(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 October 2007 (18.10.2007)

PCT

(10) International Publication Number
WO 2007/117983 A2

(51) International Patent Classification:
C10G 45/00 (2006.01) *C10G 17/00* (2006.01)

(21) International Application Number:
PCT/US2007/064987

(22) International Filing Date: 27 March 2007 (27.03.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/396,100 30 March 2006 (30.03.2006) US

(71) Applicant *(for all designated States except US)*: **CHEVRON U.S.A. INC.** [US/US]; 6001 Bollinger Canyon Road - 3rd Floor, San Ramon, CA 94583 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **REYNOLDS, Bruce, E.** [US/US]; 1739 Jeane Circle, Martinez, California 94553 (US).

(74) Agent: **PRATER, Penny, L.**; Post Office Box 6006, San Ramon, California 94583-0806 (US).

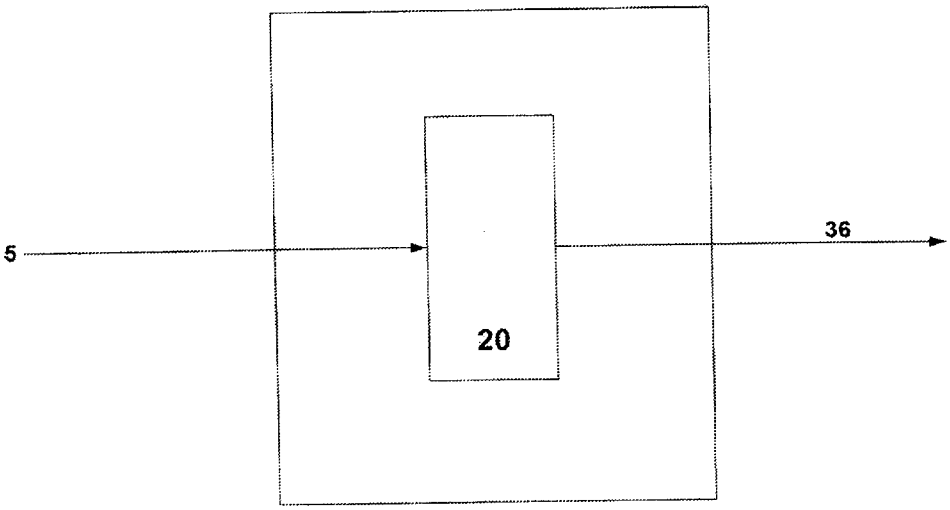
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: FULL CONVERSION HYDROPROCESSING



(57) **Abstract:** The present invention relates to a process for producing a synthetic crude with properties which make the synthetic crude particularly advantageous for refining in a conventional refinery. In the process, at least a portion of a crude or other hydrocarbon feedstream is upgraded in a reaction zone at very high levels of conversion. Reaction products are recovered as the synthetic crude.

WO 2007/117983 A2

FULL CONVERSION HYDROPROCESSING

FIELD OF THE INVENTION

The present invention relates to a process for producing a synthetic crude with properties which make the synthetic crude particularly advantageous for refining in a conventional refinery.

BACKGROUND OF THE INVENTION

Global energy usage continues to rise with no sign of abatement, creating a growing demand for oil resources. Light, sweet crude oil production is not increasing enough to meet this growing demand. Additionally, the reserves of light, sweet crude oil are being depleted more rapidly than new reserves are being found. To fill this gap, larger quantities of heavy oil feedstreams such as heavy crude oils or extra heavy crude oils derived from various carbonaceous resources are being brought on stream. The cost of development of these heavy crude oil resources has been decreasing over the last several decades making them more economical to recover.

Heavy crudes often require some processing to reduce their viscosity and to make them pumpable. Several processes which may be used for this purpose include partial upgrading by hydroprocessing, by coking or by blending the heavy crude with light hydrocarbons. Additives may also be used. Another alternative for handling heavy crude is to form an oil-in-water emulsion, optionally with the addition of additives to reduce the crude's viscosity. All of these processes create a pumpable generic type synthetic crude suitable for refinery processing. However, the economics of processing these pumpable generic type synthetic crudes are prohibitively expensive, because of the low conversion rates of the heavy crude oil resources.

U.S. Patent 3,369,992 discloses a distillate low pour point synthetic crude oil produced from a virgin distillate and a reduced crude from a high wax content and high pour point crude. This synthetic crude is formed by mixing the virgin distillate with a fraction obtained by coking the reduced crude. The coker overhead volatile

product is fractionated into a heavy stream for recycle to the coker and a distillate fraction which is recovered as a low pour point synthetic crude.

U.S. Patent 4,454,023 discloses a process, including visbreaking, distillation, and solvent extraction for rendering a heavy viscous crude pumpable.

U.S. Patent 5,233,109 discloses a synthetic crude produced by catalytically cracking a biomass material comprising a plant oil and/or an animal oil and/or a rubber material.

U.S. Patent 6,016,868 discloses an integrated process for treating production fluids to form a synthetic crude oil. The production fluids are recovered from the application of in situ hydrovisbreaking of heavy crudes and natural bitumen deposited in subsurface formations.

U.S. Patent Application Publication 2004/0164001 A1 discloses a business process that monetizes bitumen reserves utilizing proven refining processes to ultimately produce high quality refined oil products.

Additional disclosures relating to the preparation of a synthetic crude are taught in U.S. Patent 5,968,991; 5,945,459; 5,856,261; 5,856,260; 5,863,856 and 5,292,989.

While some processes have been proposed to reduce the viscosity of a crude, none have been offered for producing a synthetic crude which is tailored for the current needs of a particular refinery. Furthermore, no process has been described for producing a synthetic crude which is effectively vacuum gas oil or lighter.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides a process for treating a hydrocarbon feedstream such as a crude oil, and particularly a heavy crude oil containing high amounts of heteroatom and metallic contaminants and producing a high quality distillate product. The process comprises passing a portion, generally a high boiling portion, of the hydrocarbon feedstream over an unsupported slurry catalyst. Removal of the contaminants during the upgrading step, and reduction of the boiling point of the feed to the upgrading reaction zone, is sufficiently high that nearly

all of the reaction products from the reaction zone are removed as distillate products, for use as, or for blending with other materials to produce a synthetic crude.

In one embodiment, the synthetic crude is tailored to meet the needs of a particular refinery or group of refineries. Thus, an integrated process is offered for upgrading a heavy oil feedstream, comprising:

(a) acquiring a dataset of desired properties of a tailored synthetic crude to be processed in a single refinery or group of refineries;

(b) generating a feedstream dataset that characterizes a hydrocarbon feedstream;

(c) using the feedstream dataset to generate an upgrading dataset of select upgrading conditions for upgrading at least a portion of the hydrocarbon feedstream; and,

(d) upgrading at least a portion of the hydrocarbon feedstream at the select upgrading conditions to produce a synthetic crude having the desired properties.

In a separate embodiment, a synthetic crude is prepared by upgrading a heavy oil feedstream at high conversion rates. Thus, a process is provided for preparing a synthetic crude, comprising:

(a) fractionating at least a portion of a hydrocarbon feedstream in a 1st fractionation zone and producing an overhead product, at least one distillate stream and a heavy oil feedstream;

(b) upgrading at least a portion of the heavy oil feedstream at upgrading conditions sufficient to produce a treated product, with at least 80 vol% of the treated product boiling in the temperature range of 1000°F or less;

(c) fractionating the treated product in a second fractionation zone at conditions sufficient to produce a upgraded distillate product; and,

(d) recovering the upgraded distillate product to produce a synthetic crude.

In one embodiment, the synthetic crude further comprises at least one distillate stream from the fractionation of the hydrocarbon feedstream.

In a separate embodiment, the synthetic crude further comprises at least a portion of the heavy oil feedstream, and, optionally, at least one distillate stream from the fractionation of the hydrocarbon feedstream.

In another embodiment, the synthetic crude further comprises a second hydrocarbon feedstream, and, optionally, at least a portion of the heavy oil feedstream and, optionally, at least one distillate stream from the fractionation of the hydrocarbon feedstream.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the conversion of the heavy oil feedstream to synthetic crude in the upgrading reaction zone.

Figure 2 illustrates the conversion of the heavy oil feedstream to synthetic crude in multiple reaction zones.

Figure 3 The process of Figure 2, further disclosing an integrated hydrofinisher

Figure 4 The conversion process of Figure, 3 wherein heavier materials are mixed with the effluent of the integrated hydrofinisher.

DETAILED DESCRIPTION OF THE INVENTION

Feedstream Characteristics

Crude oil is a suitable feedstream to the process of this invention. The crude oil comprises a fraction, termed a residuum, which boils at temperatures greater than 700°F, in some cases above 850°F or even 1000°F. The upper limit of the boiling point temperature range of the residuum is not critical. An example upper limit is 1500°F. Typically, the residuum has an API gravity that ranges from 12 to less than 0, and a viscosity greater than 5000 cP at 100°F. The residuum generally has a

significantly high concentration of nitrogen, sulfur, metal contaminants, and asphaltenes. The sulfur content of the residuum will be generally above 2%. A residuum containing greater than 4% sulfur and even greater than 6% sulfur can be processed as described herein. The nitrogen content of the residuum to the process will be above 0.3%. A residuum containing greater than 0.5% nitrogen and even greater than 1% nitrogen can also be processed as described herein. The residuum can contain more than 25 ppmw of metal contaminants such as nickel and/or vanadium. A residuum containing greater than 50 ppmw metal contaminants and even greater than 100 ppmw metal contaminants can be processed as described herein.

The feedstream to this invention may be characterized as a crude oil, such as the product from a hydrocarbonaceous originating from a natural resource. The feedstream may also originate as bottoms from a fractionation process, as a residuum bottom process stream oil, as heavy synthetic oil, as recycled oil wastes or polymers. The feedstream may also originate from other hydrocarbon sources, including, for example, bitumen, tar sands, coal, lignite, peat and oil shale.

Any crude oil feed may be used as feedstream to this invention. However, the process is particularly effective if the crude oil feed is a heavy, contaminated crude, which can be substantially rendered more easily processed by addition of the upgraded product in preparing the synthetic crude.

Synthetic crude

The tailored synthetic crude which is prepared according to the invention is generally a broad boiling hydrocarbon material comprising one or more components which have been modified by reaction. The synthetic crude is prepared as a feedstream for a refining operation, with the reactions and reaction conditions used in preparing the synthetic crude being selected to meet the needs of a particular refinery, a group of refineries, or the refining industry. While not required, the synthetic crude is frequently prepared near the source of the feedstream.

The feedstream of this invention is contacted with a catalyst in an upgrading reactor to produce a treated product. The treated product comprises at least one distillate product which is subsequently recovered from a fractionation zone. The

distillate fraction generally boils in the temperature range of less than 1000°F. A typical distillate fraction prepared according to the invention boils within the temperature range of C5 -1000°F. The distillate fraction may alternately boil within the temperature range of C5 – 900°F. The distillate fraction will typically contain less than 4 % by weight sulfur, preferably less than 2% by weight sulfur and more preferably in the range of 0.2 to 2.0 % by weight sulfur. The distillate fraction will typically contain less than 100 ppmw total metal contaminants, preferably less than 75 ppmw total metal contaminants, and more preferably less than 30 ppmw total metal contaminants. The °API Gravity of the distillate fraction will typically be greater than 5, preferably greater than 10 and more preferably in the range of 20 to 45. Because the synthetic crude may be tailored to meet the requirements of a single refinery or group of refineries, it will be recognized that a particular distillate fraction from which the synthetic crude is formulated may meet one or more, but fewer than all, of the boiling range, sulfur, nitrogen and metal limitations recited herein. This is expected, since each target refinery will have varying needs which may further vary from time to time through the year.

Upgrading Process

The upgrading process, referred to in Figures 1-4 of the present invention, renders a heavy oil feedstream for more readily processing in conventional refinery operations to make desired products, such as fuels, lubricants, chemical intermediates, and the like. In one embodiment, the upgrading process comprises hydroprocessing, using a hydroprocessing catalyst at hydroprocessing conditions. Such processes include hydrofinishing, hydrocracking and hydrodewaxing. In one embodiment, the upgrading process comprises contacting the heavy oil feedstream with hydrogen in the presence of a catalyst for removing contaminants from the heavy oil feedstream and for reducing the boiling point range of the heavy oil feedstream. The effectiveness of the upgrading process may be indicated by the degree of conversion. For purposes of this disclosure, conversion is defined as the volumetric amount of 1000°F+ material present in the upgrading product per unit time, divided by the volumetric amount of 1000°F+ material present in the heavy oil feedstream per unit time, subtracted from 1. Conversion is reported here in terms of volume %.

The hydrocarbon feedstreams , the heavy oil feedstreams and the distillate products of Figures 1-4 may each, separately or in combination, be optionally treated in an upgrading step in addition to the upgrading step of the invention. Optional treatment processes may selected from carbon rejection processes such as fluid coking, hydrocoking, or Flexicoking. Hydrogen addition processes such as hydrocracking, hydrofinishing, hydrodewaxing, hydrofinishing, hydrodesulphurization, hydrodenitrification, hydrodemetallization, etc may also be employed. The conditions for the upgrading processes disclosed in this invention are well known to those in the refining arts.

In a preferred embodiment, the upgrading process of the present invention comprises contacting the heavy oil feedstream with hydrogen in the presence of a slurry catalyst. In one respect, the slurry catalyst is a finely divided solid material with catalytic properties for removing the contaminants such as sulfur, nitrogen and metals from the heavy oil feedstream, and for reducing the asphaltene and aromatic content of the heavy oil feedstream.

A catalyst composition which is useful for the present upgrading process is disclosed, for example, in U.S. Patent Application 10/938202 filed September 10, 2004 and U.S. Patent Application 10/938003 filed September 10, 2004, both of which are incorporated herein by reference for all purposes. This catalyst composition is an unsupported slurry catalyst composition, and preferably an unsupported molybdenum sulfide based catalyst. U.S. Patent Application 10/938202 teaches a catalyst composition prepared by a series of steps, involving mixing a Group VIB metal oxide and aqueous ammonia to form an aqueous mixture, and sulfiding the mixture to form a slurry. The slurry is then promoted with a Group VIII metal. Subsequent steps involve mixing the slurry with a hydrocarbon oil and combining the resulting mixture with hydrogen gas and a second hydrocarbon oil having a lower viscosity than the first oil. An active catalyst composition is thereby formed. A catalyst composition which also may be useful for the present invention is U.S. Patent Application 10/938003. This application discloses a slurry catalyst composition prepared in a series of steps, involving mixing a Group VIB metal oxide and aqueous ammonia to form an aqueous mixture, and sulfiding the mixture to form a slurry. The slurry is then promoted with a Group VIII metal. Subsequent steps involve mixing the slurry

with a hydrocarbon oil, and combining the resulting mixture with hydrogen gas (under conditions which maintain the water in a liquid phase) to produce the active slurry catalyst.

DETAILED DESCRIPTION OF THE INVENTION

Reference is now made to Figure 1, which illustrates an embodiment of the invention.

In Figure 1 a synthetic crude 36, boiling below 1000°F, is prepared from a heavy oil feedstream 5. The process illustrated in Figure 1 includes an upgrading reactor 20, which contains a catalyst and is operated at conditions sufficient to convert substantially all of the heavy oil feedstream to a distillate product having a normal boiling point of less than 1000°F. In the embodiment illustrated in Figure 1, the distillate product is recovered as the synthetic crude of the invention. As discussed above, synthetic crudes may also be tailored to meet the needs of a specific refinery or group of refineries.

Figure 2 illustrates another embodiment of the invention. A crude oil (stream105) is passed to first fractionation zone 110 for separation into at least an overhead product stream 112, a distillate product stream 114 and a residuum stream 116. The residuum 116(in one embodiment in combination with at least a portion of recycled stream 132) is passed to an upgrading reaction zone 120, at least in part for removing contaminants such as sulfur, asphaltenes, and metals from the residuum. The treated product stream 122 which is recovered from the reaction zone 120 is passed to second fractionation zone 130 for separation into an upgraded distillate stream 134 and an unconverted heavy stream 132. In one version of this embodiment, the upgrading reaction zone 120 is maintained at conditions sufficient to produce a treated product 122, a substantial portion of which boils at a temperature of less than 1000°F. The upgrading process is particularly effective in converting the residuum feed to distillate products boiling below 1000°F.

In another version of this embodiment, the residuum is treated in the reaction zone at select upgrading process conditions to convert at least 70% of the residuum into an upgraded distillate stream boiling in the range of from C5 to 1000°F. In other

versions of this embodiment, at least 80%, or 90% or 95% of the residuum is converted to 1000°F- products. In some cases, the volumetric ratio of upgraded product 134 to stream 132 is greater than 7:1, preferably greater than 8:1 and more preferably greater than 9:1. The upgraded distillate product 134 boils in a temperature range of less than 1000°F, preferably less than 900°F. In Figure 2, the upgraded product 134 is a synthetic crude.

Stream 132 may contain a slurry catalyst from the upgrading reaction zone 120. If there is more than a trace of slurry catalyst, it is desirable to remove a portion of the catalyst prior to recycling the unreacted heavy stream. Removing the catalyst from the recycle stream may involve removing a small fraction of the recycle stream from the process; generally less than 10% of the recycle stream will be withdrawn from the system for removal of catalyst from the process.

Certain feedstreams, such as crude oils, tend to be very heavy and high boiling, and contain few components which are gases at ambient conditions. In general, however, at least a small amount of gases is expected. The overhead stream 112 shown in Figure 2 comprises components of the hydrocarbon feedstream which are vapors or low boiling liquids at ambient pressure and temperature. After recovery from the fractionation zone 110, the overhead product 112 may be used for fuel, it may be flared or it may be converted into a H2/CO syngas in a syngas reformer. Alternatively, at least a portion of the gaseous product may be blended with the synthetic crude which is produced in the present process.

The fractionation zones 110 and 130 may comprise one or more distillation columns. One may be operated at or above atmospheric pressure, and another may be operated at subatmospheric pressure (vacuum). Distillation columns suitable for this service are well known. Distillate fractions may comprise a fraction boiling in the atmospheric gas oil range, having an initial boiling point in the range of 60-250°F and an end boiling point in the range of 600°-800°F, and a fraction boiling in the vacuum gas oil range, having an initial boiling point in the range of 600°-800°F, and an end boiling point in the range of 900°-1100°F. The residuum boils within the temperature range of above 900°F - 1100°F. As used herein, boiling points and boiling ranges are

reported as normal boiling points and boiling ranges, as determined by standard ASTM D1160 distillation.

Figure 3 illustrates the addition of hydrofinishing unit 138 to the scheme of Figure 2 for further upgrading of product 134. Stream 136, the effluent of the hydrofinishing unit 138, is a synthetic crude.

In Figure 4 a blended synthetic crude comprising a 1000°F- upgraded product and a crude oil is prepared from a hydrocarbon feedstream. As illustrated in Figure 4, a hydrocarbon feedstream 105 is passed to fractionation zone 110 for separation into at least an overhead product 112, a distillate product 114 and a heavy oil feedstream 116. In this embodiment, the heavy oil feedstream is combined with recycle stream 132 and passed to an upgrading reaction zone 120, at least in part for removing contaminants such as sulfur, asphaltenes, and metals from the heavy oil feedstream. The treated product 122 which is recovered from the reaction zone 120 is passed to fractionation zone 130 for separation into an upgraded product 134 and a recycle stream 132. In one embodiment, the upgrading reaction zone 120 is maintained at conditions sufficient to produce a treated product 122, a substantial portion of which boils within a temperature range of less than 1000°F. In one embodiment, the volumetric ratio of upgraded product to recycle stream is greater than 7:1, preferably greater than 8:1 and more preferably greater than 9:1. In a preferred embodiment, the upgraded product boils in a temperature range of less than 1000°F. In another preferred embodiment, the upgraded product boils in a temperature range of less than 900°F.

In Figure 4 stream 136(the effluent of hydrofinishing unit 138) may be blended, in any combination, with the treated product 122, with the distillate fraction 114, the overhead product 112, the hydrocarbon feedstream (stream 146) or with a portion of the heavy oil feedstream which bypasses the upgrading reaction zone to produce the synthetic crude (stream 144).

The synthetic crude may be recovered, at least in part from stream 122. It may then be upgraded in a separate process prior to blending.

WHAT IS CLAIMED IS:

1. An integrated process for upgrading a crude oil, comprising:

establishing a refining dataset that characterizes a desired tailored synthetic crude for a target refinery;

(a) generating a crude oil dataset that characterizes a crude oil;

(b) using the refining dataset and the crude oil dataset to generate an upgrading dataset of select upgrading process conditions;

(c) fractionating the crude oil and recovering a residuum and at least one distillate fraction;

(d) contacting at least a portion of the residuum in a reaction zone with hydrogen in the presence of a catalyst at the select upgrading process conditions to convert at least a portion of the residuum to produce a treated product comprising an upgraded distillate stream and an unconverted heavy stream;

(e) recovering a tailored synthetic crude from the treated product.

2. The process of Claim 1, wherein the catalyst is an unsupported slurry catalyst comprising at least one Group VIB metal.

3. The process of Claim 1, wherein the residuum is treated in the reaction zone at select upgrading process conditions to convert at least 70% of the residuum into an upgraded distillate stream boiling in the range of C5 to 1000°F.

4. The process of Claim 3, wherein at least 80% of the residuum is converted to 1000°F- products.

5. The process of Claim 4, wherein at least 90% of the residuum is converted to 1000°F- products.

6. The process of Claim 5, wherein at least 95% of the residuum is converted to 1000°F- products.

7. The process of Claim 1, further comprising the step of transporting the tailored synthetic crude comprising the upgraded distillate stream to the target refinery.

8. The process of Claim 1, wherein the tailored synthetic crude comprises at least a portion of the upgraded distillate stream of claim 1.

9. The process of Claim 1, wherein the tailored synthetic crude comprises at least a portion of the crude oil feedstream of claim 1, prior to fractionation.

10. The process of claim 1, wherein the tailored synthetic crude comprises one or more streams selected from the group consisting of the crude oil feedstream, residuum, treated product, upgraded product, and distillate product.

11. The process of Claim 1, wherein the select upgrading process conditions are preselected to produce an upgrading distillate stream having a boiling range corresponding to the target boiling range specified by the refining dataset.

12. The process of Claim 1, wherein the upgraded distillate product is further treated in a hydrofinishing reaction zone at hydrofinishing conditions which are preselected to remove a portion of the sulfur and a portion of the aromatic compounds contained within the upgraded distillate product.

13. The process of Claim 12, wherein the hydrofinished product contains less than 100 ppm sulfur and less than 20 ppm nitrogen.

14. The process of Claim 1, wherein the upgrading process conditions include a reaction temperature above 700°, a hydrogen partial pressure in the range of 350-4500 psi, and a hydrogen to oil ratio of 500-10,000 SCFB.

15. The process of Claim 14, wherein the upgrading process conditions include a reaction temperature above 800°F, a hydrogen partial pressure in the range of 350-4500 psi, and a hydrogen to oil ratio of 500-10,000 SCFB.

16. The process of Claim 15, wherein the upgrading process conditions include a reaction temperature above 900°F, a hydrogen partial pressure in the range of 350-4500 psi, and a hydrogen to oil ratio of 500-10,000 SCFB.

17. The process of Claim 1, wherein the Group VIB metal is molybdenum.

18. The process of Claim 2, wherein the catalyst is promoted with a Group VIII metal.

19. The process of claim 12, wherein hydrofinishing conditions comprise a reaction temperature between 400 F. -900F. (204C.-482C.), preferably 650F.-850F. (343C.-454C.); a pressure from 500 to 5000 psig (pounds per square inch gauge) (3.5-34.6 MPa), preferably 1000 to 3000 psig (7.0-20.8 MPa); a feed rate (LHSV) of 0.5 hr (-1) to 20 hr (-1) (v/v); and overall hydrogen consumption 300 to 5000 scf per barrel of liquid hydrocarbon feed (53.4-356 m (3)/m (3) feed).

20. An integrated process for upgrading a heavy oil feedstream, comprising:

(a) establishing a communication link between an upgrading facility and a target refinery;

(b) acquiring a refining dataset from the target refinery that characterizes a tailored synthetic crude;

(c) generating a crude oil dataset that characterizes a heavy oil feedstream;

(d) using the refining dataset from the target refinery and the crude oil dataset to generate an upgrading dataset of select upgrading process conditions;

(e) fractionating a crude oil and recovering a residuum and at least one distillate fraction;

(f) contacting at least a portion of the residuum in a reaction zone with hydrogen in the presence of a slurry catalyst comprising molybdenum at the select upgrading process conditions to convert at least 70% of the residuum into an upgraded distillate stream boiling in the range of C5 to 1000°F; and

(g) recovering a tailored synthetic crude comprising the upgraded distillate stream.

FIGURE 1

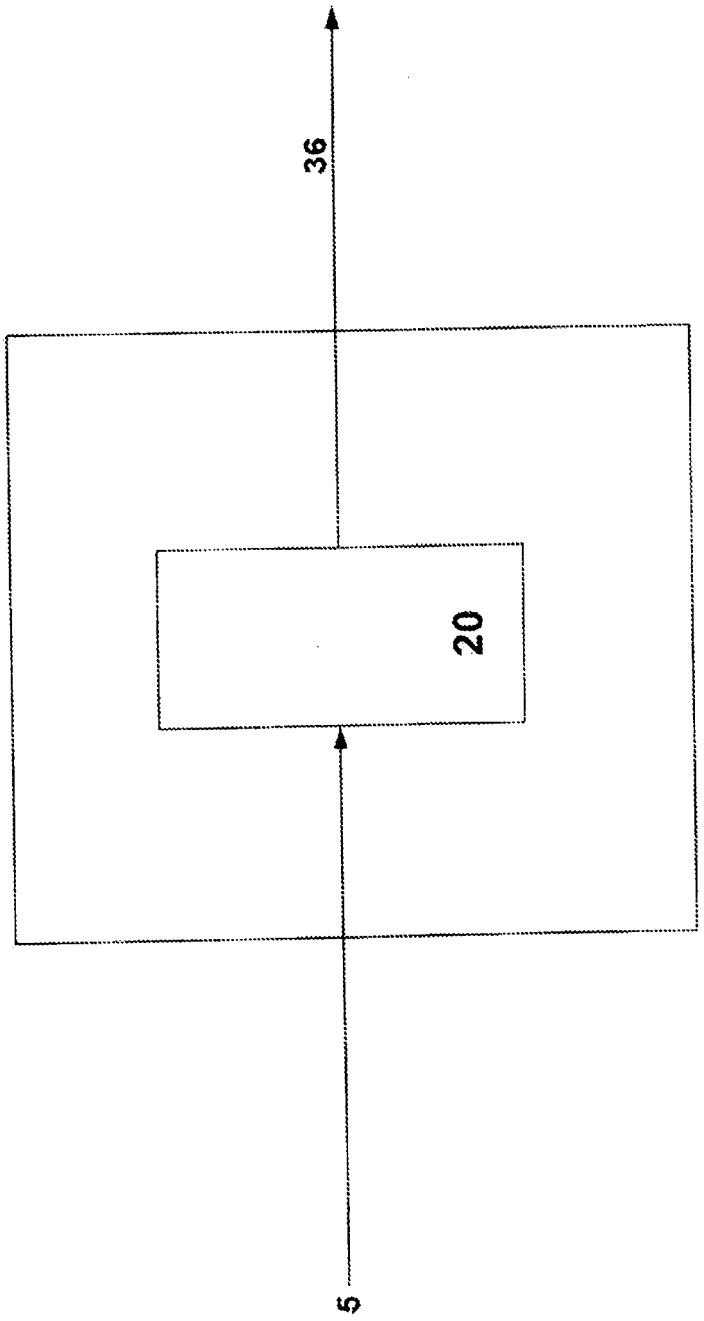


FIGURE 2

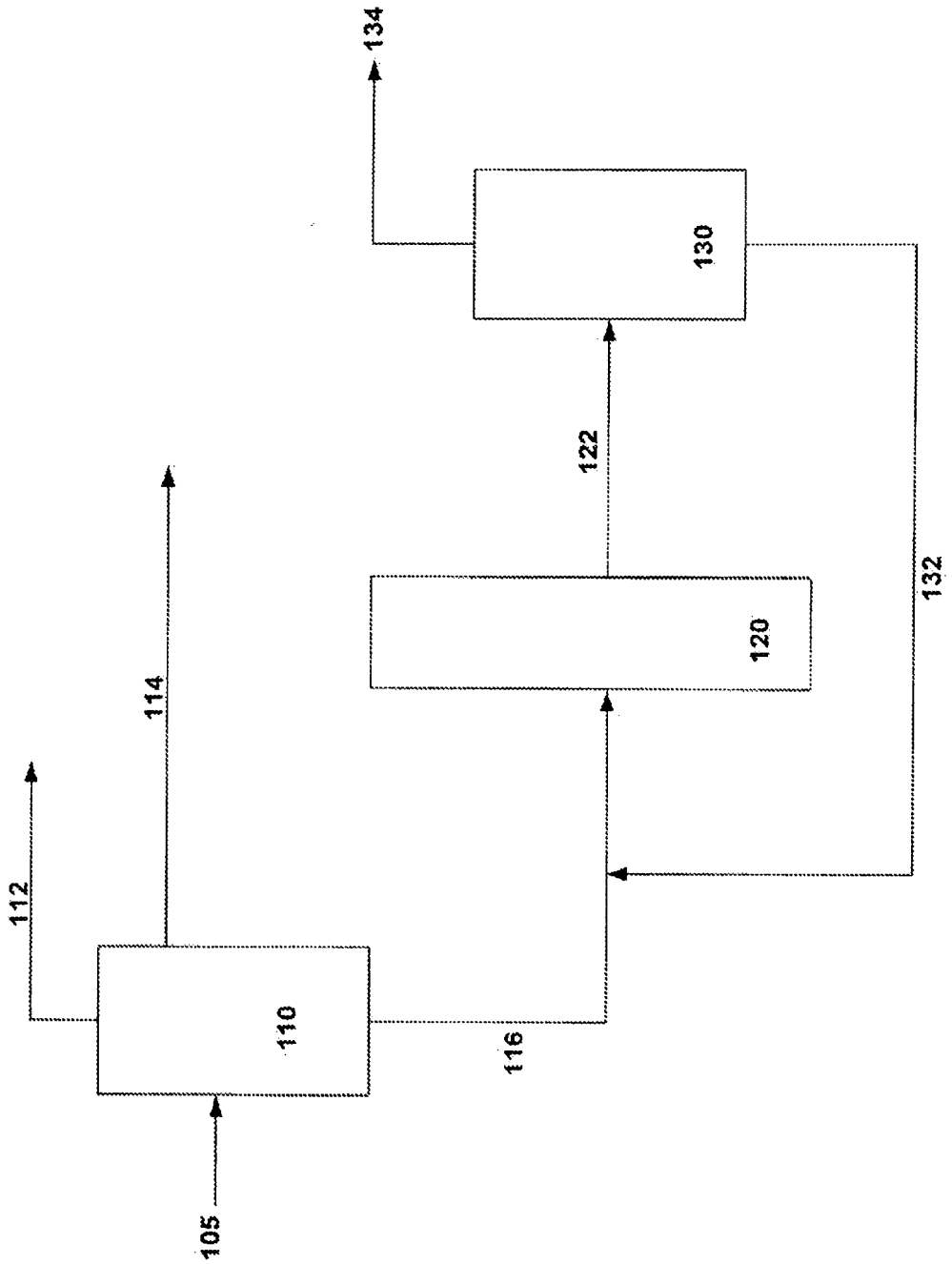


FIGURE 3

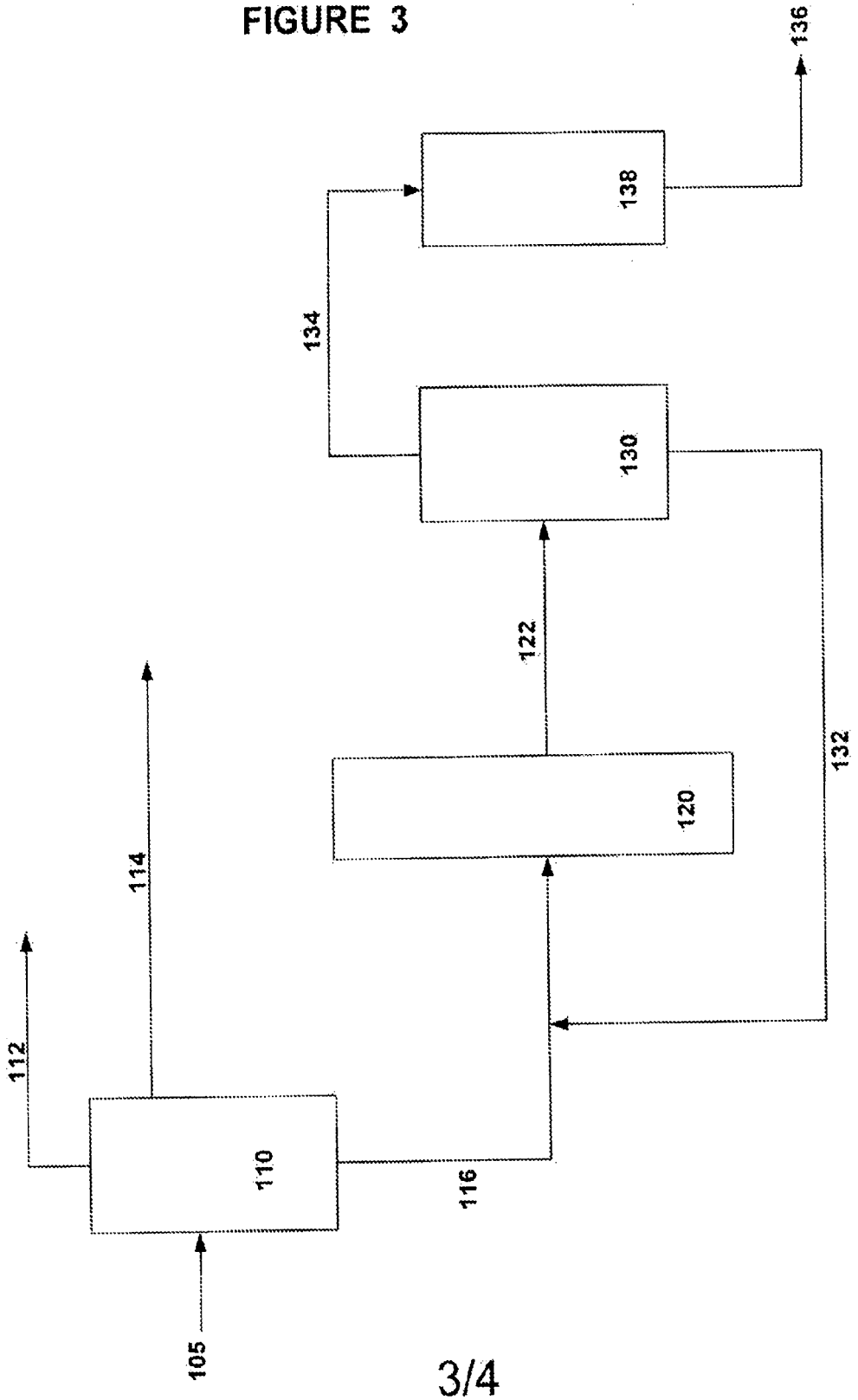
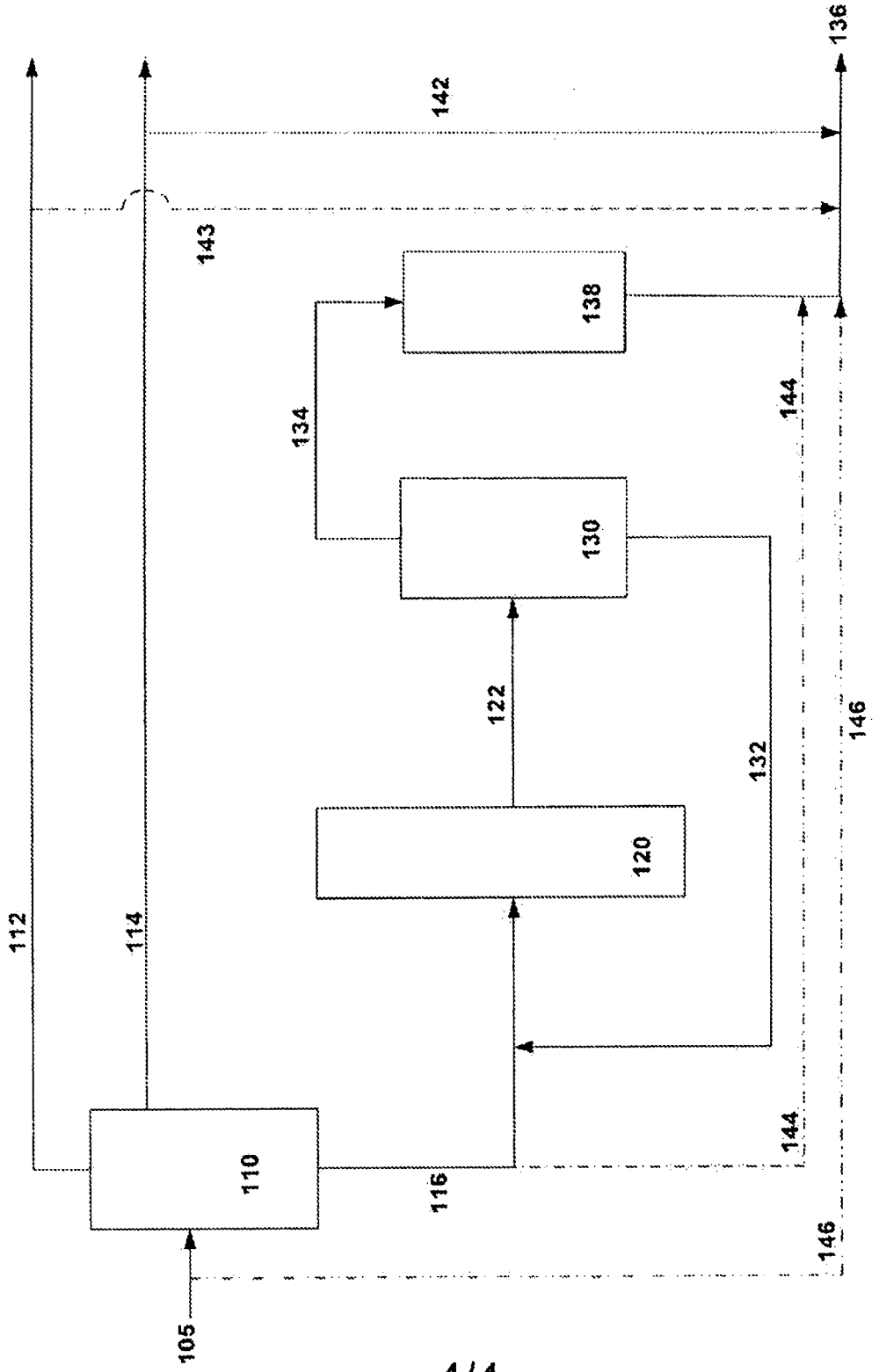


FIGURE 4


136
142
143
138
144
134
130
122
146
132
120
112
114
110
116
144
146
105