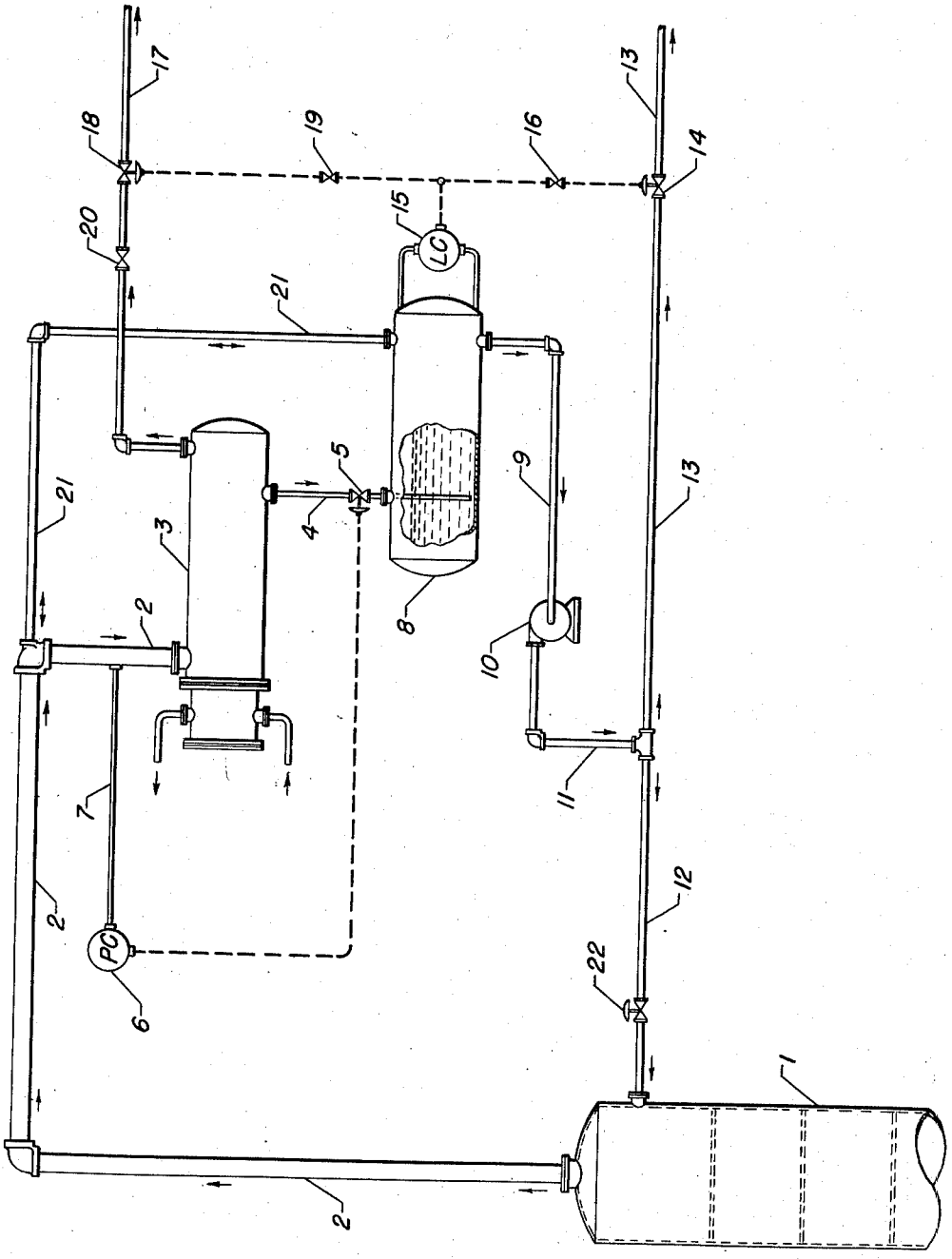
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FRACTIONATOR CONDENSING ASSEMBLY

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FRACTIONATOR CONDENSING ASSEMBLY

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This invention relates to a particular fractionation column having both the condenser and condensate receiver at substantially column pressure. More specifically, this invention relates to a fractionator overhead vapor condensing assembly which is designed and adapted to maintain the condenser at a maximum pressure and the column itself at a minimum pressure.

In the fractional distillation of fluids wherein two substances are separated by virtue of their difference in boiling point, it is usually desirable to operate at the lowest practical column pressure. The use of the lowest possible pressure permits savings in equipment since high pressure operation requires thicker walls for vessels, columns, etc., as well as more expensive pumps, compressors, valves, etc. It is furthermore desirable to maintain as low a pressure as possible since generally the difference in boiling point between various components diminishes as the pressure increases. Since separation by fractional distillation depends on a difference in boiling points, the greater this difference the more desirable are the conditions for fractionation.

The condenser pressure is usually the determining factor in establishing the pressure at which a fractionation column will operate on a commercial scale. The condenser pressure is established by consideration of the process variables involved. For example, in a commercial operation, the composition of the overhead product from a fractionator and the temperature of the available cooling water are the important factors in establishing the necessary pressure on the condenser. Once the minimum condenser pressure is determined, an objective of designing an economical and efficient process is to arrange a fractionation column to function with its pressure as close to the pressure of the condenser as possible. In other words, the pressure drop required to pass vapors from the fractionator to the condenser should be minimum. As hereinbefore stated, this avoids the necessity for expensive equipment and is conducive to a more efficient or alternatively a less difficult separation.

In designing a fractionation process it is also necessary to consider the condensate receiver pressure. The pressure of the receiver must be high enough to prevent the liquid condensate from flashing or returning to the vapor phase either completely or partially when it is discharged into the receiver.

Another consideration in designing a fractionator is the determination of whether the overhead product is totally condensable or whether a portion of the product will be recovered in the gas or vapor phase. In the latter case a means for drawing off the gasiform product is required and this must be accomplished so that no flashing or vaporization of the liquid product will occur with its consequent loss in the gas stream. It is an object of this invention to provide an assembly for condensing the overhead vapor product from a fractionation column so that the column pressure is substantially equal to the condenser

pressure and the liquid condensate receiver is also maintained at substantially the condenser pressure.

In order to achieve this result, a combination of elements is required and this combination according to the present invention consists of three essential elements although others may be added to modify or enhance the result. The first element required is that a pressure sensing point in the vapor from the top stage of the fractionation column actuates a pressure control valve which is disposed in a conduit that passes the liquid condensate from the condenser to the condensate receiver. The pressure sensing point may be in the vapor space on the top deck of the column or it may be at any point in the overhead vapor line and for convenience will usually be disposed in the overhead vapor line in the vicinity of the condenser. The second necessary element is for the liquid condensate passing from the condenser to pass into a liquid receiver maintained at a lower elevation than the condenser, the liquid entering the receiver at a point below the surface of the liquid maintained therein. This may be done with a dip leg or by connecting the condensate line to the bottom of the receiver. The third essential element of the combination is a by-pass line which connects the overhead vapor from the fractionator to the vapor space above the liquid in the condensate receiver. This by-pass is conveniently in the form of a simple, relatively small diameter conduit which maintains these two points in open communication and therefore at the same pressure. When it is desired to also recover a gaseous product, a fourth element to the combination may be added and this element consists of a gas product drawoff line which extends from the vapor space in the condenser and which contains a control valve regulating the gas drawoff rate. This control valve may be actuated to open and close in response to variations in the height of the liquid level in the condensate receiver.

As will be hereinafter shown, this arrangement of elements results in a fractionation column condensing assembly in which the same pressure is maintained in the upper part of the fractionator itself, in the condenser and in the condensate receiver all of which are in open communication. This advantage permits operation at lower pressure as hereinbefore discussed with its inherent advantages and it furthermore reduces the amount of pumping required to return reflux to the column. Although the condensate receiver is usually at minimum level above grade for structural reasons, it may be at a higher elevation than the column and reflux may then be returned by gravity. The arrangement of elements in this system permits the column to be used either with a total condensing system or with a gas producing system. Other advantages include the use of a relatively small pressure control valve since the pressure control is effected in the liquid line rather than in the vapor line. Besides being substantially smaller, the valve in the liquid line is in relatively cool service which permits the use of a cheaper valve which functions better and requires less maintenance.

The operation of this invention may be described in greater detail with reference to the accompanying drawing which illustrates the upper portion of a fractionating column employed with the novel assembly of this invention for condensing the overhead vapors from the column and discharging them as products. Referring to the drawing, the upper portion of a fractionating column **1** containing several plates is shown schematically. These plates are ordinary means for obtaining intimate contact between a rising vapor and a descending liquid and may include conventional sieve decks, bubble caps, packing or the like. The fractionated overhead product passes from the upper portion of fractionator **1** through large diameter line **2** passing overhead and eventually

into the upper portion of condenser 3. The preferable arrangement is shown wherein the overhead vapor passes into one end of condenser 3 and the liquid condensate is withdrawn through line 4 from the other end of condenser 3. The liquid condensate in line 4 is discharged into the lower portion of condensate receiver 8 beneath the surface of the liquid therein to seal the receiver, and in passing from the condenser to the receiver passes through pressure control valve 5. It may be noted here that the liquid condensate occupies much less volume than the vapors and thus, line 4 is substantially smaller than line 2. A pressure control instrument 6 which is of the conventional type is connected by line 7 to the overhead vapor line 2 and variations in the pressure in the overhead vapor line causes pressure controller 6 to actuate valve 5 in response thereto. Therefore, in operation, as the pressure in overhead vapor line 2 becomes too great, valve 5 opens so that greater quantities of condensate run into receiver 8 thereby exposing more condensing surface within condenser 3 so that greater quantities of vapor condense, thereby reducing the pressure in line 2. In normal operation at steady state conditions, valve 5 will always be open with pressure fluctuations causing an adjustment of the opening and condenser 3 will always have some of its cooling surface covered with liquid with the liquid level varying with changes in the setting of valve 5. All of the throttling effect or pressure drop across the pressure control valve, however, is downstream of condenser 3 so that condenser 3 will always be substantially at the same pressure as overhead vapor line 2 which in turn is at the same pressure as the upper portion of fractionator 1. Therefore, with this arrangement, the pressure drop across valve 5 does not affect the pressure relationship between condenser 3 and fractionator 4 but will instead merely hold up a column of liquid in line 4 to some height in condenser 3.

The liquid level in receiver 8 is maintained at some intermediate height in the receiver and is controlled, in one alternative, by liquid level controller 15 actuating valve 14. Liquid is drawn from the bottom of receiver 8 through line 9 and pumped by way of pump 10 through line 11. Line 11 discharges both through line 12 and valve 22, which returns a reflux stream to the upper portion of column 1, and through line 13 through which the liquid product is recovered. The valve 14 controlling the liquid level in receiver 8 regulates the flow of liquid through line 13. Line 21 connects the top of receiver 8 to the overhead vapor line 2 so that receiver 8 is always at the same pressure as both the column and the condenser. Therefore, there is no tendency for the liquid product in receiver 8 to flash or separate into a vapor phase. Since receiver 8 and overhead vapor line 2 are at the same pressure there is little tendency for material to flow through line 21, however, when the liquid level in receiver 8 is dropping, a slight amount of vapor passes from line 2 to receiver 8. Also, when the liquid in receiver 8 is below the boiling point of the vapors, some condensation at the liquid surface will cause a slight flow of vapor through line 21 into receiver 8. Vapor will not be able to by-pass condenser 3, however, since the only exits from receiver 8 are from beneath the liquid level maintained therein. From the foregoing description, it may be seen that this unique arrangement of elements must be present in order for all portions of the condensing assembly to be at equal pressure.

The arrangement thus far described is suitable for a total condensing overhead stream and when such a stream is available valves 20 and 19 to be hereinafter described are closed, however, when it is desired to recover a gas stream from the fractionation valves 20 and 19 are open. Valve 19 places control valve 18 which regulates the flow rate of vapors passing through line 17 from the top of condenser 3 into operation. Valve 18 is actuated in response to fluctuations in the level in receiver 8 and maintains the flow of a normally vaporous or gaseous stream through line 17 by the following mechanism. The total overhead from column 1 passing through line 2 enters condenser 3. As the stream flows through condenser 3 it comes in contact with cool surfaces and condenses, however, the portion of the total overhead which will not condense at condenser conditions remains in the vapor phase. This material accumulates above the liquid layer in condenser 3 and is withdrawn through line 17 and control valve 18. When too much vapor is withdrawn through line 17 and normally liquid material rises toward line 17 or flashes due to a local low pressure, the regular flow of liquid condensate to receiver 8 is diminished and therefore, the level in receiver 8 drops. In response to a dropping level, level control 15 actuates control valve 18 so that the control valve closes thereby reducing the amount of vapor withdrawn through line 17 and increasing the condensate flow through line 4 to receiver 8. This arrangement of elements allows for a gas phase to be withdrawn without diminishing the condenser pressure so that the normally liquid material will not vaporize and yet permits a sealed liquid condensate receiver which functions at column pressure.

As may readily be seen, the assembly as shown in the drawing may operate alternatively on a total condensing overhead stream or on a partially condensing overhead stream and in either case, the combination of elements provides for substantially equal pressure in the column, the condenser and the condensate receiver. The column may be operated with an overhead product which is partly normally gaseous, as hereinbefore described, or it may be operated so that a portion of the product is recovered in the vapor phase and another portion of the same product in the liquid phase. In either mode of operation it is, of course, obvious that the level in receiver 8 may not be regulated both by the rate of vapor draw-off and by the rate of liquid draw-off at the same time. Therefore, one or the other of these streams must be selected to control the level in receiver 8 and the one not controlling must be regulated by some other means. Generally, a constant flow rate will be maintained in the line not controlling the level, however, it may be regulated manually or by other means. As a typical example of an operation wherein both a liquid and a vapor product are recovered, many petroleum compositions are fractionated to produce a cut which contains neither the highest boiling material nor the lowest boiling. In order to recover this cut, the composition must be prefractionated to remove all of the material boiling lower than the desired cut and when this material contains many compounds, for example, material containing both ethane and hexane, the overhead product will contain both normally liquid and normally gaseous material. It is usually desirable and convenient to recover normally liquid material as a liquid and for this process the present modification of this apparatus is useful.

It is contemplated that valves, pumps, compressors, controlling instruments, heat sources, and the like accessories that are ordinarily used in conjunction with a fractionation column will be used in conjunction with the column of this invention in the conventional way. It is also understood that other streams besides those described, such as the feed stream supplied to the column and bottom and side streams leaving the column, will be controlled. Therefore, the reflux rate may be controlled by valve 12 acting in response to some variable such as the top temperature of the column. The feed rate, bottom withdrawal rate, side cut withdrawal rate, reboiler heat and similar streams may also be controlled by any convenient means which may be independent of or related to the overhead condensing assembly of this invention.

From the foregoing it may be seen that this invention provides a versatile means for condensing the overhead vapor from a fractionating column at maximum efficiency and minimum difficulty. The peculiar combination of

elements provides for all important points in the overhead condensing system to be at substantially the same pressure and therefore the optimum conditions.

I claim as my invention:

1. A fractionator vapor condensing assembly comprising in combination an overhead vapor line, a condenser, a condensate receiver, a pressure control valve, a receiver level control valve and a pressure equalizing by-pass, said overhead vapor line connecting the upper portion of a fractionation column to said condenser, conduit means connecting the lower portion of said condenser to the lower portion of said condensate receiver with said pressure control valve positioned in the latter conduit means and adapted to regulate the flow of condensate from said condenser to said receiver responsive to pressure variations in said overhead vapor line, conduit means connecting the lower portion of said receiver with said receiver level control valve positioned therein and adapted to regulate the liquid withdrawal rate from said receiver responsive to variations in the height of the liquid level maintained in said receiver and said pressure equalizing by-pass connecting the upper portion of said condensate receiver to said overhead vapor line.

2. A fractionator vapor condensing assembly comprising in combination an overhead vapor line, a condenser, a condensate receiver, a column pressure control valve, a receiver level control valve, a gas venting conduit, a gas venting control valve and a pressure equalizing by-pass, said overhead vapor line connecting the upper portion of a fractionation column to said condenser, conduit means connecting the lower portion of said condenser to the lower portion of said condensate receiver with said pressure control valve positioned in the latter conduit means and adapted to regulate the flow of condensate responsive to variations in the pressure in said overhead vapor line, said gas venting conduit connecting to the upper portion of said condenser with said gas venting control valve positioned therein and adapted to regulate the gas flow rate therethrough responsive to variations in the condensate level in said receiver and said pressure equalizing by-pass connecting the upper portion of said receiver with said overhead vapor line.

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