

TABLE OF SIMILARITIES

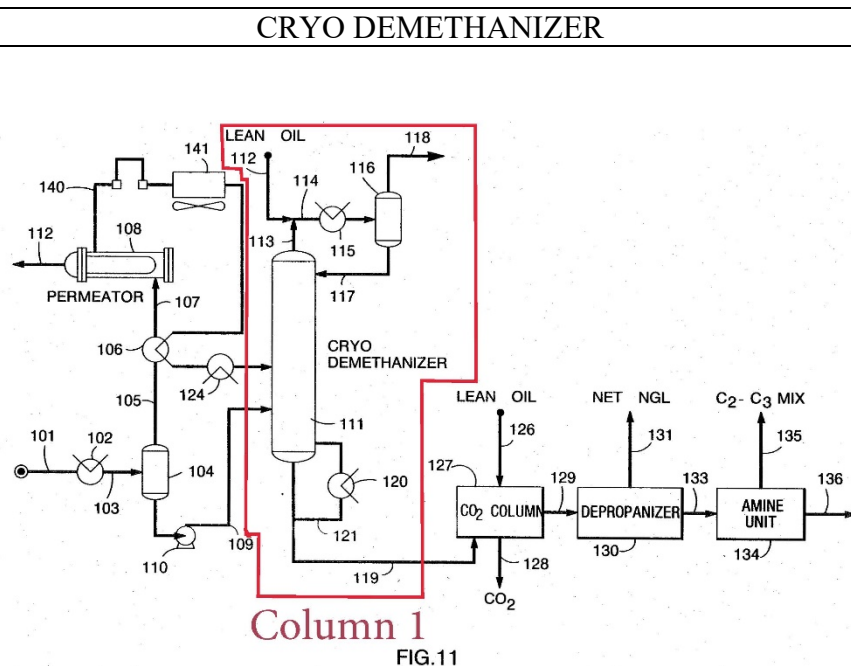
Goddin '411 Patent <u>Figure 11</u>	Three-Column <u>Ryan/Holmes Process</u>
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The following Table demonstrates the similarities between the process described in Figure 11 of the Goddin '411 Patent (EX2003), which was meaningfully addressed during prosecution of the Prim'332 Patent, and the three-column Ryan/Holmes process asserted as the primary basis for each of the obviousness Grounds in the Petition.

As demonstrated below for each of the three distillation columns in this process, and the final step of sweetening the NGL output stream, the input, process, and output for each of the three distillation columns, and the final sweetening step, are the same. In other words, the cryogenic distillation process in the Goddin '411 Patent, which was meaningfully addressed during prosecution of the Prim '332 Patent, is the same art asserted as the primary basis for each of the six obviousness Grounds in the Petition.

Three-Column Ryan/Holmes Process

Column 1

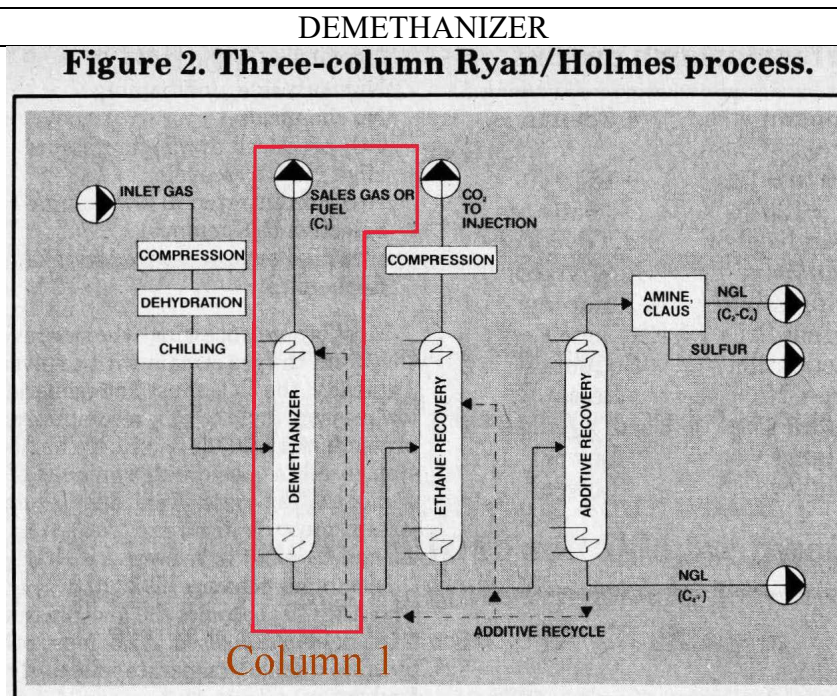


INPUT: Primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂, and “Lean Oil” (C_{4.5} hydrocarbon solvent).¹

PROCESS: Separation of Methane C₁ from CO₂ for sales of Methane C₁, using “Lean Oil” (C_{4,5} hydrocarbon solvent) to avoid CO₂ freeze-up.³

OUTPUT – Overhead: Primarily Methane C₁ Residue [sales] gas stream.⁵

Bottom: “bulk of” CO_2 and C_2 ⁶



INPUT: Primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂, and “NGL-based additive” (C₄₊ hydrocarbon solvent).²

PROCESS: Separation of Methane C_1 from CO_2 for sales of Methane C_1 , using “NGL-based additive” (C_{4+} hydrocarbon solvent) to avoid CO_2 freeze-up.⁴

OUTPUT - Overhead: Primarily Methane C₁ Sales Gas or Fuel⁷

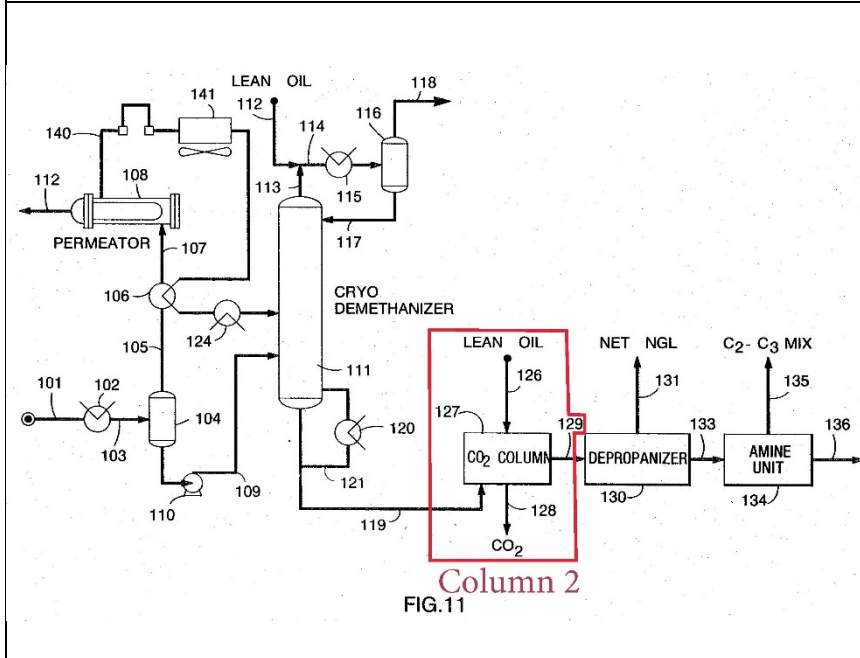
Bottom: CO₂ and C₂₊⁸

Goddin '411 Patent Figure 11	Three-Column Ryan/Holmes Process
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Goddin '411 Patent Figure 11	Three-Column Ryan/Holmes Process
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Column 2

CO₂ COLUMN



INPUT: CO₂ and C₂₊, and “Lean Oil” (C_{4,5} hydrocarbon solvent).⁹

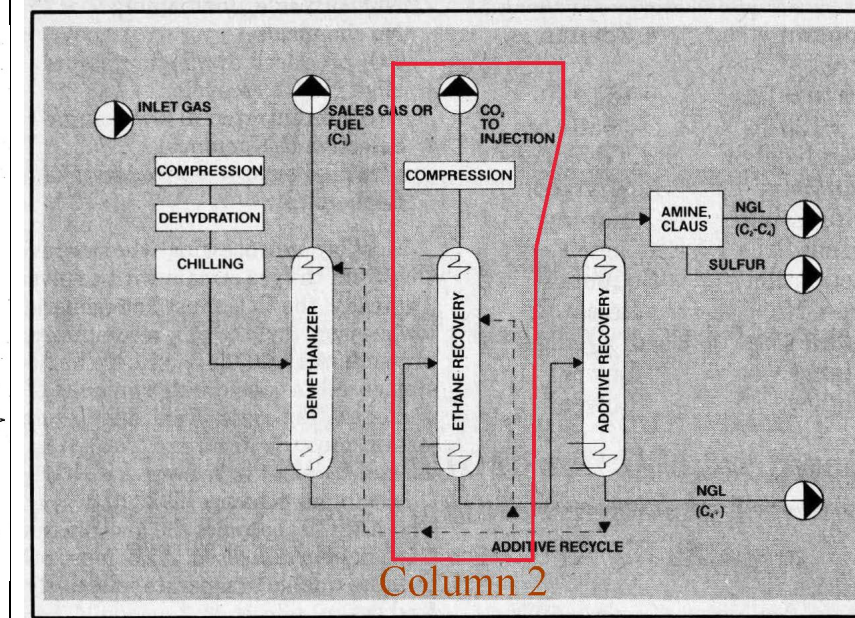
PROCESS: Separation of Ethane C₂ from CO₂, using “Lean Oil” (C_{4,5} hydrocarbon solvent) to facilitate separation of Ethane C₂ from CO₂.¹¹

OUTPUT- Overhead: Sweet high purity CO₂ product stream.¹³

Bottom: Ethane C₂ and other hydrocarbons.¹⁴

ETHANE RECOVERY

Figure 2. Three-column Ryan/Holmes process.



INPUT: CO₂ and C₂₊, and “NGL-based additive” (C₄₊ hydrocarbon solvent).¹⁰

PROCESS: Separation of Ethane C₂ from CO₂, using “NGL-based additive” (C₄₊ hydrocarbon solvent) to facilitate separation of Ethane C₂ from CO₂.¹²

OUTPUT - Overhead: CO₂ product stream.¹⁵

Bottom: Ethane C₂ and other hydrocarbons.¹⁶

Goddin '411 Patent Figure 11

Three-Column Ryan/Holmes Process

Column 3

DEPROPANIZER

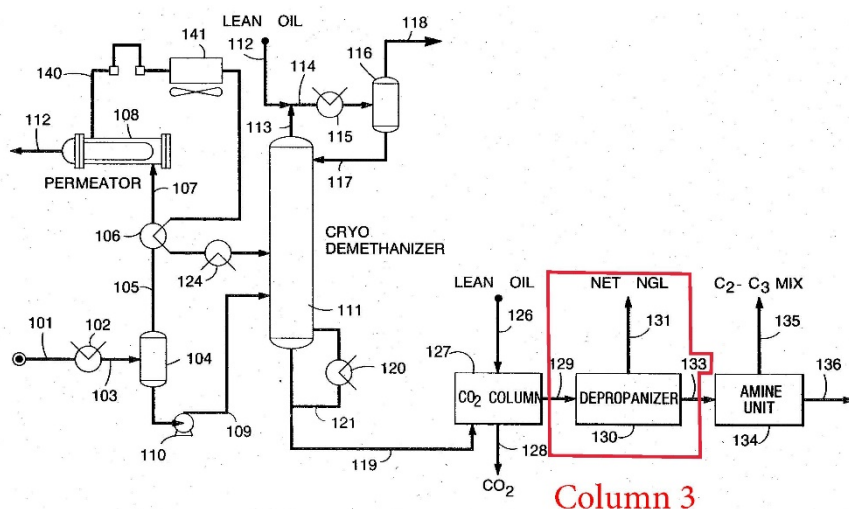
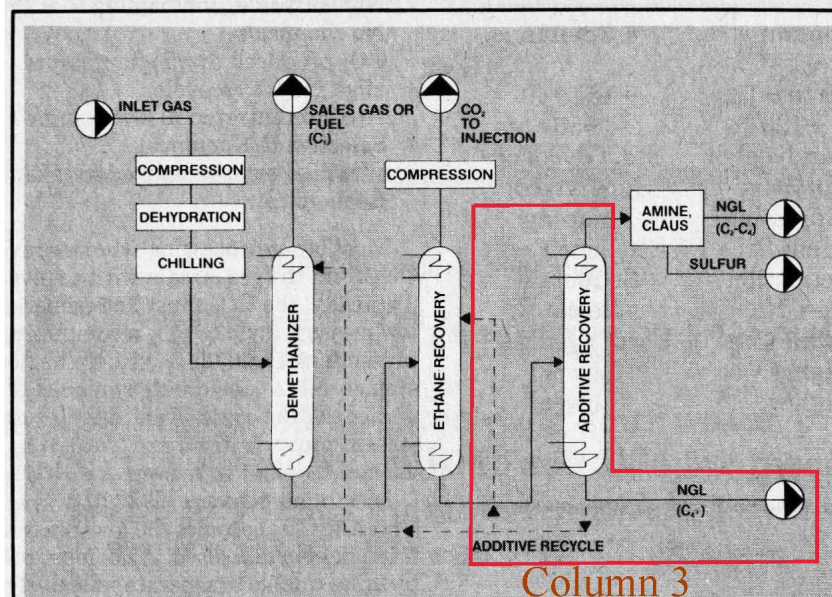


FIG.11

ADDITIVE RECOVERY

Figure 2. Three-column Ryan/Holmes process.



Column 3

INPUT: Ethane C_2 and other hydrocarbons.¹⁷

PROCESS: Separation of light (Ethane C_2 and Propane C_3) and heavier hydrocarbons (Butane C_4 and heavier hydrocarbons C_{5+}).¹⁹

OUTPUT - Overhead: Ethane C_2 and Propane C_3 ("E-P mix"), and some acid gases CO_2 and H_2S .²¹
Bottom: Butane and heavier hydrocarbons (C_{4+} aka "Net NGL").²²

INPUT: Ethane C_2 and other hydrocarbons.¹⁸

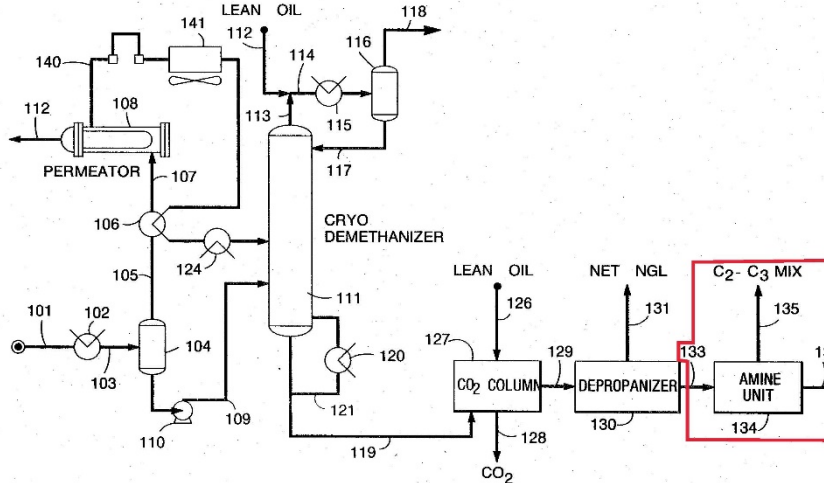
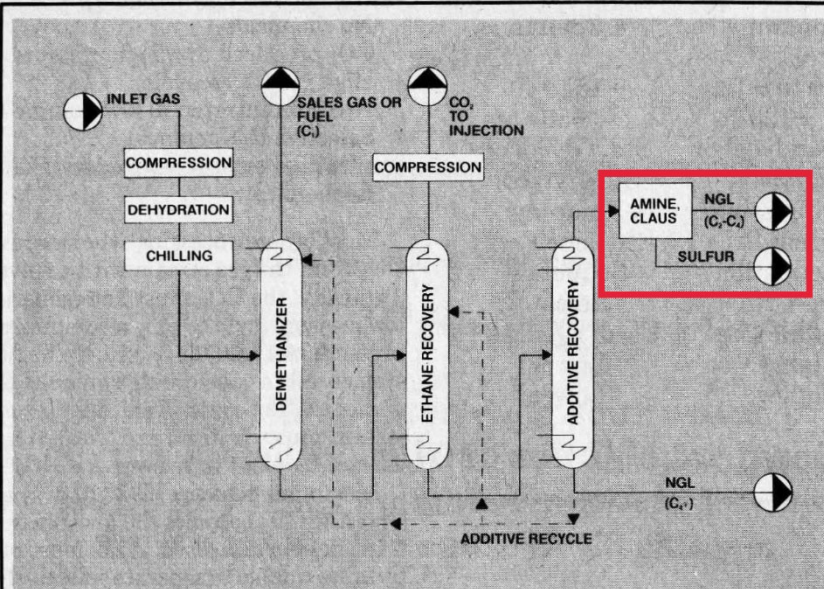
PROCESS: Separation of light (Ethane C_2 and Propane C_3) and heavier hydrocarbons (Butane C_4 and heavier hydrocarbons C_{5+}).²⁰

OUTPUT - Overhead: Ethane C_2 and Propane C_3 , and some acid gases CO_2 and H_2S .²³
Bottom: Butane and heavier hydrocarbons (C_{4+} aka "NGL" and "Additive Recycle").²⁴

Goddin '411 Patent Figure 11

Three-Column Ryan/Holmes Process

Sweetening Step

AMINE UNIT	AMINE-CLAUS
 FIG.11	Figure 2. Three-column Ryan/Holmes process. 
INPUT: Ethane C₂ and Propane C₃, and some acid gases CO₂ and H₂S (sour "E-P mix").²⁵	INPUT: Ethane C₂ and Propane C₃, and some acid gases CO₂ and H₂S.²⁶
PROCESS: Amine Scrubbing (sweetening of the Ethane C₂ and Propane C₃ ("E-P mix")).²⁷	PROCESS: Conventional amine treatment to produce sweet NGL product.²⁸
OUTPUT: - Overhead: Sweet Ethane C₂ and Propane C₃ (sweet "E-P mix").²⁹ Bottom: Acid gases CO₂ and H₂S.³⁰	OUTPUT: Overhead: Sweet Ethane C₂ and Propane C₃ ("sweet NGL product")³¹ Bottom: Sulfur³²

¹ Goddin “Cryo Demethanizer” Column 1 Input: Primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂, and “Lean Oil” (C_{4,5} hydrocarbon solvent). EX2003 at 16:62 to 17:41 (hydrocarbon enriched process stream 140 and liquid stream 109, primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂, are “introduced into cryodemethanizer column 111 ... at an intermediate level”); *id.* at 17: 46-50 (“Lean oil stream 112 is introduced into the top of cryodemethanizer column 111.”); *id.* at 18: 4 (“Lean oil, preferably C₄–C₅ hydrocarbons.”).

² Three-Column Ryan/Holmes (“RH-3”) “Demethanizer” Column 1 Input: Primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂, and “NGL-based additive” (C₄₊ hydrocarbon solvent). EX2006 at 4:14-31 TABLE 1 (feed gas composition showing primarily C_{1,2,3,4+} and CO₂, some H₂S and N₂); EX1007 at 53 (additive recycle described as “NGL-based additive” which typically is a “butanes-plus mixture”).

³ Goddin “Cryo Demethanizer” Column 1 Process: Separation of Methane C₁ from CO₂ for sales of Methane C₁, using “Lean Oil” (C_{4,5} hydrocarbon solvent) to avoid CO₂ freeze-up. EX2003 at 17:44-50 (“Lean oil stream 112 is introduced into the top of cryodemethanizer column 111 to facilitate reduction of the CO₂ content of the methane and lighter overhead gas to about 2 mol % or less without CO₂ freezeup” (emphasis added).).

⁴ RH-3 “Demethanizer” Column 1 Process: Separation of Methane C₁ from CO₂ for sales of Methane C₁, using “NGL-based additive” (C₄₊ hydrocarbon solvent) to avoid CO₂ freeze-up. EX1007 at 53 (“The demethanizer column separates methane as an overhead product from CO₂, C₂, H₂S and C₃ and heavier hydrocarbons. Recycled additive is introduced to the condenser or to the top of the column to avoid freezing in the column” (emphasis added).).

⁵ Goddin “Cryo Demethanizer” Column 1 Output – Overhead: Primarily Methane C₁ Residue [sales] gas stream. EX2003 at 17:50-64 (Overhead line 118 “residue [sales] gas stream ... has the following exemplary composition”: 83% Methane C₁ (658/797=83%).

⁶ Goddin “Cryo Demethanizer” Column 1 Output – Bottom: “bulk of” CO₂ and C₂₊. EX2003 at 17:65-67 (“Liquid stream 119, which contains the bulk of the CO₂ plus C₂ and heavier hydrocarbons, from the bottom of [cryodemethanizer] column 111.”).

⁷ RH-3 “Demethanizer” Column 1 Output – Overhead: Primarily Methane C₁ Sales Gas or Fuel. EX1007 at 53 (“The demethanizer column separates methane as an overhead product from CO₂, C₂, H₂S and C₃ and heavier hydrocarbons. ... The overhead C₁ fraction can be designed for 1 or 2% CO₂ as representative of pipeline-grade gas, or can be designed for 50 ppm CO₂ or lower suitable for feed to a liquefaction unit.”).

⁸ RH-3 “Demethanizer” Column 1 Output – Bottom: CO₂ and C₂₊. EX1007 at 54 (“The bottom product of the demethanizer is CO₂, C₂ and heavier hydrocarbons.”).

⁹ Goddin “CO₂ Column” Column 2 Input: CO₂ and C₂₊, and “Lean Oil” (C_{4,5} hydrocarbon solvent). EX2003 at 17:65 to 18:3 (“Liquid stream 119 ... contains the bulk of the CO₂ plus C₂ and heavier hydrocarbons, from the bottom of [cryodemethanizer] column 111 passes ... to CO₂ column 127 preferably entering at an intermediate level.”); *id.* at 18: 4-5 (“Lean oil, preferably C₄–C₅ hydrocarbons via line 126, is introduced into the top of CO₂ column 127.”).

¹⁰ RH-3 “Ethane Recovery” Column 2 Input: CO₂ and C₂₊. EX1007 at 54 (“The bottom product of the demethanizer [which is fed into the ethane recovery Column 2 input] is CO₂, C₂ and heavier hydrocarbons.”).

¹¹ Goddin “CO₂ Column” Column 2 Process: Separation of Ethane C₂ from CO₂, using “Lean Oil” (C_{4,5} hydrocarbon solvent) to facilitate separation of Ethane C₂ from CO₂. EX2003 at 18: 4-9 (“Lean oil, preferably C₄–C₅ hydrocarbons via line 126, is introduced into the top of CO₂ column 127 to facilitate separation of carbon dioxide from ethane. In addition, the lean oil enhances the volatility of CO₂ relative to H₂S and column 127 thereby produces a sweet high purity carbon dioxide product stream 128.”).

¹² RH-3 “Ethane Recovery” Column 2 Process: Separation of Ethane C₂ from CO₂, using “NGL-based additive” (C₄₊ hydrocarbon solvent) to facilitate separation of Ethane C₂ from CO₂. EX1007 at 53 (“Ethane recovery columns are operated to produce a CO₂ overhead product and C₂, H₂S, C₃ and heavier hydrocarbons as a bottom product. The use of additive in this column breaks the azeotrope which forms between CO₂ and C₂.”). Ryan/Holmes also refers to their Ethane Recovery Column 2 as the “CO₂ Recovery” column. EX1010 at 79 (“The bottoms from Column 1 is fed to the CO₂ recovery column (Column 2).”).

¹³ Goddin “CO₂ Column” Column 2 Output – Overhead: Sweet high purity CO₂ product stream. EX2003 at 18: 7-9 (“[T]he lean oil enhances the volatility of CO₂ relative to H₂S and column 127 thereby produces a sweet high purity carbon dioxide product stream 128.”).

¹⁴ Goddin “CO₂ Column” Column 2 Output – Bottom: Ethane C₂ and other hydrocarbons. EX2003 at 18: 9-11 (“Ethane and other hydrocarbons together with lean oil exit from the bottom of CO₂ column 127 in stream 129.”).

¹⁵ RH-3 “Ethane Recovery” Column 2 Output – Overhead: CO₂ product stream. EX1007 at 53 (“Ethane recovery columns are operated to produce a CO₂ overhead product.”).

¹⁶ RH-3 “Ethane Recovery” Column 2 Output – Bottom: Ethane C₂ and other hydrocarbons. EX1007 at 53 (“Ethane recovery columns are operated to produce ... C₂, H₂S, C₃ and heavier hydrocarbons as a bottom product.”).

¹⁷ Goddin “Depropanizer” Column 3 Input: Ethane C₂ and other hydrocarbons. EX2003 at 18: 9-13 (“Ethane and other hydrocarbons together with lean oil exit from the bottom of CO₂ column 127 in stream 129 and are introduced into a depropanizer column 130 at an intermediate level.”).

¹⁸ RH-3 “Additive Recovery” Column 3 Input: Ethane C₂ and other hydrocarbons. EX1007 at 54 (“In the ethane recovery column, ... C₂, H₂S, C₃, C₄₊ and additive are produced from the bottom of the column and flow to the additive recovery column.”).

¹⁹ Goddin “Depropanizer” Column 3 Process: Separation of light (Ethane C₂ and Propane C₃) and heavier hydrocarbons (Butane C₄ and heavier hydrocarbons C₅₊). EX2003 at 18:13-14 (“In the depropanizer butane and heavier hydrocarbons are separated as bottom stream 131.”).

²⁰ RH-3 “Additive Recovery” Column 3 Process: Separation of light (Ethane C₂ and Propane C₃) and heavier hydrocarbons (Butane C₄ and heavier hydrocarbons C₅₊). EX1007 at 54 (“The role of the additive recovery column is to remove lighter NGL’s to prevent them from being recycled. Butanes-plus is produced from the bottom of the column providing the net heavier NGL make and recovered additive to be recycled to the first two columns.”).

²¹ Goddin “Depropanizer” Column 3 Output – Overhead: Ethane C₂ and Propane C₃ (“E-P mix”), and some acid gases CO₂ and H₂S. EX2003 at 18:14-20 (“The vapor stream 133 from the top of depropanizer 130 is preferably subjected to conventional amine scrubbing in amine unit 134 and the acid gases CO₂ and H₂S sent to sulfur recovery (not shown) by line 136. The sweet C₂-C₃ stream 135 from the amine unit 134 can be sold as an ‘E-P mix’ or further fractionated.”).

²² Goddin “Depropanizer” Column 3 Output – Bottom: Butane and heavier hydrocarbons (C₄₊ aka “Net NGL”). EX2003 at 18:13-14 (“In the depropanizer butane and heavier hydrocarbons are separated as bottom stream 131.”).

²³ RH-3 “Additive Recovery” Column 3 Output – Overhead: Ethane C₂ and Propane C₃, and some acid gases CO₂ and H₂S. EX1007 at 54 (“The role of the additive recovery column is to remove lighter NGL’s to prevent them from being recycled.”); EX2006 at 4:67-68 (The Additive Recovery Column 3 overhead is “enriched in lighter hydrocarbons such as ethane and propane.”); EX1007 at 54 (“H₂S, if present in the plant feed, will be produced in the overhead of the additive recovery column.”).

²⁴ RH-3 “Additive Recovery” Column 3 Output – Bottom: Butane and heavier hydrocarbons (C₄₊ aka “NGL” and “Additive Recycle”). EX1007 at 54 (“Butanes-plus is produced from the bottom of the [additive recovery] column providing the net heavier NGL make and recovered additive to be recycled to the first two columns.”).

²⁵ Goddin “Amine Unit” Input: Ethane C₂ and Propane C₃ (“E-P mix”), and some acid gases CO₂ and H₂S (Sour “E-P mix”). EX2003 at 18:14-20 (“The vapor stream 133 from the top of depropanizer 130 is preferably subjected to conventional amine scrubbing in amine unit 134 and the acid gases CO₂ and H₂S sent to sulfur recovery (not shown) by line 136. The sweet C₂-C₃ stream 135 from the amine unit 134 can be sold as an ‘E-P mix’ or further fractionated.”).

²⁶ RH-3 “Amine, Claus” Input: Ethane C₂ and Propane C₃, and some acid gases CO₂ and H₂S. EX1007 at 54 (“The role of the additive recovery column is to remove lighter NGL’s to prevent them from being recycled.”); EX2006 at 4:67-68 (The Additive Recovery Column 3 overhead is “enriched in lighter hydrocarbons such as ethane and propane.”); EX1007 at 54 (“H₂S, if present in the plant feed, will be produced in the overhead of the additive recovery column. The sour NGL’s of the overhead are processed by conventional amine treatment to produce sweet NGL product.”).

²⁷ Goddin “Amine Unit” Process: Amine Scrubbing (sweetening of the Ethane C₂ and Propane C₃ (“E-P mix”)). EX2003 at 18:14-20 (“The vapor stream 133 from the top of depropanizer 130 is preferably subjected to conventional amine scrubbing in amine unit 134 and the acid gases CO₂ and H₂S sent to sulfur recovery (not shown) by line 136. The sweet C₂-C₃ stream 135 from the amine unit 134 can be sold as an ‘E-P mix’ or further fractionated.”).

²⁸ RH-3 “Amine, Claus” Process: Conventional amine treatment to produce sweet NGL product. EX1007 at 54 (“The sour NGL’s of the overhead are processed by conventional amine treatment to produce sweet NGL product.”).

²⁹ Goddin “Amine Unit” Output - Overhead: Sweet Ethane C₂ and Propane C₃ (“E-P mix”). EX2003 at 18:14-20 (“The sweet C₂-C₃ stream 135 from the amine unit 134 can be sold as an ‘E-P mix’ or further fractionated.”).

³⁰ Goddin “Amine Unit” Output - Bottom: Acid gases CO₂ and H₂S. EX2003 at 18:14-20 (“[T]he acid gases CO₂ and H₂S [are] sent to sulfur recovery (not shown) by line 136.”).

³¹ RH-3 “Amine, Claus” Output - Overhead: Sweet Ethane C₂ and Propane C₃ (“sweet NGL product”). EX1007 at 54 (“The sour NGL’s of the overhead are processed by conventional amine treatment to produce sweet NGL product.”).

³² RH-3 “Amine, Claus” Output - Bottom: Sulfur. EX1007 at 55, Fig. 2 (showing “Sulfur” as the bottom output of the RH-3 Amine, Claus).