SHEET MOISTURE DRYING MACHINE CONTROL MECHANISM

Filed Jan. 28, 1952 3 Sheets-Sheet 1

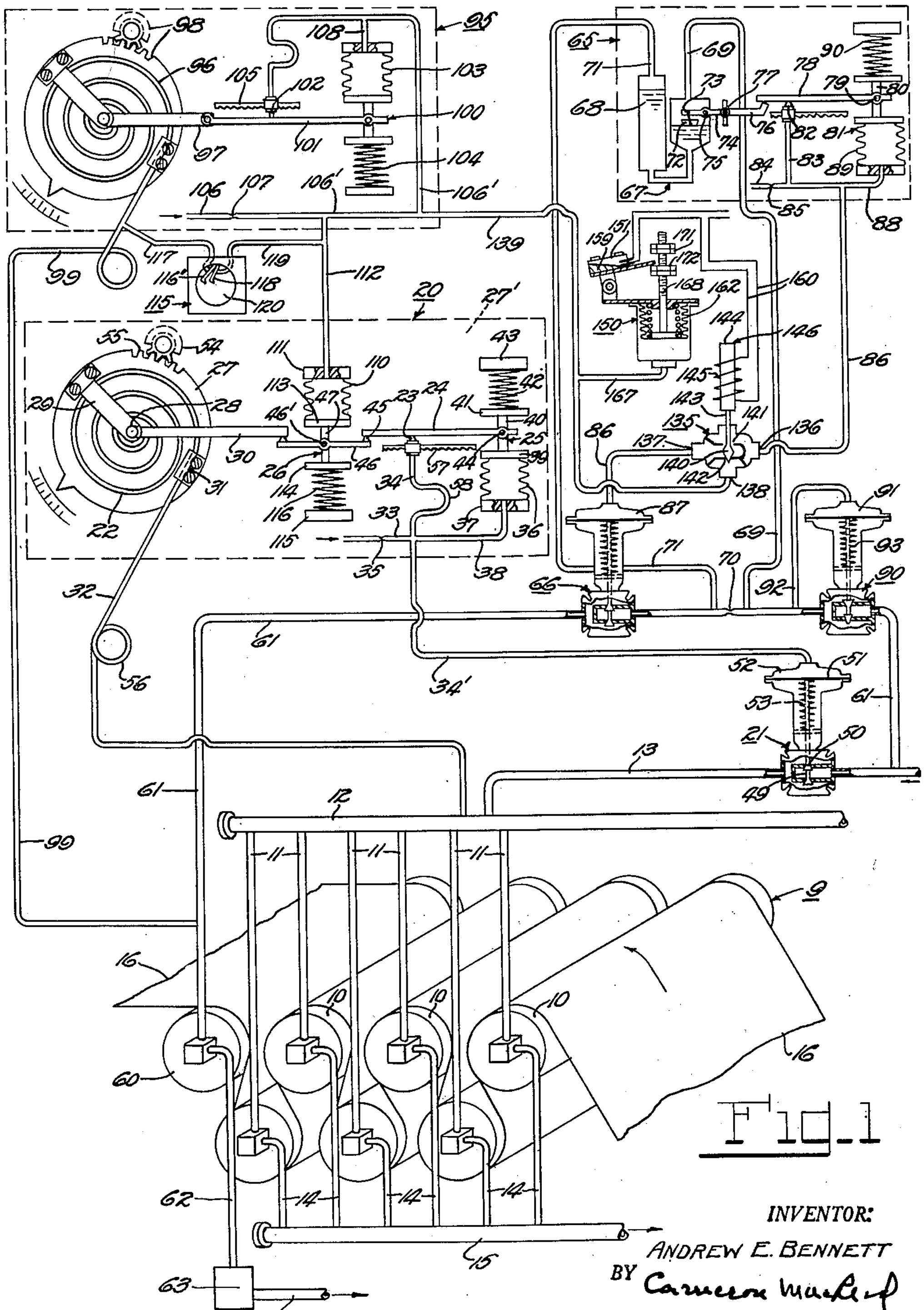

Fig. 1

INVENTOR:
ANDREW E. BENNETT
BY Cameron Macleod
Atty.

SHEET MOISTURE DRYING MACHINE CONTROL MECHANISM

Filed Jan. 28, 1952 3 Sheets-Sheet 2

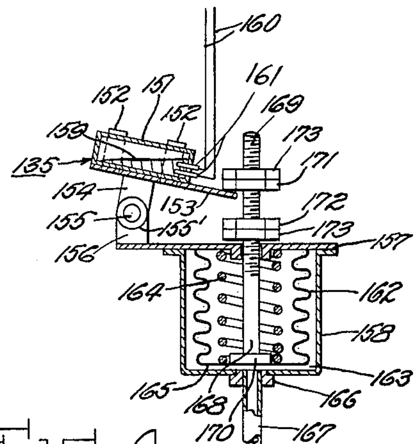

Fig. 4

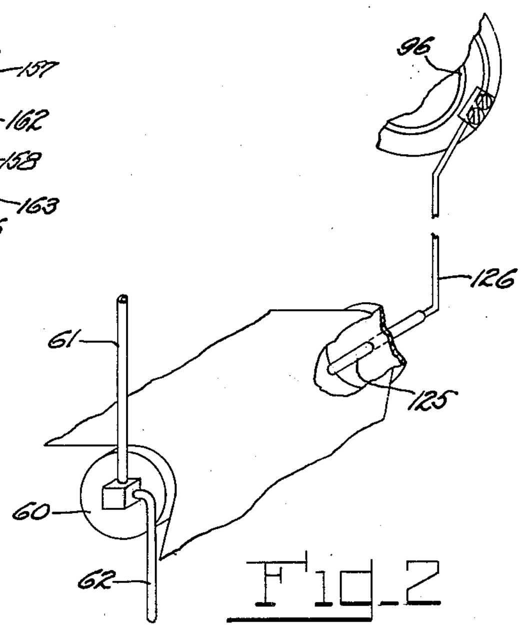

Fig. 2

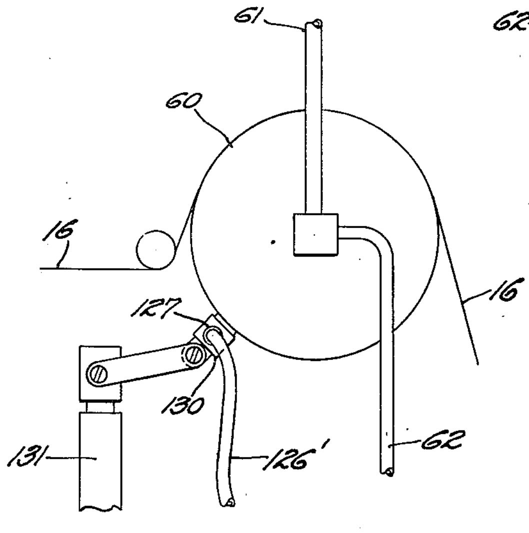

Fig. 3

INVENTOR:
ANDREW E. BENNETT
BY Cannon MacLeod
Atty.

March 3, 1953 A. E. BENNETT 2,629,939

SHEET MOISTURE DRYING MACHINE CONTROL MECHANISM

Filed Jan. 28, 1952 3 Sheets-Sheet 3

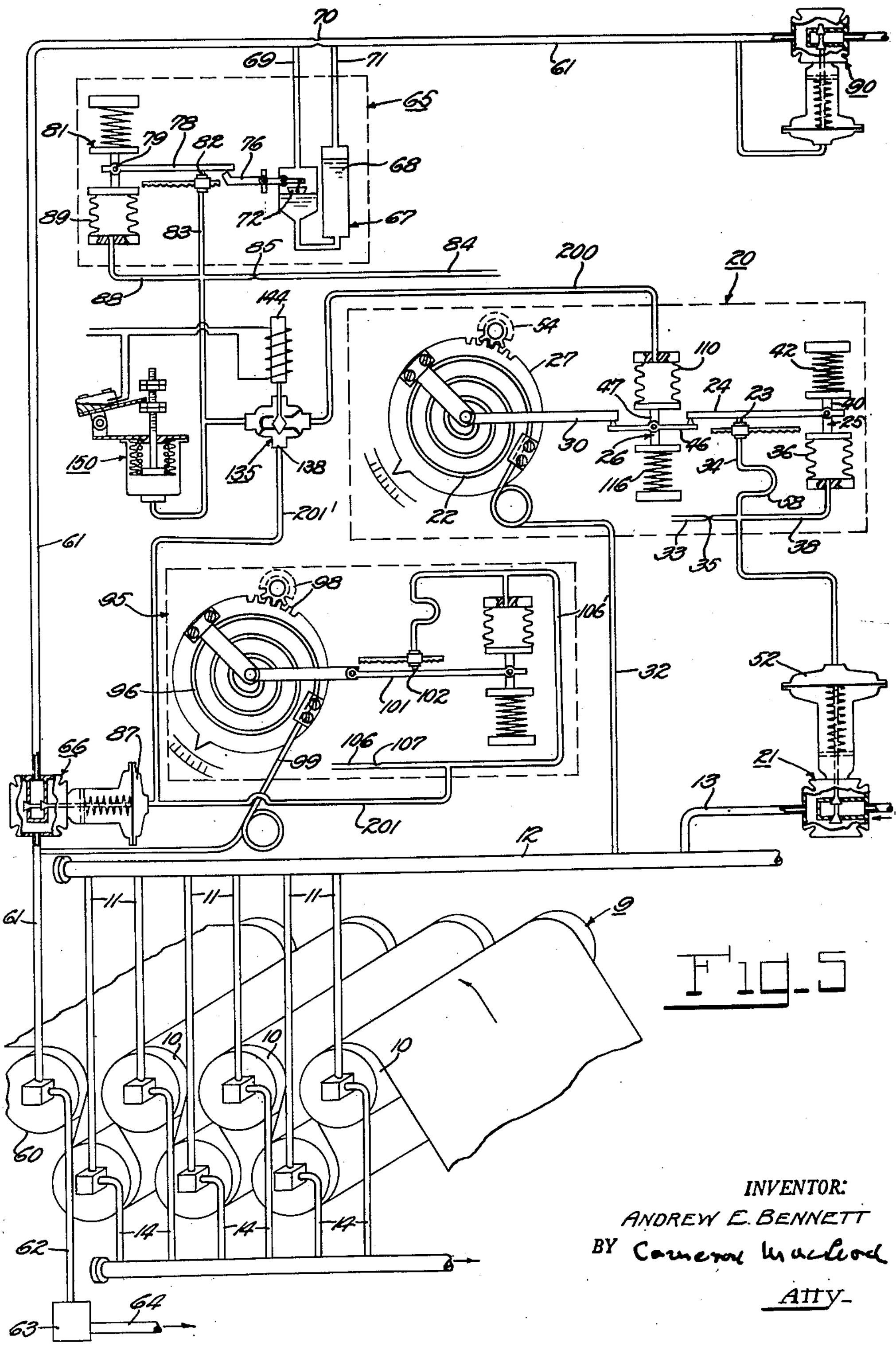

Fig. 5

INVENTOR:
ANDREW E. BENNETT
BY Cameron Macleod
Atty.

Patented Mar. 3, 1953 2,629,939

UNITED STATES PATENT OFFICE

2,629,939

SHEET MOISTURE DRYING MACHINE CONTROL MECHANISM

Andrew E. Bennett, Hingham, Mass., assignor to Mason-Neilan Regulator Company, Boston, Mass., a voluntary association of Massachusetts

Application January 28, 1952, Serial No. 268,618

14 Claims. (Cl. 34—48)

This invention relates to control mechanism for use in connection with drying machines commonly employed in industries concerned with the manufacture of paper, textiles, synthetic material and the like for reducing the moisture content of such material to a predetermined value, and more particularly the invention relates to means which coact with the moisture control mechanism in a manner hereinafter to be described to reduce the temperature of the drying machine during an interval that no sheet material is passing therethrough as may be occasioned, for example, by a break in the sheet material. When the material is again introduced to the machine, the mechanism also functions to return the drying temperature to such value as may be required to provide a predetermined sheet moisture content. By this means, when a sudden reduction in moisture load has occurred, overheating of the drying machine is prevented and the damage resulting therefrom to the sheet when again instroduced to the machine is avoided.

Drying machines of the type referred to comprise a plurality of heating elements, usually in the form of rotating drums or rolls, commonly arranged in one or more main drying sections, over which the material passes from the so-called wet end to the dry end of the machine, it being understood that the material being dried by machines of this type may be in the form of solid sheets such as paper, felt, cloth or the like, or may consist of sheets in the form of strands as, for example, are commonly termed the warp in the manufacture of cloth. And the control mechanism to which this invention relates is adapted to govern the heat input to a drying roll or rolls in one or more main drying sections to reduce the moisture content of the sheet material passing through the machine to a predetermined value. More particularly this invention relates to that type of sheet drying control mechanism wherein one or more drying rolls associated with a main drying roll section are used to reflect or indicate changes in sheet moisture, to which changes the mechanism embodying this invention responds and varies the heat input, as for example steam, to a main section of drying rolls as required to maintain the desired moisture content in the sheet as it leaves the machine. In controls of this type it is customary to supply steam to the indicating roll or rolls independently of the steam supplied to the main drying roll section, and by responding to changes in the rate of condensation of steam in an indicating roll, occasioned by changes in the moisture content

of the sheet passing over the roll, the flow of steam to the main drying roll section is varied for the purpose of retaining the desired sheet moisture content. And the mechanism herein shown and described functions together with control mechanism of the afore-mentioned type to decrease the heat input to the machine when a break in sheet material occurs and thereafter to control the said heat input at a suitable value so that either overheating or underheating of the material is prevented and the damage resulting therefrom avoided when the material is again introduced to the machine, at which time the heat input is again raised to such value as is required to maintain a selected sheet moisture content.

A preferred form of control mechanism embodying this invention is herein shown and described, wherein a constant steam input is maintained to an indicating roll and changes in the rate of steam condensation in the said roll are measured by changes in roll pressure or temperature, thereby reflecting changes in sheet moisture, such mechanism being generally similar to that shown and described in a copending application for United States Letters Patent filed October 10, 1951 under Serial No. 250,706, of which I am a co-inventor. And a modified form of control mechanism embodying this invention is also shown and described, wherein changes in the rate of steam condensation in the indicating roll are measured by changes in the rate of flow of steam to said roll.

It is an object of this invention to provide an improvement in control mechanism for maintaining the moisture of sheet material passing through a drying machine at a substantially constant value, including means for maintaining the temperature of the machine at a suitable value during a period when no material is passing therethrough, thereby preventing the sheet from becoming overheated or underheated and damaged when it is again passed through the machine.

It is an object of this invention to provide an improved control mechanism which responds to changes in moisture in a sheet of material passing over one or more drying machine rolls having a separate steam supply from that which supplies the main drying section of the machine for the purpose of varying the heat input to the said main drying section and thereby maintaining a predetermined sheet moisture content, in combination with automatic means which function with the aforesaid mechanism to reduce the heat input to the machine when a break in sheet material occurs to maintain the said heat input at a suitable value to prevent damage to the sheet material when again introduced to the machine, and thereafter to return the heat input to such value as may be required to provide a selected sheet moisture content.

It is an object of this invention to provide a first means for governing the input of heat to a main drying section of a sheet moisture drying machine, a second means for measuring the rate of condensation of steam supplied to a sheet moisture indicating section of said machine for varying the value of the heat input governed by said first means, and a third means functioning with said second means to reduce the said heat input to a predetermined value when a break in sheet material occurs and the material is off the machine, to prevent overdrying or underdrying of the material when again introduced thereto, and thereafter to increase the heat input to such value as may be required to again maintain a selected sheet moisture content.

While there is herein shown and described a preferred form of control mechanism wherein a controller which governs the steam input to a main drying roll section of a sheet material drying machine is responsive to roll pressure, it will be understood by those skilled in the art that the said heat input may also be governed by a controller responsive to roll temperature in said section or to the rate of flow of steam to the rolls of said section; and it will be further understood that while there is herein shown and described a preferred form of control mechanism including means responsive to changes in steam pressure in a sample roll having an independent constant steam input for the purpose of indicating changes in moisture in sheet material passing over the roll, as indicated in modified views such means may be responsive to roll temperature if desired, since changes in sheet moisture are reflected by both pressure and temperature. And it will be again understood that while in one embodiment of this invention there is shown and described a simple form of means for switching the control from on-moisture load to off-moisture load, various well-known means may be employed without departing from the spirit of this invention. Further objects and advantages of the invention will be apparent from the following description when taken in connection with the accompanying drawings in which—

Fig. 1 is a diagrammatic view, partly in perspective, of a control mechanism embodying this invention as applied to a paper drying machine;

Fig. 2 shows, in perspective, a modified construction of part of the mechanism shown in Fig. 1;

Fig. 3 shows, in end elevation and enlarged, a modified construction of the mechanism shown in Fig. 2;

Fig. 4 is an enlarged view, in section, of a portion of the mechanism, the parts being in the reverse position from that shown in Fig. 1; and

Fig. 5 is a diagrammatic view of a modification of the construction shown in Fig. 1.

Having reference to the drawings and particularly to Fig. 1, there is illustrated a portion of a drying roll section, generally indicated at **9**, of a paper drying machine. The section **9** includes a plurality of rolls **10** which are connected in the usual manner by pipes **11** with a main steam header **12**, supplied from a source not shown, by a conduit **13**, and are also connected by means of condensate pickup pipes, not illustrated, and pipes **14** with a condensate conduit **15** leading to a separator, also not shown. The drying rolls **10** are rotated in unison by means not illustrated, and are engaged by a paper sheet **16** which passes over and under the rolls in the direction indicated by the arrow from the wet end to the dry end of the machine all as shown, the usual felt being omitted to simplify this description.

While there is herein illustrated a plurality of drying rolls **10** forming part of a drying roll section, it will be understood by those skilled in the are that the drying roll section may consist of one large roll, such as that employed in a Yankee Drier commonly used for drying light tissue, or may comprise any other form of drying means suitable to the particular type of sheet material being processed.

Means for governing the flow of steam to the rolls **10** to provide the temperature required to reduce the sheet moisture content to a predetermined value as the sheet leaves the machine is herein illustrated as a pressure controller, generally indicated at **20**, which functions in connection with a motor valve **21** to vary the flow of steam through the supply conduit **13** as required to provide a selected sheet moisture content. The controller **20** may be of any well-known construction and for the purpose of this description, is shown diagrammatically in simplified form. It includes a spiral Bourdon coil **22**, a control couple consisting of a nozzle **23** and flapper **24**, a pneumatic proportioning device **25** and a pneumatic control point reset device **26**. While the controller is shown without a booster pilot for speeding up the motor valve action and without a reset bellows or its equivalent for eliminating so-called drift, it will be understood that either or both of these devices may be employed if desired.

The Bourdon coil **22** is mounted with one end secured to a circular back plate **27** which in turn is rotatably mounted on the controller back plate indicated at **27**[1]. The spiral coil is provided with a central shaft **28** journalled in the plate **27** at its inner end and at its outer end in an arm **29** which extends radially over the coil and is rigidly attached to the said plate **27**. A motion transmitting arm **30** is secured to the shaft **28** which in turn is in operative connection with the free end of the coil. The fixed end **31** of the coil communicates with a flexible tube **32** which, as herein shown, connects with the header **12**, the parts being arranged so that on an increase of pressure in the header, the coil unwinds turning the arm **30** clockwise, and on a decrease in header pressure, the opposite occurs.

The proportioning device **25** actuates one end of the flapper **24** which coacts with the nozzle **23** to vary the operating pressure in the system. Air or an equivalent fluid, preferably under regulated pressure, is supplied to the nozzle **23**, from a source not shown, through pipes **33** and **34**, the former having a restriction **35** of less capacity than that of the nozzle orifice so that the nozzle pressure is governed by the relative position of the flapper in respect to the nozzle. The proportioning device **25** includes a bellows **36** having a fixed mounting **37** to which one end of the bellows is connected, the interior of the bellows being in communication with pipes **33** and **34** by means of a pipe **38**. Secured to the free end **39** of the bellows is a post **40** which is also attached to a disc 41, an expansion spring 42 being confined between the disc and a fixed member 43 so that the end of the flapper 24, which is pivotally connected to the post at 44, assumes a position which is proportional to the fluid pressure in the bellows 36, the overall bellows movement being determined by the rate selected for the spring 42. The other end of the flapper 24 is engaged at 45 by one end of a lever 46 pivotally at 46[1] on a post 47 forming part of the control point reset device 26 to be described. The other end of the lever 46 is engaged by the free end of the coil arm 30 and the parts are so arranged that an increase in fluid pressure in the steam header 12 causes the coil to unwind and turn the arm 30 clockwise, thereby moving the flapper 24 away from the nozzle 23. This movement results in a decrease in pressure in the proportioning bellows 36 causing the bellows to contract and return the flapper to a throttling relation with the nozzle at a lower pressure, which pressure is proportional to the increase in steam pressure in the header 12. On a decrease in pressure in the header 12, the opposite occurs.

The motor valve 21, of the fluid pressure operated type and of any usual construction, is mounted in the steam conduit 13 by which the header 12 is supplied. As herein shown the valve 21 is of the reverse acting type. It has a valve member 49 connected with a stem 50 which is actuated by a diaphragm 51 defining one wall of a fluid pressure operating chamber 52, the pressure in which is opposed by a spring 53. The diaphragm chamber 52 is connected with the controller piping 33 and 34 by means of a pipe 34[1], the valve parts being arranged so that the valve member 49 moves toward closed position on a decrease in operating pressure. Thus when the pressure in the steam header 12 increases or decreases, the pressure in the nozzle 23 decreases or increases respectively in proportion thereto, thereby providing a proportional throttling action to the valve, and varying the flow of steam to the header 12 in a direction to return the pressure in the drying rolls 10 to a set value.

It will be understood by those skilled in the art that the pressure at which the controller is set depends on the initial position assumed by the flapper in relation to the nozzle and that this in turn depends both on the radial position assumed by the coil arm 30 at a selected pressure in the header 12 and on the vertical position of the pivotal connection 46[1] between the lever 46 and post 47 of the pneumatic reset device 26.

Suitable means for manually adjusting the radial position of the coil arm 30 is in the form of a hand operated gear 54 which meshes with a toothed section 55 on the plate 27, the pipe 32 being provided with a flexible portion 56 to permit the coil to be rotated by the gear to any selected position within the range of control setting adjustment. When the coil is rotated counterclockwise the pressure setting is raised and vice versa. The manual control point setting device just described functions in connection with the pneumatic control point resetting device 26 in a manner to be hereinafter set forth.

Means for adjusting the initial sensitivity of the controller may be in the form of a rack 57 on which the nozzle 23 is mounted, movement toward the connection 45 between the flapper 24 and the lever 46 provides greater sensitivity and vice versa. To permit of this adjustment, the pipe 34 is provided with a flexible portion as indicated at 58.

The apparatus just described illustrates a simple form of control mechanism for governing the valve 21 to maintain a set pressure in the header 12 and functions with apparatus to be described to vary the pressure setting and thereby the roll temperature as required to maintain the moisture content of the sheet as it leaves the machine at a selected value. And it will be understood that while there is shown a pressure controller by way of illustration, a temperature or rate of flow controller may be equally well utilized, the object being to provide a roll temperature such as may be required for the purpose.

In the form of control apparatus shown in Fig. 1 means are provided for responding to minute changes in sheet moisture by maintaining a constant rate of steam input into a moisture indicating roll section, herein shown as a roll 60, and responding to pressure or temperature changes in the said roll or to temperature changes at the roll surface. For this purpose, the roll 60 is provided with a separate steam supply through a conduit 61 from a source not shown, and with means for removing the condensate as by an internally mounted condensate pickup pipe, also not shown, which connects with a condensate discharge pipe 62 having a steam trap 63 which in turn communicates with a discharge conduit 64. Steam flow through the supply conduit 61 is maintained at a constant selected rate by means of a rate of flow controller, generally indicated at 65, which functions with a motor valve 66 for this purpose. The rate of flow controller 65 may be of any suitable construction and as herein shown comprises the usual mercury manometer 67 suitably filled with mercury 68 and having a connection 69 upstream of an orifice 70 in the conduit 61 and a connection 71 downstream of said orifice. A float 72, pivotally connected at 73 to one end of a lever 74 having a pivotal mounting 75 in the manometer casing, serves to rotate the lever about the pivotal mounting on a basis which is substantially proportional to changes in the pressure differential across the orifice 70 and therefore to changes in the rate of steam flow. The other end of the lever 74 has a pivotal connection with a flapper operating arm 76, a locking member 77 being provided for clamping the arm in any rotary position desired. The free end of the arm 76 engages one end of a flapper 78 pivotally connected at 79 to a post 80 of a proportioning device 81 similar in construction to that described in connection with the pressure controller 20. The flapper 78 cooperates with a nozzle 82 which receives a regulated pressure supply of operating fluid through pipes 83 and 84 from a source not shown, the latter pipe having the usual restriction 85 so that the pressure in the nozzle is governed by the relative position of the flapper in respect thereto. A pipe 86, in which a three-way valve 135 is mounted, serves to communicate the nozzle with the diaphragm chamber 87 of the motor valve 66 which is of the reverse acting type and is of similar construction to the motor valve 21 mounted in the steam conduit 13 supplying the main drying roll section 9. A second pipe 88 connects the nozzle with the bellows 89 of the proportioning device 81 which provides a proportioning action as governed by the rate of a spring 90 in the same manner as the proportioning device 25 referred to above. In operation, an increase in flow through the orifice 70 creates a proportional increase in differential pressure across the orifice. As this occurs the float 72 moves down with the level of supporting mercury, rotates the lever 74 counterclockwise and moves the flapper 78 away from the nozzle 82 to decrease the nozzle pressure. Thereupon the proportioning bellows 89 contracts and returns the flapper to a throttling relation at a reduced nozzle pressure. The motor valve 66 throttles the steam flow to the roll 60 to maintain the pressure drop across the orifice and therefore the rate of flow at a substantially constant value as determined by the control setting. The control setting is determined by the initial position of the flapper 78 in respect to the nozzle 82 and as herein illustrated the setting may be varied by locking the operating arm 76 at any desired angle to the float operated lever 74.

It is important that a constant rate of flow be accurately maintained since changes in flow introduce errors in the response of the master controller to be described and there is therefore preferably provided means for maintaining a constant pressure upstream of the orifice 70, thereby restricting any tendency of the pressure to change to that portion of the conduit 61 which is downstream of the said orifice. For this purpose a reducing regulator 90 of any usual construction may be employed. The regulator shown is of the direct acting type and is generally similar in construction to the valves 21 and 66. It is mounted in the conduit 61 upstream of the orifice 70 and has a diaphragm chamber 91 which is connected with the conduit on the downstream side of the valve by means of a pipe 92. The pressure in the diaphragm chamber 91 is opposed by a spring 93 which may be tensioned to provide a selected reduced pressure on the upstream side of the orifice 70, and since an increase of pressure tends to close the valve and a decrease in pressure tends to open it, the valve functions to maintain a substantially constant pressure upstream of the orifice.

As shown in Fig. 1, the indicating roll 60 is in contact with the paper sheet 16 as it leaves the main drying roll section 9, and since the roll is provided with a constant steam input, preferably but not necessarily, at a relatively low pressure, for example 6 p. s. i., changes in sheet moisture affect the rate of steam condensation in the roll and have a relatively large proportional effect on roll temperature. And the control apparatus shown in Fig. 1 responds to these relatively wide changes in roll temperature by responding to correspondingly relatively wide changes in roll pressure, although as shown in Figs. 2 and 3, response may be made to internal roll temperature or to the surface temperature of the roll.

Referring again to Fig. 1, a master controller, generally indicated at 95, which also may be of any well-known construction, is employed to respond to roll pressure changes and to provide an output pressure proportional thereto. The master controller includes a spiral coil 96, having a flapper actuating arm 97, and a manual control reset mechanism generally indicated at 98 both of which may be similar to the coil 22 and manual reset 54—27 described in connection with the pressure controller 20. The master controller also has a proportioning device 100 of similar construction to the proportioning device 25, shown in connection with the controller 20, together with a flapper 101 which is positioned by the coil arm 97 and proportioning device 100 in respect to a nozzle 102. Since the nozzle 102 is herein shown as being mounted above the flapper 101, the bellows 103 and spring 104 are in the reverse position from that shown in the controller proportioning device 25. A sensitive adjustment 105 likewise similar to that in the controller 20, is also provided. The fixed end of the coil 96 communicates with the steam conduit 61 by means of a pipe 99 at a point between the valve 66 and the roll 60, preferably adjacent the roll in order that it may accurately reflect changes in roll pressure. The controller nozzle 102 is connected with a regulated pressure supply of fluid from a source not shown through a pipe 106 having a restriction 107 of less capacity than that of the nozzle, pipe 106 being connected with a pipe 106^1 which communicates with the nozzle. A connection 108 between the pipe 106^1 and proportioning bellows 103 serves to communicate the nozzle pressure to the interior of the bellows 103 in the usual manner. It will be understood that a decrease of pressure in the roll 60 and therefore in the coil 96 causes the coil to wind up, thereby turning the arm 97 counterclockwise and moving the flapper 101 towards the nozzle 102 to increase the nozzle pressure. The resulting expansion of the bellows 103 moves the flapper away from the nozzle and returns the parts to a throttling relation to provide an increase in the nozzle pressure in the pipe 106^1, or in other words an increase in the master controller output pressure, on a basis which is proportional to the decrease in roll pressure. And since a relatively wide proportional change in roll pressure results from a relatively small change in sheet moisture, the master controller is sensitive to slight moisture changes and provides relatively large proportional changes in the output pressure, which changes may be utilized to govern the pressure in the rolls 10, preferably by resetting the control point of the pressure control instrument 20.

The control point resetting device 26 has a bellows 110 having a fixed mount 111 through which the interior of the bellows is connected with the master controller output pressure pipe 106^1 by means of a pipe 112. The post 47 on which the lever 46 is pivotally mounted as hereinabove described, is secured to the free end 113 of the bellows and to a disc 114 between which and a fixed member 115 an expansion spring 116 is confined. Since the vertical position of the pivot 46^1 determines the control setting of the controller 20 in respect to the setting established by the rotary position of the coil arm 30 as provided by the manually operated gear 54, the bellows 110 functions to vary the control above and below the value established by the manual set mechanism on a basis which is inversely proportional to changes in roll pressure. Thus when the sheet moisture increases, a relatively wide drop in roll pressure occurs, thereby providing a relatively large proportional increase in the output pressure in the bellows 110. This increase in output pressure expands the bellows 110 proportionally thereto and correspondingly lowers the pivot 46^1 by an amount determined by the rate selected for the spring 116. Thus the lever 46 is rotated clockwise in accordance with the movement of the pivot 46^1, thereby positioning the flapper 24 nearer to the nozzle 23 and raising proportionally the pressure setting. And it will be understood that when a decrease in sheet moisture occurs a proportional decrease in master controller output pressure takes place and thereby the pressure setting of the controller is lowered proportionally to the decrease in moisture content.

In order to record changes in sheet moisture and in the pressure in the roll 60, there is provided a recorder, diagrammatically shown at 115, which may be of any usual construction and is preferably of the two-pen type. One pen, indicated at 116^1, is responsive to changes in indicating roll pressure as reflected in pipe 99 to which a Bourdon coil, not shown, by which the pen is operated, is connected by means of a pipe 117. The other pen 118 is operated by a Bourdon coil, also not shown, which connects with the output pressure pipe 112 through a pipe 119. By means of a double range chart 120, rotated in the usual manner by a clock not shown, and representing both pressure and sheet moisture deviation, the roll pressure is directly recorded by the pen 116, and changes in sheet moisture are indirectly recorded through changes in the master controller output pressure by pen 118, which last mentioned changes are proportional to changes in the roll pressure and therefore to changes in sheet moisture content.

Fig. 2 illustrates an alternate construction wherein the transmitter coil 96 responds to the internal temperature of the roll 60 instead of to the roll pressure as shown in Fig. 1. The roll 60 to which the steam supply pipe 61 and condensate discharge pipe 62 are connected as shown in Fig. 1, is provided with a temperature bulb 125 having the usual capillary tubing 126 which connects with the fixed end of the coil 96, thereby providing a sealed thermal system which may be filled with a suitable expansible fluid. The bulb 125 extends into the interior of the roll 60 and is sensitive to changes of temperature therein.

The operation of the master controller 95 is substantially identical to that described in Fig. 1, wherein the master controller responds to changes in the roll pressure. Since the temperature in the roll 60 varies with the pressure when a change in sheet moisture occurs, the same relatively wide band of indication is provided. Thus the device functions in the same way as the pressure response shown in Fig. 1 since the coil 96 responds to changes in thermal system pressure which is substantially the equivalent to changes in roll pressure.

In Fig. 3 there is shown a means for responding to changes in the surface temperature of that portion of the cylindrical surface of the roll 60 which is engaged by the sheet 16, the roll 60 being connected with the steam inlet conduit 61 and the discharge pipe 62 as hereinabove described. For this purpose a surface temperature measuring device 130 of any well-known suitable construction is employed, preferably a measuring device of the type shown and described in the application for United States Letters Patent of Andrew E. Bennett and Daniel S. Brown, filed February 16, 1951, under Ser. No. 211,336. The measuring device 130 may be mounted on a stand 131 at the cylindrical surface of the roll 60 and at a selected position on that portion of the surface which is engaged by the paper sheet. A capillary tube 126^1 which corresponds to the tube 126 in Fig. 2 is connected to a bulb 127 in the measuring device 130, a suitable expansible fluid being employed to vary the fluid pressure in the coil 96 in response to changes in the roll surface temperature.

In the operation of the device, the master controller 95 functions in the same way as already described. Since a constant steam input is supplied to the roll 60, a change in sheet moisture results in a relatively wide change not only in the internal temperature and pressure in the roll, but in the temperature of that portion of the roll surface which is engaged by the paper sheet. This will be evident when it is noted that the change in sheet moisture initially effects a relatively wide change in the surface temperature of that portion of the roll engaged by the sheet since the quantity of steam supplied to the roll is not varied in a direction to counteract the moisture change. And it is equally clear that the relatively wide change in roll surface temperature effects a substantially corresponding change in roll pressure and internal temperature. Thus as in the construction shown in Figs. 1 and 2, a relatively wide band of indication is provided, whereby the master controller is responsive to slight changes in sheet moisture and functions immediately to reset proportionally the control setting of the instrument 20 to vary the heat input to the drying roll section 9 and maintain the sheet moisture content substantially at a selected value.

While the control mechanism hereinabove described functions to maintain the sheet moisture content to within extremely close limits, it has been found necessary when a break in the sheet 16 occurs and the sheet runs off of the machine, for the operator to manually reset the control mechanism to such lower pressure as is required to prevent overheating during the period when the paper sheet is not passing through the machine and thereby overheating a considerable portion of the sheet when it is again introduced to the machine. And the mechanism to be described functions with the control mechanism set forth above to change the control from a condition under which the drying machine is operating under a sheet moisture load to a condition under which the machine is operating without the sheet moisture load, and thereafter to return the control setting to the value required to provide the proper moisture content when the sheet is again passed through the machine. For this purpose the solenoid valve 135 is mounted in the output pressure line 86 from the controller 65 to the diaphragm chamber 87 of the control valve 66. The valve 135 is of the three-way solenoid operated type and maybe of any well-known construction. As herein illustrated it comprises a body having connections 136 and 137 which connect with pipe 86 and a third connection 138 which connects with the output pressure line 106^1 of the controller 95 by means of a pipe 139. Within the valve body a double seated valve member 140 cooperates with oppositely disposed ports 141 and 142 and is connected by means of a stem 143 to a core 144 which together with a coil 145 constitutes a solenoid generally indicated at 146 for actuating the valve member. The parts are arranged so that when the solenoid is deenergized by means to be described the port 142 is closed and the port 141 is open to connect the output pressure line 86 with the diaphragm valve 87 of the valve 66. On the other hand when the solenoid 146 is energized the valve member 140 closes the port 141 and opens the port 142, whereby the output pressure line 106^1 from the controller 95 is connected through the pipe 139 with that portion of the pipe 86 which leads from the three-way valve to the diaphragm chamber 87 of the said valve 66. Means for energizing the solenoid 146 is in the form of an electric gap switch as herein shown, generally indicated at 150, but it will be understood by those skilled in the art that any other well-known form of device may be used for this purpose whether electrically, pneumatically or hydraulically operated.

The gap switch 150 is provided with a mercury tube 151 which is secured by means of clips 152 (see particularly Fig. 4) to an operating member 153 having a support 154 pivoted at 155 on an upright 156 secured to a cover 157 with which a bellows casing 158 is provided. The tube 151 has the usual globule of mercury 159 and is so arranged that when tilted clockwise past its horizontal position as viewed in Fig. 4 the mercury globule will flow to the right to the position shown, and when tilted counterclockwise past its horizontal position, the mercury will flow to the left to the position shown in Fig. 1. A pair of conductors 160 having contacts 161 within the tube 151 together with the coil 145 surrounding the solenoid core 144 form part of a circuit whereby the solenoid may be energized from a source of electric current not shown when the contacts 161 are surrounded by the mercury 159.

Means for tilting the tube 151 is in the form of a bellows 162 disposed within the casing 158 and sealed to the cover 157 to provide a pressure chamber 163 externally of the bellows. Within bellows 162 is a compression spring 164 which is confined between the cover 157 and the free end 165 of the bellows. The casing 158 is provided with a connection 166 into which a pipe 167 is threaded and communicates with the output pressure line 139 of the master controller 95. A rod 168, threaded at its outer end as indicated at 169, extends through an opening in the cover 157 and is attached at its inner end to a plate 170 which in turn is secured to the inner face of the free end 165 of the bellows. A pair of nuts 171 and 172 and lock nuts 173 are threaded on rod 168 and are suitably positioned and spaced so that the operating member 153, which extends into the spacing between the nuts, will be tilted clockwise by the nut 171 past its horizontal position at a selected low pressure in the chamber 163, and will be tilted counterclockwise by the nut 172 past its horizontal position at a selected high pressure in the said chamber, the pivotal connection 155 being preferably provided with sufficient friction, as by a friction washer 155^1, to hold the tube 151 at the tilted position to which it has been actuated by the nuts 171 and 172.

In operation, assuming that the output pressure from the controller 95 has an operating range from 3 p. s. i. to 15 p. s. i., the spring 164 being tensioned to provide a predetermined movement to the bellows 162 over this range of pressure change, and assuming further that a relatively high output pressure obtains so that the tube 151 is tilted to the position shown in Fig. 1, wherein the electric circuit is broken and the solenoid 146 is deenergized, the nut 171 may be positioned so that when the output pressure drops to 3 p. s. i. the nut 171 has moved down to a position to tilt the tube 151 clockwise past its horizontal position to the position shown in Fig. 4. When this occurs, the mercury 159 flows to the right, thereby completing the electric circuit. The nut 172 may also be positioned on the rod 168 so that when the pressure increases from 3 p. s. i. to a predetermined value, for example, 9 p. s. i., the nut 172 will be raised to a position to tilt the tube 151 counterclockwise past its horizontal position, whereupon the mercury will flow to the left and break the electric circuit. Thus under the condition assumed, if the output pressure has been in excess of 9 p. s. i. the solenoid will deenergize until the pressure drops to 3 p. s. i. and thereafter the solenoid will remain energized until the output pressure has again risen to 9 p. s. i.

In describing the operation of the control mechanism shown in Fig. 1, it may be assumed that the paper sheet 16 is passing through the machine, that the pressure controller 20 is set to maintain a steam pressure on the rolls 10 of 25 p. s. i., that the valve 90 is set to maintain a steam pressure of 20 p. s. i. upstream of the orifice 70, and that the rate of flow controller 65 is set to maintain a constant steam input to the indicating roll 60 of 400 pounds per hour. Under these conditions and assuming that the output pressure range of the controllers is from 3 p. s. i. to 15 p. s. i. and that the steam pressure obtaining in the indicating roll 60 is approximately 6 p. s. i., the master controller 95 may have its proportioning band adjusted, for example, to provide an output pressure of 15 p. s. i. when the indicating roll pressure is at 5 p. s. i and an output pressure of 3 p. s. i when the roll pressure is at 7 p. s. i. Thus when the roll pressure is at 6 p. s. i. the output pressure of the master controller 95 will be at the midpoint of its range, namely 9 p. s. i., and the pneumatic set 26 in the pressure controller 20 will be at the midpoint in its range, namely, at the 25 p. s. i. pressure setting provided for the main drying section rolls 10 by the manually operated gear 54. Again under these conditions the solenoid 146 of the valve 135 will be deenergized and the rate of flow controller 65 will be governing the steam valve 66 to maintain a constant rate of flow through the orifice 70 of 400 pounds per hour. Also under these conditions changes in sheet moisture will be immediately reflected by changes in steam pressure in the roll 60, and the pneumatic set mechanism 26 of the pressure controller 20 will be varied by the master controller around the manual set point in proportional relation to changes in sheet moisture to vary the steam pressure in the main drying section and thereby to maintain the indicating roll pressure at substantially 6 p. s. i. I have found that under the usual operating conditions when the proportioning band of the master controller 95 is set to provide a change in output pressure from 3 p. s. i. to 15 p. s. i. on an indicating roll pressure change of plus or minus 1 p. s. i. from 6 p. s. i., a portion only of the output pressure operating range is required to maintain the indicating roll pressure well within the aforesaid pressure limits.

Let it be assumed that a break in the paper sheet 16 occurs, that the sheet has left the rolls and that for this reason the major portion of the moisture load to which the machine has been subjected is suddenly removed. When this occurs, the rate of condensation in the indicating roll 60 is immediately reduced, and since a constant steam input of 400 pounds per hour is being fed to the roll as governed by the controller 65, an increase in roll pressure takes place. When the steam pressure increases to 7 p. s. i., the output pressure in the master controller 95 decreases to 3 p. s. i., at which pressure the gap switch 150 completes the circuit through the conductors 160 to energize the solenoid of the valve 135. The valve member 140 is therefore raised to open the port 142 and close the port 141, whereby the output pressure from the controller 65 is cut off from the diaphragm chamber 87 of the steam valve and the output pressure from the master controller 95 is connected thereto. Since the output pressure of the master controller 95 is at 3 p. s. i. at this time, the steam valve 66 will immediately be actuated towards closed position and the stream pressure in the pipe 61 below the orifice 70 will be immediately increased to the pressure of 20 p. s. i. maintained by the valve 90. Thus the rate of flow controller 65 will be rendered ineffective and the master controller 95 will continue to govern the valve 66 until its output pressure again reaches 9 p. s. i. And since the master controller 95 is set to maintain a pressure of 6 p. s. i. on the said roll and the steam flow now required to maintain this pressure is relatively small, being just enough to take care of the condensation caused by the heat transfer occasioned by a felt when employed and herein not shown, and by the atmosphere, the output pressure in the master controller will be just enough above the pressure of 3 p. s. i. for the purpose and will be well below the mid pressure of 9 p. s. i. Therefore the solenoid valve 135 will remain energized and the steam valve 66 will continue to be governed by the master controller 95.

In the meantime the drop in output pressure of the master controller will also function to actuate the pneumatic set 26 of the pressure controller 20 to the low end of its pressure range. On the assumption that the range is adjusted to be on a 100% basis, the controller will immediately be reset at a point to close the steam valve 21 until the excess heat in the rolls has been removed by condensation resulting from the transfer of heat occasioned by atmospheric conditions and, when a felt is employed, by the moisture content of the felt. After the excess heat has thus been removed, the continued transfer of heat causes the pressure in the indicating roll to drop below 7 p. s. i., thereby increasing the output pressure of the master controller 95 sufficiently to open the valves 66 and 21 and provide the proper amount of heat to meet the aforesaid conditions. Thereafter the control will continue to function in this manner until the sheet is again passed through the machine. When this occurs, as the moist sheet passes over the indicating roll 60, the steam condenses more rapidly and the pressure starts to drop to the setting of 6 p. s. i. The output pressure from the master controller 95 thereupon increases from its former pressure, and when the pressure reaches 9 p. s. i., the solenoid valve is again deenergized. Thus the master controller is cut off from the chamber 87 of the valve 66 and the valve is again governed by the rate of flow controller 65. By this means a constant steam input to the indicating roll of 400 pounds per hour is again provided and the pneumatic set mechanism 26 of the pressure controller again varies the pressure setting on the main drying section around the manual set point of 25 p. s. i.

Referring to Fig. 5, there is shown a modified arrangement wherein the apparatus embodying this invention is illustrated as applied to sheet moisture control mechanism of the type which varies the control setting of a controller for varying the heat value to a main drying section of the machine by responding to changes in the rate of flow of steam to the indicating drying section. In this arrangement the pressure controller 20 is of similar construction to that shown in Fig. 1. It comprises the spiral coil 22, the proportioning device 25, the nozzle and flapper 23—24, and the pneumatic reset mechanism 26. The controller 20 functions together with the valve 21 to maintain a set pressure in the header 12 as provided by the manual set mechanism 54—27 and by the reset mechanism 26 in a manner to be described.

Means for resetting the control point of the controller 20 in response to changes in the rate of steam condensation in the indicating roll 60 is in the form of the rate of flow measuring instrument 65 wherein the parts are shown in the reverse position from that illustrated in Fig. 1. This includes the mercury manometer 67 suitably filled with mercury 68 supporting the float 72 which is in operative connection with the flapper 78 by means of the lever 76. The flapper 78 is pivotally connected at 79 to the proportioning device 81 and cooperates with the nozzle 82 which receives a regulated fluid pressure through the restriction 85 in a pipe 84 which in turn connects with the nozzle line 83 and with the pipe 88 communicating with the interior of the bellows 89 of the proportioning device 81. The manometer 67 is connected with the conduit 61 leading to the indicating roll 60 by means of the pipes 69 and 71, but in this case the pipe 69 is connected with the conduit 61 downstream of the orifice 70 and the pipe 71 is connected with the conduit upstream of the said orifice. Thus the action of the instrument 65 is reversed from that shown in Fig. 1. An increase in flow in the conduit 61 provides a proportional increase in the pressure drop across the orifice 70, thereby raising the float 72 and moving the flapper 78 towards the nozzle 82 to provide a proportional increase in output pressure in the line 83. On the other hand, a reduction in flow in the conduit 61 decreases the pressure drop across the orifice 70, thereby causing the float 72 to move down and raise the flapper 78, whereby a proportional reduction in output pressure in the line 83 occurs. The output pressure line 83 communicates with the interior of the output pressure bellows 110 of the pneumatic reset device 26 by means of a pipe 200 which includes the solenoid operated three-way valve 135 of similar construction to the valve heretofore described, and normally providing a passage for fluid through the pipe 200. The conduit 61 is provided with the reducing valve 90 which maintains a constant steam pressure upstream of the orifice 70, and is also provided downstream of said orifice with the valve 66, to be governed in a manner to be described.

In operation, an increase in moisture in the sheet passing over the roll 60 causes a proportional increase in the rate of steam condensation in the said roll, thereby resulting in an increase in the rate of flow through the orifice 70. The increase in flow creates an increased pressure drop across the orifice, thereby raising the float 72 and providing a proportional increase in output pressure in the line 83, in the pipe 200, and in the bellows 110 of the reset device 26. The bellows 110 thereupon expands and moves the flapper 24 towards the nozzle 23. And since the coil 22 turns the arm 30 clockwise to raise the flapper 24 on an increase of pressure on the header 12, a higher pressure in the header is required to bring the flapper into a throttling relation with the nozzle 23. Thus the pressure setting of the controller 20 is raised by an amount generally proportional to the increase in the rate of steam condensation in the roll 60 and therefore to the increase in sheet moisture. It will be understood that on a decrease in sheet moisture the rate of steam condensation decreases proportionally thereto, and accordingly the reduced pressure differential across the orifice 70 results in a proportional decrease in output pressure of the controller 65 and in the reset bellows 110 of the controller 20. Thus the bellows 110 contracts and raises the flapper 24 from the nozzle 23 to provide a proportionally lower pressure setting for the controller 20. By this means changes in the rate of steam flow in the conduit 61 are utilized to measure changes in the rate of steam condensation in the roll 60 to vary the heat input to the main drying section 9 in a manner to govern the moisture content of the sheet passing through the machine. While this form of control is less sensitive than the preferred form of mechanism heretofore described, the means to be described function together with this type of moisture control to reduce automatically the machine temperature to a suitable value when a break in sheet material occurs, thereby preventing the material from becoming overdried or underdried when it is again passed through the machine.

For this purpose I provide the valve 66 in the conduit 61 downstream of the orifice 70 as in the preferred form of device shown in Fig. 1. However, instead of governing the valve 66 by the rate of flow instrument 65 as shown in Fig. 1, the valve is governed by the controller 95 which is of similar construction to that shown in Fig. 1. As in Fig. 1, the coil 96 of the controller 95 is responsive to changes in pressure in the conduit 61 downstream of the valve 66 by means of the pipe 99. And as therein described, an increase in pressure in the roll 60 causes the coil 96 to unwind and move the flapper 101 away from the nozzle 102. Since the nozzle 102 is supplied with fluid by the pipe 106 through the restriction 107, a proportional decrease in nozzle pressure results in the output pressure pipe 106^1. In the arrangement herein shown, the output pressure of the controller 95 in the pipe 106^1 is connected with the diaphragm chamber 87 of the reverse acting valve 66 by means of a pipe 201. Thus an increase in pressure in the roll 60 results in a proportional decrease in output pressure in the diaphragm chamber 87, thereby causing the valve 66 to throttle the flow of steam to the roll 60. And when a decrease in pressure in the roll 60 takes place, the valve 66 functions to increase the flow of steam to the said roll. Thus the controller 95 governs the valve 66 to maintain the pressure in the indicating roll 60 substantially at a value established by the controller set mechanism 98. As in the preferred construction, I communicate the fluid pressure in the output pressure line 106^1 with the connection 138 of the three-way valve 135. For this purpose a pipe 201^1 is employed which connects the pipe 201 with the valve. The three-way valve 135 is operated by the gap switch 150 but instead of responding to changes in output pressure in the pipe 106^1 as in Fig. 1, it responds to changes in output pressure in the rate of flow response instrument 65 with which it is connected by the pipe 83.

In describing the operation of the device, let it be assumed that the controller 20 is manually set to maintain a pressure of 25 p. s. i. in the main drying section 9, that the controller 95 is set to maintain a pressure of 6 p. s. i. in the indicating roll 60 and to provide an output pressure of 3 p. s. i. when the roll pressure is 7 p. s. i. and 15 p. s. i. when the roll pressure is 5 p. s. i., and that the rate of flow instrument 65 is arranged to provide an output pressure of 15 p. s. i. at a steam flow of 425 pounds per hour, of 9 p. s. i. at a steam flow of 400 pounds per hour, and of 3 p. s. i. at a steam flow of 375 pounds per hour. Let it be assumed also that the range of the pneumatic set 26 of the controller 20 is adjusted to be on a 100 per cent basis. Under these conditions as long as the sheet is passing through the machine the controller 95 will throttle the valve 66 to maintain substantially 6 p. s. i. in the roll 60, the quantity of steam required for the purpose varying proportionally with changes in the rate of steam condensation occasioned by changes in sheet moisture. For this purpose the output pressure of controller 95 will vary around a mid-value, namely 9 p. s. i., and the rate of flow instrument 65 will respond to changes in flow across the orifice 70 and vary the setting of the controller 20 around the manually set value of 25 p. s. i. in a manner to govern the moisture content of the sheet passing through the machine.

Under the conditions just referred to, when a break in sheet material occurs, the pressure in roll 60 will increase to 7 p. s. i., thereby reducing the output pressure of controller 95 to 3 p. s. i. and closing the valve 66. Thus the flow through the orifice 70 will fall below 375 pounds per hour, the output pressure of the rate of flow instrument 65 will drop to 3 p. s. i. and on the assumption that the gap switch 150 energizes the solenoid 144 of the three-way valve 135 at this pressure, the reset bellows 110 will be disconnected from the instrument 65 and will be connected with the pipe 201^1 which communicates with the output pressure line 106^1 of the controller 95. Since the output pressure of the controller 95 is now at 3 p. s. i., the valve 66 will be closed and the pneumatic set mechanism 26 will function to close the main steam valve 21. Thereafter the controller 95 will continue to operate the valve 66 to permit such steam as may be required to maintain the pressure in roll 60 substantially at 6 p. s. i. through the period when the machine is without a sheet moisture load. The controller 95 will also throttle the valve 21 to permit such steam to enter the main drying section as may be required to maintain the said section at a temperature suited to the sheet when again passed through the machine. And since the quantity of steam required for the purpose is relatively small, the output pressure of the instrument 65 will be well below that required by the gap switch 150 to deenergize the solenoid of the three-way valve 135 on the assumption that a suitable pressure such as 9 p. s. i. is required for this purpose.

Let it be assumed that the sheet is again introduced to the machine and that the usual moisture load is then encountered. The rate of condensation in the roll 60 will thereupon immediately increase and when the output pressure of instrument 65 reaches 9 p. s. i., the gap switch 150 will deenergize the solenoid of the three-way valve, thereby disconnecting the controller 95 from the pneumatic set mechanism 26 of the controller 20 and again connecting the rate of flow instrument 65 thereto. Thus the controller 95 will continue to maintain a pressure of substantially 6 p. s. i. in the roll 60 and the instrument 65 will again vary the setting of the controller 20 around the manual set point of 25 p. s. i. It will be understood that while the controller 95 is shown as being responsive to pressure in the roll 60, it may also be arranged to respond to roll temperature in the manner described in connection with Figs. 2 and 3.

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

1. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value and to reduce the heat input to a selected value during a period when the material is off the machine, said machine including a main drying section having a source of heat supply and a sheet moisture indicating section, first means for varying the supply of heat to the main drying section, a conduit having a source of steam supply and connected with the said indicating section, second means responsive to changes in steam flow through said conduit, said changes being in proportional relation to changes in the rate of steam condensation in the said indicating section, third means responsive to changes in the rate of steam condensation in the said indicating section, one of said second and third means being in operative connection with the first means for varying the supply of heat to the main section in proportional relation to said changes in the rate of steam condensation, and mechanism responsive proportionally to said changes in the rate of steam condensation and activated when the rate of steam condensation drops below a predetermined value to transfer the control from one of said second and third means to the other said second and third means to reduce the heat value of the main drying section to said selected value.

2. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value and to reduce the heat input to a selected value during a period when the material is off the machine, said machine including a main drying section having a source of heat supply and a sheet moisture indicating section, first means for varying the supply of heat to the main drying section, a conduit having a source of steam supply and connected with the indicating section, a restriction in said conduit, second means responsive to changes in steam flow through said restriction, said changes being in proportional relation to changes in the rate of steam condensation in the indicating section, a valve in the conduit downstream of said restriction, third means responsive to changes in the rate of steam condensation in the indicating section, one of said second and third means being in operative connection with the first means for varying the supply of heat to the main section in proportional relation to the said changes in the rate of steam condensation, and at least one of said second and third means being in operative connection with said valve, and mechanism responsive proportionally to said changes in the rate of steam condensation and activated when the rate of steam condensation drops below a predetermined value to transfer the control from one of said second and third means to the other of said second and third means to reduce the heat value of the main drying section to said selected value.

3. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value and to reduce the heat input to a selected value during a period when the material is off the machine, said machine including a main drying section having a source of heat supply and a sheet moisture indicating section, first means for varying the supply of heat to the main drying section, a conduit having a source of steam supply and connected with the indicating section, a restriction in said conduit, second means responsive to changes in steam flow through said restriction, said changes being in proportional relation to changes in the rate of steam condensation in the indicating section, a valve in the conduit downstream of said restriction and a valve in the conduit upstream of said restriction, third means responsive to changes in the rate of steam condensation in the indicating section, one of said second and third means being in operative connection with the first means for varying the supply of heat to the main section in proportional relation to the said changes in the rate of steam condensation, and at least one of said second and third means being in operative connection with one of said valves, and mechanism responsive proportionally to said changes in the rate of steam condensation and activated when the rate of steam condensation drops below a predetermined value to transfer the control from one of said second and third means to the other of said second and third means to reduce the heat value of the main drying section to said selected value.

4. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, first means for varying heat from a source of supply to the main section, second means maintaining a constant rate of heat input from a source of supply to the sheet moisture indicating section, third means responsive to a change in the rate of heat transfer in said sheet moisture indicating section and in operative connection with said first means to vary the supply of heat to the main section in proportional relation to the said change in the rate of heat transfer, and mechanism in operative connection with said second and third means responsive proportionally to said changes in the rate of heat transfer and activated when the said rate of heat transfer drops below a predetermined value to limit the control to said third means for varying the heat input during a period when the said rate of heat transfer remains below a predetermined value.

5. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, first means governing the supply of heat to the main section to maintain a selected heat value therein, second means maintaining a constant rate of heat input to the sheet moisture indicating section, third means responsive to changes in the rate of heat transfer in the sheet moisture indicating section to vary the heat value maintained in said main section in proportional relation to said changes in the rate of heat transfer, and mechanism responsive proportionally to changes in the said rate of heat transfer and in operative association with said

second and third means to transfer the control to said third means to govern the rate of heat input to the sheet moisture indicating section when the said rate of heat transfer falls below a predetermined value.

6. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, first means governing the supply of heat to the main section to maintain a selected heat value therein, second means maintaining a constant rate of heat input to the sheet moisture indicating section, control point setting means associated with said first means, third means responsive to changes in the rate of heat transfer in said moisture indicating section and in operative connection with said control point setting means for varying the heat value maintained in said main section in proportional relation to said changes in the rate of heat transfer, and mechanism responsive proportionally to changes in the said rate of heat transfer and in operative association with said second and third means to transfer the control to said third means to govern the rate of heat input to the sheet moisture indicating section when the said rate of heat transfer falls below a predetermined value.

7. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, a first conduit having a source of steam under pressure providing a supply of steam to the main section, a second conduit having a source of steam under pressure providing a supply of steam to the sheet moisture indicating section, a first valve in said first conduit for varying the supply of steam to the main section, a first controller having a source of power and responsive to changes in heat value in the main section in operative connection with said first valve to maintain a selected heat value in the said main section, a second valve and a restriction in said second conduit, a second controller having a source of power and responsive to changes in flow through said restriction in operative connection with said second valve for maintaining a substantially constant rate of steam flow to said sheet moisture indicating section, a third controller having a source of power and responsive to changes in the rate of steam condensation in the sheet moisture indicating section in operative connection with the said first controller for varying the heat value setting of said first controller in proportional relation to the said changes in the rate of steam condensation, and mechanism responsive proportionally to said changes in the rate of steam condensation and activated when the rate of steam condensation drops below a predetermined value to operatively connect said third controller with said second valve to govern the steam input to said sheet moisture indicating section until the said rate of heat transfer exceeds a predetermined value.

8. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, a first conduit having a source of steam under pressure providing a supply of heat to the main section, a second conduit having a source of steam under pressure providing a supply of steam to the sheet moisture indicating section, a first valve in said first conduit for varying the supply of steam to said main section, a first controller having a source of power and responsive to changes in heat value in the main section and in operative connection with said first valve to maintain a selected heat value in said main section, a restriction in said second conduit, a second valve downstream of said restriction, a third valve upstream of said restriction, a second controller having a source of power and responsive to changes in flow through said restriction in operative connection with said second valve for maintaining a constant rate of steam flow to said sheet moisture indicating section, a third controller having a source of power and responsive to the rate of steam condensation in the sheet moisture indicating section and in operative connection with said first controller for varying the heat value setting of said first controller in proportional relation to the said changes in the rate of steam condensation, and mechanism responsive proportionally to changes in the said rate of steam condensation and operatively connecting said third controller with one of said second and third valves when said rate of condensation drops below a predetermined value to govern the rate of steam input to said sheet moisture indicating section.

9. In a pneumatic control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the sheet material, a first conduit having a source of steam under pressure connected to the main section, a second conduit having a source of steam under pressure connected to the sheet moisture indicating section, a first fluid pressure operated valve means in said first conduit, a first controller responsive to changes in heat value in the main section and varying pressure to said valve means from a source of fluid pressure in proportional relation to said changes in heat value, a pneumatic control point setting mechanism associated with said first controller having an element responsive to changes in fluid pressure for varying the setting of said controller, a second fluid pressure operated valve means for varying steam flow through said second conduit, a second controller having a source of fluid pressure and responsive to changes in the rate of flow through said second conduit to provide variations in output pressure in proportional relation thereto, a first fluid line connecting the output pressure from said second controller with said second valve means to maintain the rate of steam input to the said sheet moisture indicating section at a substantially constant value, a third controller having a source of fluid pressure and responsive to changes in the rate of steam condensation in the moisture indicating section to provide variations in output pressure in proportional relation thereto, a fluid connection from the output pressure of said third controller to the element of said control point setting mechanism

for varying the controller setting in proportional relation to said changes in the rate of steam condensation, a second fluid line connecting the output pressure of said third controller with said second valve means, a third valve means governing fluid flow through each of said fluid lines, and mechanism responsive proportionally to changes in the said rate of steam condensation and in operative connection with said third valve means to open said first fluid line and close said second fluid line when the rate of steam condensation exceeds a predetermined value and to open said second fluid line and close said first fluid line when the rate of condensation drops below a predetermined value.

10. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, first means for varying heat from a source of supply to the main section, a source of heat supply connected with the sheet moisture indicating section, second means responsive to changes in the rate of heat input to the sheet moisture indicating section and in operative connection with said first means to vary the heat supplied to the main section in proportional relation to the said changes in the rate of heat input, third means responsive to changes in the rate of heat transfer in the moisture indicating section and varying the rate of heat input to said section in proportional relation to the said changes in the rate of heat transfer, and mechanism in operative connection with said second and third means responsive proportionally to the rate of heat transfer and activated when the said rate of heat transfer drops below a predetermined value to limit the control to said third means for varying the heat input during a period when the said rate of heat transfer remains below a predetermined value.

11. In a control mechanism for governing the heat input to a sheet material drying machine to maintain the moisture content of sheet material passing therethrough at a selected value, said machine including a main drying section and a sheet moisture indicating section, and each of said sections being in heat transfer relation with the said sheet material, a first conduit having a source of steam under pressure providing a supply of heat to the main section, a second conduit having a source of steam under pressure providing a supply of steam to the sheet moisture indicating section, a first valve in said first conduit for varying the supply of steam to the main section, a first controller having a source of power and responsive to changes in heat value in the main section in operative connection with said first valve to maintain a selected heat value in said main section, a restriction in said second conduit, a second valve downstream of said restriction, a third valve upstream of said restriction, a second controller having a source of power and responsive to changes in flow through said restriction, a third controller having a source of power and responsive to the rate of steam condensation in the sheet moisture indicating section and in operative connection with one of said second and third valves to vary the rate of steam flow to the indicating section in proportional relation to the said changes in the rate of steam condensation, means operatively connecting either one or the other of the said second and third controllers with the said first controller to vary the heat value maintained in the main section, and mechanism governing said means responsive proportionally to said changes in the rate of steam condensation and activated when the rate of steam condensation exceeds a predetermined value to operatively connect the said second controller with the first controller and when the said rate of steam condensation drops below a predetermined value to operatively connect the said third controller with the said first controller.

12. In a pneumatic control apparatus for governing the heat input to a sheet moisture drying machine including a main drying section and a sheet moisture indicating section, first pneumatically operated control means having a source of fluid pressure for governing the heat input from a source of supply to the main drying section, a conduit connecting a source of steam supply to the moisture indicating section, a restriction and a pneumatically operated valve in said conduit, second pneumatically operated control means varying fluid operating pressure from a source of supply in proportional relation to changes in steam flow through said restriction, third pneumatically operated control means varying fluid pressure from a source of supply in proportional relation to changes in the rate of steam condensation in the sheet moisture indicating section, a pneumatically operated control point setting device governing the control setting of the first control means, a first fluid line connecting the control point setting device with the operating pressure from the said second control means, a second fluid line connecting said device with the operating pressure from the said third control means, and a third fluid line connecting the operating pressure from the said third control means with said valve to maintain a substantially constant heat value in the sheet moisture indicating section, valve means normally closing the second fluid line, and mechanism in operative connection with the said valve means and responsive to changes in the said rate of steam condensation, said mechanism being activated when the said rate of steam condensation drops below a predetermined value to actuate said valve means to open the second fluid line and close the first fluid line.

13. In a pneumatic control apparatus for governing the heat input to a sheet moisture drying machine including a main drying section and a sheet moisture indicating section, first pneumatically operated control means having a source of fluid pressure for governing the heat input from a source of supply to the main drying section, a conduit connecting a source of steam supply to the moisture indicating section, a restriction and a pneumatically operated valve in said conduit, second pneumatically operated control means varying fluid operating pressure from a source of supply in proportional relation to changes in steam flow through said restriction, third pneumatically operated control means varying fluid pressure from a source of supply in proportional relation to changes in the rate of steam condensation in the sheet moisture indicating section, a pneumatically operated control point setting device governing the control setting of the first control means, a first fluid line connecting the control point setting device with the operating pressure from the said second con-

trol means, a second fluid line connecting said device with the operating pressure from the said third control means, and a third fluid line connecting the operating pressure from the said third control means with said valve to maintain a substantially constant heat value in the sheet moisture indicating section, valve means normally closing the second fluid line, and mechanism in operative connection with the said valve means and responsive to changes in the said rate of steam condensation, said mechanism being activated when the said rate of steam condensation drops below a predetermined value to actuate said valve means to open the second fluid line and close the first fluid line, and said mechanism being again activated when the said rate of condensation increases to a predetermined value to actuate said valve means to open the first fluid line and close the second fluid line.

14. In a control mechanism for governing the heat input to a sheet material drying machine including a main drying section and a sheet moisture indicating section, a first controller having a source of power and governing means for varying heat input from a source of supply to the main section to maintain the heat in said section at a constant selected value, a second controller having a source of power and responsive to changes in the rate of flow of steam from a source of supply to the sheet moisture indicating section, a third controller having a source of power and responsive to changes in the rate of steam condensation in the said moisture indicating section, a power operated device for varying the rate of steam flow to the moisture indicating section, a power operated device for varying the control setting of the said first controller, first power transmission means adapted for the connection of one of said devices with said second controller, second power transmission means adapted for the connection of said one of said devices with said third controller, third power transmission means connecting the other of said devices with said third controller, and power operated mechanism for connecting said first means and disconnecting said second means and for connecting said second means and disconnecting said first means, said mechanism being responsive to changes in the said rate of steam condensation and being activated when the said rate exceeds a predetermined value to connect said first means and disconnect said second means and when the said rate drops below a predetermined value to connect said second means and disconnect said first means.

ANDREW E. BENNETT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,142,037	Stamm	Dec. 27, 1938
2,208,784	Armstrong	July 23, 1940
2,401,832	Krogh	June 11, 1946