

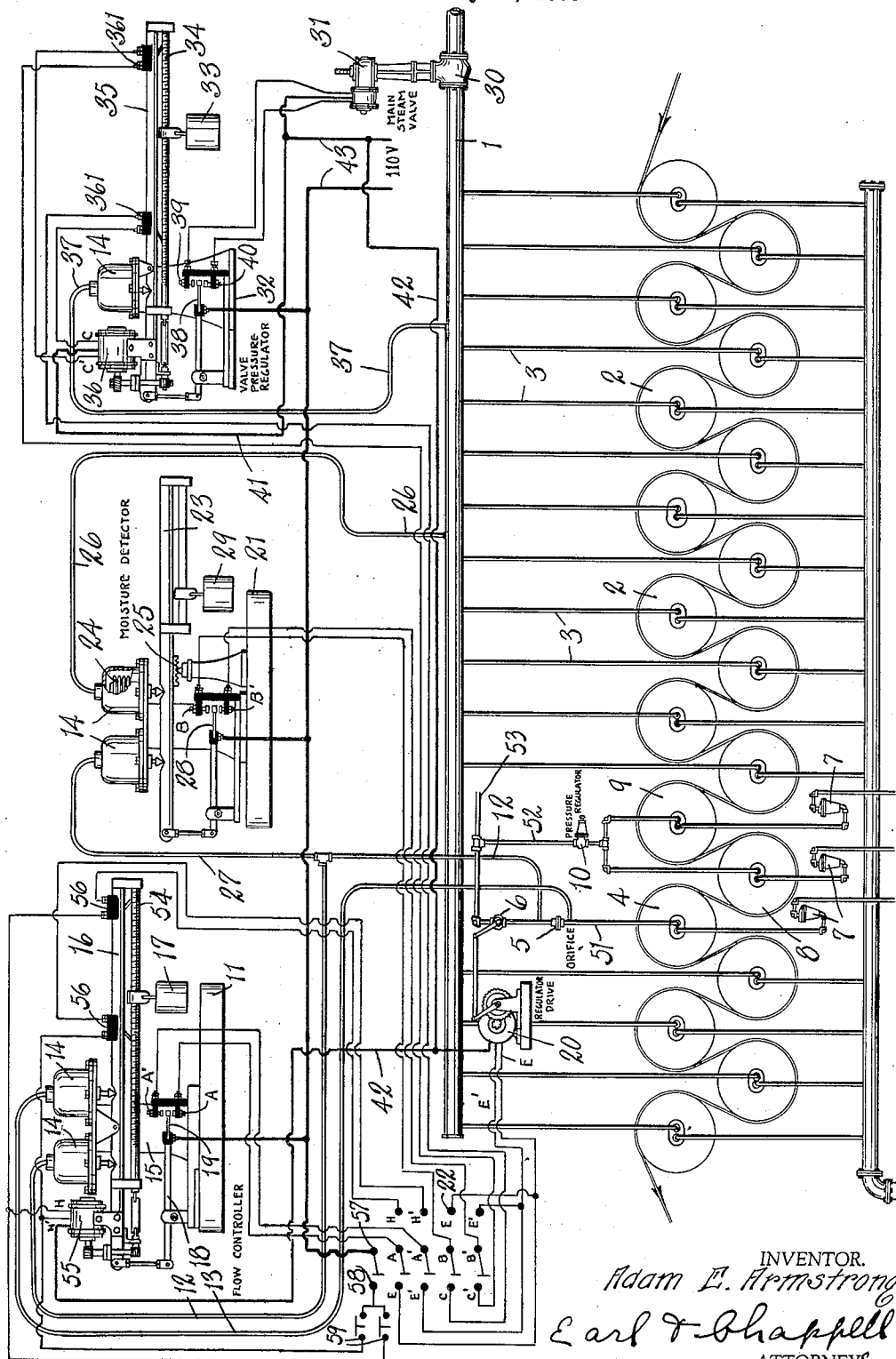
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MOISTURE CONTROL SYSTEM FOR PAPER DRYING MACHINES

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MOISTURE CONTROL SYSTEM FOR PAPER DRYING MACHINES

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21 Claims. (Cl. 34-48)

This invention relates to improvements in moisture control systems for paper drying machines.

The main objects of my invention are:

First, to provide a system adapted to regulate the flow of steam to a paper stock drying machine with great precision in accordance with the heat requirements for drying the paper passing therethrough.

Second, to provide a system adapted selectively to supply steam at a constant pressure or to automatically control the steam supply, depending upon varying drying heat requirements of a web of moist paper stock being dried.

Third, to provide a moisture control system of the type described adapted to compensate for changes in heat emission or transfer of a series of drying elements due to changes in the moisture content of the paper and thereby automatically control the moisture condition of a web of stock passed therethrough.

Fourth, to provide a machine operative according to the foregoing principles within exceedingly narrow limits.

Fifth, to provide a machine of the type described which is accurately adjustable by a simple manipulation whereby to control the drying of webs of all conditions of moisture content.

Further objects relating to details and economies of my invention will definitely appear from the description to follow. The invention is defined in the claims.

In my copending application, Serial No. 71,229, filed March 27, 1936, and in the copending application of Frederick C. Stamm, Serial No. 31,776, filed July 17, 1935, there is described a process of regulating the moisture content of a web of paper being dried in accordance with and on the basis of the rate of radiation or transfer of heat from a drying element. The principle involved is that, assuming that a closed vessel is supplied with steam at a constant rate, the pressure existing within the vessel is dependent on the radiation or transfer of heat from its walls; i. e., if the rate of radiation or transfer is increased, the pressure falls, and if it is decreased, the pressure increases. Applying this principle to the case of a moisture control for a paper drying machine, I have found that if, for a given grade of paper with a given moisture content, the steam flow to a drier located near the dry end of the machine is proportioned so that the heat input to the drier is equal to the heat supplied by the drier to the paper, the pressure within the drier will remain constant. If, however, the moisture content of the paper changes, the amount of heat transferred

or carried away from the drier is in proportion to the change and the steam pressure within the drier will vary inversely. Thus, it follows that the pressure within a drier or a small group of driers which are supplied with steam at a constant rate of flow may be used as an indication of the amount of moisture present in a web of paper passing over the drier or driers. It also follows that with proper equipment it is possible to utilize this pressure change indication of moisture to regulate the steam pressure over the entire machine with great exactitude. The present machine has been devised for this purpose.

The above mentioned applications of Stamm and the present applicant are both based on the principle that if the pressure in the indicating drier is held constant changes in the moisture content of the web traversing the indicating drier are reflected in changes in the rate of steam flow to the drier. Thus, those applications both disclosed means for maintaining constant pressure within the indicating drier, utilizing the rate of steam flow to maintain this constant pressure as an indication of sheet moisture and effecting changes in machine pressure automatically by means of the changes in steam flow to the indicating drier.

The present invention contemplates holding the steam flow to the indicating drier constant and detecting variations in sheet moisture by means of the variation in steam pressure within the indicating drier resulting from the said moisture variations. Thus, when a definite fixed quantity of steam is supplied to the indicating drier, some definite pressure will obtain therein and this pressure will have a value such that the temperature head between steam at that pressure and the web of paper traversing the drier will cause an amount of heat to be transmitted from the steam to the paper, which is exactly equal to the amount of heat supplied to the drier. Maintaining constant flow of steam, i. e., constant heat input to the indicating drier, the steam pressure will remain constant as long as the heat output from the drier is constant. Since heat output varies with changes in sheet moisture, it follows that the pressure in the indicating drier will vary inversely with the moisture content of the paper passing that drier.

Certain advantages result from basing the operation of the sheet moisture detecting means on the indicating drier pressure rather than rate of steam flow thereto. In the first place, it is easier to hold constant steam flow accurately than to maintain constant steam pressure. In

the second place, when constant flow is maintained, changes in weight or moisture in the paper result in a gradual drift in the indicating drier pressure, which makes possible more accurate steam control in the machine and better regulation with no likelihood of overshooting in effecting control of the steam due to sudden changes in the weight or moisture of the web.

A structure embodying the features of my invention is illustrated in the accompanying drawing, the single figure of which illustrates diagrammatically a machine constructed in accordance with my invention and also the wiring diagram for energizing or operating the same.

The reference numeral 1 indicates a steam supply header supplying steam to a plurality of drying cylinders or drums 2 through pipes 3. At a suitable location near the dry end of the paper machine or adjacent the left, as viewed in the figure, I select a drying cylinder, specifically designated 4, to serve as the indicating drier for my device and it will be hereinafter referred to by that term. The pipe 51 for the indicating drier is provided with a suitable orifice 5 and the quantity of steam passing through the said orifice to the indicating drier is regulated by a motor driven regulating valve 6. The condensate from the indicating drier 4 is trapped at 7 so that steam may not leave the drier although condensate and air are entirely removed. In order to improve the operation of my machine I preferably provide the driers 8, 9 immediately preceding the indicating drier 4 with suitable means, such as a conventional diaphragm type regulator 10, in the supply line 52 therefor to maintain constant pressure and therefore constant temperature in driers 8, 9. Traps 7 are likewise provided for driers 8, 9. These preceding constant pressure driers act as tempering driers for the web of paper and smooth out any radical differences in the temperature of the paper which might be caused by changes in machine pressure effected by the mechanism to be hereinafter described. To render the indicating drier effective to accurately reflect the moisture condition of the web at all times and under all steam pressures in the indicating and other driers, I preferably supply the same and also the tempering driers 8, 9 from a source of steam independent of header 1, said source being generally designated 53. However, the machine is operative even if the indicating and tempering driers are supplied from the header.

For a given rate of flow through orifice 5, a definite pressure differential will be set up over the orifice and this differential pressure will vary as the square of the velocity of flow through the orifice. In order to take advantage of the effect of the differential in regulating the machine, I connect a flow controller generally indicated 11 on opposite sides of the orifice by means of pipes 12, 13. These pipes communicate with housings 14 for a pair of suitable metal bellows, the housings being fixedly mounted on a standard 15 and the bellows being connected to hardened steel knife edges bearing on a pivoted beam 16 at opposite sides of the fulcrum thereof. It is apparent that the metal bellows in housings 14 will exert two different forces on the beam 16 by virtue of the up and down stream pressures at the orifice. These forces are applied to the beam equally distant from the fulcrum and a movable weight 17 on the beam is employed to balance the difference in the forces set up by the bellows. Therefore, for a given rate of steam flow through

orifice 5, a definite position of weight 17 will exactly balance the beam and any change in flow through the orifice will unbalance the beam in one direction or another, depending upon the nature of the change.

This movable weight is adapted to be shifted lengthwise on a motor driven screw 54 mounted on beam 16. The screw is suitably geared to a reversible motor 55 on the beam, the weight being carried by a split nut adapted to travel lengthwise of the beam as the screw is rotated. The reversing poles of motor 55 are designated by the reference characters H, H' and current is supplied for the motor through a pair of suitable limit switches 56, but only when the machine is set for constant pressure operation, as will be hereinafter explained in detail.

A pivoted switch arm 18 is operatively connected to beam 16 through a suitable linkage, this switch arm carrying a movable electrical contact 19 adapted when the beam is unbalanced to engage a lower or an upper stationary contact, which contacts are designated A and A' respectively. The function of the same will be hereinafter more particularly described. The linkage and the mounting of beam 16 and arm 18 are such that the movement of the electrical contact 19 resulting from a movement of the bellows is greatly magnified, say in the ratio of fifty to one, which of course results in considerable movement of the switch contact for a very small bellows movement. It will be appreciated that the controller 11 is therefore sensitive to small variations in differential pressures over orifice 5.

To operate the regulator valve 6 and maintain the steam flow to the indicating drier at a constant rate, I provide the back geared reversible electric motor 20 connected by a suitable linkage to an operating arm for valve 6. This motor is under certain circumstances controlled by means of switch arm 18 of flow controller 11, and at other times is controlled from a moisture detector generally indicated 21, as will be described, and in order to effect such selective connection of the reversible drive I employ a switch generally indicated by the reference numeral 22.

Instrument 21 which will be referred to as a moisture detector is in general similar to flow controller 11, save for the fact that the bellows thereof are both operatively connected to the beam 23 on the same side of the fulcrum thereof. For illustrative purposes, one of the housings has been cut away and the bellows is designated 24, it being understood that the bellows in housings 14 of the flow controller are identically similar thereto. In the case of moisture detector 21, the forces exerted by the two metal bellows thereof, due to pressures, are both balanced by a movable weight. The bellows located nearest the fulcrum 25 receives its pressure through a pipe 26 from the main steam header 1, while the bellows located farthest from the fulcrum receives its pressure through a pipe 27 from a point just ahead of orifice 5. The movable contact in the case of the moisture detector is designated 28 and the stationary contacts are designated B and B' respectively.

As previously explained, the pressure on the bellows farthest from the fulcrum 25 rises and falls with the indicating drier pressure and serves as an indication of moisture in the paper.

Due to the location of the bellows relative to fulcrum 25, a definite relationship exists between their leverages or mechanical advantages on the

beam. For example, assuming that the forces set up by the two bellows push rods due to the pressures in the indicator and main steam header respectively are exactly balanced by the movable weight 29 on beam 23, so that switch contact 28 is midway between stationary contacts B and B', and assuming further that the bellows are effective on the beam at distances of one inch and ten inches respectively from the fulcrum, then if the indicating drier pressure changes, the steam header pressure must be changed ten times as much to maintain equilibrium of the beam. The location of weight 29 on beam 23 is determined at the time of installation and instrument 21 during constant pressure operation serves to maintain a definite pressure in the indicating drier in direct proportion to the steam header pressure. The contacts B and B' are selectively connected through switch 22 to motor 20 or to a valve pressure regulator motor to be described.

The supply of steam to the main steam header 1 is controlled by a main steam valve 30 adapted to be opened and closed by a reversible motor driven mechanism generally indicated 31. This mechanism is under the control of a valve pressure regulator designated generally 32 and consisting of a device similar in general structure to flow controller 11 and moisture detector 21. In the case of the regulator 32, the balance weight 33 is, like weight 17 on beam 16, adapted to be shifted lengthwise on a motor driven screw 34 mounted on beam 35. The screw is suitably geared to a reversible motor 36 carried on the beam, the weight being carried by a split nut adapted to travel lengthwise of the beam as the screw is rotated. Motor 36 is energized from stationary contacts B, B' of the moisture detector through a pair of suitable limit switches 361. The bellows of pressure regulator 32 is connected through a pipe 37 with the main steam header 1, transmitting its force to the beam at a point to the left of the fulcrum thereof as illustrated.

The current for motor 36 is supplied only when the machine is set for automatic operation, as will be hereinafter explained in detail. Suffice it to say at this time that the weight 33 is used to balance the force set up by the metallic bellows acting on beam 35 due to the controlled pressure acting upon the bellows, and in the event the equilibrium of beam 35 is disturbed, the movable switch contact 38 governed thereby engages one or the other of a pair of stationary contacts 39, 40 to actuate the motor driven valve 30 in one direction or the other. It is apparent that by changing the pitch of screw 34 the speed of travel of the nut thereon may be set so that the steam header pressures will not be changed so rapidly as to affect the operation of governors of turbines or engines, in the event the system is operating on exhaust steam.

The switch 22 serves as the interconnection between the various stationary contacts A, A', B, B' and the various motor terminals to be described, which are involved when the system is changed from constant pressure operation to automatic control and vice versa. This switch may be any convenient type, but is preferably a double-throw multiple-pole switch.

I have made a conventionalized disclosure of such a switch 22, it having four center terminals connected respectively to the stationary contacts A, A', B, B'. For the sake of clarity, these reference characters are likewise employed to designate the switch terminals to which the said contacts are connected. I have employed the refer-

ence characters C, C', E, E', and H, H' to designate the reversing poles of the motors 36, 20, and 55 respectively, and also the terminals of the switch 22 to which they are connected. The current feed lines for motors 36, 20, and 55 are designated by the reference numerals 41 and 42 and are connected to one side of a 110-volt source 43. It will be noted that the poles E, E' of motor 20 are adapted to be electrically energized in both positions of the switch, namely, by the moisture detector contacts B, B' when the switch is thrown to the right, i. e., for constant pressure operation, and by the flow controller contacts A, A' when the switch is thrown to the left, i. e., for automatic control. In the position for constant pressure operation, the poles H, H' of beam motor 55 are adapted to be electrically energized through the flow controller contacts A, A', and with the switch in position for automatic control, the motor poles C, C' are connected to contacts B, B'. The respective movable contacts 19, 28, and 38 are connected to the 110-volt source 43 as illustrated. For the purpose of energizing motor 55 in either direction when the device is set for automatic operation, I provide an additional center terminal 57 on switch 22, which is connected to the source of current supply and is connected with a fixed contact 58. A circuit may be completed from the last named contact to either of the terminals H, H' of motor 55 by selectively actuating push button switches 59, whereby to position the weight 17 on beam 16 readily when the machine is set for automatic operation, i. e., with the switch thrown to the left. Of course, if desired, the last named circuit may also include limit switches 56, but I have purposely omitted illustration of this expedient in order to minimize the complexity of the drawing.

The system of my invention is adapted for operation in two distinct manners as determined by the setting of switch 22, namely, on the one hand for what I have termed constant pressure operation and on the other hand for automatic control, and the same will now be described with reference to both situations.

Constant pressure operation

The machine is set for constant pressure operation when it is started. To do this, the manually operated switch 22 is thrown to the right as illustrated in the figure. This places the poles E, E' of regulator drive motor 20 in operative relation to contacts B, B' for electrical energization thereby in the event that movable contact 28 engages either of the aforesaid contacts. At this time the terminals C, C' of motor 36 on the valve pressure regulator 32 are dead electrically and the motor 20 is also disconnected electrically from the terminals A, A' of flow controller 11. The poles H, H' of beam motor 55 are electrically connected to the flow controller contacts A, A' whereby the movable contact 19, when it goes out of balance, energizes motor 55 to advance or retract weight 17 and thereby maintain the same in proper position corresponding to changes effected through drive motor 20 by moisture detector 21. This keeps beam 16 and switch arm 19 in equilibrium with the latter midway between contacts A, A', and thereby automatically conditions the flow controller for the time when it is thrown into control of regulator drive motor 20 by switching to automatic operation. The main steam valve 30 is in control of the steam in the header 1 and is in turn controlled by the movable and stationary

contacts 38 and 39 or 40 of the valve pressure regulator 32. The weight on the main valve pressure regulator 32 may now be set for the desired machine pressure and the paper threaded over the machine.

As stated above, while the system is set for constant pressure operation, the switch arm of moisture detector 21 electrically controls the regulator drive 20 which in turn actuates the regulating valve 6 for the indicating drier. As previously explained in connection with the apparatus, a definite relationship exists between the mechanical advantage of the bellows forces on the beam of instrument 21, a ratio of one to ten having been found to be correct in general. Thus, with constant pressure assured in the main steam header by reason of the setting of valve pressure regulator 32, moisture detector 21 in effect becomes a pressure regulator or balancing device for the indicating drier by virtue of the fact that the forces exerted on the beam by the header bellows (i. e., the bellows immediately adjacent the fulcrum) and by the beam weight 29 are constant and any loss in equilibrium of beam 23 is chargeable to variations at the indicating drier. As previously explained, the position of weight 29 on instrument 21 is predetermined at the time of installation and thereafter remains the same. Thus, moisture detector 21 will maintain a definite pressure on the indicating drier 4, which is in direct proportion to the header pressure, by actuating motor 20.

It should be noted that when the system is set for constant pressure operation flow controller 11 is disconnected by switch 22 from the regulator drive motor 20. The up and down stream pressures over orifice 5 are always in communication with the bellows of instrument 11 and therefore the movable contact 19 energizes reversible beam motor 55 through contacts A, A', causing weight 17 to move in the proper direction necessary to keep beam 16 in equilibrium and switch contact 19 in neutral intermediate position.

The foregoing control of the parts by means of switch 22 provides a convenient means for giving the system an initial setting when the web is first fed therethrough and for approximately balancing the heat input against the heat requisite for drying. After the operator is satisfied that the pressure in the main steam header 1 (which he has adjusted by shifting weight 33) is correct for the moisture desired in the paper being produced, he manually throws switch 22 to automatic control position or to the left as illustrated in the figure.

Automatic control

Throwing the switch to automatic control position transfers the electrical connection of moisture detector 21 from regulator drive 20 to the beam motor 36 of instrument 32 by disconnecting terminals B, B' from poles E, E' and connecting them to poles C, C'. It also transfers the control of regulator drive 20 from moisture detector 21 to flow controller 11 by connecting terminals A, A' to poles E, E', which means that the flow controller assumes control of the quantity of steam in pounds per hour being fed to the indicating drier and that the rate of flow will thereafter be held constant. The valve pressure regulating contacts 38 and 39 or 40 function as before to control the pressure on the machine through valve 30.

As previously stated, with the rate of flow to the indicating drier constant, the pressure therein will remain unchanged, unless the radiation

therefrom is changed by physical changes in the paper passing over the drier. If no change takes place in the paper, no change takes place in the indicating drier pressure, no change takes place in instrument 21, and the system remains in balance, but if the system becomes unbalanced, it corrects the pressure on the machine for the changed moisture content in the following manner.

Assuming, for example, that an increase of moisture takes place in the paper passing the indicating drier, this causes the steam pressure in the drier to be lowered since the input thereto is constant. The lowering of indicating drier pressure becomes effective at the bellows of instrument 21 remote from the fulcrum, thus causing the equilibrium of instrument 21 to be disturbed, with the result that switch contact 28 engages contact B'. The pole C' of motor 36 is therefore energized, causing the motor to move weight 33 out on beam 35. This in turn causes contact 38 to engage contact 40 to actuate motor drive mechanism 31 and open valve 30, thus raising the pressure over the machine. When the machine pressure has been increased sufficiently, its reaction through pipe 26 on the bellows of instrument 21 immediately adjacent the fulcrum will balance the loss of reaction on the indicating drier pressure bellows of the same instrument, so that instrument 21 will again be placed in equilibrium with its switch arm in neutral position, breaking the electrical circuit to the beam motor 36 of regulator 32.

In actual practice, the effect of an increase in steam pressure in the machine on detector 21 is twofold. It should be remembered that the increase in machine pressure is the result of a decrease in pressure in indicating drier 4. An increase in machine pressure tends first to place instrument 21 in equilibrium by increasing the force on the header bellows, but at the same time the higher machine pressure results in a tendency to check the increase of the moisture in the paper, which is responsible for the indicating drier pressure drop. A change in moisture content in the sheet causes a gradual drift or change in indicating drier pressure and if the header pressure were not compensated for this drift in the indicating drier pressure would continue to change until the pressure within the drier were such that the temperature head between the steam in the drier and the paper would be just sufficient to cause the heat output of the drier to equal the heat input, but since the header pressure is constantly compensated for changes in drier pressure, the drier pressure drift is arrested.

If, with the system operating on automatic control, it is desired to change the moisture content of the sheet of paper being dried, it is only necessary to change the location of the weight 17 on flow controller 11. This may be accomplished by manipulation of either one of the push buttons 59 by the operator. This changes the quantity of steam being fed to indicating drier 4, which will of course change the pressure in the indicating drier. As previously explained, any change in pressure in the indicating drier automatically changes the steam supply header pressure. The specific automatic operations to alter the moisture content of the web would be as follows. Assuming it were desired to increase the moisture content, weight 17 is shifted away from the bellows housing 14. This increases the rate of flow to the indicating drier, raises its pressure, and throws instrument 21 out of balance.

This causes the switch contact 28 of instrument 21 to actuate beam motor 36, thereby running weight 33 in toward the motor. This procedure throws instrument 32 out of balance and its arm switch contact 38 energizes the motor driving valve 30 to cut down the machine pressure until the pressures acting on the bellows of instrument 21 are again in balance, at which time the entire system again becomes static.

From the foregoing, the advantages of my system will be apparent. The operation thereof is extremely simple since, during automatic control, the only adjustment necessary to change the moisture content of the sheet is that of changing the location of the weight on instrument 11. The resultant alteration is automatically made and the control will hold the moisture at the new setting within narrow limits. This simplicity is extremely desirable in a mill producing a paper to a customer's specification, in which the desired moisture is specified. The constant pressure operation feature enables the machine to be started and automatically brought to balanced operating position prior to transfer to automatic control. The pressure at which it is desired to operate is easily and quickly arrived at by merely changing the location of weight 33 on regulator 32.

Beam 35 in practice is calibrated in pounds and the weight 33 provided with a pointer registering with the beam calibrations whereby to facilitate positioning of the weight in manually setting instrument 32 for any desired pressure. I have not illustrated these provisions inasmuch as they are simple and readily understandable by anyone.

All the equipment and instruments employed in my system are of very rugged design and the system is entirely foolproof. Because of its ruggedness and simplicity, it is well adapted to withstand paper mill conditions and give long satisfactory service.

I have illustrated and described my improvements in an embodiment which is very practical. I have not attempted to illustrate or describe other embodiments or adaptations as it is believed this disclosure will enable those skilled in the art to embody or adapt my improvements as may be desired.

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

1. In a moisture regulating device for a paper drying machine, including a plurality of advance drying units and an indicating drier unit, means for supplying steam to said units, including a main steam header having a regulating valve therein, means for maintaining steam in said header at constant pressure including means for actuating said regulating valve in accordance with variations in the steam pressure, and means for setting said actuating means to come into operation in accordance with the pressure desired; and means for maintaining the pressure in said indicating drier proportional to the steam header pressure, comprising a pivoted beam having a weight secured thereto at one side of the fulcrum thereof, a pair of bellows housings, bellows in said housings having means for transmitting forces therefrom to said beam at different distances from the fulcrum on the side thereof opposite the weight, means for communicating said housings with said header and with the steam supplied to the indicating drier respectively, a movable electrical contact operatively connected to said beam to be moved thereby

when the equilibrium of the beam is disturbed, stationary contacts on opposite sides of said movable contact and adapted to be engaged thereby when said equilibrium is disturbed, and a motor driven regulating valve for said indicating drier operatively connected with said stationary contacts to govern the admission of steam to the indicating drier in accordance with the engagement of said movable contact with one or the other of said stationary contacts.

2. In a moisture regulating device for a paper drying machine, including a plurality of advance drying units and an indicating drier unit, a main steam header, means for supplying steam to said header at constant pressure, means communicating said advance drying units with said header, means for supplying steam to said indicating drier unit, and means for maintaining the pressure in said indicating drier proportional to the steam header pressure, comprising a pivoted beam having a weight secured thereto at one side of the fulcrum thereof, a pair of pressure responsive devices having means for transmitting forces therefrom to said beam at different distances from the fulcrum on the side thereof opposite the weight, means for communicating said devices with said header and with the steam supplied to the indicating drier respectively, a movable electrical contact operatively connected to said beam to be moved thereby when the equilibrium of the beam is disturbed, a stationary contact adapted to be engaged by said movable contact when said equilibrium is disturbed, and a motor driven regulating valve for said indicating drier operatively connected with said stationary contact to govern the admission of steam to the indicating drier.

3. In a moisture regulating device for a paper drying machine, including a number of advance drying units and an indicating drier unit, a main steam header having a regulating valve therein, means for supplying steam to said header at constant pressure including a means for actuating said regulating valve in accordance with variations in the steam pressure, and means for setting said actuating means to come into operation in accordance with the pressure desired, means communicating said advance drying units with said header, means for supplying steam to said indicating drier unit, and means for maintaining the pressure in said indicating drier proportional to the steam header pressure, comprising a pivoted beam having a weight secured thereto at one side of the fulcrum thereof, a pair of pressure responsive members having means for transmitting forces therefrom to said beam at different distances from the fulcrum on the side thereof opposite the weight, means for connecting said members with said header and with the steam supplied to the indicating drier respectively, a regulating valve for said indicating drier to govern the admission of steam thereto, and means for actuating said last named valve when the equilibrium of said beam is disturbed.

4. In a moisture regulating device for a paper drying machine, including a number of advance drying units and an indicating drier unit, a main steam header having a regulating valve therein, means for supplying steam to said header at constant pressure, means communicating said advance drying units with said header, means for supplying steam to said indicating drier unit, and means for maintaining the pressure in said indicating drier proportional to the steam header pressure, comprising a pivoted beam having a

weight secured thereto at one side of the fulcrum thereof, a pair of pressure responsive members having means for transmitting forces therefrom to said beam at different distances from the fulcrum on the side thereof opposite the weight, means for connecting said members with said header and with the steam supplied to the indicating drier respectively, a regulating valve for said indicating drier to govern the admission of steam thereto, and means for actuating said last named valve when the equilibrium of said beam is disturbed.

5. In a moisture regulator for a web drying machine adapted to supply steam to the machine at constant pressure during initial operation thereof and to variably control the steam pressure during subsequent operation of the machine, said machine having a plurality of drying units including an indicating drier unit and means for supplying steam to said units including a main steam header having a regulating valve therein; means for adjusting said valve to determine the pressure desired in said header and for thereafter maintaining said header pressure constant during said initial operation, valve means to control the flow of steam to said indicating drier, balancing means communicating with the flow of the steam to the indicating drier and operating during said initial operation to actuate said indicating drier control valve means to variably admit steam to said indicating drier and thereby maintain the pressure in the latter directly proportional to that in the header, means operating during said subsequent operation for automatically actuating said regulating valve adjusting means to vary the pressure in said header, means operating during said subsequent operation to actuate said indicating drier control valve means to maintain the flow of steam to said indicating drier constant, said balancing means during said subsequent operation being connected to said automatic actuating means to control the latter for effecting said variations in header pressure in response to variations in pressure of the steam flowing to the indicating drier, to thereby effect variations in the header pressure which are inversely proportional to variations in pressure of the steam supplied to the indicating drier, and means for selectively connecting said balancing means for operation with said indicating drier control valve means or with said automatic actuating means during initial and subsequent operations of the machine respectively.

6. In a moisture regulator for a web drying machine adapted to supply steam to the machine at constant pressure during initial operation thereof and to variably control the steam pressure during subsequent operation of the machine, said machine having a plurality of drying units including an indicating drier unit and means for supplying steam to said units including a main steam header; means for adjusting the pressure in said header and for thereafter maintaining said header pressure constant during said initial operation, means to control the flow of steam to said indicating drier, balancing means communicating with the flow of the steam to the indicating drier and operating during said initial operation to actuate said indicating drier control means to variably admit steam to said indicating drier and thereby maintain the pressure in the latter directly proportional to that in the header, means operating during said subsequent operation for automatically actuating said header pressure adjusting means to vary the pressure in

said header, means operating during said subsequent operation to actuate said indicating drier control means to maintain the flow of steam to said indicating drier constant, said balancing means during said subsequent operation being connected to said automatic actuating means to control the latter for effecting said variations in header pressure in response to variations in pressure of the steam flowing to the indicating drier, to thereby effect variations in the header pressure which are inversely proportional to variations in pressure of the steam supplied to the indicating drier, and means for selectively connecting said balancing means for operation with said indicating drier control means or with said automatic actuating means during initial and subsequent operations of the machine respectively.

7. In a moisture regulator for a web drying machine adapted to supply steam to the machine at constant pressure during one stage of the operation thereof and to variably control the steam pressure during another stage of the operation of the machine, an indicating drier unit in the machine, a main steam header, means for controlling the supply of steam to said header and indicating drier unit including a regulating valve for said header and a separate flow control means for the indicating drier, balancing means communicating with the steam supplied to the indicating drier and adapted to be connected to said indicating drier control means during said one stage of the machine operation for variably admitting steam to said indicating drier unit to maintain the pressure in the latter directly proportional to that in the header, adjusting means for said header pressure regulating valve, means for actuating said flow control means for the indicating drier during said other stage of the machine operation to maintain the steam input to the indicating drier constant, said balancing means being adapted to be connected to said regulating valve adjusting means during said other stage of operation to effect variations in header pressure inversely proportional to variations in the indicating drier pressure when a constant flow of steam is supplied to that latter, and means for selectively connecting said balancing means with said flow control means or for connecting said balancing means with said regulating valve adjusting means during said respective stages in the operation of the machine.

8. A regulating system for a web drier machine having provision for supplying steam to the machine at constant pressure during preliminary operation thereof and for thereafter variably controlling the steam pressure during automatic operation in accordance with the heat requirements of the web being dried, comprising a steam header, a plurality of drier units, means for communicating the same with said header, an indicating drier in said drying machine, means effective during said preliminary operation to maintain a predetermined constant pressure in said header, steam supply means for said indicating drier, means effective during said preliminary operation for maintaining a supply of steam to said indicating drier directly proportional to the header pressure, means effective during said automatic operation for maintaining the steam flow to said indicating drier constant, means for automatically adjusting the header pressure in accordance with the heat requirement of the web being dried during said automatic operation, and means for selectively placing said

means effective during preliminary operation or said means effective during automatic operation into control of the system.

9. In a system for controlling moisture in a web drying machine adapted to supply steam to the machine at constant pressure during initial operation thereof and to variably control the steam pressure during subsequent operation thereof, a main steam header, an indicating drier in said machine, a plurality of further driers acting on the web in addition to said indicating drier, means for supplying all said driers with steam, including means communicating said further driers with said header, the steam pressure in said indicating drier varying inversely with the heat being imparted thereby to a web of paper traversing the same and the pressure in the supply means for said indicating drier varying directly with the indicating drier pressure, means for maintaining the steam in said header at a constant pressure during the initial operation of the machine, and balancing means for maintaining the steam pressure in said indicating drier proportionate to the header pressure during said initial operation, said last named means comprising a pivoted beam, a pair of pressure sensitive devices coacting with said beam on one side of the fulcrum thereof, a fixed weight connected to the beam at the opposite side of said fulcrum, means for communicating said devices with the header and with the indicating drier supply means respectively whereby, with constant pressure in the header, the equilibrium of the beam will be disturbed only by variations in the indicating drier pressure, a movable contact arm operatively connected to the beam, and a pair of stationary contacts, one of which is engaged by said movable contact when the beam equilibrium is disturbed in either direction, a regulating valve for said indicating drier, a motor drive therefor, and means for connecting said stationary contacts to said motor drive whereby to actuate the drive and valve to effect a balancing of the header and indicating drier pressures to maintain the proportion therebetween during said initial operation, means for actuating said motor drive to control said valve to maintain the rate of flow to said indicating drier constant during subsequent operation, header pressure regulating means adapted to be connected to said stationary contacts to automatically vary the value of the pressure in the main steam header inversely with variations in the indicating drier pressure during said subsequent operation of the machine, and means for selectively effecting the connection of said motor drive or said header pressure regulating means to said stationary contacts during said initial and subsequent operation respectively.

10. In a system for controlling moisture in a web drying machine having a plurality of drier units, said system being adapted to supply steam to the machine at constant pressure during an initial stage in the operation thereof and to variably control the steam pressure during a subsequent stage of operation, a main steam header, means communicating said drier units with said header, said machine having an indicating drier, means for supplying steam to said header and indicating drier, the steam pressure in said indicating drier varying inversely with the heat being imparted thereby to a web of paper traversing the same, means for maintaining the steam in said header at a constant pressure during said initial stage, means for controlling the flow of

steam to said indicating drier, balancing means having means connecting the same to the steam supply means for the indicating drier and to the header, said balancing means being adapted to be connected to said flow control means to maintain the pressure in said indicating drier proportional to the header pressure during said initial stage, header pressure regulating means adapted to be connected to and controlled by said balancing means during said subsequent stage of operation to automatically vary the value of the pressure in said header inversely of variations of pressure in the indicating drier, and means for selectively connecting said balancing means to said flow control means or to said header pressure regulating means.

11. In a system for controlling moisture in a web drying machine, a main steam header, a plurality of drier units, an indicating drier, the steam pressure in said indicating drier varying inversely with the heat imparted to a web of paper passing thereover, means for communicating said drier units with said header, means for supplying steam to said header at a constant pressure, means for supplying steam to said indicating drier, and means for maintaining the steam pressure in said indicating drier proportionate to the header pressure, said last named means comprising a pivoted beam, a pair of pressure responsive devices coacting with said beam on one side of the fulcrum thereof, means for communicating said devices with the header pressure and with the pressure of the steam supplied to the indicating drier respectively, a regulating valve for said indicating drier, and means operative when the equilibrium of said beam is disturbed for actuating said regulating valve.

12. In a moisture control system for a web drying machine adapted to supply steam to the machine at constant pressure during preliminary operation thereof and to variably control the steam pressuring during subsequent operation, comprising a plurality of drying units including a unit adapted to be employed as an indicating drier unit for the web, a main steam header for said drier units, steam feed means for said indicating drier unit, means for regulating the steam header pressure, means for balancing the pressures in said steam header and indicating drier unit during preliminary operation to maintain the same in predetermined relation to one another, means for maintaining constant flow of steam to the indicating drier during subsequent operation, means for controlling said regulating means to effect variations in the value of the header pressure inversely proportional to variations in the indicating drier pressure during subsequent operation, and switch means for selectively conditioning the system for preliminary or subsequent operation.

13. In a moisture control system for a web drying machine adapted to supply steam to the machine at constant pressure during one stage of the operation thereof and to variably control the steam pressure during another stage of operation, said machine including a plurality of drying units including a unit adapted to be employed as an indicating drier unit for the web, a main steam header for said drier units, steam feed means for said indicating drier unit, means for balancing the pressures in said steam header and indicating drier unit during one stage of machine operation to maintain the same in predetermined relation to one another, means for maintaining constant flow of steam to the indi-

indicating drier during said other operative stage, means for controlling the value of the header pressure so that the value of said header pressure is always inversely proportional to the existing indicating drier pressure during said other stage, and switch means for selectively conditioning the system for said stages of operation.

14. A system for regulating moisture content of a web traversing a drying machine having a plurality of drying elements including an indicating drier, a main steam header, means for adjusting and maintaining constant the pressure in said header comprising a reversible motor driven valve therein, a pivoted beam, a bellows in communication with said header having means engaging the beam at one side of the fulcrum thereof, an adjustable weight on the other side of the fulcrum, means for adjusting the weight longitudinally of the beam, a movable electrical contact operatively connected to said beam, and a stationary contact connected to the valve drive motor and adapted to be contacted by said movable contact when the equilibrium of the beam is disturbed, and a reversible motor on said beam having driving means connected to said weight adjusting means; a flow controller having a pivoted beam, a pair of bellows transmitting force to said beam on opposite sides of the fulcrum thereof, and a weight adjustable lengthwise on said flow controller beam; means actuated by said flow controller for maintaining the flow of steam to said indicating drier constant, comprising a motor driven indicating drier pressure regulator valve, a movable contact actuated by said flow controller beam when the equilibrium thereof is disturbed, and a stationary contact connected to the drive for said indicating drier regulator valve and adapted to be contacted by said last named movable contact; a moisture detector device having a pivoted beam and a pair of bellows transmitting force thereto on the same side of the fulcrum thereof, a weight on the beam at the opposite side of the fulcrum, means subjecting the bellows nearer the last named fulcrum to steam header pressure, means communicating the bellows remote from the fulcrum to indicating drier pressure, a movable contact operatively connected to said moisture detector beam, a stationary contact adapted to be engaged by said last named contact when the equilibrium of said moisture detector beam is disturbed, and switch means for selectively connecting said last named stationary contact with the drive for said regulator valve or for connecting the stationary flow controller contact with said regulator valve drive and the stationary moisture detector contact with the motor on the first named beam.

15. A regulating system for a web drier machine having provision for supplying steam to the machine at constant pressure during a preliminary stage in the operation thereof and for thereafter variably controlling the steam pressure in accordance with the heat requirements of the web being dried during a subsequent stage in the operation of the machine, comprising a steam header for the machine, an indicating drier in said drying machine, means for feeding steam thereto, a main control valve in said header, means operative during said preliminary stage for automatically adjusting said valve to maintain a predetermined constant pressure in said header, means operative during said preliminary stage for maintaining the supply of steam to said indicating drier directly proportional to the

header pressure, and means operative during said subsequent stage to control said valve to admit steam to said header in quantities varying inversely with the pressure existing in the indicating drier, there being means for maintaining a constant flow of steam to said indicating drier during said subsequent stage.

16. A moisture control system for a web drying machine having a plurality of advance drier units and an indicating drier unit, comprising means for supplying steam to said advance and indicating drier units, means for controlling the supply of steam to said units including a motor driven regulator valve coacting with the supply pressure responsive mechanisms connected to said steam supply means and adapted to be selectively brought into control of said valve during different stages of the operation of the machine, one of said mechanisms being adapted to actuate the motor drive for said valve to maintain a constant flow of steam to said indicating drier during one stage of operation and including a pivoted beam having a weight adjustable thereon, and a pressure responsive element coacting with said beam in opposition to the force exerted thereon by the weight, the other of said mechanisms being adapted to actuate the motor drive for said valve to maintain constant pressure in the indicating drier during another stage of operation, means for selectively bringing said mechanisms into control of said motor driven valve, and means for adjusting the said weight on the beam of said one of said mechanisms to maintain the equilibrium of the beam when the other mechanism is in control of the valve.

17. A moisture control system for a web drying machine, having a plurality of advance drier units and an indicating drier unit, comprising means for supplying steam to said advance and indicating drier units, means for controlling the supply of steam to said units including a regulator valve coacting with the supply means for said indicating drier unit, means for actuating said valve, a pair of mechanisms connected to said steam supply means and adapted to be selectively brought into control of said valve actuating means during different stages of the operation of the machine, one of said mechanisms being adapted to actuate said valve actuating means to maintain a constant flow of steam to said indicating drier during one stage of operation and including a pivoted beam, and a pressure responsive element coacting with said beam and tending to deflect the same out of equilibrium, the other of said mechanisms being adapted to actuate said valve actuating means to maintain constant pressure in the indicating drier unit during another stage of operation, means for selectively bringing said mechanisms into control of said valve actuating means, and means for exerting a variable force on the beam of said one of said mechanisms in opposition to the force exerted thereon by said element to maintain the equilibrium of the beam when the other mechanism is in control of the valve actuating means.

18. A moisture control system for a web drying machine adapted to supply steam to the machine at constant pressure during one period of the operation thereof and to variably control the steam pressure during another period, said machine comprising an indicating drier unit, a plurality of advance drying units, and means for supplying steam to said units, mechanism for

maintaining the pressure of steam supplied to said indicating drier unit proportional to the pressure in said advance units during said one period in the operation of the system, mechanism for maintaining flow of steam to the indicating drier unit constant during said other period in the operation of the system, said last named mechanism including a pivoted beam having a weight adjustable thereon and pressure responsive means in communication with and subject to steam supplied to said indicating drier and coacting with said beam in opposition to the force exerted thereon by the weight, a stationary contact, a movable contact, means connecting said movable contact to the beam whereby to be moved thereby to engage the stationary contact when the equilibrium of the beam is disturbed, a motor driven valve controlling flow of steam to the indicating drier unit, means for electrically energizing the motor drive for said valve upon engagement of said contacts, switch means for selectively bringing said first and last named mechanisms into effect during said respective periods, and motor driven means effective when the first named mechanism is in operation to maintain said beam in balance.

19. A moisture control system for a web drying machine including an indicating drier unit, means for supplying heating medium to said unit, the pressure of the medium therein varying inversely with the moisture in the web, means for controlling the supply of steam to said unit, selective means for actuating said control means to maintain constant pressure in said unit during one stage of operation of the system and to maintain constant flow of steam to the unit during another stage of operation, a plurality of tempering driers traversed by the web immediately prior to traversing the indicating drier unit, means for supplying heating medium to said tempering driers, and means for maintaining constant the pressure of the medium in the tempering driers whereby to subject the web to a uniform heating effect prior to reaching the indicating drier unit.

diately prior to traversing the indicating drier unit, means for supplying heating medium to said tempering driers, and means for maintaining constant the pressure of the medium in the tempering driers whereby to subject the web to a uniform heating effect prior to reaching the indicating drier unit.

20. A moisture control system for a web drying machine including an indicating drier unit, means for supplying heating medium to said unit, the pressure of the medium therein varying inversely with the moisture in the web, means for controlling the supply of steam to the unit, means for actuating said control means to maintain constant pressure in the unit during one stage of operation of the system and to maintain a constant flow of steam to the unit during another stage, a tempering unit traversed by the web immediately prior to traversing the indicating drier unit, means for supplying heating medium to said tempering unit, and means for maintaining constant the pressure of the medium in the tempering unit whereby to subject the web to a uniform heating effect prior to reaching the indicating drier unit.

21. In a moisture control system for a web drying machine including a plurality of advance drying units and an indicating drier unit, means for supplying steam to said units including a main steam header, means for maintaining constant the steam flow to the indicating drier unit, and means for automatically regulating the steam pressure in the header and advance drying units to maintain this pressure inversely proportional to the pressure in the indicating drier unit, said last named pressure varying inversely with the moisture in the web.

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