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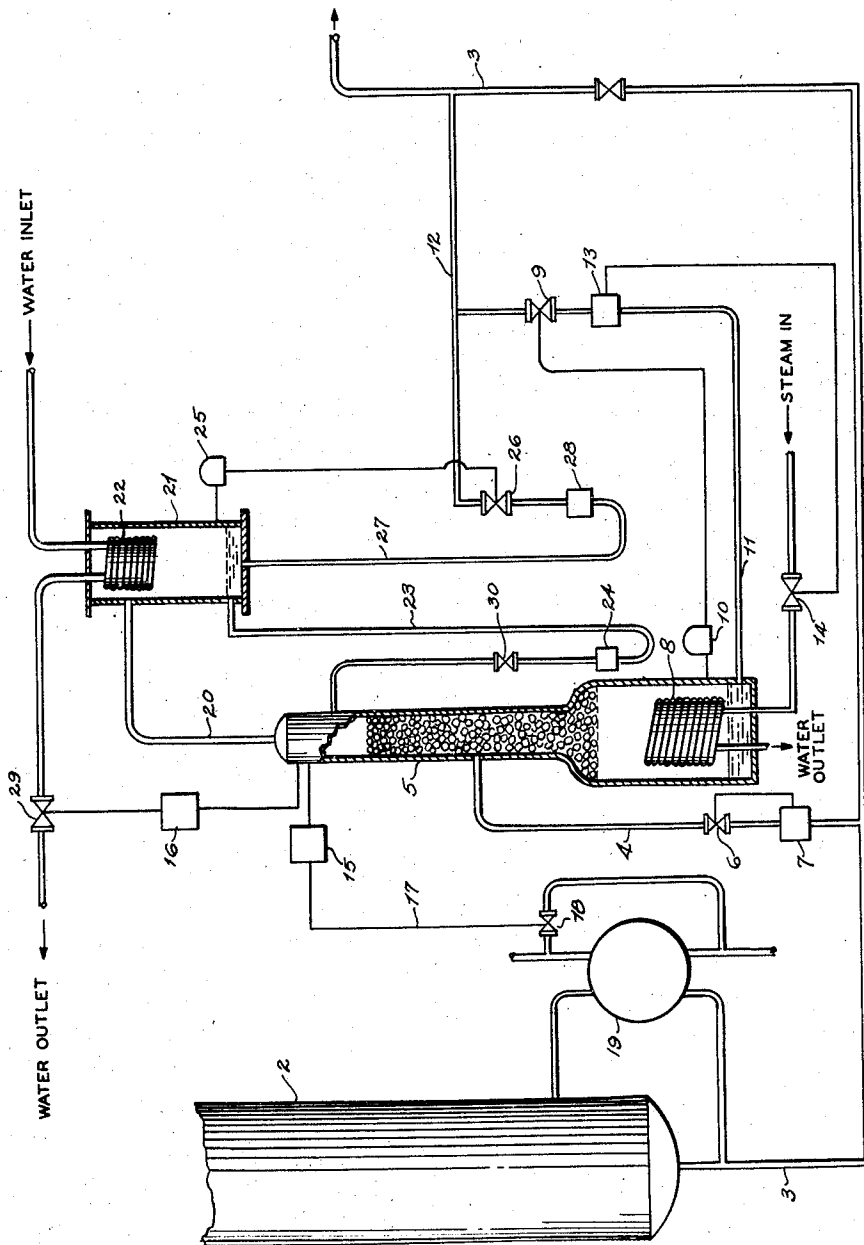
A. H. BLAIR

2,489,949

METHOD OF CONTROLLING A FRACTIONATING COLUMN

Filed Oct. 1, 1945

2 Sheets-Sheet 1



INVENTOR

Allen H. Blair

BY *Raymond W. Barclay*

AGENT

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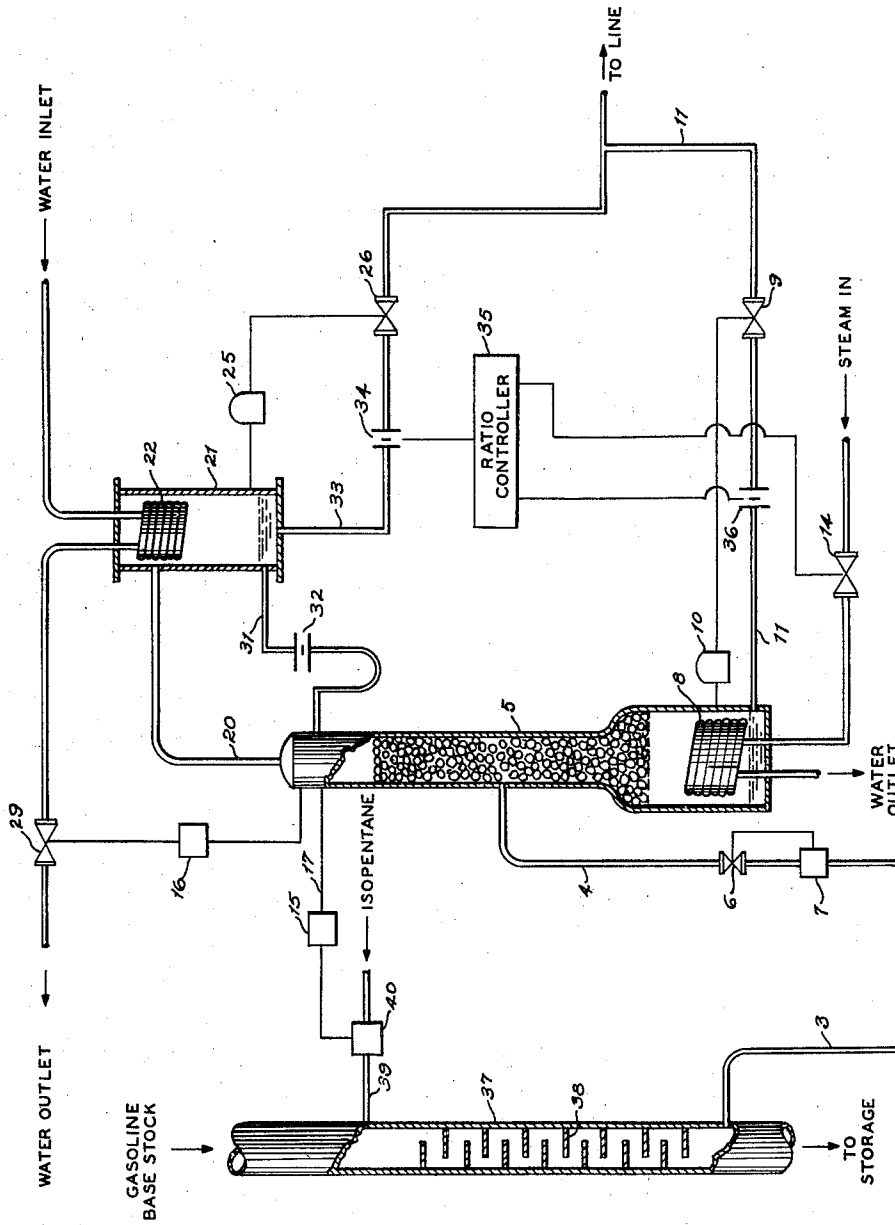


FIG. 2

INVENTOR

Allen H. Blair

BY *Raymond W. Barclay*

AGENT

UNITED STATES PATENT OFFICE

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METHOD OF CONTROLLING A
FRACTIONATING COLUMN

Allen H. Blair, Beaumont, Tex., assignor to Socony-Vacuum Oil Company, Incorporated, New York, N. Y., a corporation of New York

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This invention relates to a method and means for continuously indicating the content of low boiling components in a multi-component stream and more particularly is directed to a method for quantitatively indicating and controlling the content of low boiling components in a hydrocarbon stream.

Heretofore, in order to control and determine the content of low boiling components in a mixture of hydrocarbons, it has been necessary to resort to gas analysis such as those of Podbielniak. This type of analysis, as well recognized by those skilled in the art, is extremely time consuming and at best is only of limited accuracy giving discontinuous spot results.

The primary object of the present invention accordingly is to automatically and continuously indicate and control the content of low boiling components of hydrocarbon mixtures. A further object is to provide a means for quantitatively determining the amount of light hydrocarbon component in a petroleum fraction. A still further object is to quantitatively control the content of the lowest boiling component of fractionating tower bottoms and thereby reduce to a minimum loss of desirable volatile constituents contained in said bottoms. A still further object is to control the volatility of a blended gasoline stream by quantitatively controlling the content of low boiling component fed to said stream.

These and other objects which will be apparent to those skilled in the art are accomplished in accordance with the present invention wherein a small fractionator, hereinafter referred to as a pilot tower, is automatically fed a stream comprising a mixture of hydrocarbons such as is found in petroleum and fractions thereof. The temperature maintained in the pilot tower is such that the overhead product formed consists essentially of the two lightest boiling components contained in the hydrocarbon mixture. By maintaining a constant percentage of overhead in the pilot tower and providing a means for indication of the temperature in the upper portion thereof, the pressure being constant, a quantitative indication of the amount of lowest boiling component in the overhead and hence in the hydrocarbon mixture can be effected.

Thus, the essential features of this invention include introducing a hydrocarbon mixture into a

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heated zone whereby the mixture is fractionated into a gaseous overhead product consisting essentially of two components and a liquid fraction containing the remaining heavier hydrocarbon components; maintaining the ratio of overhead to liquid fraction constant; indicating the temperature of the overhead at constant pressure and thereby giving a quantitative indication of the content of the lightest boiling component present in the overhead and hence an indication of the amount of that component present in the hydrocarbon mixture.

It may be further desirable, in those cases where the hydrocarbon stream entering the pilot tower issues from a fractionator to quantitatively control the content of lowest boiling component in said stream. Under such conditions precise control can be effected by indicating the top temperature in the pilot tower which will indicate any change in content of the lowest boiling component of the hydrocarbon stream, present in the overhead. By adjustment of the fractionator heat supply which can be made to function responsive to the pilot tower top temperature through an airline connection, the amount of lowest boiling component in the hydrocarbon mixture may be accurately controlled since any minute change in its content will produce a relatively great change in the pilot tower top temperature which having the heat supply of the fractionator responsive to it will immediately effect adjustment of the heating medium flow rate or temperature. Likewise, variables other than fractionator heat supply such as the ratio relationship between reflux and overhead may be made to function responsive to the top temperature of the pilot tower. In this way, the content of light hydrocarbon components in a stream of hydrocarbons issuing from a fractionator may be precisely regulated. In a similar manner, the content of lowest boiling component in a blended hydrocarbon stream such as gasoline may be controlled, and hence the volatility of the stream adjusted by regulating the feed rate of the proportionating pump controlling the flow of low boiling component being blended with the hydrocarbon base stock responsive to the pilot tower top temperature.

An illustrative example employing the foregoing principles is the indication and control of

light hydrocarbon components present in fractionating tower bottoms. In such instances it is often desirable to maintain the content of low boiling components at a constant low percentage while reducing to a minimum the loss of valuable volatile constituents to the overhead product. Thus, the propane content of fractionating tower bottoms may be subjected to extremely precise control, maintaining the same at a constant low percentage while the loss of desirable butanes is reduced to a minimum. This precise control is made possible by virtue of the relatively great change in the pilot tower top temperature which will result from a minute change in its feed propane content. Of extreme value, also, is the fact that a given propane content will always be indicated by the same temperature, regardless of the type of operation or other circumstances encountered during processing.

Having described in a general way the nature of this invention, it may be more readily understood by reference to a preferred embodiment which is diagrammatically illustrated in the accompanying drawings. It is to be understood that a fractionating tower system as shown may be designed and operated to control the content of the lowest boiling component in any fractionated hydrocarbon mixture. However, the system as described below contemplates maintaining the propane content or light hydrocarbon fractionating tower bottoms at a controlled low percentage.

Referring now more particularly to Figure 1, bottoms from fractionating tower 2 are automatically fed through conduit 3 and at a constant rate through conduit 4 to pilot tower 5, the rate of flow being adjusted by valve 6 which in turn is regulated through an air line by a flow responsive control 7. The tower is suitably packed with Raschig rings or like material and has in its base a steam heated coil 8. Fractionating tower bottoms upon entering the pilot tower are separated into a heavy liquid product denoted as pilot tower bottoms and a lighter gaseous fraction denoted as overhead. The quantity of pilot tower bottoms is maintained at a constant depth in the lower portion of the pilot tower by control valve 9 which functions responsive to liquid level control 10. The pilot tower bottoms product is removed from the lower portion of the pilot tower and passes through conduits 11, 12 and 3 to further processing stages. The steam input to heating coil 8 is regulated by valve 14 which functions responsive to flow control 13.

Adjustment of the top temperature of the pilot tower is brought about by adjustment of the temperature of the fractionator heat supply, that is by adjustment of the amount of heating medium flowing through fractionator reboiler 19, by means of by-pass valve 18 which is connected by air line 17 to a temperature responsive control 15 which responds to the temperature in the upper portion of the pilot tower. Thus, any change in propane content in the overhead will produce a correspondingly great change in the pilot tower top temperature which in turn will be adjusted by controlling the heat supply. The propane content of the overhead and consequently of the fractionating tower bottoms may thus be regulated to a constant desirable low figure.

Vapor from the top of the pilot tower passes through conduit 20 to an accumulator 21 where it is condensed by coming in contact with water cooled coils 22. A portion of the condensed over-

head is refluxed passing through conduit 23, the rate of flow being shown by a flow indicator 24. The reflux rate will be regulated under this scheme by hand control of valve 30, the reflux product being conducted to the top of the pilot tower as indicated. The ratio relationship between reflux and overhead may vary from about 2 to 1 to about 10 to 1 depending on the operating conditions and pilot tower construction. In general a reflux ratio of about 7 to 1 has been found to give excellent results. The remaining portion of overhead product is removed from the bottom of the accumulator by conduit 27, the rate of flow being shown by flow indicator 28. The rate of removal of condensed overhead from the accumulator is controlled by valve 26 which functions responsive to liquid level control 25. The overhead product is then conducted by conduits 12 and 3 to further processing stages together with the major portion of the fractionator and pilot tower bottoms product.

The pressure of overhead in the pilot tower is maintained constant by water outlet control valve 29 which functions responsive to pressure control 16. In general for maintaining the propane content of light hydrocarbons at a low percentage as described, the pressure may vary from about 100 to about 200 pounds per square inch. A pressure of about 160 pounds per square inch was found to yield excellent results under the usual operating conditions.

The propane content of light hydrocarbon fractionating tower bottoms may thus be adjusted to a desirable constant figure by regulating the heat supply of the fractionating tower responsive to the top temperature of the pilot tower. This will be accomplished since the overhead will substantially be a two-component mixture. Accordingly the top temperature of the tower will be, in effect, an average of the boiling points, under the particular pressure being run, of these two components, weighted in the ratio of their appearance in the pilot tower overhead. For example, knowing the boiling points of each of the two components at the pressure being run and the top temperature of the pilot tower, the percentage of lowest boiling component present may be readily calculated. Deviations caused by gas law principles must of course be taken into consideration to give a true calculation of the content of low boiling component in the overhead. Since the pilot tower takes a fixed percentage of overhead, this percentage must be taken into account to quantitatively determine the amount of low boiling component in the fractionating tower bottoms.

The controlled temperature of the present fractionating system may likewise be employed to maintain the propane content of the fractionator bottoms within fixed narrow limits. For example, assuming a 0.1% propane content in fractionator bottoms and a 5% ratio of pilot tower overhead to feed; the top temperature of the pilot tower would be 168° F. if 160 pounds per square inch pressure is being maintained. A 1° F. change in the pilot tower top temperature would indicate a change of 0.01% propane in the fractionator bottoms. Consequently if the top temperature be controlled to within 1° of 168° F. the propane content of the fractionator bottoms will always be between 0.09 and 0.11%.

The present invention moreover affords an inexpensive means of maintaining a substantially propane free butane-butylene fraction for alkylation and like purposes where it is desirable that

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propane should be absent. Without an accurate control of the fractionator bottoms propane content the only way to insure a propane free butane-butylene mixture is to intentionally keep a small quantity of butanes in the fractionator overhead. This quantity would probably average about 1.5% of the fractionator overhead if the control pilot tower of the present invention were not employed. This would, as recognized by those in the art, represent a considerable loss of valuable butylenes. By means of the control tower, it is possible to maintain a small quantity of propane in the fractionator bottoms, thus insuring a minimum butylene loss and also keeping the butane-butylene mixture substantially propane free. The loss under such conditions of butylenes has been found to be substantially reduced to one-half of the former loss thus making the economics of the present process very attractive.

The control of the content of light hydrocarbon component in a hydrocarbon mixture is accordingly of very practical significance, and is brought about in accordance with the present invention by automatically feeding a hydrocarbon stream to a pilot tower which effects separation of the stream into a light two-component overhead and a heavy pilot tower bottoms product, the percentage of overhead being maintained constant. The content of light hydrocarbon component may be indicated quantitatively by inspection of the temperature of the overhead. This is brought about by virtue of the existing relationship between the pilot tower top temperature and said content. The amount of light component may be precisely controlled by accurate adjustment of the heat supply of a fractionator feeding a hydrocarbon stream to a pilot tower, said adjustment being accomplished by a temperature responsive control device connecting the heat supply of the fractionator and the upper portion of the pilot tower. Thus, any minute change in light hydrocarbon component will cause a relatively great change in the top temperature of the pilot tower, which will be reflected in the temperature responsive control which in turn will effect an adjustment in the heat supply of the fractionator. In this way the content of light hydrocarbon component in the hydrocarbon stream may be controlled to a desired percentage.

While a preferred embodiment of the invention has been described above in detail, namely maintenance of a low propane content in fractionating tower bottoms, it is to be understood the process and apparatus of this invention may be employed to indicate and control the content of low boiling component in any multi-component mixture. Thus, the process of the present invention may be effectively employed in the blending of petroleum hydrocarbon streams by quantitatively controlling the content of lowest boiling component in one or more of the streams. The proportioning pumps feeding the hydrocarbon streams can be made to function responsive to the pilot tower top temperature. This will be more readily understood by reference to Figure 2 where an apparatus is shown for controlling the volatility of a blended gasoline stream by regulating the addition of isopentane thereto responsive to the top temperature of the pilot tower. Gasoline base stock which may be derived from catalytic or thermal cracking of petroleum hydrocarbons is passed through blending tube 37 provided on its interior with a number of baffle plates 38. Isopentane is fed through

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conduit 39 and blended with the gasoline stock, the feed rate of isopentane being controlled by proportionating pump 40, which functions responsive to the top temperature of pilot tower

5. A portion of the blended gasoline is automatically fed through conduit 3 and at a constant rate through conduit 4 to the pilot tower 5, the rate of flow being adjusted by valve 6 which in turn is regulated through an air line 10 by a flow responsive control 7. The pilot tower is operated as described above causing a separation of the blended gasoline stream into a heavy liquid product denoted as pilot tower bottoms and a lighter gaseous fraction denoted as overhead. The quantity of pilot tower bottoms is maintained at a constant depth in the lower portion of the pilot tower and passes through conduit 11 by which it is conducted to the main portion of the blended stream passing through tube 37 to storage.

20 Adjustment of the top temperature of the pilot tower is brought about by regulation of the feed rate of isopentane, that is by adjustment of the amount of isopentane passing through proportionating pump 40 which is connected by air line 17 to a temperature responsive control 15 which responds to the temperature in the upper portion of the pilot tower. Thus, any change in the isopentane content in the overhead will produce a correspondingly great change in the pilot tower top temperature which in turn will be adjusted by controlling the isopentane feed rate. The isopentane content of the overhead and consequently of the blended gasoline may thus be regulated to give a desired volatility to the final product.

Vapor from the top of the pilot tower passes through conduit 20 to an accumulator 21 where it is condensed by coming in contact with water cooled coils 22. A portion of the condensed overhead is refluxed passing through conduit 31, the rate of flow being controlled to a desired quantity by maintaining the proper overhead level in accumulator 21, thus defining the rate of gravity flow through an orifice plate 32. The remainder of overhead product is removed from the bottom of the accumulator by conduit 33, passing through orifice 34. The rate of removal of condensed overhead from the accumulator is controlled by valve 26 which functions responsive to liquid level control 25. The overhead product is then conducted back together with the pilot tower bottoms product to the main portion of blended stream passing through tube 37 to storage. The rate of flow of condensed overhead through orifice 34, responsively controls the ratio of overhead to bottoms product by means of ratio controller 35, which controls valve 14 regulating the input to heating coil 8 responsive to said ratio. Bottoms product removal rate is controlled by liquid level controller 10.

The pressure of overhead in pilot tower is maintained constant as in the apparatus of Figure 1 by water outlet control valve 29 which functions responsive to pressure control 16. The isopentane content of a blended gasoline stock, and hence the volatility of said stock, may thus be adjusted to a desirable figure by regulating the feed rate of the proportionating pump responsive to the top temperature of the pilot tower. While the above described embodiment of the invention has been confined to isopentane addition to a gasoline stock, it will be understood by those in the art that the feed rate control of any other suitable low boiling hydrocarbon may

likewise be adjusted responsive to the top temperature of the pilot tower. Hence the details set forth above are not to be construed as limiting the invention except as defined by the following claims.

I claim:

1. In a method for preparing a flowing liquid stream of mixed liquids of predetermined composition by continuously forming said liquid stream under controllable conditions, the improvement which comprises diverting a portion of the stream so formed to a fractionation zone, controlling said portion to maintain a constant rate of flow to said fractionation zone, distilling said portion in said zone to provide an overhead fraction and a bottoms fraction, condensing said overhead, controlling said distillation to maintain said overhead at a constant rate of flow, measuring the temperature of the overhead vapors from said zone, modifying said controllable conditions of formation of said liquid stream responsive to variations in said measured temperature to maintain composition of said liquid stream constant, and returning said overhead and said bottoms to said stream at a point therein below diversion of said portion.

2. In a method for preparing a flowing liquid multi-component stream of predetermined composition by continuously forming said liquid stream under controllable conditions, the improvement which comprises diverting a portion of the stream to a fractionation zone, controlling said portion to maintain a constant rate of flow to said fractionation zone, distilling said portion in said zone to provide an overhead fraction consisting essentially of the two lowest boiling components of said stream and a bottoms fraction of the remaining heavier components of said stream, condensing said overhead, controlling said distillation to maintain said overhead at a constant rate of flow, maintaining the pressure of the overhead vapors constant, measuring the temperature of said overhead vapors from said zone at constant pressure, modifying said controllable conditions of formation of said liquid stream responsive to variations in said measured temperature to maintain constant the composition of said liquid stream in its lowest boiling component and returning said overhead and said bottoms to said stream at a point therein below diversion of said portion.

3. In a method for operating a fractionating tower under controllable conditions to quantitatively regulate the content of lowest boiling component of fractionator bottoms issuing from said tower in the form of a liquid stream, the improvement which comprises diverting a portion of the stream to a pilot tower, controlling said portion to maintain a constant rate of flow to said pilot tower, distilling said portion in said pilot tower to provide an overhead fraction and a bottoms fraction, condensing said overhead, controlling said distillation to maintain said overhead at a constant rate of flow, measuring the temperature of the overhead vapors from said pilot tower, modifying said controllable conditions of formation of fractionator bottoms responsive to variations in said measured temperature to quantitatively control the composition of the fractionator bottoms stream in its lowest boiling component and returning said overhead and said pilot tower bottoms to said stream at a point therein below diversion of said portion.

4. In a method for operating a fractionating tower under controllable conditions to quantita-

tively regulate the content of lowest boiling component of fractionator bottoms issuing from said tower in the form of a liquid stream, the improvement which comprises diverting a portion of the stream to a pilot tower, controlling said portion to maintain a constant rate of flow to said pilot tower, distilling said portion in said pilot tower to provide an overhead fraction consisting essentially of the two lowest boiling components of said stream and a bottom fraction of the remaining heavier components, controlling said distillation to maintain said overhead at a constant rate of flow, maintaining the pressure of the overhead vapors constant, measuring the temperature of said overhead vapors from said pilot tower at constant pressure, modifying said controllable conditions of formation of fractionator bottoms responsive to variations in said measured temperature to quantitatively control the composition of the fractionator bottoms stream in its lowest boiling component and returning said overhead and said pilot tower bottoms to said stream at a point therein below diversion of said portion.

5. In a method for operating a fractionating tower under controllable conditions to quantitatively regulate the propane content of fractionator bottoms comprising a mixture of propane and higher hydrocarbons and issuing from said tower in the form of a liquid stream, the improvement which comprises diverting a portion of the stream to a pilot tower, controlling said portion to maintain a constant rate of flow to said pilot tower, distilling said portion in said pilot tower to provide an overhead fraction consisting essentially of propane and isobutane and a bottoms fraction of the remaining heavier components, controlling said distillation to maintain said overhead at a constant rate of flow, maintaining the pressure of the overhead vapors constant, measuring the temperature of said overhead vapors from said pilot tower at constant pressure, modifying the heat supply of said fractionating tower responsive to variations in said measured temperature to quantitatively control the propane content of the fractionator bottoms stream and returning said overhead and said pilot tower bottoms to said stream at a point therein below diversion of said portion.

6. In the method of blending liquid hydrocarbon streams under controllable conditions to quantitatively regulate the content of low boiling hydrocarbon contained therein, the improvement which comprises diverting a portion of the blended stream to a pilot tower, controlling said portion to maintain a constant rate of flow to said pilot tower, distilling said portion in said pilot tower to provide an overhead fraction and a bottoms fraction, condensing said overhead, controlling said distillation to maintain said overhead at a constant rate of flow, measuring the temperature of the overhead from said pilot tower, modifying said controllable conditions of blending said hydrocarbon streams responsive to variations in said measured temperature to quantitatively control the low boiling hydrocarbon content of said blended stream and returning said overhead and said pilot tower bottoms to said stream at a point therein below diversion of said portion.

7. In the method of blending gasoline stock under controllable conditions to continuously adjust the volatility thereof, the improvement which comprises diverting a portion of a stream of said stock blended with a light hydrocarbon

to a pilot tower, controlling said portion to maintain a constant rate of flow to said pilot tower, distilling said portion in said pilot tower to provide an overhead fraction and a bottoms fraction, condensing said overhead, controlling said distillation to maintain said overhead at a constant rate of flow, measuring the temperature of the overhead from said pilot tower, modifying said controllable conditions of blending the stock responsive to variations in said measured temperature to quantitatively control the content of said light hydrocarbon in said blended stream and returning said overhead and said pilot tower

bottoms to said stream at a point therein below diversion of said portion.

ALLEN H. BLAIR.

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