

June 11, 1946.

A. E. KROGH

2,401,832

CONTROL SYSTEM

Filed Aug. 6, 1942

3 Sheets-Sheet 2

FIG. 2.

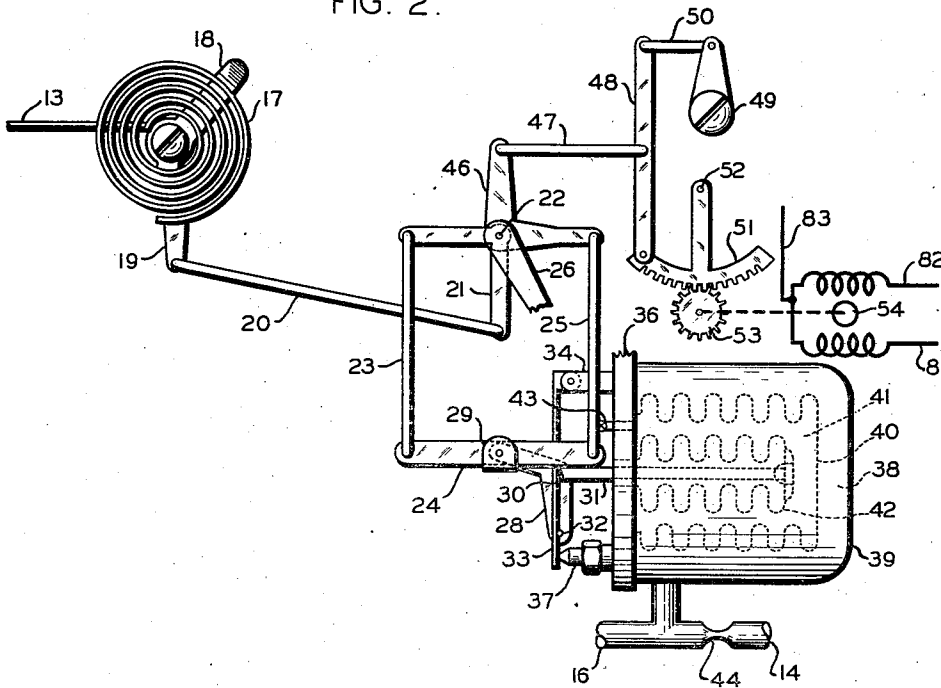


FIG. 4.

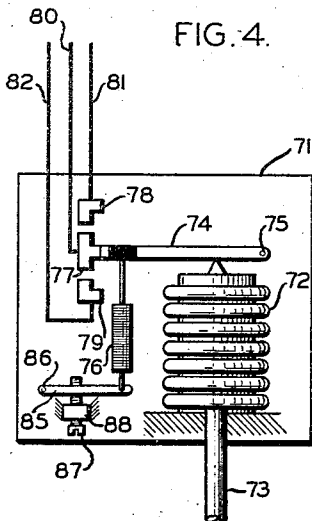
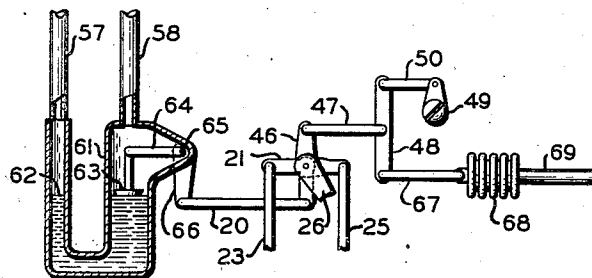


FIG. 3.



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FIG. 5.

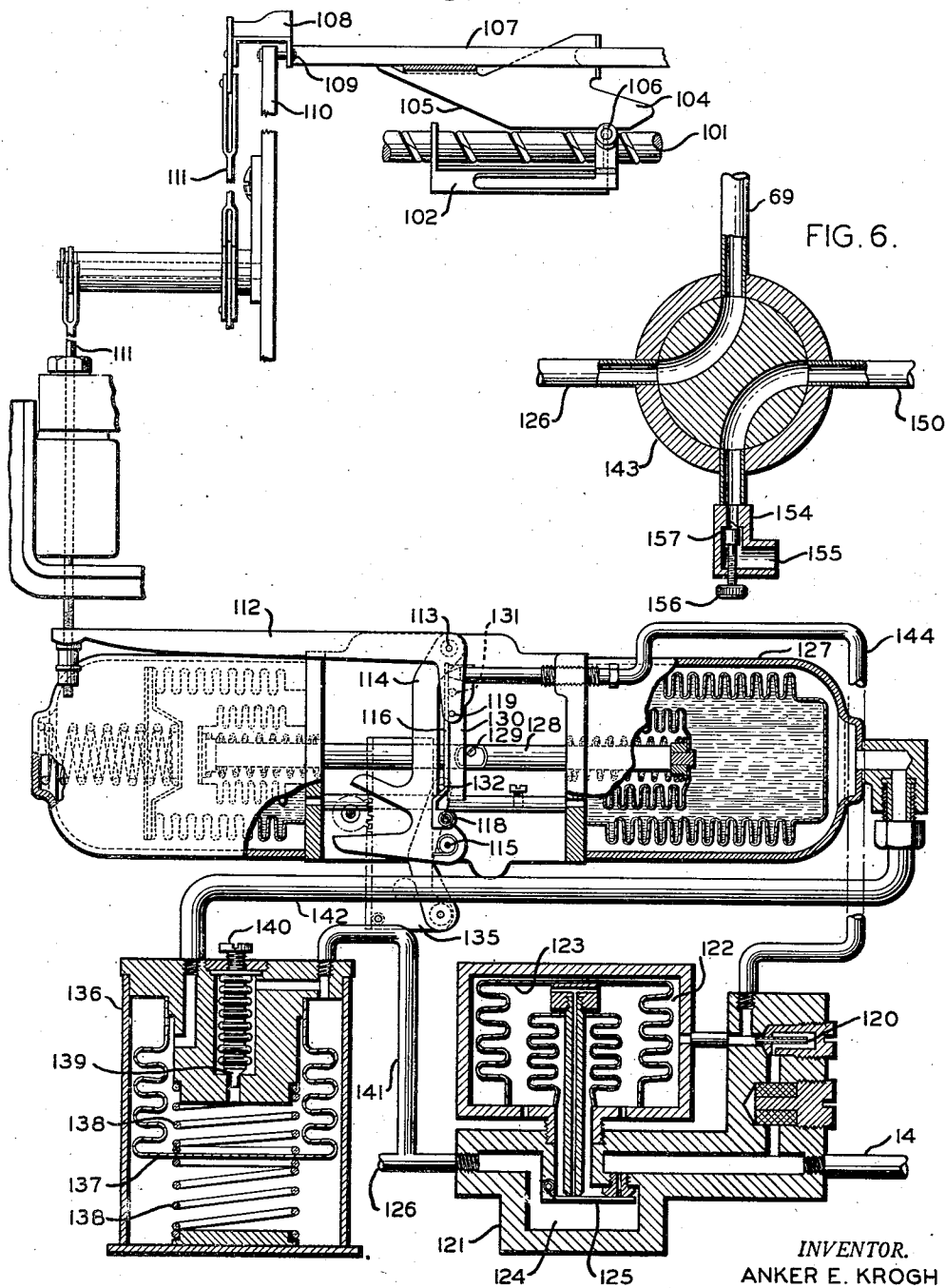
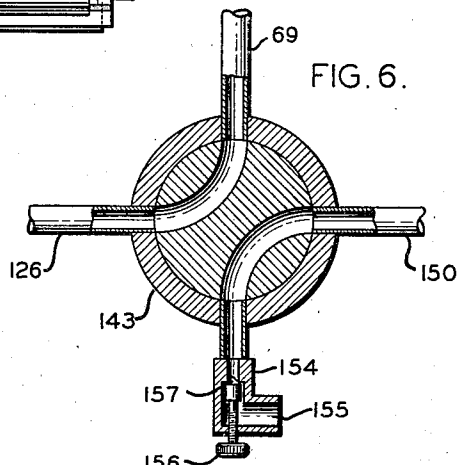


FIG. 6.



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CONTROL SYSTEM

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13 Claims. (Cl. 34-48)

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The present invention relates to drying machines, and more particularly to a system for controlling the temperature of a paper drying machine so that the moisture content of a web of paper passing over such a machine may be held at some predetermined desired value.

Many ways of controlling the supply of steam to the drying cylinders or drums of paper drying machines have been tried in the past. Each of these, however, had some drawback. In some the control system was too complicated while in others the web could not be kept with a constant moisture content. In any event the control systems previously known were to a large extent unsatisfactory and depended too much upon manual supervision.

It is an object of the present invention to provide a control system for a paper dryer that, during the drying operation, is fully automatic in operation and will maintain the moisture content of a paper web at a constant value.

It is a further object of the invention to provide a control system for a paper drying machine in which the drying cylinders are divided into a plurality of groups or sections. The last section over which the web passes, or the dry end section, is maintained at a constant temperature and the section prior to this section has the flow of steam, or other drying medium, maintained at a constant value which may be altered in response to variations in the moisture content and the rate of variation of the moisture content of the web being dried.

It is a further object of the invention to provide a control system for drying machine which consists of a plurality of air operated control instrumentalities which are so interlocked that the moisture content of the web leaving the machine is maintained at some constant value. The control system is also provided with means to keep the various parts thereof in the position in which they were when a break in the web occurred.

It is a further object of the invention to provide a dryer control system which maintains the last section of dryers over which the web passes at some constant temperature which may be varied when the control for the section of drying cylinders prior to the last section reaches one of its limits.

While the control system herein described was particularly designed for use with a paper dryer, and will be so described, it will be readily apparent to those skilled in the art that the system can also be used with a machine used to dry other types of webs either artificial or natural.

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The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects obtained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

In the drawings:

Figure 1 is a view of the entire control system,

Figure 2 is a diagrammatic view of the temperature or pressure control instrument,

Figure 3 is a diagrammatic view of a portion of the flow control instrument,

Figure 4 is a view of the pressure responsive switch,

Figure 5 is a view, partly in section, of the air control portion of the moisture measuring instrument, and

Figure 6 is a sectional view of the four way valve and restriction T.

Referring first to Figure 1, there are shown the number of drying rolls or drums over which a web to be dried is passed from left to right. The rolls are divided into a plurality of sections which are individually controlled and to produce their drying effects upon the web. The first section of rolls over which the web passes is known as the wet end section and is supplied with steam by means of a header 7 that is common to all of the rolls in this section. The second section of the drying machine is known as the dry end section and is supplied by a header 8 that is common to all of the rolls in this section. The main header 9 supplies steam through a valve 10 to header 7 and through a valve 11 to the header 8. The valves 10 and 11 are shown herein as diaphragm valves that are biased in an opening direction by a spring and which are closed varying amounts by means of air pressure which is applied to the diaphragm that works in opposition to the spring.

The temperature of the rolls in the dry end section is controlled by a temperature controller 12 that is shown herein as being an air operated controller. This instrument may be responsive to either the temperature or the pressure of the steam in the rolls forming the dry end section, and, to this end, is connected by means of a tube 13 with the interior of one of the rolls if the pressure is to be measured, and with a temperature bulb located in one of the rolls if the temperature is to be measured. This instrument is

supplied with air under a constant pressure from a supply pipe 14, and serves to regulate this air in accordance with pressure or temperature changes in the rolls forming the dry end section to thereby vary the pressure applied through a pipe 16 to the diaphragm of valve 11 to control the amount of steam supplied to this section.

The air control instrument 12 is preferably a Brown Air-O-Line controller which is shown and described in C. B. Moore Patent 2,125,081, issued on July 26, 1938, and now in extensive commercial use, but is shown herein in a diagrammatic form as an air controller having follow-up and reset provisions. To this end there is shown in Figure 2 a spiral Bourdon tube 17, the fixed inner end of which is attached to the end of tube 13. This tube is mounted in a suitable fashion on a bracket 18 to the casing of the instrument 12. The outer end of the spiral is provided with an arm 19 that is moved to the right or to the left as the temperature or pressure being measured increases or decreases, respectively. Movement of this arm operates through a link 20 to adjust a bell-crank lever 21 around its pivot 22. The horizontal arm of the bell-crank supports the upper end of a link 23, the lower end of which is pivotally attached to one end of a floating lever 24. The other end of the floating lever is attached to the lower end of a normally stationary link 25. As the spiral 17 moves due to changes in the value of the condition being measured, it operates to raise and lower the left end of the lever 24 and also to move a pen arm 26 that is attached to the shaft 22 across a chart 27 to make a record of the value of the condition.

One arm of a bell-crank 28 is attached by means of a bracket 29 to the mid-point of the floating lever 24. This bell-crank is pivoted at 30 to the end of a rod 31 and is provided on its other end with a pin 32 that is adapted to operate a flapper 33. The flapper is pivoted to a bracket 34 and is normally biased in a counter-clockwise direction so that it tends to throttle a nozzle 37 that projects from the left face of a support 36 to which the bracket 34 is attached.

The support 36 is provided with an opening, one side of which communicates with the nozzle 37 and the other side of which is in communication with a chamber 38 that is formed between a cup shaped casing member 39 and a flexible bellows 40 both of which are attached to the support 36. A second chamber 41 is formed between the bellows 40 and a second, smaller bellows 42 which is also attached at its open end to the bracket 36. The chamber 40 is in communication with the atmosphere through a variable restriction 43. Rod 31 which supports on its outer end the bell-crank 28, is fastened at its inner end to the head of the bellows 42. Air is supplied to this instrument through the line 14, and a fixed restriction 44.

In the operation of this control instrument, when for example the temperature in the drums of the dry end section increases, the Bourdon tube 17 will be expanded to move arm 19 to the right. This acts through the lever system to lower the left end of floating lever 24 so that pin 32 on the bell-crank 28 can be shifted to the right to permit the flapper 33 to throttle the flow of air through nozzle 37. This produces two results, the first of which is to increase the pressure in the chamber 38 and the line 16 so that the pressure on the diaphragm of valve 11 will be increased to close this valve an amount propor-

tional to the pressure increase and cut down the supply of steam to the drums. The second result follows from the pressure increase in chamber 38 and acts on the bellows 40, the inter-bellows space 41 and the bellows 42 to shift the rod 31 to the right and thereby give a follow-up movement to the flapper 33 to prevent over-correction of the pressure change. This movement is followed by a subsequent movement of rod 31 and the flapper in the original direction as the pressure in chamber 41 is slowly equalized with that of the atmosphere through the restriction 43. Ultimately, if there is no further change in the temperature of the drums 5, the flapper 33 will come to rest at substantially its original position with respect to the nozzle 37, with a different pressure in the system.

In order to change the control point of the instrument, or normal value of the temperature which it will maintain in the cylinders 5, the right end of the floating lever 24 may be raised or lowered to shift the normal position of the flapper 33. This is accomplished by having the upper end of link 25 attached to the horizontal arm of a bell-crank 46, the vertical arm of which is connected by a link 47 to the midpoint of a differential lever 48. If the control point is to be adjusted manually, the upper end of this link is moved by means of a knob 49 that is connected to the upper end of lever 48 by a link 50. As the knob is rotated, lever 48 will be moved to the right or to the left to thereby rotate bell-crank 46 to raise and lower the right end of lever 24. If the control point is to be adjusted automatically, a gear segment 51 to which the lower end of lever 48 is attached may be rotated around its pivot 52 by means of a pinion 53 that is on or geared to a motor 54. In normal operation, one end of the lever 48 would be held stationary while the other is adjusted to change the control point of the instrument.

Steam to the header 7 which supplies the wet end section of the drying machine is controlled by means of a flow meter 56 instead of by an instrument that is responsive to the temperature or pressure of the steam. To this end, a pair of pressure taps 57 and 58 are connected to the legs of a U-tube manometer 61 that forms part of the instrument 56 and which is shown diagrammatically in Figure 3. These taps at their upper ends extend into the supply pipe on either side of an orifice plate 59 which creates a differential pressure varying with the flow. The instrument 56 is preferably a Brown Air-O-Line flow controller of the type disclosed in the above mentioned Moore patent, but is shown herein as being the same type of air controller as that in Figure 2.

The manometer 61 is provided with a measuring liquid 62 upon the surface of which, in one of the legs, there is a float 63. As the flow to the header 7 varied, the differential pressure across the orifice will change to raise or lower the level of the liquid upon which the float 63 rests. In this manner the float which is connected to a lever 64 operates to move this lever around a shaft 65. The shaft 65, preferably has one end attached to the arm 64 in the manometer, and the other end attached to an arm 66 which is exterior of the manometer, the shaft passing through a pressure tight bearing. Movement of the arm 66 acts through link 20 to adjust the air control instrument in exactly the same manner in which arm 19 of the Bourdon tube serves to

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adjust the air control instrument of Figure 2. This instrument can also have its control point adjusted manually in a manner above described, or it can be adjusted automatically. The automatic adjustment is shown herein as being responsive to pressure variations applied to a link 67 by means of a bellows 68. This bellows is supplied with air pressure that varies in accordance with some condition in a manner to be described. It will be apparent that variations in the pressure in the bellows 68 will serve to move the lower end of lever 48 in the same manner in which rotation of the motor 54 will serve to move this lever in the instrument of Figure 2.

In some cases it may be desirable to extend the range of the drying machine by varying slightly the temperature that is normally maintained in the dry end section when the amount of steam supplied to the wet end section has reached one of its limits. It is also occasionally desirable to vary the temperature of the dry end section, when some predetermined limit is reached that is neither the maximum nor the minimum opening of the valve 10, since some times better control is obtained if the valve 10 works through only a small intermediate portion of its range. To this end, there is provided a pressure operated switch 71 which is responsive to the pressure of air in the line 70 from the flow meter to the valve 10. The opening and closing of this switch at some given maximum or minimum pressures in the line 70 serves to control the operation of motor 54. To this end, the switch is provided with a bellows 72 that is connected by means of pipe 73 to the line 70. As the pressure in the bellows increases or decreases, it moves a lever 74 around its pivot 75 against the tension of a spring 76 or permits spring 76 to move the lever. Upon the outer end of lever 74, there is a contact 77 that engages, upon an increase in pressure, with a stationary contact 78, and upon a decrease of pressure, with a stationary contact 79. The contact 77 is connected by means of a wire 80 to one side of a suitable supply line, while contacts 78 and 79 are connected by means of wires 81 and 82 to the field windings of motor 54, the armature of the motor being connected through a wire 83 to the other side of the supply line. Therefore, as the pressure in the bellows varies sufficiently to permit the contact 77 to engage either contact 78 or contact 79, the motor 54 will be run in one direction or the other to adjust the control point of the controller 12. A switch 84 is provided to prevent operation of the control point adjusting motor so that if it is not desirable to have this adjustment, it may be readily done away with. In order to adjust the limits, between which the valve 10 may be operated without affecting the motor 54, the contacts 78 and 79 can be adjusted relative to the position of contact 77 or the spring 76 may be adjusted. This latter is shown accomplished by fastening the lower end of the spring 76 to one end of the lever 85 that is pivoted at 86. An adjusting screw 87 extends through the lever 85 and a stationary support 88. As the screw is rotated, the lever 85 will be moved up or down to vary the tension of the spring 76, thus changing the limits at which the motor 54 will be operated.

In order to control the dryer in accordance with the moisture content of the web passing over the drying rolls, it is necessary to provide some type of moisture responsive instrument which can be used to reset the control point of the flow controller 56 in response to moisture

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variations in the web. This is done by an air operated moisture controller 90 which is provided with a rate responsive attachment. This moisture controller can have a moisture measuring circuit which is the same as that disclosed and claimed in the W. P. Wills Patent 2,115,805 which issued September 24, 1940. In this patent, the moisture is measured by measuring the electrical conductivity of the web since this condition of the web varies in accordance with moisture changes. To this end, there is provided a roller 91 which is in engagement with the web and which is connected by means of wires 92 and 93, and switch 94 to the instrument 90. The roller 91 is supported by a lever 95 that is pivoted at 96 and biased in a clockwise direction by spring 97. This spring presses the roller 91 against the web which is supported by a second roller 98 that is grounded.

While it is usual to measure the moisture of the web just after it leaves the drying machine, it is sometimes of advantage to make a measurement at a point prior to the last dryer roll over which the web passes. To this end there is provided a second roller 99 corresponding to the roller 91 which is connected by wire 100 to another terminal of the switch 94. By merely throwing the switch from the position in which it is shown to a position in which its blade engages the contact on the end of wire 100, the instrument 90 will be made responsive to moisture at a point in the path of the web before it leaves the drying machine.

As explained in the above mentioned Wills patent, in response to moisture variations in the web, a shaft 101 in the instrument 100 is proportionally rotated to move a pen carriage 102 across a chart 103 to make a record of the moisture content of the material. The instrument 90 is also provided with a so-called control table which can be adjusted between the edges of the chart through a path parallel to the path of the pen carriage. The mechanism forming part of this control table when cooperating with the pen carriage serves to adjust the air control mechanism in a well known manner which is shown, for example, in Krogh Patent 2,159,971, issued on May 30, 1939.

The control table has as a part thereof, a cam 104 (see Figure 5) formed with a cam edge 105 that cooperates with a roller 106 projecting upwardly from the pen carriage. As the pen carriage moves relative to the control table, the cam 104 will be moved up and down in accordance with relative positions of the roller 106 and the edge 105. This cam is attached to a bar 107 to move the latter with the cam and to also move a yoke member 108. The bar and the yoke are on opposite sides of a pivot shaft 109 which projects from the side frame 110 of the instrument. The arrangement is such that as the pen carriage moves up-scale or to the right in Figure 5 along the edge 105 of the cam, this cam and its rod 107 will be moved upwardly while the yoke 108 moves downwardly since the rod and yoke are on opposite sides of the pivot 109. The yoke 108 is connected through suitable linkage 111 to an actuating element the movement of which gives control effects to the air operated controller.

The lever 112 is pivoted at 113 to an adjustable fulcrum member 114, in the form of a lever having a stationary fulcrum pivot 115. The movements of the lever 112 produce control effects by moving a flapper valve 116 away from or permitting it to approach a nozzle or bleed

orifice member 117. The flapper valve 116 is mounted on a stationary pivot 118 and is biased for movement in the direction in which it approaches and restricts the discharge through the nozzle 117. The lever 112 acts on the flapper 116 through a pin 119 carried by a depending arm of the lever.

The nozzle 117 receives air from the pipe 14, supplying air at a suitable and approximately constant pressure, through a restricted passage formed by a small bore pipe 120 included in a pilot valve mechanism 121 and a pipe 144, so that the pressure in the nozzle 117, which constitutes the primary control pressure of the control apparatus, increases and decreases as the flapper valve 116 moves toward and away from the nozzle. The primary control pressure is transmitted by the pipe 144 to a chamber 122 of the pilot valve mechanism. One wall 123 of that chamber is movable, and separates the chamber 122 from a second pilot valve chamber 124. The pressure in the latter is regulated by a valve 125 actuated by the said movable wall 123. The pressure in the chamber 124 is thus maintained in constant proportion to the primary control pressure in the chamber 122, and constitutes the ultimate control pressure of the apparatus.

The ultimate control pressure is transmitted by a pipe 126 to the device to be controlled which as shown in Figs. 1 and 3 is the remote control point setting bellows 68 of the flow controller 56. The ultimate control pressure is also ultimately transmitted by pipes 141 and 142 to mechanism 127, forming a part of the control apparatus, and adapted, following and as a result of each initial change in the ultimate control pressure, effected through lever 112, to give the lever 114 an initial follow up adjustment, and a delayed compensating adjustment. The follow-up adjustment neutralizes a portion of the initial adjustment of the flapper valve 116 effected by the lever 112. The delayed compensating adjustment slowly neutralizes more or less of the effect of the preceding follow-up adjustment.

The mechanism 127 comprises bellows elements two of which are connected by a connecting rod 128, which carries a projection 129. The latter acts on lever 114 through a lever 130 pivoted at 131, and a pin 132 interposed between the levers 130 and 114. The pin 132 is supported by a member 138 adjustable to vary the leverage with which the lever 130 acts on the lever 114. The latter is biased for movement in the clockwise direction, as seen in Fig. 5.

Details of the construction and operation of the mechanism 127, not specifically referred to herein, will be understood by those skilled in the art from the drawings, and need not be described herein, particularly as that mechanism is not only fully disclosed in said prior Moore Patent No. 2,125,081, but is in extensive use.

Interposed between the pilot valve 121 to the mechanism 127 of the air control instrument is a rate response device 136. This device serves to inject into the control effect delivered by this controller a component that is responsive to the rate of change of the moisture content. This rate responsive device consists of a container that is divided into a pair of chambers by means of a flexible partition 137 that is held in a given neutral position by springs 138. The two chambers formed in the container are connected through a variable restriction 139 that can be adjusted by means of a screw 140. The upper chamber of the rate responsive device is connected by the

pipe 142 to the mechanism 127 of the instrument, and the lower chamber is connected by means of the pipe 141 to the pilot valve 121. It is noted at this time that the pipe 126 extends from the pilot valve to a four-way valve 143 and from this four-way valve through pipe 69 to the control point adjusting bellows 68 of the flow controller 56.

In the operation of this control instrument, if for example, the moisture content of the web should increase, the shaft 101 will be rotated in a direction to move the pen carriage 102 up-scale or to the right in Figures 1 and 5. This causes the roller 106 to move along the edge 105 of the cam of the control table to raise that cam and its rod 107 and to lower the yoke 108. This acts to permit lever 112 to move in a counter-clockwise direction so that flapper 116 can throttle the flow of air through the nozzle 117. Pressure will accordingly be built up in the chamber 122 of the pilot valve 121 above wall 123 to move the latter downwardly and open the inlet to chamber 124 from the pipe 14 to increase the pressure in the system. This simultaneously produces two results. First, air pressure will be built up in pipe 126, and pipe 69 to the bellows 68 in flow meter 56. Such operation will move the link 47 to the left to raise the control point of that instrument and increase the supply of steam to the drying drums in the wet end section. This increase in the supply of steam will raise the temperature of these drums and lower the moisture content of the web to its normal value. The second operation that is produced as a result of opening the valve 125 in chamber 124 is to increase the pressure in pipe 141. Such increase gives an immediate small follow-up and a delayed large follow-up movement to the air controller portion of the moisture measuring instrument 98. The immediate small follow-up is due to the compression of bellows 137 which in turn compresses the air in the upper chamber of the rate responsive device 136 to increase the pressure in pipe 142 and in the right end of the mechanism 127. Such operation causes the rod 128 to move to the left and acting through pin 129, lever 130, pin 132, and lever 114, will shift the flapper a small amount from the nozzle 117. Later, as the air leaks through the restriction, a large follow-up movement will be obtained. The speed of this large follow-up or the setting of the restriction 139 is related to the lag characteristics of the instrument and process so that the follow-up will take place at a rate proportional to the rate of change of the moisture. In other words, if the moisture content of the web is changed slightly, the leakage through restrictions 139 can take place as fast as the pressure in the chamber 124 changes. This produces in effect, an immediate follow-up. If, however, the moisture content of the web is changed rapidly, pressure will increase in the pilot valve chamber 124 faster than it can pass the restriction 139, so that the control point of the flow meter will be set higher than necessary. As the air leaks past the restriction, the main follow-up in the mechanism 127 will take place, and the air pressure will be lowered so that the control point setting of the flow meter will be brought back to a normal value for the moisture content. This extra raising and lowering of the control point of the flow meter compensates for the rate of change of the moisture, and will act more quickly to bring the moisture content of the material back to normal. As the follow-up is occurring in the mechanism 127,

a subsequent reset or compensating action is produced as the rod 128 is slowly moved back to its original position under the action of springs acting on the rod.

Provisions are also made to manually control the supply of air to the control point resetting bellows 68 of the flow meter. To this end, a branch pipe 150 extends from the supply pipe 14 and includes in it a pressure regulator 151, a restriction T 152 and pressure gauge 153, and a second restriction T 154 which, in the position of the four-way valve that is shown, connects this line with the atmosphere. Each of the restriction T's is provided, as shown in Figure 6, with a passage 155 that is variably restricted by means of a conical end 157 of an adjustment screw 156. As the screw 156 is moved toward or backed away from a shoulder in the passage, more or less air can escape therethrough.

In the normal operation of the system, the four-way valve 143 is in the position shown so that the moisture instrument 90 is connected to the flow meter 56 and air exhausts to the atmosphere through T's 151 and 154 from the pipe 150. When it is desired to control the flow meter manually, as would probably be the case if the web should break, the four-way valve is moved to a position in which pipe 128 is connected with restriction 154 and pipe 150 is connected with pipe 69. The restriction 154 is so adjusted that the instrument 90 will tend to maintain, because of it, an air pressure that is an average value of the pressure which is normally maintained in the bellows 68. This can be determined by experiment. The pressure supplied to the bellows 68 through pipe 150 can be regulated by manually adjusting the regulator 151. Normally speaking, this regulator would be so adjusted that the temperature of the drums in the wet end section will be kept slightly below normal. In the case of the paper breaking, the operator will merely move the four-way valve to the position in which pipe 150 is connected with pipe 69. Because of the setting of the restriction T 154, the instrument 90 will be kept in an adjustment for an average pressure value to be applied to the bellows 68, and because of the adjustment of the regulator 151, the flow meter control point will be adjusted to a position in which the temperature of the drums in the wet end section of the dryer will be kept slightly below normal.

The operation of the control system should be apparent from the above detailed description. A short summary of the manner of operation will, however, be given at this time. When the control system is working normally, the controller 12 will maintain the temperature of the cylinders in the dry end section at a constant predetermined value. The flow meter 56 will also be maintaining the temperature of the drums in the wet end section at some predetermined value by regulating the amount of steam supplied to these drums. This amount of steam, however, will be adjusted from time to time as the moisture content of the material varies. This adjustment is taken care of by the moisture measuring instrument 90. In normal operation, the switch 84 will be opened so that there will be no automatic adjustment of the control point of the controller 12, and the switch 84 will be in the position shown in Figure 1 so that the moisture content of the material will be measured after it has passed entirely through the dryer. If for some reason, it is desired to measure the moisture content of the material before it is completely through the drum, the

switch 84 will be thrown to the left to connect the instrument 90 to the measuring roll 99.

If it is desired to adjust the control point of the controller 12 in response to variations of the pressure produced by the flow meter 56, the switch 84 can be closed. Thereafter, the control point of controller 12 will be shifted in one direction or the other when the pressure in line 70 reaches one of the other of predetermined limits. It is noted that the speed of motor 54 and the gearing is such that the control point of instrument 12 will only be shifted a very small amount, often only a fraction of a degree, upon each operation thereof.

Upon a break occurring in the web going through the dryer, the four-way valve 143 will be thrown from the position shown to its second position, thereby connecting the control point setting bellows of the controller 56 with air at a predetermined pressure and connecting the output of the instrument 90 with the restriction T 154. By the addition of the rate responsive unit to the air controller of the instrument 90, a better control is obtained, since a deviation of the moisture content of the web from its desired value can be more quickly corrected than would be the case without this feature.

From the above description, it will be seen that I have invented a complete and very versatile control system to be applied to web drying machines.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of this invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of this invention as set forth in the appended claims, and that in some cases certain features of this invention may sometimes be used to advantage without a corresponding use of other features.

Having now described this invention, what I claim as new and desire to secure by Letters Patent is:

1. In a drying machine having a plurality of drying drums which are divided into a plurality of sections including a dry end section, means to supply a drying medium to each of said sections individually, means to regulate the supply of drying medium to the rolls on the dry end of said machine, means responsive to the temperature of the drying medium in said dry end section to adjust said regulating means to maintain said section at a constant temperature, a second means to regulate the flow of drying medium to a section prior to said dry end section, control means responsive to the flow of drying medium to said section prior to said dry end section to adjust said second regulating means, and means to adjust said control means in response to the moisture content of the material being dried.

2. In a drying machine having a plurality of drying drums which are divided into sections including a dry end section, means to supply a drying medium to each section individually, a first regulating means to regulate the supply of drying medium to the dry end section, a first control instrument responsive to the temperature of said dry end section acting on said regulating means to maintain the temperature of said section at a constant value, a second regulating means to regulate the supply of drying medium to a section prior to said dry end section, a second control instrument having adjustable control

point means and responsive to the flow of drying medium to said second mentioned section acting on said second regulating means to maintain the flow therethrough at some constant value, means responsive to the moisture content of the material being dried, and means operated by said last mentioned means to adjust the control point of said second control instrument.

3. In a drying machine having a plurality of drying drums, means to supply steam to heat said drums, means to measure the flow of steam to some of said drums, means operated by said measuring means to adjust the means to supply steam to said drums, means to measure a condition indicative of the moisture content of a web dried by said drums, means to adjust said flow measuring means to vary the amount of steam it will tend to maintain in the supply to said drums, and means operated by said condition measuring means to adjust said adjusting means.

4. In a drying machine having a plurality of drying drums which are divided into a plurality of sections including a dry end section, means to supply a drying medium to each section individually, means responsive to a physical condition of the drying medium in said dry end section to control the drying medium supplied thereto to maintain said dry end section at a constant temperature, a control instrument having adjustable control point means and including means responsive to the flow of the drying medium for a section prior to the dry end section, said instrument operating to maintain the flow of drying medium thereto at a constant value, means responsive to the moisture content of the material being dried, and mechanism operated by said last mentioned means to adjust said control point means so that said instrument will maintain a different flow to its section, said mechanism including means to inject into its control of said control point means a component responsive to the rate of change of the moisture content of the material being dried.

5. In a drying machine having a plurality of drying drums, means to supply steam to said drums, a valve to regulate the supply of steam, a control instrument operative to measure the amount of steam flowing to said drums and to adjust said valve to maintain the supply of steam at a normal value, control point adjusting means to adjust the instrument to change the normal value of the steam supply, means to measure the moisture content of the material dried by said machine, and means operated by said measuring means to adjust said control point adjusting means in accordance with the value of the moisture content and its rate of change.

6. In a drying machine having a plurality of drying drums which drums are divided into a plurality of sections and including a dry end section, means to supply a drying medium to each of said sections individually, a control instrument responsive to the temperature of said dry end section and operative to regulate the supply of drying medium therefor, a control instrument responsive to the flow of drying medium to a section prior to said dry end section and acting to regulate the supply of drying medium thereto, said last mentioned control instrument having pressure responsive control point adjusting means, means to measure the moisture content of the material being dried, a supply fluid under pressure, means operated by said moisture measuring means to adjust the pressure of said supply of fluid, manually operated means to adjust the pressure of said supply, and manually oper-

ated means to alternately supply one of said adjusted pressure supplies to said control point adjusting means.

7. In a drying machine having a plurality of drying drums, means to supply a drying medium to said drums, means to regulate the supply of drying medium to some of said drums, an air control instrument having pressure operated control point adjusting means, said instrument being responsive to the flow of said drying medium to said drums and operating to adjust said regulating means to keep the flow of said drying medium constant, means responsive to the moisture content of the material being dried, a source of fluid under pressure, air control means adjusted by said responsive means to regulate said source of fluid, a second supply of fluid under pressure, means to manually adjust said second supply of fluid, and means to apply either the fluid adjusted by said air control means or said manually adjusted fluid to said control point adjusting means.

8. In a drying machine having a plurality of drying drums which are divided into sections including a dry end section, means to supply a drying medium to each section individually, a first control means responsive to the temperature of the dry end section acting to maintain the temperature of said section constant, regulating means to control the supply of drying medium to a section prior to the dry end section, a second control means operative to adjust said regulating means between limits, means operatively connected to said first control means and automatically actuated by said second control means upon the attainment of either of said limits to act on said first control means to vary the temperature at which it will maintain said dry end section, and means responsive to the moisture content of the material being dried to adjust said second control means.

9. In a drying machine having a plurality of drying drums which are divided into a plurality of sections including a dry end section, means to supply a drying medium to each of said sections individually, a first regulating means to adjust the supply of drying medium to the dry end of the machine, control means responsive to the temperature in said dry end section to adjust said regulating means to maintain said temperature constant, a second regulating means to adjust the supply of drying medium to a section of the dryer prior to the dry end section, second control means working between limits to adjust said second regulating means, and means operatively connected to said first control means and automatically operated by said second control means upon the attainment of one of the limits to act on said first control means to thereby cause said first control means to vary the temperature at which it will maintain said dry end section.

10. In a drying machine having a plurality of drying drums that are divided into sections including a dry end section, a supply of steam for said drums, valves to regulate the flow of steam to each section individually, a first instrument having control point adjusting means to measure the temperature of the drums in said dry end section and to adjust the valve controlling the steam to that section to keep the temperature of the drums at some normal value, a second instrument to measure the flow of steam to a section of drums prior to the dry end section to adjust the valve controlling the steam to that section to a normal value between predetermined

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limits, means to measure the moisture content of material being dried by the drying machine, mechanism operated by said last mentioned means to vary the normal value of flow maintained by said second instrument in accordance with the moisture content of said material and the rate of change of the moisture content, and means operatively connected to said first instrument and operated when the valve controlling the flow of steam to the section prior to the dry end section reaches one of its limits to adjust the control point adjusting means of said first instrument.

11. In a drying machine having a plurality of drying drums that are divided into sections, means to supply a heating medium to each of said sections, separate regulating means to adjust the supply of heating medium to each section, means to measure the value of the temperature of the drums in one of said sections, means to control the operation of said regulating means for that section operated by said temperature measuring means, means to measure the flow of heating medium to another section of said drums, means operated by said flow measuring means to control the operation of the regulating means for that section, and pneumatic means operatively connected to said flow measuring means to adjust the value of the flow maintained by said flow measuring means including a bellows, a supply of compressed air for said bellows, means to regulate the pressure of the air, a pipe through which air is supplied from its source to said bellows, an adjustable leak in said pipe, and means to disconnect said air supply from said bellows.

12. In a drying machine having a plurality of drying drums which are divided into sections including a dry end section, means to supply a drying medium to each section individually, a first control means responsive to the temperature of

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the dry end section acting to maintain the temperature of said section constant, regulating means to control the supply of drying medium to a section prior to the dry end section, a second control means operative to adjust said regulating means between limits, means operatively connected to said first control means and actuated upon the attainment of either of said limits to act on said first control means to vary the temperature at which it will maintain said dry end section, said second control means having pneumatic control point adjusting means, means to measure the moisture content of the material being dried, a first supply of air under pressure regulated by said moisture measuring means, a second supply of air under pressure, manual means to adjust said second air supply, a variable leak member, a valve, connections between said valve and said control point adjusting means, said first and said second air supplies and said variable leak, and means in said valve to connect said first or second air supply alternately with said control point adjusting means and said variable leak.

13. In a drying machine having a plurality of drying drums which are divided into a plurality of sections including a dry end section, means to supply a drying medium to each of said sections individually, means to maintain the temperature of the section on the dry end of the machine constant in response to a physical condition of the drying medium in said section, means including an instrument responsive to flow of the drying medium and having an adjustable control point to control the flow of drying medium to a section over which the material to be dried passes prior to the dry end section, and means responsive to the moisture content of the material being dried to adjust the control point of said instrument.

ANKER E. KROGH.