United States Patent

Heere

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[54] DIRECT READING REFLUX RATIO CONTROLLER FOR A DISTILLATION APPARATUS

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[*] Notice: The portion of the term of this patent subsequent to Dec. 15, 1986, has been disclaimed.

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[21] Appl. No.: **871,398**

Related U.S. Application Data

[63] Substitute for Ser. No. 461,391, June 4, 1965, abandoned.

[52] **U.S. Cl.** **202/160,** 202/161, 203/2, 203/DIG. 18, 235/151.12, 58/127

[51] **Int. Cl.** **B01d 3/42**

[58] **Field of Search** ..... 179/90 R; 235/151.12; 203/2, 203/DIG. 18, 98; 202/160, 161; 73/53, 54; 58/127; 137/166

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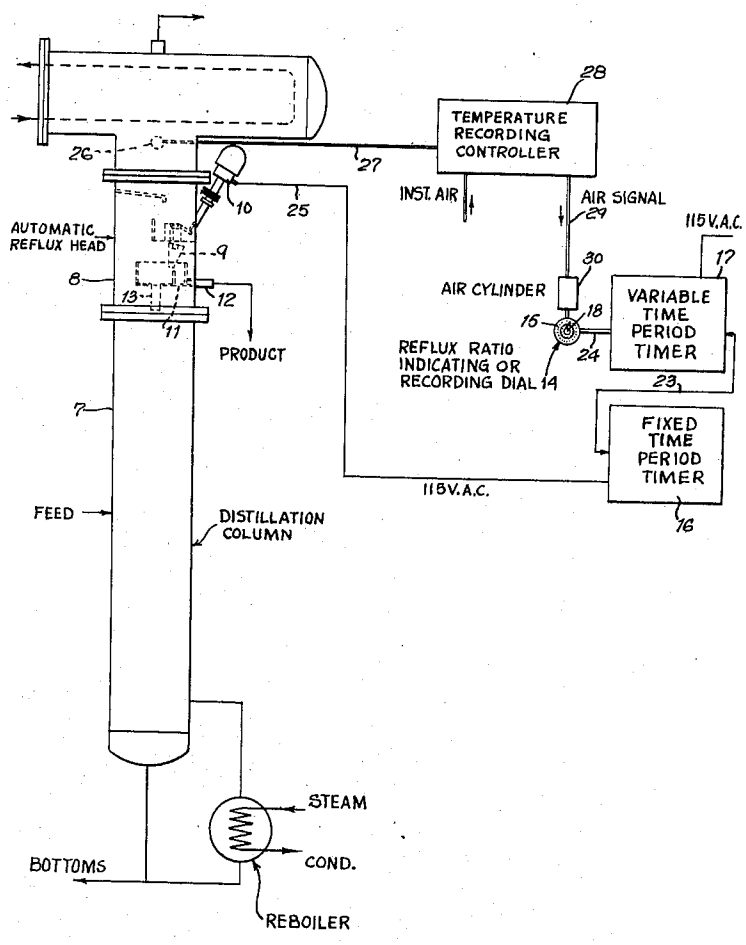
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Primary Examiner—Wilbur L. Bascomb, Jr.

[57] **ABSTRACT**

A direct reading time ratio controller for use with distillation apparatus for controlling its reflux ratio. The controller controlling means for alternately effecting product delivery and reflux return, comprising alternately operable associated fixed period and variable period timers for controlling the means and readable means operatively associated with the variable period timer to change and set its operating time and directly indicating the reflux ratio.

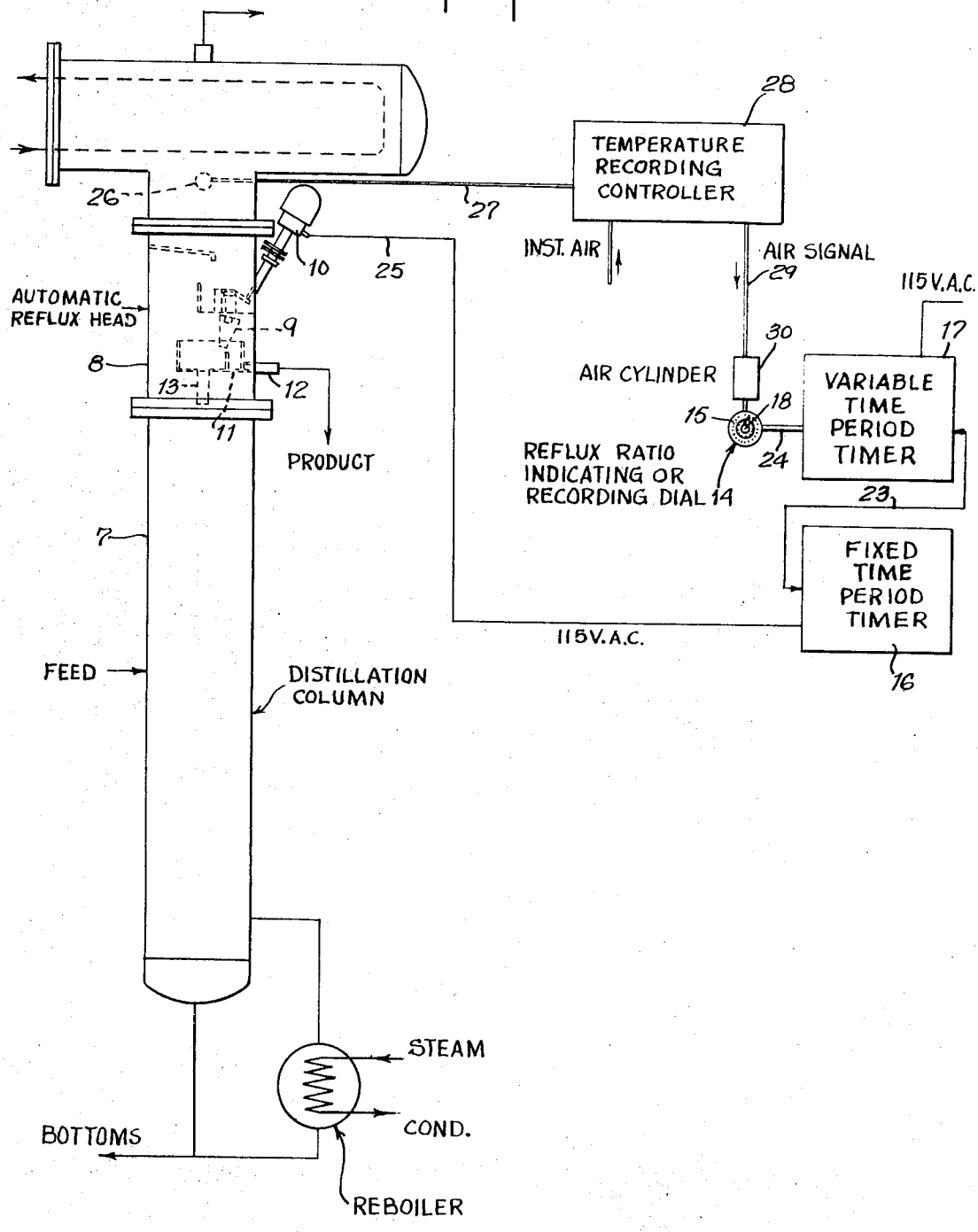
4 Claims, 5 Drawing Figures



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3 Sheets-Sheet 1

Fig. 1.



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3 Sheets-Sheet 2

Fig. 2.

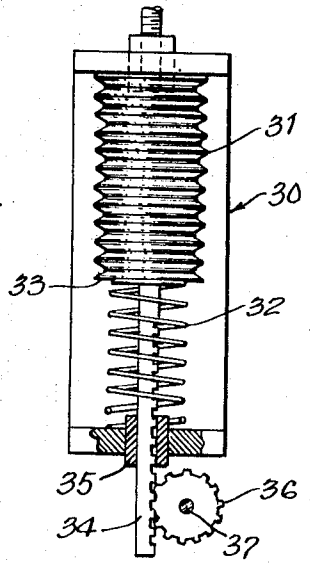


Fig. 3.

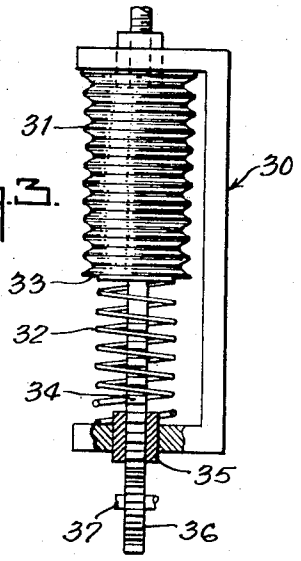
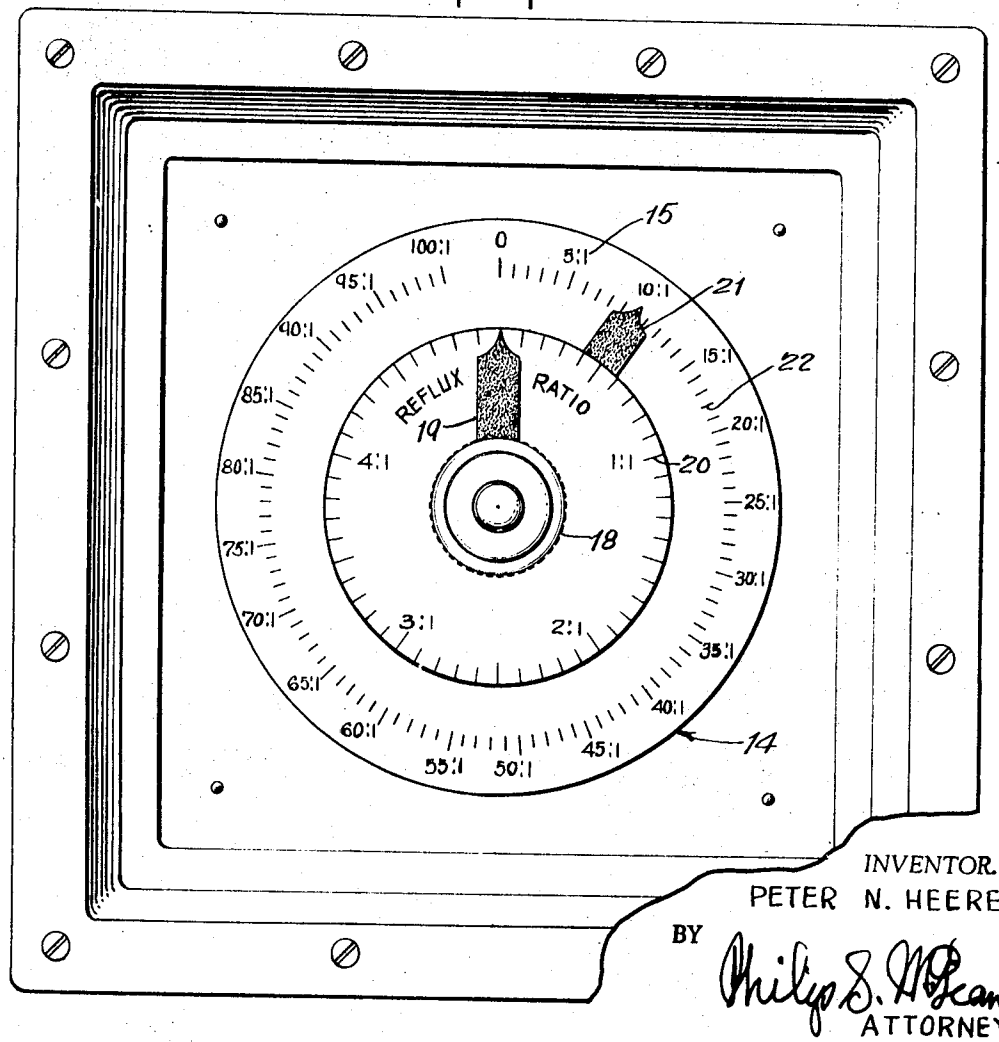


Fig. 4.



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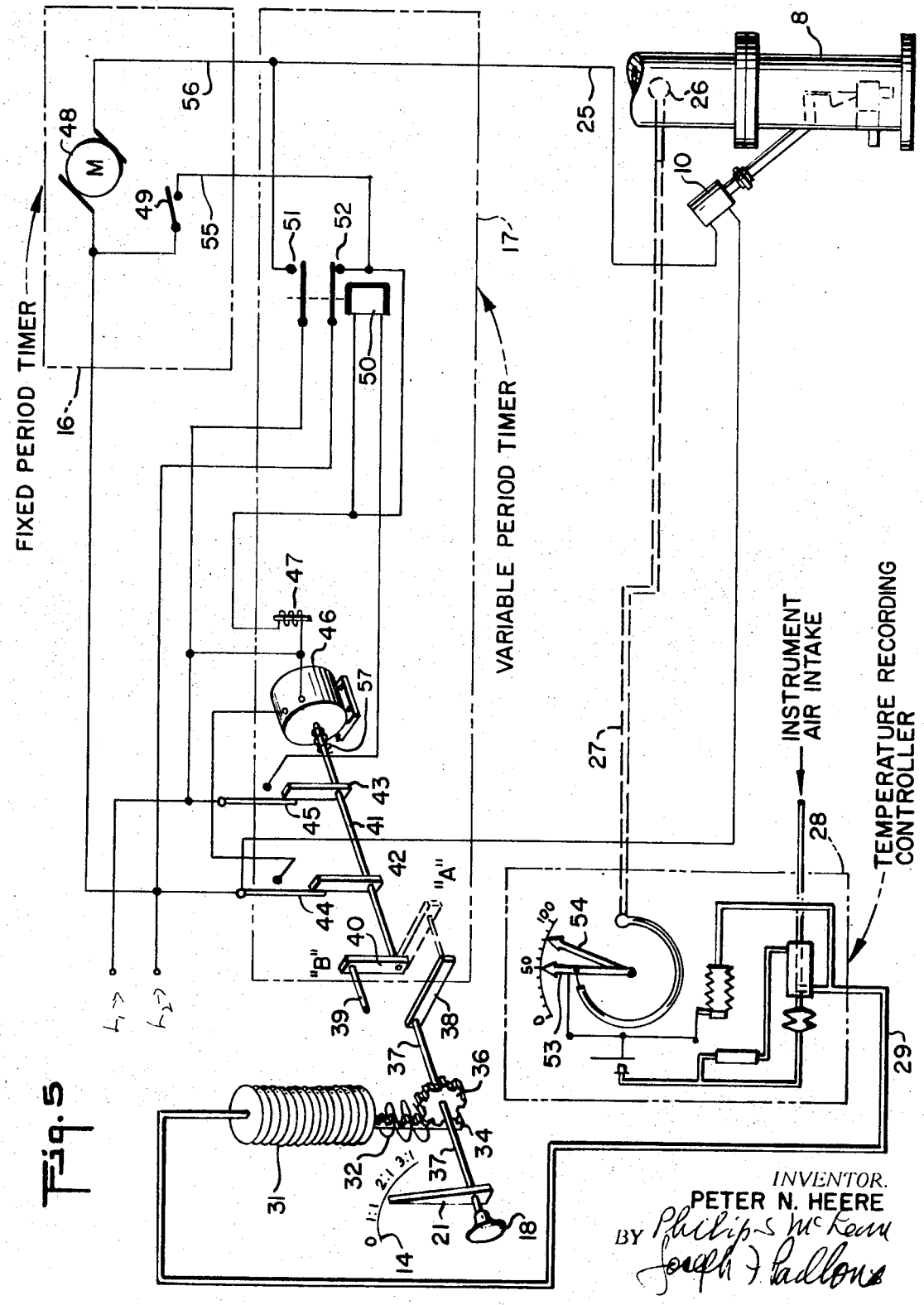


Fig. 5

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DIRECT READING REFLUX RATIO CONTROLLER FOR A DISTILLATION APPARATUS

This present application is substituted for application Ser. No. 461,391, filed June 4, 1965 and now abandoned.

The invention herein disclosed relates to the control of the ratio of time periods or the length of one period to that of the other.

For illustrative purposes the invention is disclosed as applied to the control of the timing of reflux ratios in a distillation column. The invention, however, is not limited to that function.

The present invention is concerned with the means for determining the time period of these two phases of operation.

Special objects of the invention are to provide a timing control of simple practical form which will be direct reading in the sense of showing the different ratios which will be established by one single adjustment of an indicating, recording, or program fixing dial.

Other special objects of the invention are to provide a practical form of remote control by which the action may be governed by temperature or other conditions existing at a more or less remote point.

The foregoing and other desirable objects have been attained in this invention by a novel combination and features of construction; all as hereinafter set forth and illustrated in the accompanying drawings.

The drawings referred to illustrate present practical embodiments of the invention but as will appear, the structure may be modified and changed in various ways; all within the true intent and scope of the invention as hereinafter defined and claimed.

Prior to the present invention it was customary to use a timer associated with a distillation column to control the time of product delivery to reflux return, with the timer alternately in repeating order operating to maintain a fixed product time and a fixed reflux return time so that the reflux ratio at all times was constant. Such a timer is the cam **9** of Galustan U.S. Pat. No. 2,556,752 of June 12, 1951. The cam **9** remained constantly in operation until the temperature of a thermocouple in the distillation apparatus increased above a certain value and in response thereto another timer cam **29** was placed in service.

The present invention is a direct reading reflux ratio controller for a distillation apparatus having first means for alternately effecting product delivery and reflux return, the controller comprising the combination of fixed period and variable period timers connected to always operate alternately in repeating order, said timers operatively associated with said first means for always controlling said first means to always alternately in repeating order effect product delivery only in the fixed time period determined by the fixed period of operation of said fixed period timer and to effect reflux return only in the particular period determined by the setting of the period of operation of said variable period timer, second means operatively associated with the variable period timer for changing and setting at different values the time period of operation of said variable time period timer to effect different reflux ratios; and readable means calibrated in reflux ratios and operatively associated with said adjustable means for indicating directly the reflux ratio determined at any particular time by the particular setting of the period of operation of said variable period timer and the fixed period of operation of the fixed period timer.

FIG. **1** in the drawings is a diagrammatic view, illustrating application of the invention to a distillation column.

FIGS. **2** and **3** are enlarged vertical sectional views of the air motor for effecting adjustment of the reflux ratio control dial, the sectional views being taken at right angles to each other.

FIG. **4** is a face view of the control dial.

FIG. **5** is a schematic diagram of the invention.

In Fig. **1** there is shown a distillation apparatus including a horizontally disposed tank, which is a condenser, in communication with a vertically disposed main column including a

distillation column **7**, and a reflux head **8**, like that shown in my U. S. Pat. No. 2,903,401. As shown and described in my patent, vapors from the main column pass into the condenser wherein they convert into a liquid condensate which then flows downwardly by gravity towards the distillation column. A solenoid **10** is associated with the head **8**.

In the course of flow the condensate flows into the reflux head **8** and is intercepted by funnel **9** actuable to two positions. In its position shown in Fig. **1**, funnel **9** receives and discharges the condensate into that section of the collector box having discharge **13** so that the condensate flows into the distillation column **7** and this is known as "reflux" or "reflux return." This occurs in the period the solenoid **10** is in deenergized condition. The funnel **9** is movable to and maintained in its other position in the period solenoid **10** is in energized condition where it again receives the condensate flowing downwardly from the condenser towards said column, but now its discharge end is disposed in the other section **11** of the collector box thereby to be in communication with the outlet **12** so that the condensate flows out of the funnel and then delivered out of the head **8** through outlet **12** and this condensate bears the legend "product" in Fig. **1**.

The action of the solenoid in this case determines the reflux ratio, serving when energized to fix the product time and when de-energized to fix the reflux time.

To enable this ratio of reflux to product to be set by a single direct reading instrument, there is provided an indicating or recording and control dial **14** carrying designations **15** of the reflux ratios which it pre-determines and this dial is connected with two timers in tandem; one a fixed period timer **16** for product timing and the other a variable period timer **17** for reflux return periods.

With the product timing a constant value, any change in reflux time will effect a variation in the reflux ratio and thus desired ratios, as appearing on the dial may be selected by a single setting of the dial and without necessity of any second adjustment or calculation of any sort.

Adjustment for reflux ratio is made, in the illustration, by turning a control knob **18** to the desired reflux ratio indication, which knob is connected to drive a pointer **19** reading on an inner scale **20**, calibrated from 1:1 through 5:1 and geared to drive a pointer **21** reading on an outer scale **22** carrying the final reflux ratio designations **15**. For cases where a high degree of accuracy is not essential, the reflux ratios can also be indicated on a single dial using one pointer.

In the illustration, the gearing is proportioned 20:1 so that it will take 20 revolutions of the adjusting knob to effect a complete revolution of the outer pointer from 0 to 100 on the outer scale and so that one revolution of the knob will effect movement of the pointer through a range of five ratios.

Details of this control instrument and of the fixed and variable timers are not shown since, except for the reflux ratio scales and the combination disclosed, these are items now available as standard equipment from numerous manufacturers.

The two timers, in the illustration, are driven by separate synchronous motors and are connected in tandem so that the fixed period timer **16**, as it comes to the end of the period for which it is set, will start the variable timer **17** and the latter as it completes its timing function, will start the fixed period timer, the action being repeated so long as the energizing circuit is closed.

Fig. **1** shows the two timers as separate units but these may be combined in one structure and be driven by a single motor.

They are indicated as connected by wiring **23** and connected with the program dial by mechanical linkage **24**, with wiring **25** extended to the solenoid **10**.

The fixed period timer is usually set for a fixed definite time at the factory and sealed or secured so as to remain at that constant value.

Fig. **1** illustrates the fact that the control unit may be adjusted by hand to fix the variable time period and in addition, when so required, may be controlled and adjusted from a

remote control point by varying the air signal to the air cylinder.

In the illustration, a temperature measuring bulb **26** is provided at the top of a distillation column and connected by capillary tubing **27** with a temperature recording controller **28** connected by air tubing **29** to an air motor **30**, arranged to adjust the ratio control dial and thereby the variable timer.

As shown in Figs. **2** and **3**, this air motor **30** is in the form of an expansible bellows **31**, subjected to the air pressure in the line **29** and subject to the contracting force of a spring **32**, connected with the movable head **33** of the bellows. The latter is shown as having a rack **34** extended down through a guide **35** and engaged with a pinion **36** on the spindle **37** of the adjusting knob **18**.

Fig. **5** shows a detailed schematic arrangement and a specific embodiment of the subject invention using standard commercially available components such as a temperature recorder controller **28**, fixed period timer **16** and variable period timer **17**. A different arrangement doing the same function could be shown for the similar components as manufactured by other suppliers. The arrangement is shown as an application for the control of a distillation column. The same arrangement, however, can be used to control other applications when a ratio between fixed and variable time is required. For those cases a controller with an applicable measuring source, such as variations in pressure, refractive index, specific gravity, etc., would be used and it would transmit the required pressure signal to the expansible bellows **31** of this invention.

As shown in the schematic arrangement, the temperature indicating or recording controller **28** has an index hand **54** which can be set at the desired distillation column temperature. Temperature measuring bulb **26** measures and transmits the temperature to the controller **28** by means of conduit **27**, said temperature being indicated by hand **53**. The controller then transmits a pneumatic signal through conduit **29** to the expansible bellows **31**. The expansible bellows extend as required by compressing spring **32** and operate a rack and pinion gear **34** and **36** to turn shaft **37** and attached arm **38** to a position corresponding to the air signal. The value of the air signal in terms of reflux ratio or the ratio of fixed time of product flow to the variable time of reflux flow is indicated or recorded by pointer **21** fastened to shaft **37** on scale **14**.

The schematic arrangement shows two timers, a fixed period timer **16** and a variable period timer **17**. When lines L-1 and L-2 are electrically energized the fixed timer 16 times a pre-set period of time and then sends an electrical signal by line **55** to the variable timer **17**, timer **17** then times a period of time proportional to the setting of arm **38** which in turn is set by expansible bellows **31**. When the variable period timer **17** completes its period, it closes switch **51** and transmits an electrical signal by line **56** to the fixed period timer **16**. The above cycle is repeated as long as lines L-1 and L-2 remain energized.

Further components of the variable period timer **17** illustrated consist of a motor **46**, clutch **47**, relay **50** and relay switches **51** and **52**, an arm **40** with a pin **39** which is normally held by the spring **55** against arm **38** in the "A" position; switches **44** and **45** are open at this time. When the fixed period timer **16** completes its period it sends a signal by line **55** which starts the variable timer **17**. Arm **40** then travels counter-clockwise in an arc, the length of which depends on the position of arm **38**, until it reaches position "B." At that position switches **44** and **45** are opened by arms **42** and **43**, the timer **17** completes its period and starts timer **16** operating. Arm **40** then returns to position "A." Further components of the fixed period timer **16** are motor **48** and switch **49**.

By means of the above arrangement the time period for the variable period timer **17** or the ratio of variable to fixed time (reflux ratio) is changed so as to keep the top column temperature at the desired value.

Fixed reflux ratio control as illustrated by the dial Figure **4** can be similarly illustrated by the detailed schematic arrangement by eliminating the expansible bellows **31**, spring **32**, rack **34** and gear **36** and setting the required value of ratio directly by knob **18** on shaft **37**.

In further amplification of the operation of the illustration shown in Fig. **5**:

With electrical energy being supplied to lines L_1 and L_2 the relay switch **51** is in closed position and switch **49** and relay switch **52** are in open position, so that through line **56** timer motor **48** starts and continues to operate and simultaneously solenoid **10** is energized and is so maintained until the fixed period timer times out. Switches **49** and **52** remain open and **51** remains closed until the end of the fixed time period and at the end of that time conventional means (not shown) associated with the motor **48** closes switch **49**. Instantaneously at the closing of switch **49**, clutch **47** is energized, through line **55** connected to one end of the coil of clutch **47** and a conventional electrical connection (not shown) electrically connects line L_1 to the common electrical connection between a terminal of the motor **46** and the other end of the coil of clutch **47** so that the circuit through the coil of clutch **47** can be completed, thereby to actuate its core associated with conventional means (not shown) to close switches **44** and **45**; and instantaneously upon closing of switch **45**, relay **50** is energized to open relay switch **51** and close relay switch **52**. When switch **51** is opened, it breaks the circuit to motor **48** causing the fixed period timer to reset and switch **49** to open and also to break the circuit of solenoid **10** which becomes deenergized. With switches **44**, **45** and **52** being closed, motor **46** is started and continues to rotate causing rotation of shaft **41** to swing arms **40**, **42** and **43** locked to shaft **41** from position A to position B at which switches **44** and **45** are opened. The length of time required to move those arms from position A to B is the particular time period of operation of the variable period timer **17** and this is determined by the setting of arm **38**. Opening of switch **44** causes motor **46** to stop and simultaneously opening of switch **45** breaks the circuit to relay **50**. Relay **50** now being deenergized, **52** opens to break the circuit of clutch **47** causing timer **17** to reset and the arms **40**, **42** and **43** return to position A, and at the same time switch **51** closes, starting again the motor **48** of the fixed period timer **16**

With this combination, the over head temperature of the column is effective to control the reflux, thus to maintain the desired operation of the column.

Other forms of remote control and operators for the control dial may be used and it will be realized that the control system, in whole or in part, may be applied to other uses involving time ratios, such as to govern the ratio of "OFF" to "ON" periods in the operation of pumps and other machines such as moving belts, feeders, etc., to control their delivered output per period of time. By the use of two variable dials a still greater number of control variations are possible.

The combination of fixed and variable period timers in this invention has special advantages in regard to simple single adjustment but it is within the contemplation of the invention that the two timers operating alternately in tandem may be both of the variable type and if desired be one or both locally or remotely controlled and that other variations of these relations may be utilized.

The ratios illustrated may be considered at present as preferable for reflux control but these ratios may be altered as conditions require.

In the example here shown, for reflux control the fixed timer period for product, may be considered as for 3 seconds and the variable timer period, for reflux, may be considered as beginning for 3 seconds, with a 1:1 ratio and running up to 300 seconds, a 100:1 ratio.

In all forms the invention has advantages of simplicity, few parts, low cost and adaptability to existing control panels and other equipment.

The control, or programming dial, presents a neat and attractive appearance and conveys information instantly understandable to an operator or to one not particularly conversant with operation of the system.

The operation of the apparatus, shown and described and constituting an embodiment of the invention is as follows:

With the main column and condenser in operation and solenoid **10** connected by wiring **25** to the timer **16** which is always operable for a fixed time period for maintaining at a constant value the product timing, that is for maintaining at constant value the time period for discharge of the condensate out of outlet **12**, such as 3 seconds for example, and with the pointer **19** or **21** set at a specific reflux ratio on the calibrated reflux ratio dial, as for example at 2:1, the operable period of the timer **17** is set at 6 seconds and upon supplying electrical energy through the 115 V line, the timers operate alternately in repeating order as follows:

The timer **17**, which is electrically connected by wiring **23** to timer **16**, operates for 6 seconds in which time period the solenoid **10** is in deenergized condition whereby the funnel **9** is maintained in a first position shown in Fig. **1** to effect reflux return over that period. At the end of its 6-second period of operation timer **17** effects starting of the timer **16** which will operate for its fixed time period, **3** seconds, during which fixed time period the solenoid is energized and so maintained and in response thereto the funnel **9** is moved to and maintained in a second position to be in communication with the outlet **12** for effecting delivery of the condensate out of the head as "-product" over that 3-second period. At the end of that 3-second period, and independent of any temperature change in the main column or condenser the timer **16** will effect starting of the timer **17** which will operate for its set time period of operation, namely 6 second, in which period the solenoid is deenergized and in response thereto the funnel moves back to and is maintained in its first position whereby reflux return is effected over that 6 seconds period. This cycle of operation in which the timers operate alternately in repeating order is repeated continually to effectively maintain the 2:1 reflux ratio which at all times is quickly ascertainable with certainty by an operator by merely glancing at the readable device **14**.

In the event that a different reflux ratio, for example 5:1, be desired, this is effectuated without shut-down by merely turning the knob **18** to move the pointer **19** or **21** to the 5:1 indication. The turning of knob **18** obviously causes actuation of linkage **24** which re-sets the time period of operation of the timer 17 to a 15 seconds value.

The timer **17** and timer **16** keep operating in alternate in repeating order as before described, with the only difference being that the particular period operation of the timer **17** is now 15 seconds instead of 6 seconds due to the change in setting of the time value of operation of the timer **17** from 6 to 15 seconds by the turning of the knob **18**.

The reflux ratio of the apparatus may be changed at will to any desired value by merely turning the knob **18** to drive the pointers **19** and **21** to any one of the reflux ratio indications, and to actuate the linkage **24** to re-set the time of operation of the variable period timer to a value in seconds corresponding to 3 times (because the fixed time is always 3 seconds in this example) the first number of the reflux ratio indication to which said pointer 19 or 21 points. For example, by turning the knob **18** so that the pointer **21** points to 1:1, 3:1, 10:1, 20:1, the linkage **24** is actuated so that the time period of operation of the timer **17** is changed and set to 3 seconds, 9 seconds, 30 seconds, 60 seconds, respectively, the respective times of operation of timer **17** whereby those particular respective reflux ratios are achieved due to the period of operation of timer **16** being always fixed at 3 seconds in this example. The cycle of operation of timer **16** for its fixed time period and then the timer **17** for its variable time period whatever it may be is continual and uninterruptible despite any temperature change in the main column or condenser. Obviously, although the cycles of operation are always the same, the reflux ratio of certain cycles will differ from that of others due to changing and setting of timer **17** at different values.

Instead of manually actuating the knob **18** to drive the pointer **19** or **21** to different reflux ratio indications and to actuate linkage **24** to change and set the time period of operation of the timer **17**, the knob **18**, together with pointer **19** or **21** as well as the linkage **24** are controlled and adjusted by the air signal from the remote control before described.

Whether timer **17** is set manually or by the temperature controller, and while electric energy is supplied by the 155 V line the reflux ratio of the apparatus is always controlled solely by the timers **16** and **17** which always operate alternately in repeating order continually and the reflux ratio at any particular time is directly ascertainable by reading device **14**.

What is claimed is:

1. A direct reading reflux ratio controller for a distillation apparatus having a column, first means for alternately effecting product delivery and reflux return, a solenoid coil associated with said first means,

the controller comprising the combination of fixed period and variable period timers connected to always operate alternately in repeating order,

said timers operatively associated with said first means for always controlling said first means to always alternately in repeating order effect product delivery only in the fixed time period determined by the fixed period of operation of said fixed period timer and to effect reflux return only in the particular period of operation of the variable period timer determined by the setting of the period of operation of said variable period timer,

said coil connected to said fixed period timer,

second means operatively associated with the variable period timer for varying and setting at different values the time period of operation of said variable time period timer to effect different reflux ratios;

and readable means calibrated in reflux ratios and operatively associated with said adjustable means for indicating directly the reflux ratio determined at any particular time by the particular setting of the period of operation of said variable period timer and the fixed period of operation of the fixed period timer.

2. A controller according to claim **1**, the coil and the timers being so constructed and arranged that when in operation, the fixed period timer always operates for a fixed time period whereby the coil is maintained in energized condition in that period whereby said first means effects product delivery in that period, and at the end of the fixed time period of operation of the fixed time period timer and independent of any temperature change in the distillation apparatus, the coil is deenergized and the variable time period timer is placed in service and operates for a particular time period determined at any particular time by the particular setting of the time period of operation of the variable time period timer whereby the coil is maintained in deenergized condition in that particular time period whereby said first means effects reflux return in that particular period, and at the end of said particular time period of operation of the variable time period timer the fixed period timer is placed in service.

3. A controller according to claim **1** amended, and temperature responsive means associated with the interior of the upper end of said column and operatively connected with said adjustable means for varying and setting at different values the time period of operation of said variable period timer in response to temperature changes in the upper part of said column.

4. In a distillation apparatus which includes a condenser and a main column in communication with the condenser and including a distillation column towards which condensate flows from the condenser, and first means for effecting reflux ratio by alternate delivery outside of the main column of the condensate flowing towards the distillation column and return of the flowing condensate to the distillation column, said first means including second means alternately movable to and maintainable in a first position whereby said delivery occurs and a second position whereby said return occurs and an electrical coil operatively associated with the second means;

the improvement comprising:

a fixed time period timer and a variable time period timer always operatively associated with each other for always operating alternately in repeating order,

the fixed time period timer electrically connected to the coil,

adjustable means operatively associated with the variable time period timer for changing and setting at different values the operating time period of the variable time period timer,

the timers always operatively associated with the coil for always controlling the first means to always effect reflux ratio solely by the alternate in repeating order operation of the timers,

readable means calibrated in reflux ratios and operatively associated with the adjustable means for indicating directly at any particular time the reflux ratio determined at that time by the particular setting of the time period for operating the variable time period timer by the adjustable means and the fixed time period for operating the fixed time period timer,

the first means and the timers being so constructed and arranged that always in alternating and repeating order the fixed time period timer operates for a fixed period of time whereby the coil is energized and in response thereto, the second means is moved to and maintained in one of said positions in the period corresponding to the fixed period of operation of said fixed time period timer, at the end of the time of operation of the fixed time period timer and independent of any temperature change in the main column or condenser the variable time period timer is placed in service and operates for a particular time period determined at any particular time by the particular setting thereof whereby the coil is deenergized and in response thereto the second means is moved to and maintained in the other of said positions in the period of time corresponding to said particular time period of operation of the variable time period timer, and at the end of the time of operation of the variable period timer and independent of any temperature change in the main column or condenser, the fixed period timer is placed in service.

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