Oct. 3, 1967 R. E. STYRING ETAL 3,344,583

TRANSPORTING ETHANE IN A CRUDE OIL PIPELINE

Filed Dec. 9, 1964 2 Sheets-Sheet 1

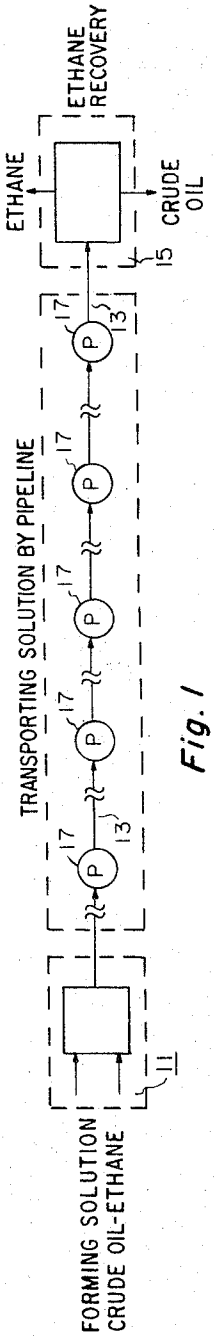


Fig. 1

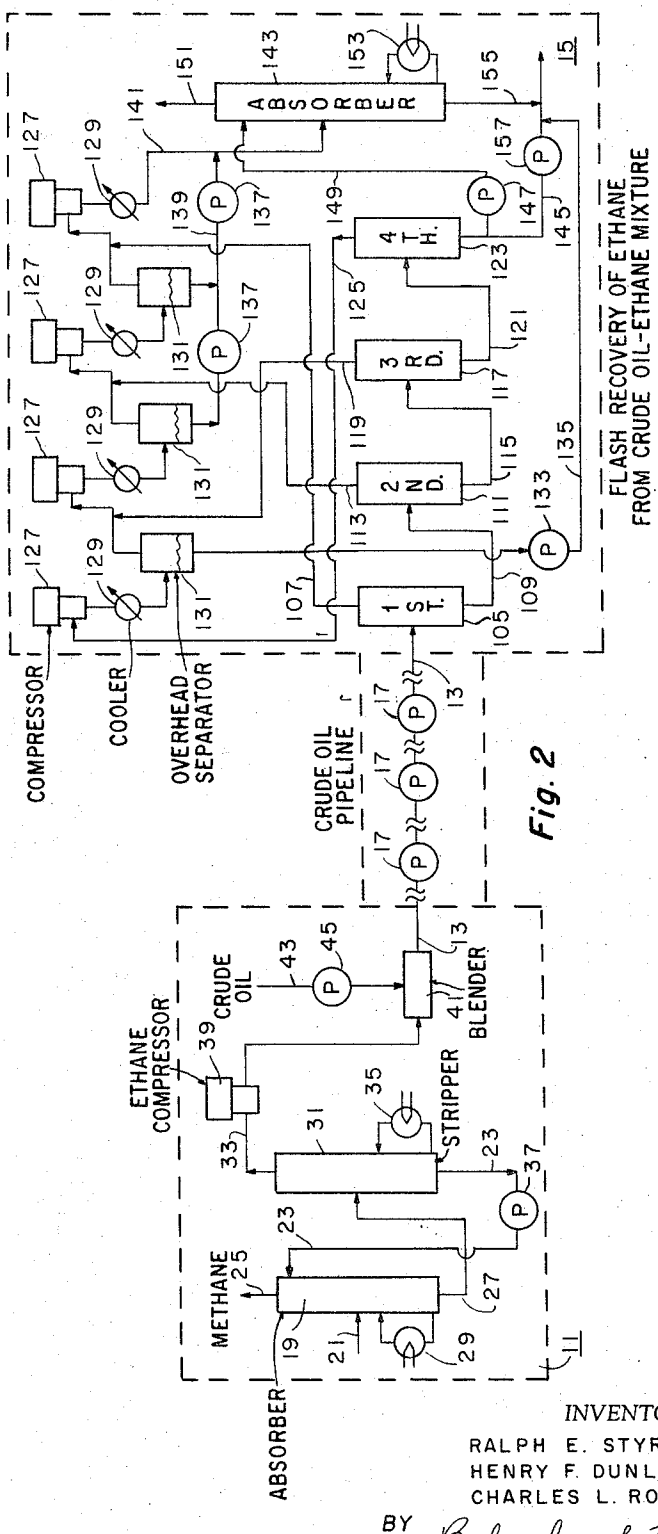


Fig. 2

INVENTORS
RALPH E. STYRING
HENRY F. DUNLAP
CHARLES L. ROGERS

BY Blucher & Sharp

Oct. 3, 1967 R. E. STYRING ET AL 3,344,583

TRANSPORTING ETHANE IN A CRUDE OIL PIPELINE

Filed Dec. 9, 1964 2 Sheets-Sheet 2

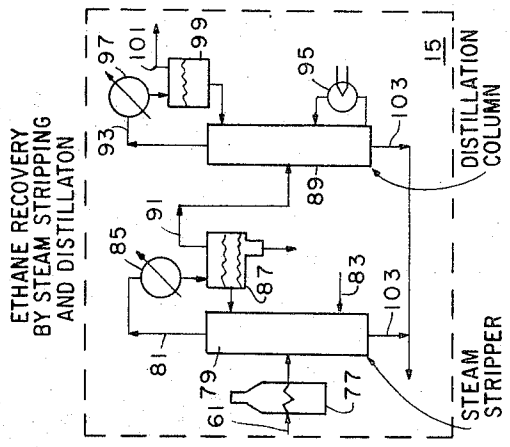


Fig. 5

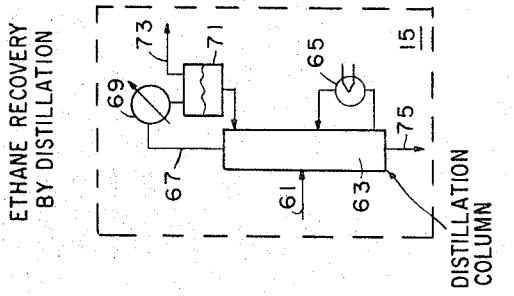


Fig. 4

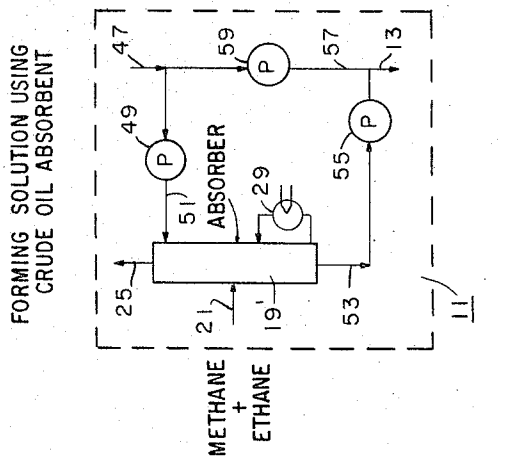


Fig. 3

INVENTORS
RALPH E. STYRING
HENRY F. DUNLAP
CHARLES L. ROGERS
BY Blucher & Sharp

United States Patent Office

3,344,583

Patented Oct. 3, 1967

3,344,583

TRANSPORTING ETHANE IN A CRUDE OIL PIPELINE

Ralph E. Styring, Henry F. Dunlap, and Charles L. Rogers, Dallas, Tex., assignors to The Atlantic Refining Company, Philadelphia, Pa., a corporation of Pennsylvania

Filed Dec. 9, 1964, Ser. No. 417,087
19 Claims. (Cl. 55—44)

This invention pertains to methods for mixing ethane with crude oil to form a liquid solution, for transporting this liquid solution in a pipeline at standard operating temperatures, and for extracting from the solution the ethane thus transported.

Previously, it has been proposed to transport butane, propane, natural gasoline and condensate in crude oil pipelines by blending small percentages by volume of these light hydrocarbons with crude oil. It has also been proposed to remove these light hydrocarbons at the refinery by distillation. But when ethane has been transported in pipelines of any substantial length, it has always been thought necessary to pump the ethane in a gaseous state. In addition, whenever it was necessary to ship large quantities of relatively pure ethane by means other than pipelines, it has always been thought necessary to ship the ethane in insulated, refrigerated containers. Such methods of shipping ethane have many disadvantages.

Accordingly, it is an object of this invention to provide a better, safer and more economical method for transporting ethane over long distances.

Another object of this invention is to provide a method for transporting in a long pipeline large quantities of ethane in liquid solution with crude oil.

Still other objects of this invention are to provide methods for blending ethane and crude oil to form a liquid solution, for transporting the mixture in a liquid state in a long pipeline, and for recovering the ethane thus transported.

These and other objects of this invention are more specifically illustrated and described by reference to the following description and accompanying drawings which schematically depict the various embodiments of this invention and in which:

FIGURE 1 is a block diagram representing an ethane and crude oil blending system connected to a long pipeline transporting system which is in turn connected to an ethane recovery system.

FIGURE 2 shows a system similar to that of FIGURE 1 wherein ethane is separated from methane using gasoline or hexane as the absorbent, the ethane is compressed and blended with crude oil, and ethane recovery from a crude oil-ethane mixture is accomplished by a series of flash separators, compression of the overhead flashed vapors and reabsorption of heavier hydrocarbons in the crude oil.

FIGURE 3 shows the blending system of FIGURE 2 using crude oil as the absorbent for ethane.

FIGURE 4 shows a recovery system using a single distillation column.

FIGURE 5 shows a recovery system using a steam stripper and a distillation column in series.

It has been found that ethane may be efficiently, economically and safely transported in solution with crude oil if the vapor pressure of the solution is maintained at a level below 400 pounds per square inch absolute at 95° F. and if there is at least 3 percent by volume of ethane in the solution. In addition, it has also been found that the solution must be flowed through a pipeline for a substantial distance. When two or more pump stations are spaced along the pipeline to flow the liquid, the pressure

on the solution in the pipeline between pumping stations is maintained at a level above the bubble point of the solution. The pressure on the solution may drop below the bubble point between the last pump station and the point where the ethane is to be separated from the solution. Moreover, it has been found that the presence of propane and butane in the solution must be less than 15 percent by liquid volume. Methane may be present provided that the above conditions are met.

Accordingly, as illustrated in FIGURE 1, this invention comprises, blending at first point **11** in a pipeline, crude oil with a hydrocarbon comprised of at least 10 percent by volume of ethane to form a solution or mixture of the crude oil and ethane. As previously pointed out, it is important that the final mixture contains less than 15 percent by liquid volume of propane and butane, at least 3 percent by liquid volume of ethane and have a final vapor pressure of less than 400 pounds per square inch absolute at 95° F. The blended mixture is then flowed through pipeline **13** for a substantial distance to second point **15** on the pipeline. Preferably this distance will be at least 20 miles. The solution mixture is flowed through the pipeline by pump or booster stations **17**. On long lines two or more pump stations will be used, and it is important that at all times during the flow of the blended crude oil-ethane solution between pump stations, the pressure on the mixture be above the bubble point of the mixture. At a third point between the last pump station and second point **15** the pressure of the solution may be allowed to drop below the bubble point because at second point **15** the ethane will be separated. But generally, it is preferred to maintain the pressure of the mixture above the bubble point between the first and second points. As stated, this pressure is maintained by spacing pump or booster stations **17** along the line at intervals which maintain this pressure in an economical manner. On long lines, such intervals will be approximately 25 to 75 miles. As stated, during all but the last stage of transport of the solution mixture, the solution is always in the liquid state thereby eliminating the many problems that would be encountered if the ethane were allowed to form bubbles or vaporize. At second point **15** on the pipeline, the ethane is extracted from the solution so as to separate and recover at least 85 percent by liquid volume of the ethane added to the crude oil.

Ethane may be added to or blended with the crude oil in a number of ways. For example, if substantially pure ethane were available, it could be bled directly in the crude oil in the pipeline, but generally the ethane will be mixed with methane and two ways of handling such a mixture and blending ethane in crude oil are illustrated in FIGURES 2 and 3. In the system shown in FIGURE 2, a hydrocarbon gaseous mixture containing at least 25 percent by volume of ethane is introduced into fractionating absorber **19** through inlet line **21** at a first intermediate point between the top and bottom of the fractionating absorber. Simultaneously, with introduction of the mixture, there is introduced through return line **23** at a point between the top of fractionating absorber **19** and the first intermediate point, hexane or gasoline to absorb hydrocarbons containing at least two carbon atoms from the first hydrocarbon gaseous mixture. At first overhead point **25** above the point of introduction of the hexane or gasoline, there is removed a first vapor phase containing at least 85 percent by volume of methane. The liquid remaining in the fractionating absorber is withdrawn from a point below the first intermediate point through stripper inlet line **27**. When desired, heat may be added to the fractionating absorber by way of side heater **29**. The liquid from the fractionating absorber is introduced into stripping column **31** at a second intermediate point between the top

and bottom of the stripping column. At second overhead point **33**, which is above the second intermediate point at which the liquid from the absorber is introduced into the stripper, there is removed a second vapor phase enriched in ethane. The top pressure and temperature of the stripping column are maintained at the dew point of the second vapor phase and the bottom temperature and pressure of the stripping column are maintained at the bubble point of the liquid in the bottom of the stripping column. Heat is added to the stripping column by way of side heater **35**. The liquid remaining in the stripping column is withdrawn from the stripping column at a point below the second intermediate point by way of return line **23**. This liquid is returned through pump **37** to the absorber. The second vapor phase removed from the stripping column at second overhead point **33** is compressed by compressor **39** to a pressure greater than the bubble point of the crude oil-ethane mixture, for example, 1200 p.s.i. The compressed second vapor phase is then blended in blender **41** with crude oil flowing in pipeline **43** so as to form a mixture of crude oil and compressed, liquefied second vapor phase. This mixture contains at least 3 percent by volume of ethane and will contain less than that amount of ethane which would raise the vapor pressure of the mixture to 400 pounds per square inch absolute at 95° F. The crude oil is at a pressure above the bubble point of the compressed, liquefied second vapor phase during the blending of the two streams. The pressure of the crude oil is maintained by pump **45**. The blended crude oil-ethane mixture is then flowed through pipeline **13** to the point of ethane extraction as previously mentioned.

In the system shown in FIGURE 3, crude oil is used as the absorbing liquid rather than gasoline. In this system, a portion of the crude oil flowing in crude oil line **47** is withdrawn and pumped by way of pump **49** through crude oil inlet line **51** into fractionating absorber **19'** at a point between the top of the absorber and the intermediate point wherein the first hydrocarbon gaseous mixture is introduced. The crude oil absorbs hydrocarbons containing at least two carbon atoms from the first hydrocarbon gaseous mixture. At overhead point **25**, above the point of introduction of the crude oil, there is removed a vapor phase containing at least 85 percent by volume of methane. At a point below the first intermediate point of introduction of the hydrocarbon gaseous mixture through outline line **53**, there is withdrawn liquid crude oil enriched in ethane. This liquid is passed through pump **55** where the pressure of the liquid is increased to a predetermined pressure above the bubble point of the enriched mixture. This enriched crude oil is then blended with high pressure crude oil flowing in pipeline **57** to form a mixture containing at least 3 percent by volume of ethane and less than the amount of ethane required to raise the vapor pressure of the mixture to 400 pounds per square inch absolute at 95° F. The pressure of the crude oil in pipeline **57** is maintained by pump **59**.

Refer now to the different systems for recovering or extracting ethane from crude oil as shown in FIGURES 2, 4, and 5. These methods are all suitable for recovering ethane from a mixture of ethane and crude oil containing less than 15 percent by liquid volume of propane and butane. The mixture is herein called a crude oil-ethane mixture and contains at least 3 percent by liquid volume of ethane and has a vapor pressure of less than 400 pounds per square inch absolute at 95° F.

The simplest method of extracting ethane from this mixture is shown in FIGURE 4 wherein the mixture is introduced through inlet line **61** into distillation column **63** at a point intermediate the top and bottom of the distillation column. Distillation column **63** is maintained at a top temperature and pressure which are at the dew point of the overhead vapor from the distillation column and at a bottom temperature and pressure which are at the bubble point of the liquid in the distillation column. Heat is added to the distillation column by way of side heater **65**. Under these conditions, there is separated at overhead point **67** a vapor phase enriched in ethane. This vapor phase is cooled at condenser **69** to form a gas phase enriched in and comprised substantially of ethane and a liquid phase enriched in and comprised substantially of hydrocarbons having more than two carbon atoms. The cooled vapors and liquids are passed to separator **71** wherein the liquid phase is recycled into the distillation column by introducing the liquid phase at a point between the intermediate point wherein the crude oil-ethane mixture was introduced into the distillation column and the overhead point where the vapors are withdrawn. At the top of separator **71**, the ethane is recovered by way of line **73**. The liquid remaining in the distillation column is withdrawn at a point below the intermediate point by way of line **75**. This liquid remainder is comprised essentially of crude oil containing less than 15 percent by liquid volume of propane and butane.

A better method of recovering or extracting the ethane from the crude oil-ethane mixture is shown in FIGURE 5. In this method, the mixture flowing in line **61** is passed through heater **77** where the crude oil-ethane mixture is heated to a temperature of at least 300° F. The heated mixture is introduced into steam stripper **79** at a first point intermediate the top and bottom of the steam stripper to separate at first overhead point **81** a first vapor phase enriched in ethane. Simultaneously with introduction of the heated mixture, steam from steam line **83** is introduced into the stripper at a point between the first intermediate point and the bottom of the steam stripper. This steam is at a pressure at least as great as the pressure inside steam stripper **79**. The first vapor phase removed from the steam stripper at first overhead point **81** is cooled at cooler **85** to form a first gas phase enriched in ethane and a first liquid phase enriched in hydrocarbons having more than two carbon atoms and a liquid water phase. This cooled first vapor phase is passed to separator **87** where the liquid water phase is separated and removed. The first liquid hydrocarbon phase is also separated and recycled into the steam stripper by introducing this first liquid hydrocarbon phase at a point between the first intermediate point and the first overhead point. The first gas phase is also separated at separator **87**. This first gas phase is then introduced into distillation column **89** by way of line **91** at a second point intermediate the top and bottom of distillation column **89**. At second overhead point **93**, there is separated a second vapor phase enriched in ethane. This is accomplished by maintaining the top temperature and pressure of distillation column **89** at the dew point of the second vapor phase and by maintaining the bottom temperature and pressure of the distillation column at the bubble point of the liquid therein. Heat may be added to the column by way of distillation column side heater **95**. The second vapor phase removed at second overhead point **93** is cooled at condenser **97** to form a second gas phase enriched in and comprised substantially of ethane and a second liquid phase enriched and comprised substantially of hydrocarbons having more than two carbon atoms. This cooled second vapor phase is passed to separator **99** wherein the second liquid phase is separated and recycled into the distillation column by introducing the second liquid phase at a point between the second intermediate point and the second overhead point on said distillation column. The second gas phase from separator **99** is the recovered ethane which is recovered in line **101**. The liquids remaining in the steam stripper **79** and in distillation column **89** are withdrawn through line **103** from points on the steam stripper and distillation column which are below the first and second intermediate points. This liquid remainder is comprised substantially of the crude oil containing less than 15 per cent by volume of propane and butane.

A third and preferred system for extracting ethane from the crude oil-ethane mixture is shown in FIGURE 2.

In this system, crude oil in pipeline **13** is introduced into first flash separator **105** at a first intermediate point between the top and bottom thereof. The top pressure in first flash separator **105** is at least 50 p.s.i. below the vapor pressure of the mixture at the operating temperature of the flash separator. A first vapor phase enriched in ethane is removed at first overhead point **107**. The liquid remaining in the first flash separator is withdrawn at a point below the first intermediate point and is introduced by way of line **109** into second flash separator **111** at a second intermediate point between the top and bottom of the second flash separator. A second vapor phase enriched in ethane is removed at a second overhead point **113**. The top pressure in the second flash separator is between 20 p.s.i. and 100 p.s.i. less than the pressure in the first flash separator. The liquid remaining in the second flash separator is withdrawn at a point below the second intermediate point on the second flash separator. This liquid is introduced by way of line **115** into third flash separator **117** at a third intermediate point between the top and bottom thereof. The top pressure in the third flash separator is between 20 p.s.i. and 100 p.s.i. less than the pressure in the second flash separator. A third vapor phase enriched in ethane is removed at third overhead point **119**. The liquid remaining in the third flash separator is withdrawn at a point below the third intermediate point and is introduced by way of line **121** into fourth flash separator **123** at a fourth intermediate point between the top and bottom thereof. As shown in FIGURE 2, fourth flash separator **123** is the last separator in the series. The last flash separator in the series must operate at a subatmospheric pressure between 0 and 6 p.s.i. absolute. A fourth overhead vapor phase enriched in ethane is removed at fourth overhead point **125**.

Each of the overhead vapor phases from each of the flash separators are individually compressed to a predetermined pressure by way of compressors **127** and each of the compressed vapor phases are cooled at coolers **129**. The cooled, compressed vapor phases from all but the first flash separator are passed to overhead separators **131** to divide the cooled, compressed vapor phases into a liquid phase and a gas phase. The gas phases from these overhead separators are each combined with the overhead vapor phase from the flash separator preceding it in the series before the overhead vapor phases are compressed. The liquid phase from the overhead separator for the flash separator operating at subatmospheric pressure will be essentially crude oil and is returned by way of pump **133** and line **135** to the crude oil recovery portion of the system hereinafter described. The other liquid phases separated at the other overhead separators are combined through pumps **137** and line **139** with the cooled, compressed vapor phase from the compressor for the overhead vapor phase from the first flash separator.

The combined liquids and compressed vapors are introduced by way of line **141** into fractionating absorber **143** at a point intermediate the top and bottom of the absorber. The liquid remaining in the last flash separator of the series, or the fourth separator of FIGURE 2, is withdrawn by way of line **145**. At least a portion of this liquid is increased in pressure by pump **147** to a predetermined pressure and is introduced by way of line **149** into fractionating absorber **143** at a point between the intermediate point of introduction of the combined liquids and compressed overhead vapor phases at the top of the absorber. The predetermined pressures for the liquid from the flash separator and for the combined, compressed vapor phases is at least as great as the top pressure of the absorber. At the top of the absorber through line **151** is withdrawn a vapor phase comprised of at least 75 percent by volume of ethane. The temperature in the absorber is maintained by side heater **153**. At a point below the intermediate point of introduction of the combined liquids and compressed overhead vapor phases, the liquid remaining in the absorber is withdrawn through crude oil recovery line **155**. Part of the liquid remaining in the last flash separator of the series may be added directly to oil recovery line **155** by way of pump **157**. The liquid in line **155** is comprised essentially of the crude oil containing less than 15 percent by volume of propane and butane.

In the ethane recovery system shown in FIGURE 2, there are four flash separators. The minimum number of flash separators is three for an ethane recovery system when the ethane has been mixed with crude oil containing less than 15 percent by liquid volume of propane and butane, but four flash separators are shown since this is the preferred number. Also, it should be noted that each of the flash separators must operate at a pressure between 20 p.s.i. and 100 p.s.i. less than the pressure in the flash separator just preceding it in the series. The last flash separator operates at subatmospheric pressure between 0 and 6 p.s.i. absolute regardless of the operating pressure of the flash separator just preceding the last flash separator.

In the foregoing description, there has been described a method for transporting ethane in solution with crude oil over long distances. By operating in the manner set forth, substantial economies are effected as compared to other ethane transporting systems. The description of the over-all method is followed by a description of two systems for adding ethane to crude oil. The system using crude oil as the absorbent for ethane is especially novel and useful in the over-all process. The description of the two systems for adding ethane to crude oil is followed by a description of three methods for recovering or extracting ethane from crude oil. The method using flash separators is particularly novel and useful to the over-all process. In this system, light ends including ethane are flashed from the crude oil-ethane mixture. The flashed light ends are compressed and the light ends heavier than ethane are then reabsorbed in the crude oil.

It will be understood that various changes in the details and arrangement of equipment which have been described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principles and scope of the invention, as expressed in the appended claims.

We claim:

1. A method for transporting ethane over substantial distances comprising separating ethane from methane to form a hydrocarbon comprised of at least 10 percent by volume of the separated ethane, blending at a first point in a pipeline, said hydrocarbon with crude oil to form a mixture of said crude oil and said hydrocarbon, said mixture containing less than 15 percent by liquid volume of propane and butane and containing at least 3 percent by liquid volume of ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F., flowing said mixture through said pipeline for a substantial distance to a second point on said pipeline, and separating from said mixture at said second point at least 85 percent by volume of said ethane in said hydrocarbon blended with said crude oil.

2. The method of claim **1** wherein the distance between the first and second points is at least 20 miles.

3. The method of claim **1** wherein the pressure of the mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

4. A method for transporting ethane over long distances in a liquid crude oil-ethane mixture comprising:

(a) introducing at a first intermediate point between the top and bottom of a fractionating absorber a first hydrocarbon containing at least 80 percent by volume of ethane and methane,

(b) simultaneously introducing at a point between said

top of said absorber and said first intermediate point an absorbent selected from the group consisting of hexane and gasoline to absorb hydrocarbons containing at least two carbon atoms from said first hydrocarbon,

(c) removing at a first overhead point above the point of introduction of said absorbent a first vapor phase containing at least 85 percent by volume of methane,

(d) withdrawing the liquid remaining in said absorber from a point below said first intermediate point,

(e) introducing said liquid from said absorber into a stripping column at a second intermediate point between the top and bottom of said stripping column,

(f) removing at a second overhead point above said second intermediate point a second vapor phase enriched in ethane,

(g) maintaining said stripping column at a top pressure and temperature which are at the dew point of said second vapor and at a bottom temperature and pressure which are at the bubble point of the liquid in said stripping column,

(h) withdrawing the liquid remaining in said stripping column from a point below said second intermediate point and introducing said liquid from said stripping column into said absorber at said point between said top of said absorber and said first intermediate point,

(i) compressing said second vapor phase to a pressure at least as great as the bubble point of said crude oil-ethane mixture,

(j) blending said compressed liquefied second vapor phase with crude oil flowing in a pipeline to form said crude oil-ethane mixture comprised of a mixture of said crude oil and said compressed liquefied second vapor phase, said mixture containing at least 3 percent by volume of ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.,

(k) flowing said mixture through said pipeline to a second point on said pipeline, and

(l) separating from said mixture at said second point at least 85 percent by volume of said ethane in said mixture.

5. The method of claim **4** wherein the distance between the first and second points is at least 20 miles.

6. The method of claim **4** wherein the pressure of the mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

7. A method for transporting ethane over long substantial distances comprising:

(a) introducing at an intermediate point between the top and bottom of a fractionating absorber a first hydrocarbon containing at least 25 percent by volume of ethane,

(b) simultaneously introducing at a point between said top of said absorber and said intermediate point crude oil to absorb hydrocarbons containing at least two carbon atoms from said first hydrocarbon,

(c) removing at an overhead point above the point of introduction of said crude oil a vapor phase containing at least 85 percent by volume of methane,

(d) withdrawing from said absorber at a point below said first intermediate point liquid crude oil enriched in ethane,

(e) increasing the pressure of said enriched crude oil from said absorber,

(f) blending said enriched crude oil with crude oil flowing in a crude oil pipeline to form a mixture, said mixture containing at least 3 percent by volume of said ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.,

(g) flowing said mixture through said pipeline for a substantial distance to a second point on said pipeline, and

(h) separating from said mixture at said second point at least 95 percent by volume of said ethane in said mixture.

8. The method of claim **7** wherein the distance between the first and second points is at least 20 miles.

9. The method of claim **7** wherein the pressure of the mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

10. A method of adding ethane to crude oil comprising:

(a) introducing at an intermediate point between the top and bottom of a fractionating absorber a first hydrocarbon containing at least 25 percent by volume of ethane,

(b) simultaneously introducing at a point between said top of said absorber and said intermediate point crude oil to absorb hydrocarbons containing at least two carbon atoms from said first hydrocarbon,

(c) removing at an overhead point above the point of introduction of said crude oil a vapor phase containing at least 85 percent by volume of methane,

(d) withdrawing from said absorber at a point below said first intermediate point liquid crude oil enriched in ethane,

(e) increasing the pressure of said enriched crude oil from said absorber, and

(f) blending said enriched crude oil with crude oil flowing in a crude oil pipeline to form a mixture, said mixture containing at least 3 percent by volume of said ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.

11. A method for transporting ethane over long distances comprising:

(a) separating ethane from methane to form a hydrocarbon comprised of at least 10 percent by volume of the separated ethane,

(b) blending at a first point in a pipeline said hydrocarbon with crude oil to form a liquid mixture of said crude oil and said hydrocarbon, said liquid mixture containing less than 15 percent by liquid volume of propane and butane and containing at least 3 percent by liquid volume of ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.

(c) flowing said liquid mixture through said pipeline for a substantial distance to a second point on said pipeline,

(d) introducing said liquid mixture at a point intermediate the top and bottom of a distillation column, said distillation column being maintained at a top temperature and pressure which are at the dew point of the overhead vapor from said distillation column and at a bottom temperature and pressure which are at the bubble point of the liquid in said distillation column, to separate at an overhead point a vapor phase enriched in said ethane,

(e) cooling said vapor phase from said distillation column to form a gas phase enriched in and comprised substantially of said ethane and a liquid phase enriched in and comprised substantially of hydrocarbons having more than two carbon atoms,

(f) separating said liquid phase from said gas phase and recycling said liquid phase into said distillation column by introducing said liquid phase into said distillation column at a point between said intermediate point and said overhead point, and

(g) withdrawing the liquid remaining in said distillation column from a point below said intermediate point, said liquid remainder being comprised essentially of said crude oil.

12. The method of claim 11 wherein the distance between the first and second points is at least 20 miles.

13. The method of claim 11 wherein the pressure of the mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

14. A method for transporting ethane over long distances comprising:

(a) separating ethane from methane to form a hydrocarbon comprised of at least 10 percent by volume of the separated ethane,

(b) blending at a first point in a pipeline said hydrocarbon with crude oil to form a liquid mixture of said crude oil and said hydrocarbon, said liquid mixture containing less than 15 percent by liquid volume of propane and butane and containing at least 3 percent by liquid volume of ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.,

(c) flowing said liquid mixture through said pipeline for a substantial distance to a second point on said pipeline,

(d) heating said liquid mixture to a temperature of at least 300° F.,

(e) introducing said heated mixture into a steam stripper at a first point intermediate the top and bottom of said steam stripper to separate at a first overhead point a first vapor phase enriched in said ethane,

(f) simultaneously introducing steam into said steam stripper at a point between said first intermediate point and said bottom of said steam stripper, said steam being at a pressure at least as great as the pressure inside said steam stripper,

(g) cooling said first vapor phase from said first overhead point of said steam stripper to form a first gas phase enriched in said ethane, a first liquid hydrocarbon phase enriched in hydrocarbons having more than two carbon atoms and a liquid water phase,

(h) separating and removing said liquid water phase,

(i) separating and recycling said first liquid hydrocarbon phase by introducing said first liquid hydrocarbon phase into said steam stripper at a point between said first intermediate point and said first overhead point,

(j) separating and introducing said first gas phase into a distillation column at a second point intermediate the top and bottom of said distillation column to separate at a second overhead point a second vapor phase enriched in said ethane, said distillation column being maintained at a top temperature and pressure which are at the dew point of said second vapor phase and at a bottom temperature and pressure which are at the bubble point of the liquid in said distillation column,

(k) cooling said second vapor phase from said distillation column to form a second gas phase enriched in and comprised substantially of said ethane and a second liquid phase enriched in and comprised substantially of hydrocarbons having more than two carbon atoms,

(l) separating and recycling said second liquid phase into said distillation column by introducing said second liquid phase into said distillation column at a point between said second intermediate point and said second overhead point, and

(m) withdrawing the liquid remaining in said steam stripper and in said distillation column from a point below said first and second intermediate points, said liquid remainder being comprised substantially of said crude oil.

15. The method of claim 14 wherein the distance between the first and second points is at least 20 miles.

16. The method of claim 14 wherein the pressure of the liquid mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said liquid mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

17. A method for transporting ethane over long distances comprising:

(a) separating ethane from methane to form a hydrocarbon comprised of at least 10 percent by volume of the separated ethane,

(b) blending at a first point in a pipeline said hydrocarbon with crude oil to form a liquid mixture of said crude oil and said hydrocarbon, said liquid mixture containing less than 15 percent by liquid volume of propane and butane and containing at least 3 percent by liquid volume of ethane and having a vapor pressure of less than 400 pounds per square inch absolute at 95° F.,

(c) flowing said liquid mixture through said pipeline for a substantial distance to a second point on said pipeline,

(d) introducing said liquid mixture into a first flash separator at a first intermediate point between the top and bottom of said first flash separator, said first flash separator having a top pressure at least 50 p.s.i. below the vapor pressure of said mixture at the operating temperature of said flash separator,

(e) withdrawing the liquid remaining in said first flash separator at a point below said first intermediate point and introducing said liquid from said first flash separator into a second flash separator at a second intermediate point between the top and bottom of said second flash separator to remove at a second overhead point a second vapor phase enriched in said ethane, the top pressure in said second flash separator being between 20 p.s.i. and 100 p.s.i. less than the pressure in said first flash separator,

(f) withdrawing the liquid remaining in said second flash separator at a point below said second intermediate point and repeating step (d) for at least one additional flash separator with the last flash separator operating at a subatmospheric pressure between 0 and 6 p.s.i. absolute,

(g) withdrawing each of said overhead vapor phases from each of said flash separators and individually compressing each of said overhead vapor phases to a predetermined pressure,

(h) combining said individually compressed overhead vapor phases and introducing said combined compressed vapor phases into a fractionating absorber at a point intermediate the top and bottom of said absorber,

(i) withdrawing the liquid remaining in said last flash separator,

(j) increasing the pressure of at least a part of said liquid from said last flash separator to a predetermined pressure,

(k) introducing said liquid from said last flash separator at said increased pressure into said fractionating absorber at a point between the intermediate point of introduction of said combined compressed overhead vapor phases and the top of said absorber,

(l) said predetermined pressures for said liquid from said last flash separator and said combined compressed vapor phases being at least as great as said top pressure of said absorber,

(m) withdrawing at the top of said absorber a vapor phase comprised of at least 75 percent by volume of said ethane, and

(n) withdrawing at a point below said intermediate

point of introduction of said combined compressed overhead vapor phases the liquid remaining in said absorber, said liquid remainder being comprised essentially of said crude oil.

18. The method of claim **17** wherein the distance between the first and second points is at least 20 miles.

19. The method of claim **17** wherein the pressure of the liquid mixture in the pipeline is maintained by at least two pumping stations spaced along said pipeline and the pressure of said liquid mixture in said pipeline between said pumping stations is maintained at a level above the bubble point of said mixture.

References Cited

UNITED STATES PATENTS

1,762,423	6/1930	Scharpenberg	48—190
2,241,717	5/1941	Robinson et al.	55—40
2,661,812	12/1953	Gilmore	55—40
2,966,402	12/1960	Hasche	48—190
3,210,271	10/1965	Byerly et al.	208—356
3,232,725	2/1966	Secord et al.	48—190

SAMIH N. ZAHARNA, *Primary Examiner.*
REUBEN FRIEDMAN, *Examiner.*
C. HART, *Assistant Examiner.*