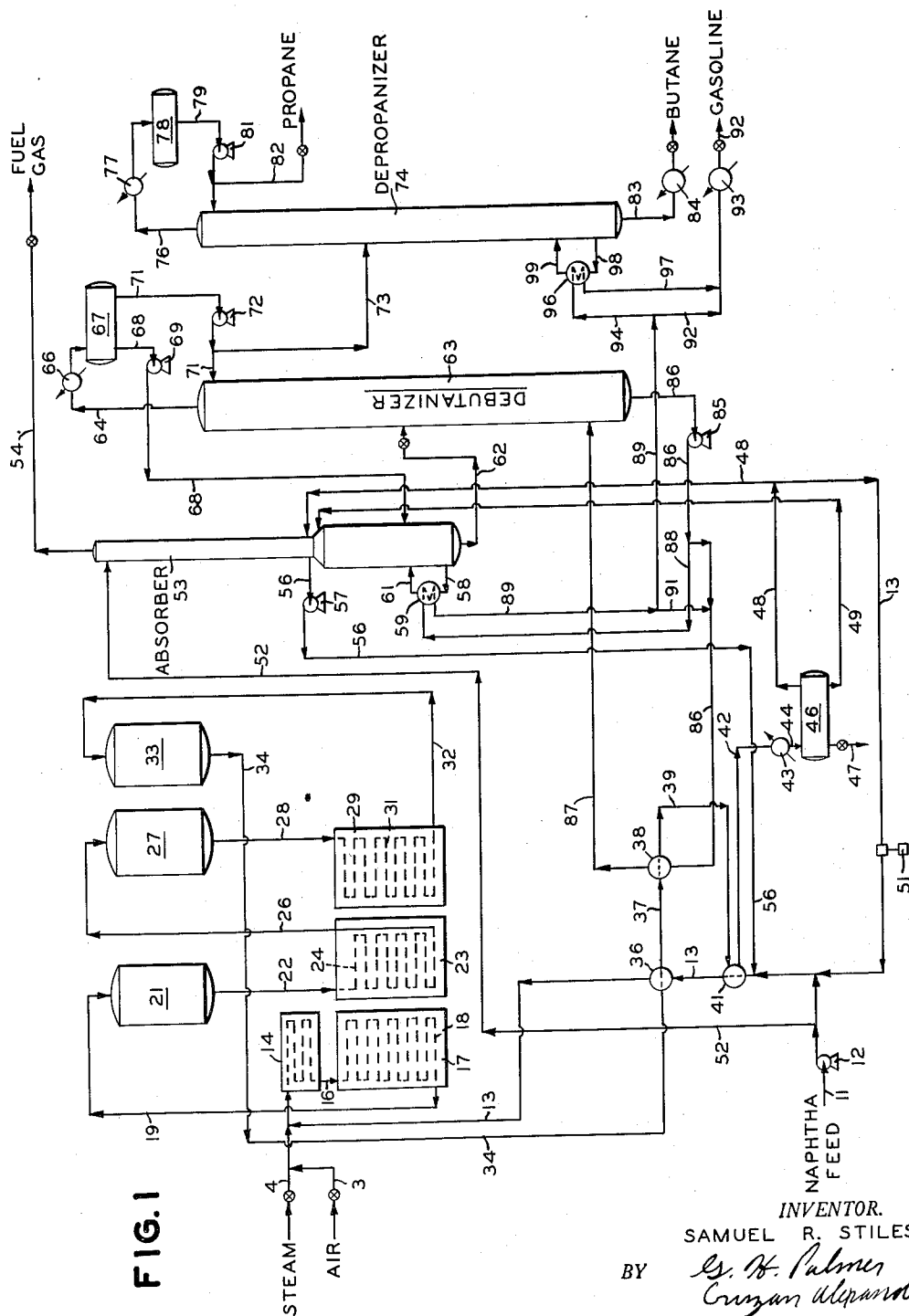
S. R. STILES

2,954,341

HYDROCARBON CONVERSION PROCESS

Filed June 15, 1955

2 Sheets-Sheet 1



1

2,954,341

HYDROCARBON CONVERSION PROCESS

Samuel R. Stiles, Cresskill, N.J., assignor to The M. W. Kellogg Company, Jersey City, N.J., a corporation of Delaware

Filed June 15, 1955, Ser. No. 515,615

10 Claims. (Cl. 208—365)

This invention relates to a method for supplying heat to a series of distillation zones. In one aspect, this invention relates to the recovery of hydrocarbon conversion products from a hydrocarbon conversion reaction. In another aspect, this invention relates to the reforming of naphtha. In a more particular aspect, this invention relates to a novel heat exchange system.

In many hydrocarbon conversion processes such as thermal or catalytic reforming, catalytic cracking etc., the conversion of feed material to desired products takes place at comparatively high temperatures, frequently at about 600 to 1200° F. In order to recover and separate the desired products it is usual to fractionate the product, usually in a series of successive fractionation zones. Frequently, as in the case of naphtha hydroforming processes, it is desired to cool the reaction product sufficiently to separate recycle gas comprising hydrogen prior to sending the reaction product to the product recovery system. In addition, it is usually necessary to supply heat for reboiling to the bottom of the product fractionators. If the hot reaction product is cooled sufficiently to separate hydrogen recycle gas, the amount of heat required by the fractionators will be considerably more than is required if the product is merely cooled to the desired initial fractionation temperature since light hydrocarbons, e.g., methane and ethane, which are normally withdrawn as gases must be condensed.

Previously, reboiler heat to product fractionators has been supplied by means of furnaces or by indirect heat exchange of hot reaction product with bottoms from each fractionator to which it is desired to supply heat. Heat exchange of fractionator bottoms with hot reaction product is usually accomplished in or near each fractionator. This involves transporting hot product to each of the fractionators to which heat is to be supplied and makes necessary the use of large quantities of the expensive alloy piping needed for transporting the hot product. In addition, due to the high pressure of the hot product, undesirably high pressure drops are encountered in the use of product for this purpose and these high pressure drops necessitate correspondingly powerful pumps or compressors in order to maintain pressure in the reaction zone. In the case of reforming processes in which recycle gas is used, the additional power requirements are usually met by powerful and large recycle gas compressors. The liquid product or products separated in the fractionators must usually be cooled before being sent to storage, thus making it necessary to remove some of the heat which was added to the fractionators by heat exchange with the hot product. This represents a substantial heat loss.

It is an object of my invention to provide an improved process for the recovery of hydrocarbon conversion products.

It is a further object of my invention to provide an improved and more efficient process for supplying heat to fractionation zones used to fractionate hydrocarbon conversion products.

2

It is another object of my invention to recover heat from hydrocarbon conversion products.

It is another object of my invention to use less high test resistant piping and heat exchange equipment in a hydrocarbon conversion process.

It is another object of my invention to provide an improved heat exchange system for supplying heat to fractionation zones used to fractionate the products resulting from reforming of naphtha.

Other objects and advantages will become apparent to those skilled in the art from the accompanying description and disclosure.

My invention is applicable to any hydrocarbon conversion process in which hot product is cooled and fractionated in two or more fractionation zones, at least two of which have different bottom temperatures. The bottom temperatures of the fractionation zones should be lower than the temperature of the hot product prior to cooling. My invention is especially applicable to hydrocarbon conversion processes such as reforming, catalytic cracking, hydroforming etc., in which a feed material such as naphtha or gas oil is treated to produce a hot reaction product which is cooled and fractionated to produce hydrocarbon products such as gasoline, butane, etc.

According to this invention, a hot reaction product stream from the hydrocarbon conversion process is cooled and is fractionated in successive fractionation zones operated at lower bottoms temperature than the temperature of the hot product stream. One of the fractionation zones is operated at a relatively high bottoms temperature and another is operated at a relatively low bottoms temperature. Heat is supplied to the lower portion of the relatively high temperature fractionation zone by indirect heat exchange with the hotter reaction product stream and heat is supplied to the lower portion of the relatively low temperature fractionation zone by indirect heat exchange with material from the lower portion of the relatively high temperature fractionation zone.

In accordance with a modification of this invention, a hot product stream from a hydrocarbon conversion process is cooled and is fractionated in at least three successive fractionation zones all operated at lower bottoms temperatures than the temperature of the hot product. One of the fractionation zones is operated at a relatively high bottoms temperature and at least two of the fractionation zones are operated at relatively low bottoms temperatures. Heat is supplied to the lower portion of the relatively high temperature fractionation zone by indirect heat exchange with the hot product stream. Heat is supplied to the lower portion of a first relatively low temperature fractionation zone by indirect heat exchange with material from the lower portion of the relatively high temperature fractionation zone. Heat is supplied to the lower portion of a second relatively low temperature fractionation zone, operated at a lower temperature than the first relatively low temperature fractionation zone, by indirect heat exchange with at least a part of the same hydrocarbon stream which was used to supply heat to the first relatively low temperature fractionation zone. At least part of the hydrocarbon stream used to supply heat to the second relatively low temperature fractionation zone is recovered as a product of the process.

Any conventional heat exchange techniques can be used to perform the heat exchange operations necessary in using my invention. For instance, heat may be supplied to fractionators by using heat exchange tubes located within the fractionators themselves or by using external exchangers and conveying the material to be heated to and from the fractionators. Intermediate heat exchange mediums may also be used in connection with

the indirect heat exchange operations used in connection with my invention.

In order to obtain economically feasible exchanges of heat, it is preferable to maintain a logarithmic mean temperature difference of at least 50° F., when carrying out heat exchange in accordance with my invention. In some instances when heat is supplied to the lower portion of a relatively low temperature fractionation zone by indirect heat exchange with a bottoms fraction from a relatively high temperature fractionation zone in accordance with my invention, it may be desirable to introduce additional quantities of low boiling hydrocarbons into the relatively low temperature fractionation zone in order to maintain it at a sufficiently low bottom temperature for efficient heat exchange. If, for example, the relatively low temperature fractionation zone is designed to strip fuel gas from the product of a reforming process with propane and heavier hydrocarbons being withdrawn as liquid, the normal bottom temperature of such a fractionation zone might not be low enough to permit the economical transfer of heat to it in accordance with my invention. This situation could occur because of a relatively low proportion of light hydrocarbons, e.g., propane and butane, in the product. In such a situation, it is desirable to introduce additional light hydrocarbons into the relatively low temperature fractionation zone in order to allow operation at a lower bottom temperature. Propane and butane can be conveniently recycled from a later stage of the product recovery process for the purpose.

By supplying reboiling heat to a relatively high temperature fractionation zone by indirect heat exchange with hot reaction product and supplying reboiling heat to a relatively low temperature fractionation zone by indirect heat exchange with the bottoms of the relatively high temperature fractionation zone, substantial economies can be effected in the use of the special alloy piping and heat exchange equipment which is required to handle the hot product. In addition, considerable savings are realized because of the fact that the undesirably high pressure drops previously encountered in the use of high pressure, hot product are substantially reduced.

When liquid product from a relatively high temperature fractionation zone is utilized to supplying reboiling heat to a relatively low temperature fractionation zone, additional economies are realized because the liquid product is partially cooled in the process and this results in less additional cooling being necessary before it is sent to storage.

For a further and better understanding of my invention, reference should be had to the accompanying drawings in which:

Figure 1 is a diagrammatic illustration of a suitable arrangement of apparatus, in which individual pieces of equipment are shown in elevation, showing a preferred embodiment of my invention in connection with recovery of products from a naphtha hydroforming process.

Figure 2 is a diagrammatic illustration of suitable arrangement of apparatus, in which individual pieces of equipment are shown in elevation, showing another embodiment of my invention in connection with recovery of products of a naphtha hydroforming process.

In Figure 1, 7,500 barrels per stream day of 57.4° A.P.I. naphtha enters the process through conduit 11 and pump 12 at a temperature of 100° F. About 3,700 barrels per stream day of naphtha feed continue through conduit 11 to conduit 13 where the feed is combined with recycle gas. Additional naphtha enters conduit 13 from conduit 56 as described below. The mixture is passed through a conventional heat exchanger 41 where its temperature is raised to 445° F. From heat exchanger 41 the mixture of feed and recycle gas continues through conduit 13 to a conventional heat exchanger 36 where the temperature of the mixture is raised to 755° F. by

indirect contact with hot reaction product in conduit 34. During the regeneration cycle, steam and air are introduced thru conduits 3 and 4 and are used to remove contaminating material from the catalyst. From conduit 13 the mixture passes through a conventional preheat coil 14 and into a suitable direct fired furnace 17 via conduit 16. Furnace 17 contains a heating coil 18 in which the mixture is heated to a temperature of 975° F. From furnace 17 the mixture passes through conduit 19 to a reactor 21. This reactor is a conventional fixed bed reactor which contains a conventional platinum hydroforming catalyst. Reactor 21 is maintained at a pressure of 519 p.s.i.g. and its operation is substantially adiabatic because of the heavy insulation used. Hot gaseous effluent leaves reactor 21 through conduit 22 at a temperature of 875° F. and passes to a second furnace 23 where it is heated to a temperature of 975° F. in a heating coil 24. Furnace 23 is similar to furnace 17. From furnace 23 the heated mixture passes through a conduit 26 to a second reactor 27. Reactor 27 is similar to reactor 21, contains a similar catalyst and is operated at a pressure of 500 p.s.i.g. Hot gaseous effluent leaves reactor 27 through conduit 28 at a temperature of 930° F. and passes to a third furnace 29 where it is raised to a temperature of 975° F. in a heating coil 31 contained therein. Furnace 29 is similar to furnace 17. From furnace 29 the heated mixture passes through conduit 32 to a third reactor 33. Reactor 33 is similar to reactor 21, contains a similar catalyst and is operated at a pressure of 481 p.s.i.g. Hot gaseous reaction product containing reformed product, propane, butane and hydrogen leaves reactor 33 through conduit 34. The reforming process is operated with an overall weight space velocity of about 3.

The hot reaction product from the hydroforming process passes through conduit 34 to heat exchanger 36 where it is cooled to a temperature of 672° F. The hot reaction product then passes through conduit 37 to a conventional heat exchanger 38 where it is cooled to a temperature of 530° F. by indirect contact with debutanizer bottoms as described below. From heat exchanger 38, the reaction product passes through conduit 39 to heat exchanger 41 where it is cooled to a temperature of 220° F. and then passes through conduit 42 and condenser 43 to separator drum 46. Condenser 43 and drum 46 are operated at a temperature of 100° F. and a pressure of 447 p.s.i.g. Liquid product which is condensed by condenser 43 is withdrawn from drum 46 through conduit 49 and passed to a conventional absorber 53. Any water present is removed from drum 46 through conduit 47. Uncondensed gaseous material is withdrawn from the top of drum 46 through conduit 48. A portion as recycle gas is withdrawn from conduit 48 through conduit 13 and pump 51 and is mixed with naphtha feed entering through conduit 11. The remainder of the gaseous material which is not recycled continues through conduit 48 into absorber 53.

A portion of the naphtha feed is withdrawn from conduit 11 through conduit 52 and passed to the top of absorber 53. The naphtha feed admitted to the top of absorber 53 is used to scrub valuable hydrocarbon products, e.g., butane and heavier hydrocarbons, from the fuel gas which is withdrawn from absorber 53. A side stream of naphtha is withdrawn from absorber 53 through conduit 56 and is passed via pump 57 to conduit 13 where it is mixed with recycle gas and feed and passed to the hydroforming reaction as previously described. Fuel gas is withdrawn from the top of absorber 53 at a temperature of 105° F. and is withdrawn from the system through conduit 54.

A bottoms fraction comprising naphtha, propane and butane is withdrawn from absorber 53 through conduit 62 and passes to a debutanizer 63 which is a conventional fractionation column. From debutanizer 63 an overhead fraction comprising butane and propane is withdrawn

through conduit 64 at a temperature of 204° F. and passes to drum 67 via condenser 66. Drum 67 is maintained at a temperature of 178° F. and a pressure of 285 p.s.i.g. A portion of the condensed overhead from debutanizer 63 is withdrawn from drum 67 through conduit 67 and is passed via pump 69 to absorber 53 for the purpose of increasing the relative proportion of light hydrocarbons in absorber 53 in order to permit operation of absorber 53 at a sufficiently low bottom temperature so that heat can be supplied economically in accordance with my invention. The remainder of the condensed overhead is withdrawn from drum 67 through conduit 71 and pump 72. Part of the overhead is recycled from pump 72 to the top of debutanizer 63 through conduit 71 and the remainder is passed to a depropanizer 74, which is a conventional fractionation column, through conduit 73.

An overhead propane fraction is withdrawn from depropanizer 74 through conduit 76 and is passed through condenser 77 to drum 78. Drum 78 is maintained at a temperature of 100° F. and a pressure of 215 p.s.i.g. Condensed propane is withdrawn from drum 78 through conduit 79 by means of pump 81. From pump 81 part of the propane is recycled to the top of depropanizer 74 and the remainder is withdrawn through conduit 82 as propane product. A bottoms fraction is withdrawn from depropanizer 74 through conduit 83, as cooled in cooler 84 and withdrawn at a temperature of 100° F. as butane product.

A bottoms fraction comprising naphtha is withdrawn at a temperature of 490° F. from debutanizer 63 through conduit 86 and pump 85. A portion of this fraction continues through conduit 86 to heat exchanger 38 where it is heated by indirect heat exchange with hot reaction product to a temperature of 524° F. It is then returned to debutanizer 63 through conduit 87. From conduit 86 a portion of the bottoms fraction from debutanizer 63 passes through conduit 86 to a conventional heat exchanger 59 where its temperature is lowered to 380° F. by indirect contact with a bottoms fraction from absorber 53. The bottoms fraction from absorber 53 is withdrawn from the absorber through conduit 58 and is returned to the absorber through conduit 61. The bottom of absorber 53 is maintained at a temperature of 360° F. and a pressure of 400 p.s.i.g. The debutanizer bottoms fraction is withdrawn from heat exchanger 59 through conduit 89. A portion of this fraction passes through conduit 91 to conduit 86 and is passed to heat exchanger 38 as previously described. Another portion of the debutanizer bottoms fraction from conduit 89 is withdrawn through conduit 92 and cooler 93 as debutanized gasoline. A third portion of the debutanizer bottoms fraction from conduit 89 is passed via conduit 94 to a conventional exchanger 96 where its temperature is lowered to 320° F., by indirect contact with a bottoms fraction from depropanizer 74. The depropanizer bottoms fraction used for this heat exchange is withdrawn from the depropanizer through conduit 98 and returned to it through conduit 99. The lower portion of depropanizer 74 is maintained at a pressure of 235 p.s.i.g. and a bottom temperature of 212° F. From exchanger 96 the debutanizer bottoms fraction is passed through conduit 97, conduit 92 and cooler 93 and is withdrawn at a temperature of 100° F. as debutanized gasoline.

By utilizing the debutanizer bottoms to supply heat to the lower portion of the absorber and depropanizer columns and using the hot reaction product to supply heat to the debutanizer bottoms, it is possible to eliminate much of the costly alloy piping and heat exchange equipment which would be needed if the hot reaction product were used to supply heat to the lower portions of the absorber and depropanizer columns as well. It should be noted that heat exchangers 59 and 96 do not have to be capable of withstanding the temperature of the hot reaction product when the present invention is

utilized. In this particular example, the saving in equipment cost over the cost of equipment for a conventional operation in which the hot reaction product is used to supply heat to the bottoms fractions of all three fractionators is substantial.

In addition, substantially less power is required to operate the recycle gas compressor because the excessive pressure drops which would be encountered if hot product were used to supply heat to the bottoms fractions of all three fractionators have been substantially reduced by means of my invention.

A further advantage can be seen in the lower cooling requirements for cooler 93. Since the portion of the gasoline product which is used to supply heat to the lower portion of depropanizer 74 is cooled thereby, it is not necessary to provide as much cooling duty to cool this portion to the temperature at which it is withdrawn.

In Figure 2, the hot reaction product enters through conduit 37 at a temperature of 796° F. Conduit 37 is identical with conduit 37 in Figure 1 and the reaction product is obtained in the same manner as was described in connection with Figure 1. The reaction product in conduit 37 passes to a conventional heat exchanger 111, where it is cooled to 535° F., by indirect contact with debutanizer bottoms as described below. The reaction product passes from heat exchanger 111 through conduit 39 which is identical with conduit 39 in Figure 1.

Cooled liquid reaction product enters a conventional absorber 116 through conduit 49, which is identical with conduit 49 in Figure 1. Gaseous reaction product enters absorber 116 through conduit 48, which is identical with conduit 48 in Figure 1. Fuel gas is withdrawn from absorber 116 through conduit 117 and is withdrawn from the system. From absorber 116 a side fraction of 61.6° A.P.I. naphtha is withdrawn through conduit 55 and pump 114. Conduit 56 is identical with conduit 56 in Figure 1. A portion of the naphtha feed is admitted to the top of absorber 116 through conduit 52 which is identical with conduit 52 in Figure 1.

A bottoms fraction comprising naphtha, propane and butane is withdrawn at a temperature of 360° F. from absorber 116 and passed to a debutanizer 119, which is a conventional fractionation column, via conduit 118. An overhead fraction comprising butane and propane is withdrawn from debutanizer 119 at a temperature of 198° F., and passes to drum 123 through conduit 121 and condenser 122. Drum 123 is operated at a temperature of 182° F., a pressure of 285 p.s.i.g. From drum 123, a portion of the condensed debutanizer overhead is returned to absorber 116 via conduit 124 and pump 126. The remainder of the condensed overhead passes through conduit 127 to pump 128. From pump 128 part of the condensed overhead is recycled to the top of debutanizer 119 through conduit 127 and the remainder passes to a depropanizer 132, which is a conventional fractionation column, through conduit 129 and conduit 131.

A mixture of propane and butane from an outside source is admitted to depropanizer 132 through conduit 131. From depropanizer 132 an overhead fraction comprising propane is withdrawn through conduit 133 at a temperature of 115° F. The overhead fraction is condensed in condenser 134 and then passes through conduit 133 to drum 136, which is maintained at a temperature of 100° F., and a pressure of 215 p.s.i.g. From drum 136 the condensed overhead passes through conduit 137 to pump 138 from which a portion is recycled to the top of depropanizer 132 through conduit 137 and the remainder is recovered as propane product through conduit 139. A bottoms fraction is withdrawn from depropanizer 132 through conduit 141 at a temperature of 208° F., is cooled in cooler 142 to a temperature of 100° F. and is recovered as butane product.

A bottoms fraction comprising naphtha is withdrawn from debutanizer 119 through conduit 143 at a temperature of 490° F. A portion of this bottoms fraction passes

through conduit 146 and conduit 147 to a rerun tower 148, which is a conventional fractionation column and the remainder continues through conduit 143 and pump 144. A portion of the debutanizer bottoms from conduit 143 passes to a conventional heat exchanger 168 through conduit 167. In heat exchanger 168 the temperature of the debutanizer bottoms fraction is lowered to 380° F., by indirect contact with a bottoms fraction from absorber 116. The debutanizer bottoms fraction leaves heat exchanger 168 through conduit 169. A bottoms fraction from absorber 116 is withdrawn through conduit 173, indirectly contacted with the debutanizer bottoms fraction in heat exchanger 168 and returned to absorber 116 through conduit 172. The lower portion of absorber 116 is maintained at a temperature of 360° F. and a pressure of 400 p.s.i.g.

From conduit 169 part of the debutanizer bottoms fraction enters conduit 171 and the remainder enters conduit 113. Part of the debutanizer bottoms fraction from conduit 171 is passed to rerun tower 148 through conduit 147. The remainder continues through conduit 171 to a conventional heat exchanger 178 where its temperature is lowered to 320° F., by indirect contact with a bottoms fraction from depropanizer 132. A depropanizer bottoms fraction is withdrawn from depropanizer 132 through conduit 181, indirectly contacted with the debutanizer bottoms fraction in heat exchanger 178 and returned to depropanizer 132 through conduit 179.

The debutanizer bottoms fraction is withdrawn from heat exchanger 178 through conduit 113. The debutanizer bottoms fraction in conduit 113 passes to heat exchanger 111 where its temperature is raised to 542° F. by indirect contact with the hot reaction product. From heat exchanger 111 the debutanizer bottoms fraction is withdrawn through conduit 112 and part of it is returned to debutanizer 119 through conduit 177 and conduit 176. The remainder of the debutanizer bottoms fraction in conduit 112 passes to a conventional heat exchanger 162 where it is cooled to a temperature of 507° F., by indirect contact with a bottoms fraction from rerun tower 148. From heat exchanger 162 the debutanizer bottoms fraction is returned to debutanizer 119 through conduit 176. A bottoms fraction from rerun tower 148 comprising heavy naphtha is withdrawn through conduit 157 and pump 158. Part of this bottoms fraction is passed through conduit 164 to cooler 161 and is recovered as heavy naphtha product at a temperature of 105° F. The remainder of the rerun tower bottoms fraction passes from conduit 157 to heat exchanger 162 via conduit 159. In heat exchanger 162 it is heated by indirect contact with a debutanizer bottoms fraction and is then returned to rerun tower 148 through conduit 163. The bottom of rerun tower 148 is maintained at a temperature of 420° F. and a pressure of 15 p.s.i.g.

An overhead fraction comprising gasoline is withdrawn from rerun tower 148 through conduit 149 and is passed through condenser 151 to drum 152. Drum 152 is maintained at a temperature of 170° F., and atmospheric pressure. Condensed overhead is withdrawn from drum 152 through conduit 153 by means of pump 155 and a portion is returned to rerun tower 148 through conduit 153. The remainder of the condensed overhead from conduit 153 passes through conduit 154 to cooler 156 and is recovered as gasoline product at a temperature of 100° F.

The processes illustrated in Figures 1 and 2 are specific examples of processes to which my invention is particularly applicable. My invention is not limited to use with these types of processes but is applicable to any conversion process requiring recovery and separation of a high temperature product in a plurality of distillation zones.

I claim:

1. In a hydrocarbon conversion process in which a hot reaction product stream is cooled and is recovered in a plurality of fractionation zones operated at lower tem-

peratures than the temperature of said hot product stream, one of said fractionation zones being operated at a relatively low bottoms temperature and another of said fractionation zones being operated at a relatively high bottoms temperature, the method for supplying heat to said fractionation zones which comprises supplying heat to the lower portion of said relatively high temperature fractionation zone by indirect heat exchange with said hot product stream, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with material from the lower portion of said relatively high temperature fractionation zone, and thereafter recovering said hot product stream in said plurality of fractionation zones.

2. In a hydrocarbon conversion process in which a hot reaction product stream is cooled and is fractionated in a plurality of fractionation zones operated at lower temperatures than the temperature of said hot product stream, one of said fractionation zones being operated at a relatively low bottom temperature and another of said fractionation zones being operated at a relatively high bottom temperature, the method for supplying heat to said fractionation zones which comprises supplying heat to the lower portion of said relatively high temperature fractionation zone by indirect heat exchange of material from the lower portion of said relatively high temperature fractionation zone with said hot product stream, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with material from the lower portion of said relatively high temperature fractionation zone, and thereafter fractionating said hot product stream in said plurality of fractionation zones.

3. In a hydrocarbon conversion process in which a hot reaction product stream is cooled and is fractionated in a plurality of fractionation zones operated at lower temperatures than the temperature of said hot product stream, one of said fractionation zones being operated at a relatively low bottom temperature and another of said fractionation zones being operated at a relatively high bottom temperature, the method for supplying heat to said fractionation zones which comprises withdrawing a hydrocarbon stream from the lower portion of the relatively high temperature fractionation zone, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with said hydrocarbon stream, contacting said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of said hydrocarbon stream is increased to above the temperature maintained in the lower portion of said relatively high temperature fractionation zone, and returning said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

4. In a reforming process in which naphtha is reformed under reforming conditions in the presence of a reforming catalyst and the hot reaction product is cooled and is fractionated in successive fractionation zones operated at lower temperatures than the temperature of the hot product, one of said fractionation zones being operated at a relatively high bottom temperature and another of said fractionation zones being operated at a relatively low bottom temperature, the method for supplying heat to said relatively high and relatively low temperature fractionation zones which comprises withdrawing a hydrocarbon stream from the lower portion of said relatively high temperature fractionation zone, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with a portion of said hydrocarbon stream, thereby cooling said portion of said hydrocarbon stream, recovering a part of said cooled portion as a product of the process, contacting the remainder of said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of the remainder of said hydrocarbon

stream is raised to above the temperature of the lower portion of said relatively high temperature fractionation zone and returning the remainder of said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

5. In a reforming process in which naphtha is reformed under reforming conditions in the presence of a reforming catalyst and the hot reaction product is cooled and is fractionated in successive fractionation zones operated at lower temperatures than the temperature of the hot product, one of said fractionation zones being operated at a relatively high bottom temperature and another of said fractionation zones being operated at a relatively low bottom temperature, the method for supplying heat to said relatively high and relatively low temperature fractionation zones which comprises withdrawing a hydrocarbon stream from the lower portion of said relatively high temperature fractionation zone, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with a portion of said hydrocarbon stream, contacting said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of said hydrocarbon stream is raised to above the temperature of the lower portion of said relatively high temperature fractionation zone and returning said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

6. In a reforming process in which naphtha is reformed under reforming conditions in the presence of a reforming catalyst and the hot reaction product is cooled and is fractionated in successive fractionation zones operated at lower temperatures than the temperature of the hot product, one of said fractionation zones being operated at a relatively high bottom temperature and others of said fractionation zones being operated at relatively low bottom temperatures, the method for supplying heat to said relatively high and relatively low temperature fractionation zones which comprises withdrawing a hydrocarbon stream from the lower portion of said relatively high temperature fractionation zone, supplying heat to the lower portion of a first relatively low temperature fractionation zone by indirect heat exchange with a portion of said hydrocarbon stream, thereby cooling said portion of said hydrocarbon stream, supplying heat to the lower portion of a second relatively low temperature fractionation zone by indirect heat exchange with a part of said cooled portion of said hydrocarbon stream, said second relatively low temperature fractionation zone having a lower bottom temperature than said first relatively low temperature fractionation zone, recovering a part of said cooled portion as a product of the process, contacting the remainder of said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of the remainder of said hydrocarbon stream is raised to above the temperature of the lower portion of said relatively high temperature fractionation zone and returning the remainder of said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

7. In a process for reforming naphtha at a temperature above 600° F., in which a hot reaction product stream is cooled and is fractionated in successive fractionation zones operated at lower than the temperature of the hot product, one of said fractionation zones being operated at a relatively high bottom temperature and others of said fractionation zones being operated at relatively low bottom temperatures, the method for supplying heat to said relatively high and relatively low temperature fractionation zones which comprises supplying heat to the lower portion of a first relatively low temperature fractionation zone by indirect heat exchange with a hydrocarbon stream from the lower portion of said relatively high temperature fractionation zone, thereby cooling said hydrocarbon stream, supplying heat to the lower portion

of a second relatively low temperature fractionation zone by indirect heat exchange with at least a part of said cooled hydrocarbon stream, said second relatively low temperature fractionation zone having a lower bottom temperature than said first relatively low temperature fractionation zone, recovering at least a part of said cooled hydrocarbon stream as a product of the process and supplying heat to the lower portion of said relatively high temperature fractionation zone by indirect heat exchange with said hot product stream, all of said heat exchanges being accomplished with a logarithmic mean temperature difference of at least 50° F.

8. In a hydrocarbon conversion process in which a hot reaction product stream is cooled and is fractionated in a plurality of fractionation zones operated at lower temperatures than the temperature of said hot product stream, one of said fractionation zones being operated at a relatively low bottom temperature and another of said fractionation zones being operated at a relatively high bottom temperature, the method for supplying heat to said fractionation zones which comprises introducing a light hydrocarbon selected from the group consisting of propane and butane into said relatively low bottom temperature fractionation zone, thereby increasing the relative proportion of light hydrocarbons in said relatively low bottom temperature fractionation zone, withdrawing a hydrocarbon stream from the lower portion of the relatively high temperature fractionation zone, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with said hydrocarbon stream, contacting said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of said hydrocarbon stream is increased to above the temperature maintained in the lower portion of said relatively high temperature fractionation zone, and returning said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

9. In a reforming process in which naphtha is reformed under reforming conditions in the presence of a reforming catalyst and the hot product is cooled and is fractionated in successive fractionation zones operated at lower temperatures than the temperature of the hot product, one of said fractionation zones being operated at a relatively high bottom temperature and another of said fractionation zones being operated at a relatively low bottom temperature, the method for supplying heat to said relatively high and relatively low temperature fractionation zones which comprises withdrawing a hydrocarbon fraction comprising propane and butane from the upper portion of said relatively high temperature fractionation zone, passing said fraction to said relatively low temperature fractionation zone, thereby increasing the relative proportion of light hydrocarbons present in said relatively low temperature fractionation zone, withdrawing a hydrocarbon stream from the lower portion of said relatively high temperature fractionation zone, supplying heat to the lower portion of said relatively low temperature fractionation zone by indirect heat exchange with a portion of said hydrocarbon stream, thereby cooling said portion of said hydrocarbon stream, recovering a part of said cooled portion as a product of the process, contacting the remainder of said hydrocarbon stream in indirect heat exchange with said hot product, whereby the temperature of the remainder of said hydrocarbon stream is raised to above the temperature of the lower portion of said relatively high temperature fractionation zone and returning the remainder of said hydrocarbon stream to the lower portion of said relatively high temperature fractionation zone.

10. In a hydrocarbon conversion process in which a hot reaction product stream is cooled and is fractionated successively in first and second fractionation zones operated at lower temperatures than the temperature of the hot product, said first fractionation zone being op-

11

erated at a relatively low bottom temperature and said second fractionation zone being operated at a relatively high bottom temperature, the method for supplying heat to said first and second fractionation zones which comprises supplying heat to the lower portion of said second fractionation zone by indirect heat exchange with said hot product stream, supplying heat to the lower portion of said first fractionation zone by indirect heat exchange with material from the lower portion of said second fractionation zone, and thereafter fractionating

12

said hot product stream successively in said first and second fractionation zones.

References Cited in the file of this patent

UNITED STATES PATENTS

1,764,190	Bell	June 17, 1930
1,899,897	Loomis	Feb. 28, 1933
2,348,681	Houghland	May 9, 1944
2,429,115	Atkins	Oct. 14, 1947
2,711,385	Hannah	June 21, 1955

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,954,341

September 27, 1960

Samuel R. Stiles

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 28, for "fractitionation" read -- fractionation --; column 2, line 4, for "test" read -- heat --; column 5 line 6, for "67" read -- 68 --; line 27, strike out "as"; same column 5, line 38, for "86" read -- 88 --; column 8, line 22, for "hig" read -- high --; line 47, for "sydrocarbon" read -- hydrocarbon --.

Signed and sealed this 11th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents