Feb. 22, 1944. W. B. PLUMMER 2,342,166

PROCESSING WELL FLUIDS

Filed June 25, 1941 2 Sheets-Sheet 1

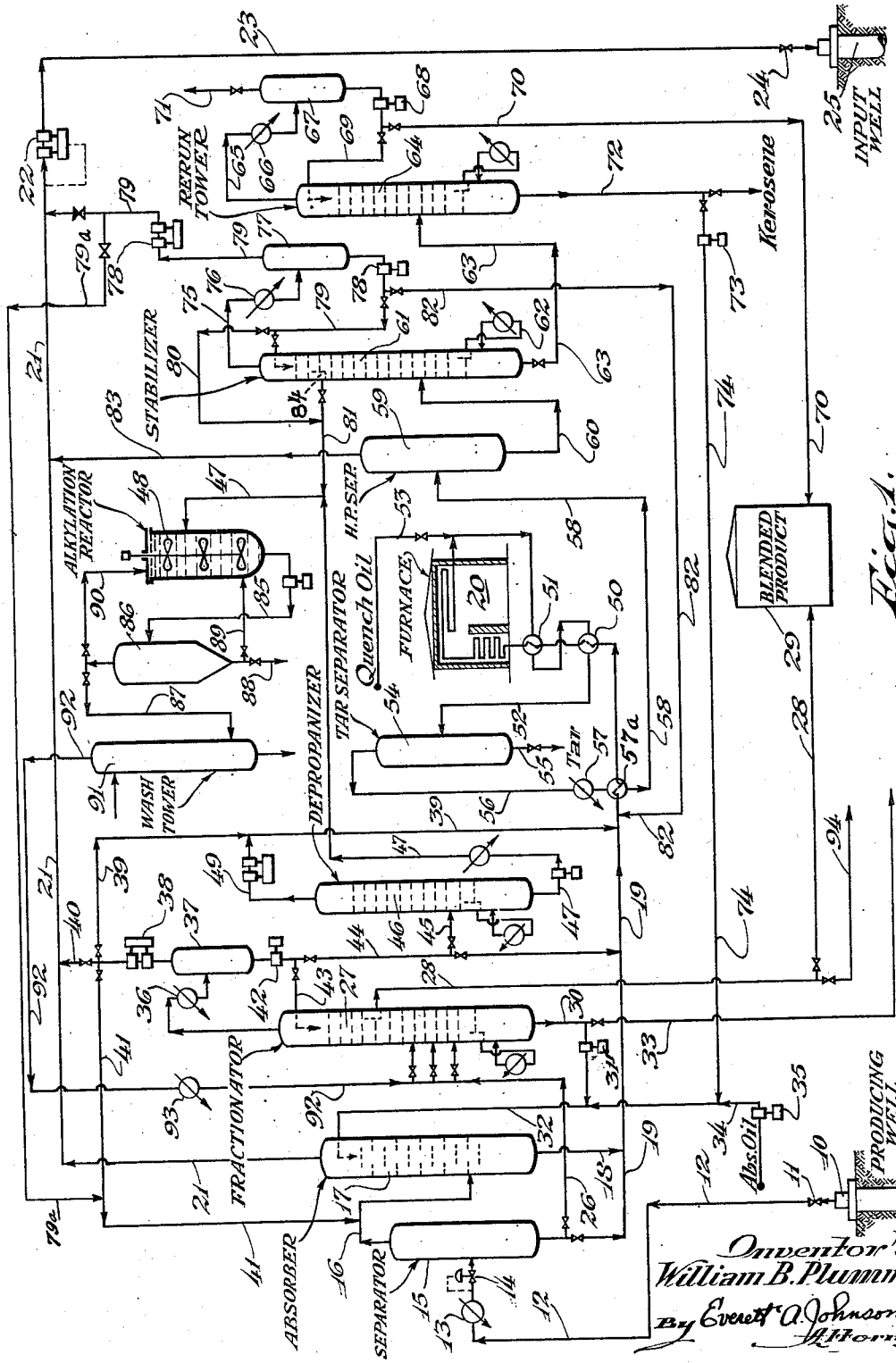


Fig. 1.

Inventor:
William B. Plummer
By Everett A. Johnson
Attorney

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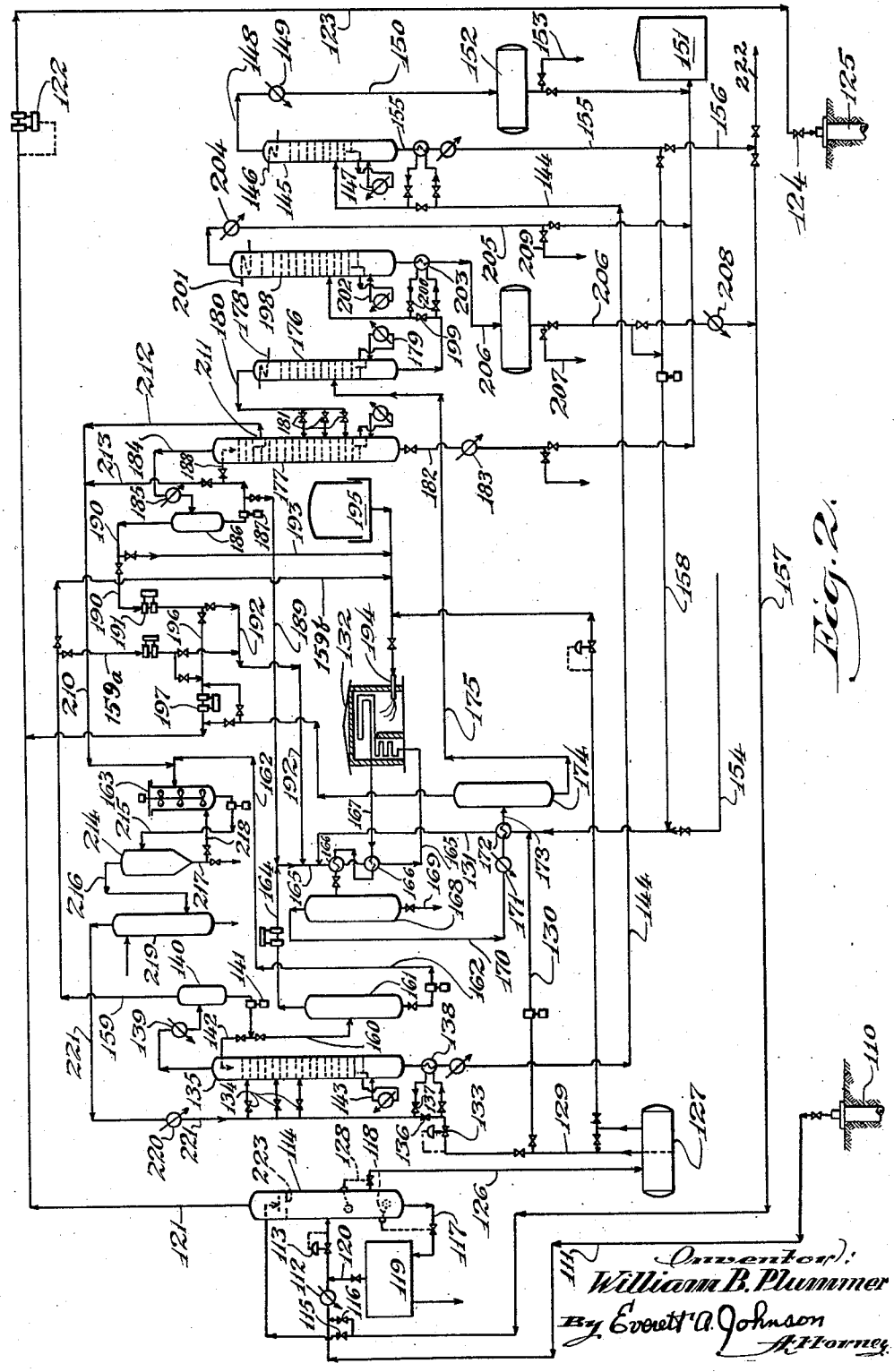


Fig. 2.

Inventor:
William B. Plummer
By Everett A. Johnson
Attorney

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UNITED STATES PATENT OFFICE

2,342,166

PROCESSING WELL FLUIDS

William B. Plummer, Chicago, Ill., assignor to Standard Oil Company, Chicago, Ill., a corporation of Indiana

Application June 25, 1941, Serial No. 399,663

1 Claim. (Cl. 260—683.4)

This invention relates to methods of hydrocarbon conversion which are particularly applicable for use in connection with wells of the so-called distillate or condensate type, although applicable also in connection with production from other types of wells when it is desired to cycle gas to repressure an underground formation. More particularly this invention relates to a combination process of distillate recovery and gas reversion.

Production from certain deep hydrocarbon reservoirs of the so-called distillate type is wholly or largely in the vapor phase although these vapors contain substantial amounts of normally liquid hydrocarbons commonly including gasoline hydrocarbons and hydrocarbons boiling somewhat above the gasoline range. The existence of these hydrocarbons in the vapor phase in the sub-surface reservoir is due to the high pressure existing in the formation which brings about a phenomenon known as retrograde vaporization, whereby a hydrocarbon system which would give a liquid phase as well as a vapor phase at moderate pressures or even at atmospheric pressure exists as a single dense vapor phase in the reservoir. If gases coming from these extremely high pressure wells, e. g., at pressures of the order of 4000 pounds per square inch, are reduced in pressure to pressures of the order of 1000 to 1200 pounds per square inch, a condensate will form. In handling production from such reservoirs, the well fluids are reduced in pressure and sometimes cooled to bring about the phenomenon of retrograde condensation, whereby a large part of the normally liquid hydrocarbons and also a substantial part of three and four carbon atom hydrocarbons are thrown out in the liquid phase and separated. This liquid phase then can be stabilized or flashed at atmospheric pressures. The gases originally separated, as well as those resulting from the stabilization or flashing operation, are recycled to the underground formation from which they were produced, thereby maintaining the pressure in such formation and maintaining or enhancing the retrograde vaporization phenomenon therein. Such procedure greatly improves the ultimate recovery from the reservoir. In some instances these gases are used for the maintenance of the pressure in or the repressuring of an underground reservoir other than that from which they originated.

It also has been proposed to recover the liquid components of high pressure well fluid by a process of high pressure absorption at well head pressure or at some intermediate pressure between well head pressure and the pressure at which the maximum recovery would be effected by pressure reduction alone.

It is an object of my invention to provide methods of improving the yield of motor fuel in connection with production from oil and gas wells and particularly with production from wells of the distillate type. Another object of the invention is to obtain the increased production of motor fuel without substantially diminishing the volume of gas available for recycling to the subsurface reservoir or for cycling to a different one. A further object is to provide a method for increasing the yield of motor fuel from the producing operations and simultaneously increasing the amount of gas available for repressuring.

Another object of my invention is to provide a gas of improved characteristic for pressure maintenance or repressuring purposes. Another feature and object of this invention is the provision of a gas reversion process in conjunction with a retrograde condensation or high pressure absorption operation in which the gas reversion and distillate recovery processes are combined to accomplish results which cannot be accomplished by either process alone. More particularly it is an object of my invention to combine a distillate recovery operation and a gas reversion process using in part the same equipment for both operations.

A still further object of my invention is to provide a process wherein the isobutane from distillate wells may be alkylated with olefins from the thermal gas reversion of the distillate. Other and more detailed objects and advantages of my invention will become apparent as the description thereof proceeds.

The production from distillate wells normally includes a large amount of methane and lesser amounts of higher paraffinic hydrocarbons. Ordinarily this includes a substantial amount of C_2, C_3 and C_4 hydrocarbons, a substantial amount of hydrocarbons in the gasoline boiling range, i. e., up to about 400° F., and usually some still heavier hydrocarbons in varying amounts. In distillate recovery, whether by retrograde condensation or high pressure absorption types of process, it is customary to recycle practically all of the C_1, C_2 and C_3 hydrocarbons and a large part of the C_4 hydrocarbons to the underground formation. The desirable normally liquid hydrocarbons are recovered and are not available for recycling. Therefore, because of the diminished supply of recycle gas, pressure maintenance is not ordinarily completely successful. The process of my invention, however, uses certain of these lower

hydrocarbons for the production of additional amounts of hydrocarbons boiling in the motor fuel range without seriously diminishing the supply of gases available for recycling and in many instances it serves to increase the supply and to improve the function of the gases in the sub-surface retrograde vaporization phenomenon.

Briefly this is accomplished by first separating the distillate from gases by retrograde condensation or by high pressure absorption at pressures of about 1000 pounds per square inch or more, and maintaining the gases under said pressure. These gases are available for recycling and since at least 90 mol per cent of the gas is returned to the formation and the cost of recompression is very considerable, it is desirable and important from an economy standpoint to reduce the pressure as little as possible. I then separate the distillate into a predominantly C_3 and C_4 fraction, a light naphtha in the gasoline boiling range, and a heavy naphtha. The heavy naphtha and the normally gaseous C_3 and C_4 hydrocarbons are fed in a common stream to a gas reversion furnace to produce a high antiknock rating naphtha of gasoline boiling range plus gases which together with unused gas from the initial high pressure separation step are recycled to the formation. Likewise, all or a part of the total distillate can be fed to a gas reversion furnace.

My invention will be described further with particular reference to the accompanying drawings which show in Figures 1 and 2, respectively, two alternative flow diagrams illustrating my invention. These drawings form a part of this specification and in them like reference numerals indicate like or corresponding parts.

Referring now to Figure 1: A producing well 10 furnishes well fluids from a sub-surface reservoir which is normally a deep high pressure reservoir of the distillate type. A single well is shown but of course it will be apparent that the production from any number of such producing wells can be combined and that normally my process will operate on the combined production from a group of such producing wells. The well fluids pass through valve 11 and then through line 12, cooler 13 and pressure reduction valve 14 to separator 15. The cooler and pressure reduction valve are controlled to give a temperature and pressure in the separator 15 which may be varied within considerable limits depending on the desired operation and particular character of the well finish. However, they are such as to give a substantial recovery of liquid hydrocarbons by means of the retrograde condensation phenomenon. The pressure in separator 15 normally will be between 800 pounds per square inch and 3000 pounds per square inch, and is chosen on an economic basis, i. e., pressure should be as high as possible in order to reduce the cost of recompressing the gases. On the other hand, a lower pressure within the retrograde condensation range permits the separation of a larger amount of the liquid phase. The lower limit of the retrograde condensation range varies with the composition of the particular well fluids and in most cases the pressure in separator 15 should be above about 1000 pounds per square inch.

Recovery of liquids in separator 15 is better at lower temperatures but the temperature used is dependent upon the economic factor involving the cost of cooling and the cost of eliminating hydrate difficulties. The apparatus can be operated at temperatures of from −25° F. to +125° F. but ordinarily it is operated in the temperature range of 0° F. to 75° F.

Gas phase formed in the retrograde condensation separator 15 is predominantly methane but also includes ethane and minor amounts of heavier hydrocarbons. This gas phase passes through line 16 and through absorber 17 where it is contacted with recycle oil from the gas reversion operation, supplemented if desired by extraneous naphtha or the heavy portion of the distillate. The rich oil from the absorber 17 passes by lines 18 and 19 to gas reversion furnace 20. The gas phase from absorber 17 passes through line 21 and compressor 22 and thence through line 23 and valve 24 to one or more input wells 25, through which it is recycled to the underground formation from which production was effected through well 10. Alternatively, it may be cycled to a different sub-surface reservoir for pressure maintenance or repressuring purposes.

The liquid phase formed in separator 15 includes not only a major part of the normally liquid hydrocarbons present in the well fluids but also includes substantial amounts of normally gaseous hydrocarbons particularly C_3 and C_4 paraffinic hydrocarbons. This liquid phase is excellent feed for the gas reversion process and can be sent by line 19 to furnace 20 and subjected to gas reversion under high pressure. However, when desired, the liquid phase can be passed from separator 15 to high pressure fractionator 27 by valved line 26. From the fractionator 27 a light naphtha cut comprising normal butane can be withdrawn through valved line 28 and passed to blended product tank 29. The liquid product in tank 29 includes the gasoline produced both by the distillate recovery step and the gas reversion step. A heavy naphtha can be withdrawn from fractionator 27 by line 30 and passed by pump 31 and line 32 to absorber 17 as absorber oil or withdrawn from the system by valved line 33. Auxiliary absorber oil can be furnished to the process by valved line 34 and pump 35.

Overhead from fractionator 27 passes through partial condenser 36 to separator 37 from which gas can be taken off through compressor 38. These off gases can be sent by valved line 39 and line 19 to the gas reversion furnace. Alternatively all or a portion of the gases can be returned to the high pressure gas line 21 by valved line 40 and thence to the input well 25. Alternatively these gases can be returned to absorber 17 by valved line 41 and line 16. The liquids from this separator 37 are withdrawn by means of pump 42 and a portion of them is returned to the top of the fractionator 27 through valved line 43 to serve as reflux. Another portion of the liquid fraction can be sent via valved line 44 to form part of the feed to gas reversion furnace 20. Preferably, however, it can be passed by valved line 45 to depropanizer 46. The liquid isobutane is withdrawn from tower 46 and pumped through line 47 to alkylation reactor 48 and processed as described below. The propane and other gases removed overhead from tower 46 by line 49 are liquefied and pumped or compressed and sent by line 39 to the gas reversion furnace 20.

All or a part of the total distillate or the combined stream of hydrocarbons including the rich absorber oil, C_3 and C_4 hydrocarbons, and fixed gases from the distillate recovery and/or gas

reversion can be passed through line 19, heat exchangers 50 and 51 to gas reversion furnace 20 for conversion into the normally liquid hydrocarbons, particularly gasoline range hydrocarbons.

Referring to the gas reversion step in more detail, the hydrocarbons entering the furnace are preheated by means of heat exchangers 50 and 51 and then passed by any desired routing through the coils of the gas reversion furnace. The gas reversion step is carried out at a temperature of from about 900 to about 1100° F., for example 975° F., and at a pressure of between 100 and 3000 pounds per square inch, for example 1500 pounds per square inch. It is preferred to operate the gas reversion furnace at a high pressure, preferably at least 1000 pounds per square inch.

The hot products from the gas reversion furnace 20 pass by transfer line 52 to the heat exchangers 51 and 50 where it serves to preheat the incoming hydrocarbons. If desired these hot reversion products can be quenched by the introduction of quench oil at 53. The high pressure separation of the lighter fixed gases can be made immediately following the thermal gas reversion process before or after tar separation. Thus hydrogen, methane, and more or less ethane, can be separated at a pressure of between about 750 and 1500 pounds per square inch, compressed and recycled to the formation.

The gas reversion products pass by line 52 into tar separator 54. The tar is withdrawn from the system by valved line 55. The overhead from tar separator 54 is passed by line 56, cooler 57, heat exchanger 57a, and line 58 to high pressure separator 59. This separator can be operated at a pressure of between about 800 and about 3000 pounds per square inch. The temperature ordinarily will be below about 200° F. The recovered gas reversion products are withdrawn from the base of high pressure separator 59 in the liquid phase and passed by line 60 to stabilizer 61 which can be provided with reboiler 62. The high pressure gases from separator 59 can be taken by line 83 to high pressure line 21 and passed to input well 25.

The liquid product from stabilizer 61 is passed by line 63 through rerun tower 64 to produce a gasoline end point naphtha overhead which is withdrawn through line 65 and partial condenser 66 to separator 67. The liquid phase can be sent in part through pump 68, valved line 69 to the top of the rerun tower 64 as reflux, and in part through valved line 70 to the product storage tank 29. Any gases accumulated in separator 67 can be vented through valved line 71. A kerosene-gas oil cut is obtained as a bottoms which either may be withdrawn from the system by valved line 72 or returned as absorber oil to the absorber 17 by pump 73 and line 74, thus ultimately being recycled to the gas reversion step. If desired, this liquid product may have a comparatively low initial boiling point thereby containing the heavy portions of what is normally considered gasoline, thus producing through line 70 a light, very high octane number gas-converted product.

Gases from the stabilizer 61 are taken off through line 75 and partial condenser 76 to separator 77. The liquid phase can be sent in part by pump 78 and valved line 79 to the top of stabilizer 61 as reflux or by valved lines 80, 81, and 47 to alkylation reactor 48. Another portion can be routed through valved line 82 and line 19 to the gas reversion furnace 20. In the preferred embodiment, however, the olefins contained in the liquid phase withdrawn from separator 77 are alkylated with the isobutane recovered from the well distillate. Trapout 84 is provided to recover from stabilizer 61 a propane-propylene cut with some C_2 and C_4 hydrocarbons which are sent by line 81 to alkylation reactor 48. The gas phase from separator 77 passes by compressor 78 in line 79 to high pressure gas line 21 and thence to the input well 25. Likewise, the gases leaving compressor 78 can be introduced into lines 79a and 41 and thence absorber 17 by line 16.

Referring more in detail to the alkylation process, the olefins via line 81 and the isobutane fraction recovered from depropanizer 46 are passed to alkylation reactor 48.

The reactor 48 can be of any type in which intimate contacting of the feed wtih the catalyst is accomplished.

Concentrated sulfuric acid containing between about 93% and about 101.5% H_2SO_4 and preferably about 96–97% H_2SO_4 at temperatures of between about 15° F. and about 95° F. and preferably at about 65° F. is a particularly effective catalyst for the alkylation of paraffins with olefins. According to my process the isobutane present in line 47 is alkylated with olefins of 3 and 4 carbon atoms using as a catalyst sulfuric acid of the above concentration under the above conditions.

The emulsified hydrocarbon-acid mixture from reactor 48 is directed to separator 86 through line 85. In separator 86 sufficient additional contact between the catalyst and the feed stock is accomplished to obtain additional alkylation. The emulsion in separator 86 breaks, the alkymer and unreacted gases passing overhead through line 87 and the separated acid being withdrawn through line 88. This acid can be recycled to reactor 48 through line 89 or withdrawn, or a portion of it can be recycled and a portion of it continuously withdrawn for regeneration.

A portion of the alkymer and unreacted hydrocarbons can be recycled to reactor 48 from line 87 through valved line 90. It is desirable to neutralize or wash the reaction products before introducing into a fractionator to prevent acid, SO_2, etc., from carrying over. To accomplish this washing tower 91 can be provided wherein the product from line 87 is contacted with water or dilute caustic, or both. The product is then cooled in cooler 93 and passed by line 92 to fractionator 27. In fractionator 27 an alkymer of gasoline boiling range is separated and withdrawn through line 28 by which it can be directed to blending tank 29 or withdrawn for separate use through valved line 94. Any hydrocarbons heavier than gasoline are withdrawn through line 30 and rejected from the system by valved line 33 or sent by lines 31 and 32 as absorber oil in tower 17. Unconverted gases pass overhead from fractionator 27, partial condenser 36 and separator 37.

While the simple flow diagram and arrangement of apparatus shown in Figure 1 is advantageous in many respects it is also desirable in some instances to use more extensive processing and equipment. This is particularly true where large production is available and where the characteristics of the formation and well fluids are such that the production of the well or wells declines only very slowly so that a high capital investment is justified in obtaining increased ef-

ficiency. Figure 2 illustrates some of these possibilities.

Referring to Figure 2 in more detail the production from one or more producing wells 110 which are preferably of the distillate type passes through line 111 cooler 112 and pressure reduction valve 113 to separator absorber 114, which, if valves 115 and 116 are closed and no absorber oil is introduced, operates as a retrograde condensation separator similar to that shown in Figure 1. One difference, however, is that Figure 2 shows the use of an antifreeze system as one method of preventing natural gas hydrate trouble. A liquid or gas antifreeze material, for example calcium chloride brine, can be circulated with the well fluids through pressure reduction valve 113 and this serves to prevent the formation of natural gas hydrates. In the case of liquid antifreeze material the antifreeze separates at the bottom of vessel 114 and is withdrawn by valved line 117 under control of float 118 which floats at the interface between the antifreeze and the hydrocarbons. The antifreeze is withdrawn to a regeneration, storage and recycling system 119 from which it goes back into the line either preceding or following cooler 112. In Figure 2 the regenerated antifreeze is returned by valved line 120 between cooler 112 and pressure reduction valve 113.

It will be understood, however, that some of these apparatus arrangements may be omitted depending upon the character of the well fluids and the character of the subsequent operations, thus for example, if the well fluids are available at moderate pressures, for instance, 1500 to 3000 pounds per square inch, a pressure reduction ordinarily will not be needed and is not desirable. If the product is very low in water content or if the absorber 114 is operated at a temperature above that at which hydrates form under the particular conditions involved, the antifreeze step can be omitted. An alternative method of avoiding the natural gas hydrates is to dry the well fluids by passing them through a drier, calcium chloride for example. In such an operation it is desirable to have two or more drying chambers with one on stream while the second is regenerated.

The well fluids enter a high pressure separator-absorber 114 and the gases, chiefly methane, pass from the separator into line 121 and compressor 122, shown controlled by the pressure in line 121, through line 123 and valve 124 to one or more input wells 125. The liquid hydrocarbons are withdrawn from vessel 114 through valved line 126 to surge tank 127. The flow of distillate fluid from vessel 114 is controlled by the depth of the liquid hydrocarbons within the separator-absorber and float control valve 128 can be provided for this purpose. The surge drum can be operated at about the same pressure as separator 114. Thus for instance the retrograde condensation separator-absorber 114 can be operated at about 1500 pounds per square inch and the surge drum 127 operated at about 1200 pounds per square inch.

The liquid from surge drum 127 can be passed by valved lines 129, 130 and 131 to high pressure gas reversion furnace 132. Likewise, all or a portion of the liquid product withdrawn from the separator-absorber 114 can be passed through pressure reduction valve 133 and one of valved lines 134 into stabilizer 135. Before entering the stabilizer all or a part of the liquid can be passed in heat exchange with the stabilized product by wholly or partially closing valve 136 and opening the valves 137, thereby passing the cool stream from the surge drum through the heat exchanger 138.

In stabilizer 135 hydrocarbons lighter than butane are removed and the stabilizer is operated at such pressure, top temperature and reflux ratio as to eliminate part of the gaseous hydrocarbons as are not desired in the finished motor fuel. Reflux can be furnished by passing the overhead from stabilizer 135 through a partial condenser 139 to a separator 140 from which a part of the liquid phase can be pumped by means of pump 141 through valved line 142 back into the top of stabilizer 135. When desired reboiler 143 can be provided near the base of stabilizer 135.

The liquid product from tower 135 includes one source of the liquid feed to the gas reversion process. It is withdrawn through heat exchanger 138 and valved line 144 to rerun tower 145 which is provided with a dephlegmating coil 146 and reboiler 147. Stabilized gasoline of a desired end point is taken off overhead through line 148, passed through cooler 149 and by line 150 ultimately is carried to blended product storage 151. However, intermediate storage 152 and light naphtha draw-off 153 can be provided. The heavy distillate withdrawn from the bottom of rerun tower 145 constitutes the main liquid stream to the gas reversion furnace 132. However, extraneous naphtha can be introduced to the system by valved line 154, for example. When desired a portion of the heavy naphtha withdrawn from rerun tower 145 by line 155 can be sent via valved lines 156 and 157 to the high pressure absorber 114 as an absorber oil. When the vessel 114 is operated merely as a retrograde condensation separator, substantially all of the recycle gas oil and heavy naphtha is pumped to the gas reversion furnace 132 by valved lines 158 and 131.

Overhead from fractionator 135 passes through partial condenser 139 to separator 140 from which gas can be taken off through valved line 159. These off-gases can be sent by valved line 159*a* to the gas reversion furnace as charging stock or by valved line 159*b* as fuel in the furnace. Alternatively, all or a portion of the gases can be returned to the high pressure gas line 121. The liquids from separator 140 are withdrawn by means of pump 141 and a portion of them is returned to the top of the fractionator 135 through valved line 142 to serve as reflux. Another portion of the liquid fraction can be sent to form part of the liquid feed to the gas reversion furnace. Preferably, however, it can be passed by valved line 160 to depropanizer 161. The liquid isobutane is withdrawn from the depropanizing tower 161 and pumped through line 162 to alkylation reactor 163 and processed as described hereinbelow. The propane and other gases removed overhead from tower 161 by line 164 are compressed and sent by line 165 to the gas reversion furnace 132.

Referring to the gas reversion step in more detail, the hydrocarbons entering the furnace are preheated by means of heat exchangers 166 and then passed by any desired routing through the coils of the gas reversion furnace. The gas reversion step is carried out at a temperature of between about 900° F. and about 1100° F., for example about 975° F., and at a pressure between about 100 and about 3000 pounds per square inch. It is preferred to operate the gas reversion furnace at a high pressure, preferably at least 1000

pounds per square inch, for example 1500 pounds per square inch.

The hot products from the gas reversion furnace 132 pass by transfer line 167 to the heat exchangers 166 where they serve to preheat the incoming hydrocarbon stream, or, if desired, these hot gas reversion products can be quenched. The high pressure separation of the lighter fixed gases can be made immediately following the thermal gas reversion process either before or after tar separation. Thus hydrogen, methane and more or less ethane can be separated at a pressure of between about 750 and 1500 pounds per square inch, compressed and recycled to the formation.

In the embodiment illustrated in Figure 2 the gas reversion products pass by line 167 into tar separator 168. The tar is withdrawn from the system by valved line 169. The overhead from tar separator 168 is passed by line 170 to a cooler 171, heat exchanger 172, and by line 173 to the high pressure separator 174. The heat exchange medium in exchanger 172 can be the cold distillate withdrawn from vessel 114. The high pressure separator following the gas reversion process can be operated at a pressure of between about 800 and about 3000 pounds per square inch, which is substantially the pressure at the outlet of the gas reversion furnace. The temperature ordinarily will be below about 200° F.

The recovered gas reversion products are withdrawn from the base of high pressure separator 174 in the liquid phase and passed by line 175 to fractionator 176 and ultimately to stabilizer 177. The feed from the high pressure separator to the fractionator can be passed in heat exchange with the bottoms from the stabilizer 177 if desired.

Ordinarily the fractionator 176 is operated in such fashion that a liquid phase is removed as bottoms, which can be used as liquid feed to the gas reversion step, and a gas phase is taken overhead to stabilizer 177. Fractionator 176 can be supplied with dephlegmating coil 178 and a reboiler 179. The overhead from this fractionator 176 passes into stabilizer 177 via line 180 and one of the alternative valved lines 181. The motor fuel fraction can be withdrawn from the stabilizer 177 by valved line 182 and passed to storage through cooler 183 which can be an exchanger on line 175. The overhead from stabilizer 177 passes through line 184 and partial condenser 185 to separator 186. A portion of the liquid phase from this separator can be passed by pump 187 through valved line 188 to serve as reflux in stabilizer 177. The remainder of the liquid phase can be recycled through valved line 189 and line 165 to the coils of the gas reversion furnace 132. Those materials which cannot be condensed by condenser 185 and appear as the gas phase in separator 186 can be used as fuel, can be compressed and recycled to the high pressure gas reversion process, or can be compressed and recycled to the high pressure gas line 121. Thus it can be passed through valved line 190, compressor 191, valved line 192, etc., to the coils of the gas reversion furnace 132, or through valved line 193 to burner 194 or fuel gas storage 195, and/or it may be passed through valved line 196, compressor 197, etc., to one or more input wells 125. In many instances it will be possible to eliminate part of the compressors illustrated, since ordinarily it will not be desired to use all of the possible alternative arrangements as shown.

Reverting now to the bottoms from fractionator 176, these contain gasoline range hydrocarbons and unconverted gas oil, and can, if desired, be passed in heat exchange with the recycle gas oil withdrawn from bubble tower 198 by closing valve 199 and opening valves 200. This bubble tower 198 is conventionally equipped with dephlegmating means 201 and reboiler 202. It is so operated as to eliminate a heavier-than-gasoline bottoms and a gasoline overhead. The latter is passed to condenser 204 and by line 205 to blended storage tank 151 while the bottoms pass through heat exchanger 203 and are recycled to gas reversion furnace 132 by valved line 206 and line 158, or withdrawn as a kerosene cut by valved line 207, or passed through cooler 208 and by line 157 to be used as absorber oil in vessel 114. The gasoline fraction recovered from bubble tower 198 can be blended with the products in storage tank 151 or may be withdrawn by valved line 209 for further treatment or use.

Referring more in detail to the alkylation process, the olefins via line 210 and the isobutane fraction recovered from depropanizer 161 are passed to alkylation reactor 163. A trapout 211 is provided to recover from stabilizer 177 a propane-propylene cut with some C_2 and C_4 hydrocarbons which are sent by lines 212 and 210 to the alkylation reactor 163. Alternatively these hydrocarbons can be obtained by valved line 213 from separator 186. The reactor 163 can be of any type in which intimate contacting of the feed with the catalyst is accomplished.

Concentrated sulfuric acid containing between about 93% and about 101.5% H_2SO_4 and preferably about 96–97% H_2SO_4 at temperatures of between about 15° F. and about 95° F. and preferably at about 65° F. is a particularly effective catalyst for the alkylation of paraffins with olefins. According to my process the isobutane introduced by line 162 is alkylated with olefins of 3 and 4 carbon atoms using as a catalyst sulfuric acid of the above concentration under the above conditions.

The emulsified hydrocarbon-acid mixture from reactor 163 is directed to separator 214 through line 215. In separator 214 sufficient additional contact between the catalyst and the feed stock is accomplished to obtain additional alkylation. The emulsion in separator 214 breaks, the alkymer and unreacted gases passing overhead through line 216, the separated acid being withdrawn through line 217. This acid can be recycled to reactor 163 through line 218 or withdrawn, or a portion of it can be recycled and a portion of it continuously withdrawn for regeneration. A portion of the alkymer and unreacted hydrocarbons can be recycled to reactor 163.

It is desirable to neutralize or wash the reaction products before introducing into a fractionator to prevent acid, SO_2, etc., from carrying over. To accomplish this washing tower 219 can be provided wherein the product from line 216 is contacted with water or dilute caustic. The product is then cooled in cooler 220 and passed by line 221 to fractionator 135. In fractionator 135 an alkymer of gasoline boiling range is separated and withdrawn through line 144 by which it can be directed to rerun tower 145. Any hydrocarbons heavier than gasoline are separated in the rerun tower and rejected from the system by valved line 222 or carried by lines 156 and 157 as absorber oil in tower 114, or passed to the gas reversion furnace by lines 158 and 131.

Although I have described a system wherein

the same fractionating tower is used on the recovered distillate and the alkylation product, it is also contemplated that separate fractionating systems can be used.

Vessel 114 when operated as an absorber usually can be operated at a somewhat higher pressure and, if desired, at a slightly higher temperature than when used as a retrograde condensation separator. Thus as an absorber its pressure may range from 1000 pounds per square inch to 4000 pounds per square inch, usually from about 1200 to 3000 pounds per square inch, for example 2000 pounds per square inch. The absorber oil in any desired ratio, for example 2 gallons to 6 gallons per thousand cubic feet of gas, can be introduced above baffles 223, or part of it or even all of it passed through cooler 112 into the absorber along with the well fluids. The absorber oil, comprising heavy distillate bottoms from rerun tower 145, recycle gas oil from bubble tower 198, or a mixture of heavy distillate and recycle gas oil, is removed from vessel 114 along with the distillate hydrocarbons and finds its way through surge drum 127, stabilizer 135, and rerun tower 145.

It will be understood, of course, that the various flow diagrams presented are merely illustrative of some of the possibilities and that other alternatives will occur to those skilled in the art in the light of this description and that my invention is not restricted to the details shown. On the other hand, it will also be understood that these flow diagrams are simplified for purposes of convenience and that various items of pumping and compressing equipment, insulation, control devices, safety equipment and various other details are not indicated.

This is a continuation-in-part of my application Serial No. 353,633, entitled "Processing well fluids," filed August 22, 1940.

I claim:

A method of recovering distillate hydrocarbons from high pressure well fluids and for the production of increased amounts of motor fuel hydrocarbons from said well fluids which comprises separating from said well fluids at pressures within the retrograde condensation a liquid fraction, subjecting the total liquid fraction to a fractionation in the presence of an alkylate derived from the source defined below, recovering an isobutane fraction, a propane fraction, a gasoline fraction and a residual liquid fraction, subjecting the residual liquid fraction and said propane fraction to a thermal conversion, separating a gas rich in C_2—C_4 olefins from the gaseous products of the conversion step, alkylating said isobutane fraction with said C_2—C_4 olefins to form hydrocarbons in the gasoline boiling range, fractionating the total alkylate with said liquid fraction, and recovering a combined alkymer and well fluid fraction of gasoline boiling range.

WILLIAM B. PLUMMER.