

May 19, 1931.

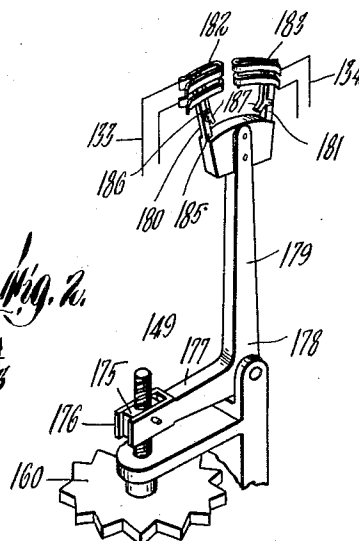
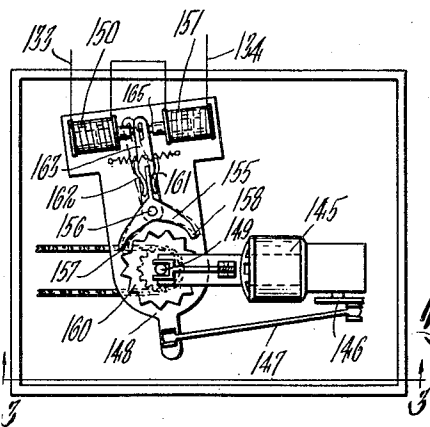
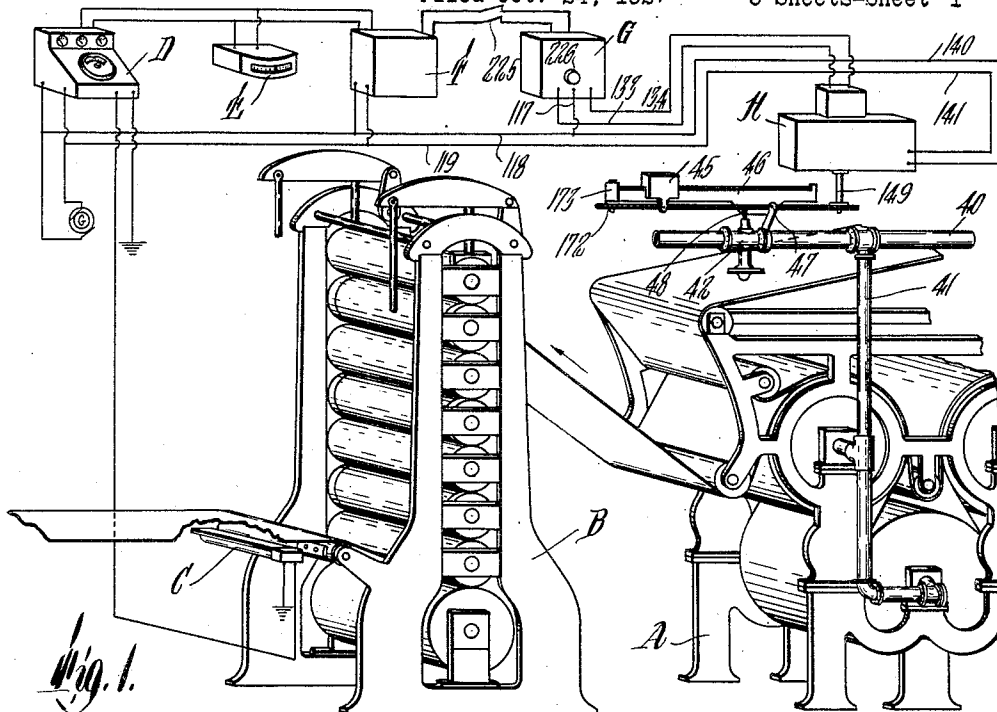
A. ALLEN ET AL

1,805,474

APPARATUS FOR CONTROLLING MOISTURE CONTENT OF PAPER OR THE LIKE

Filed Oct. 24, 1927

3 Sheets-Sheet 1



May 19, 1931.

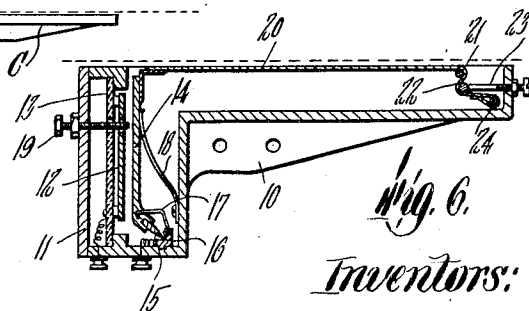
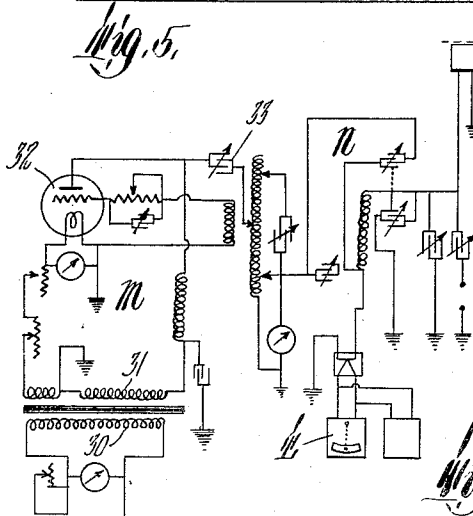
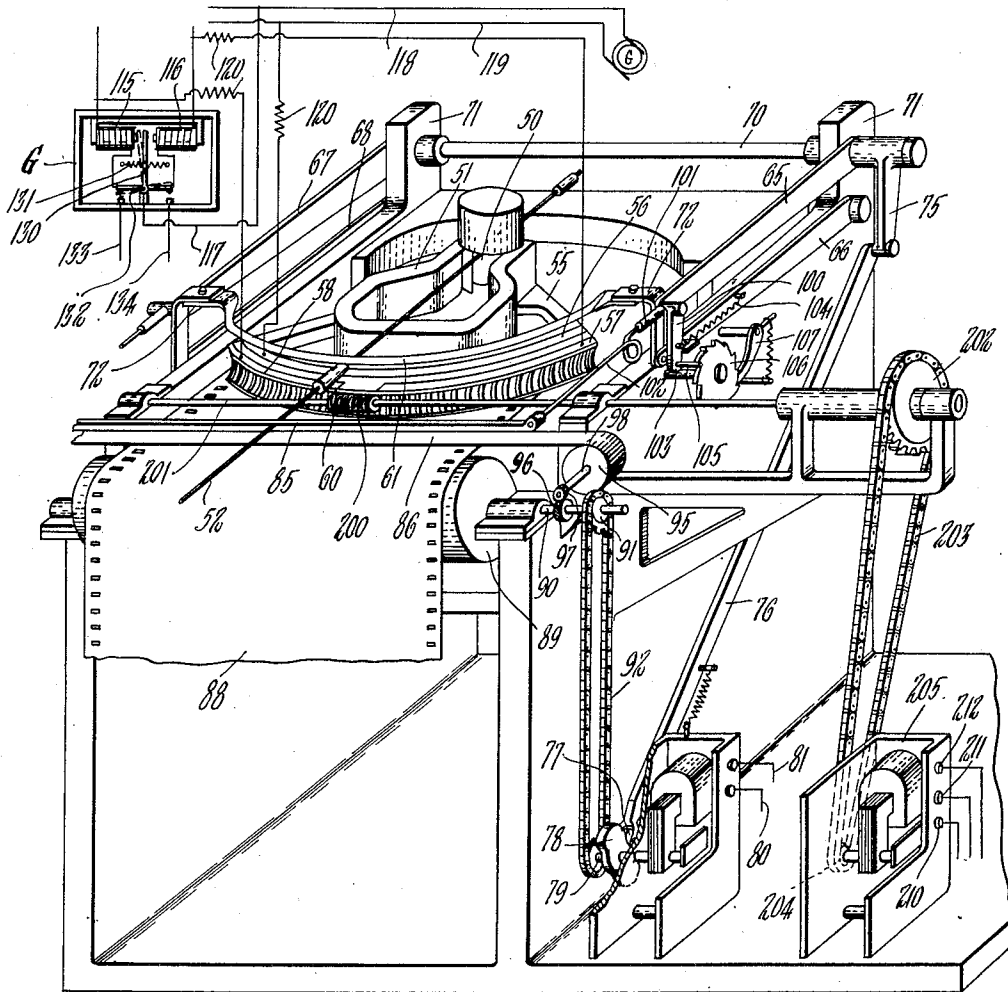
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3 Sheets-Sheet 2



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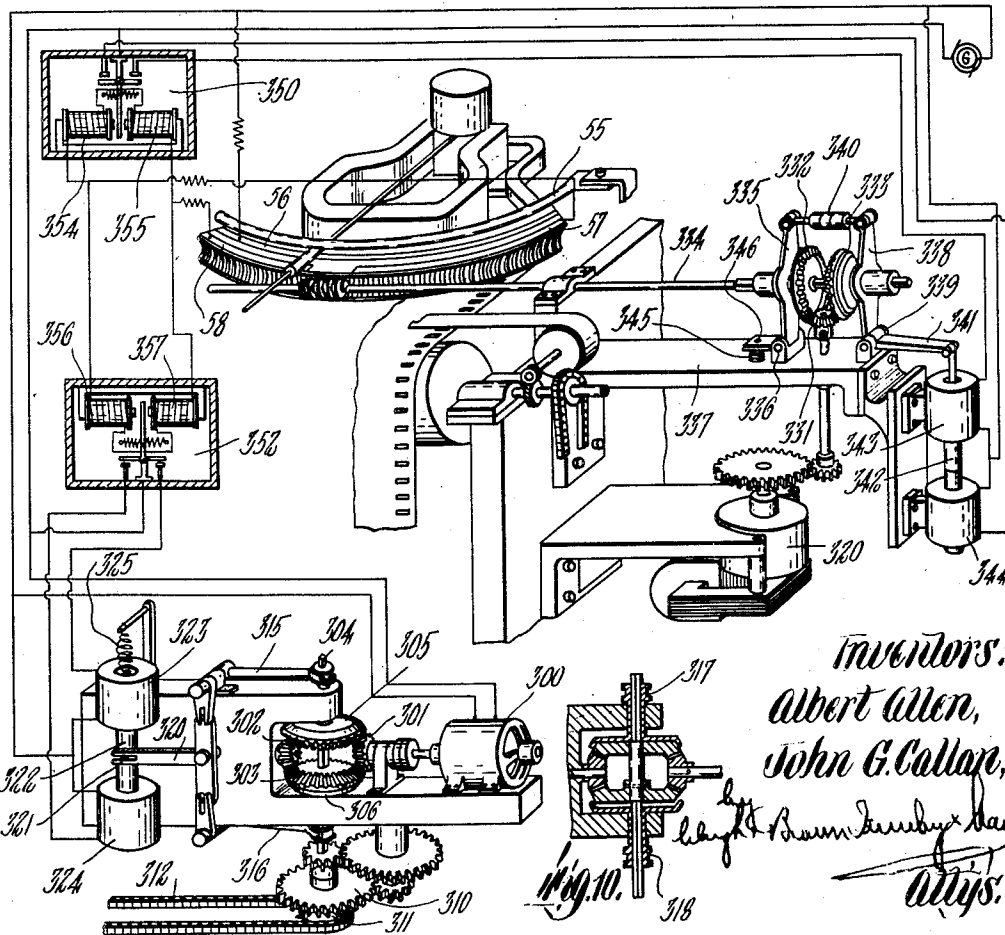
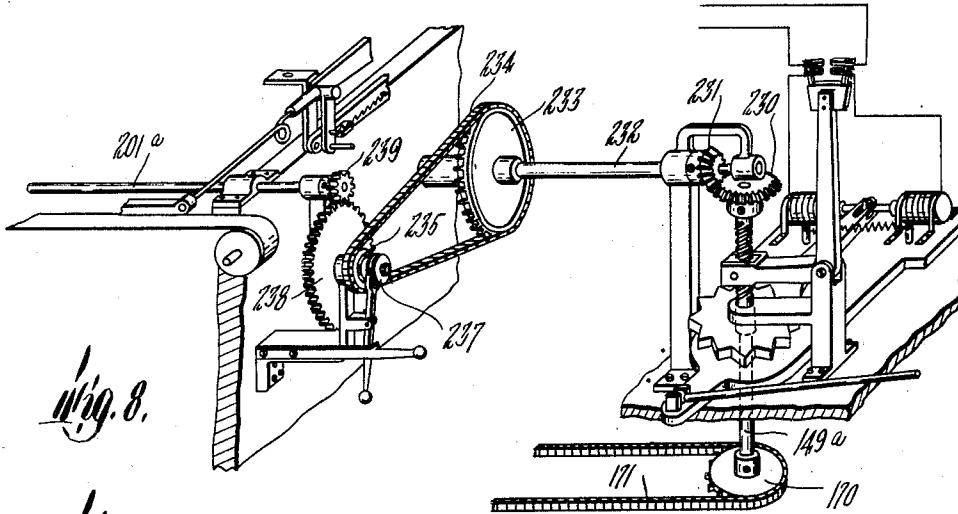
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APPARATUS FOR CONTROLLING MOISTURE CONTENT OF PAPER OR THE LIKE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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APPARATUS FOR CONTROLLING MOISTURE CONTENT OF PAPER OR THE LIKE

Application filed October 24, 1927. Serial No. 228,220.

This invention has for its object to maintain automatically a close regulation of the moisture content of paper, or the like, at any desired point in its process of manufacture or treatment. For this purpose the moisture content of the material at that point alone is caused to control throughout its working range the moisture response of a moisture sensitive means which is arranged to control the medium and means for drying the material prior to its arrival at that point, this control being such as to maintain the moisture content of the material automatically within predetermined limits.

15 The nature of this invention will be better understood from a more detailed description of certain embodiments thereof disclosed by way of example and shown in the accompanying drawings in which—

20 Figure 1 shows somewhat diagrammatically a portion of a paper machine to which is applied the mechanism for carrying out the purposes of this invention.

25 Figure 2 is a detail of a portion of the valve-operating mechanism.

Figure 3 is a section on line 3—3 of Figure 2.

30 Figure 4 is a detail in perspective to a larger scale of a portion of the mechanism shown in Figures 2 and 3.

Figure 5 is a perspective of an indicating, recording and valve-controlling mechanism.

Figure 6 is a longitudinal section through a hygrometric device.

35 Figure 7 is a wiring diagram of the oscillatory circuits.

Figure 8 is a fragmentary perspective illustrating as a modification a mechanical driving connection between the indicating, recording and controlling instrument and the valve-operating mechanism.

40 Figure 9 is a fragmentary perspective illustrating as a further modification an electrical synchronizing connection between the instrument and mechanism.

45 Figure 10 is a detail section of a portion of the mechanism shown in Figure 9.

Referring first to Figure 1, at A is indicated part of the drier stack of a paper machine, being either the last of the main stack

for a machine without means of top sizing, or the last of the "small stack" beyond the size tub in machines so equipped. B represents the machine calender immediately following the last drier. As illustrated this represents the paper at its final stage just prior to reeling up, the moisture content of the paper being taken after it passes the calender stack B, this being accomplished by means of a hygrometric device C. This hygrometric device, however, could be placed at any point in a paper machine, paper coating machine, or the like, at which the paper or other material should have a determinate moisture content arising from or residual from thermally controllable processes or operations preceding the measuring point.

The hygrometric device C as shown is of a type very sensitive to moisture variations in the paper or other material and is more especially described and claimed in the application for patent of Albert Allen, Serial No. 152,126, filed December 2, 1926, for hygrometers. The specific form, which is found in practice to be very satisfactory, is shown more in detail in Figure 6. Referring to this figure, it will be seen that the hygrometric device comprises a box-shaped element 10 having an enlarged end portion 11. Within this end portion is positioned an electrical condenser of the book type comprising a fixed conductor plate 12 carried by a sheet of insulation 13 and a movable conductor plate 14. The plate 14 is shown as provided with a knife edge bearing element 15 which is pressed against an angular seat member 16 as by means of one or more springs 17. The free end of the movable plate 14 is urged toward the fixed plate 12 as by means of one or more leaf springs 18. A stop screw 19 which passes through openings in the insulation plate 13 and the fixed plate 12 may be used to limit the closeness of approach of the movable plate 14 to the fixed plate 12. To the free end of the movable plate 14 is shown attached a hygrometric ribbon 20. This ribbon may be of any suitable hygrometric material, one material which has been found quite satisfactory for the purpose being artificial silk, such as made by the well known viscose process. This

ribbon readily absorbs or gives up moisture in accordance with the surrounding atmosphere and elongates on acquisition of moisture and shortens as the moisture is given off. The ribbon is shown as extending across slightly beneath the open upper face of the receptacle 10, passing about a rod 21 at the opposite end of this casing from the condenser, then about a rod 22 which may be adjusted by means of the screw 23 to adjust the tension on the ribbon, and then about an anchoring fixed rod 24. This hygrometric device is positioned across the width of the paper so that the paper passes over its open side in close proximity to the hygrometric ribbon. It does not need to touch the hygrometric device, particularly where the upper edge portions of the casing are flanged laterally away from the opening over which the paper passes. This casing, together with the moving web of paper, encloses a body of air which is rapidly circulated by the movement of the paper while in intimate contact with the surface of the paper and with the ribbon, so that the moisture content of the ribbon becomes a measure of that of the paper. The movable plate 15 of the condenser may be grounded, while the fixed plate 12 is shown as connected to a radio frequency apparatus shown in outline at D in Figure 1. This radio frequency apparatus acts to greatly multiply the response to changes of moisture of the hygrometric element so that the mechanism may be made responsive in the required sensitive degree to moisture changes of the hygrometric element, though it should be understood that any other suitable means might be employed.

The circuits of the radio frequency apparatus and related parts which have been found very effective in practice are shown in the Allen application above referred to and are fully described and claimed in the application for patent of Robert F. Field, Serial No. 227,694 filed October 21, 1927, for oscillatory circuits and method of compensating for voltage changes impressed thereon, though it should be understood that other suitable circuits may be employed if desired. These circuits are shown diagrammatically in Figure 7. Referring to this figure, energy is taken from a source of supply such as an ordinary alternating current lighting system, through the primary 30 of a transformer, the secondary 31 of which forms a portion of a primary oscillatory circuit M, having therein an electron tube 32 and combinations of inductances and capacitances such as to determine a natural frequency of oscillation of a predetermined desired value. Coupled, as by means of the capacitive coupling 33, with the primary oscillatory circuit M is a secondary oscillatory circuit N. This circuit is provided with such inductances and capacitances as to have

a period of oscillation slightly different from that of the circuit M but near enough to resonance therewith so that there is an appreciable response of current flow in the circuit N due to the excitation from the primary circuit M. A portion of the capacitance of the circuit M is that of the book condenser comprising the plates 12 and 14, the capacity of which is varied by variations in the length of the hygrometric ribbon occasioned by changes in its moisture content, which in turn is responsive to changes of moisture content of the material, the moisture content of which is to be controlled. The current response in the secondary oscillatory circuit N may be evidenced by a suitable instrument such as the thermo-ammeter shown at E, and may be used through the mechanism shown at F to actuate mechanism for regulating the drier mechanism as will later appear. From the foregoing description it will be seen that the mechanism for actuating the drying regulating mechanism comprises a hygrometric body so related in permanent position to the material, the moisture of which is to be controlled, that its own moisture content is responsive to that of the material and that the moisture content of this hygrometric body controls the action of the mechanism by which the drying regulating mechanism is controlled.

For the purpose of illustration, means for heating the drier drums of the drier A by a method commonly employed in connection with paper machines is shown in Figure 1. Referring to this figure, at 40 is indicated the exhaust from the paper mill engine, either to the condenser or to atmosphere. From this exhaust pipe extends a branch pipe 41 to the drums or drier cylinders of the drier. At 42 in the exhaust line is shown a controlling valve by which the back pressure on the exhaust may be regulated, thus to determine the pressure and hence the temperature of the steam supply through the branch pipe 41 to the drier. It will be understood, however, that regulation of the heat supply, or more generically the carrying away of moisture from the paper or other material in the process of drying, may comprise the regulation of any other suitable mechanism than that herein shown. The valve 42 in the embodiment illustrated is of the diaphragm controlled pressure regulating type whereof the loading on the diaphragm, and consequently the pressure that it will determine, is fixed by the position of a weight 45 slidably mounted on a lever 46 fulcrumed at 47 at one side of the valve stem 48. The position of this weight relative to the lever 46 is determined by actuating mechanism H, the casing of which is shown in Figure 1, this mechanism being controlled through a suitable relay G from the instrument at F.

The instrument at F is illustrated more

particularly in Figure 5, and includes an indicator which may be used as supplemental to or in place of the thermo-ammeter E. Its primary function, however, is to respond to the magnified or amplified moisture responses of the hygometric device C and the pertinent apparatus transmitted to it to make electrical contacts such as will control the mechanism H so as to cause correction and rectification of any deviations from proper moisture content of the paper recognized by the hygometric device. Ordinarily it will also be so designed as to record on a chart plotted against time the moisture content of the paper. As shown in Figure 5 it comprises a d'Arsonval type milli-voltmeter having a rotating element 50 journaled between the poles of the permanent magnet 51 and carrying a pointer or needle 52, the position of which is dependent on the current passing through the milli-voltmeter, this being arranged in place of, or, as shown, in parallel with the thermo-ammeter E.

The correlation of the oscillatory circuits M and N and the spacing adjustment between the plates 12 and 14 of the hygometrically-controlled condenser are so adjusted that when the normal desired amount of moisture is present, the current response in the secondary oscillatory circuit N which controls the position of the needle 52, holds this needle in mid-position, deficiencies of moisture causing the needle to swing in one direction and excesses of moisture from that desired causing the needle 52 to swing in the opposite direction. Beneath the needle 52 is mounted a sector 55 which carries on its upper face a continuous annular strip 56 of conducting material and arranged parallel thereto relatively short similar strips 57 and 58. The strips 57 and 58 are spaced apart centrally of the sector so that in the normal position of the sector 55 and in the normal position of the needle 52 denoting the desired moisture content, the needle 52 extends over the central portion of the strip 56 and between the strips 57 and 58. Should the needle swing away from this space between the strips 57 and 58 the mechanism is so arranged that periodically electrical connections are made through the needle between the strip 56 and that strip 57 and 58 on the side to which the needle has been moved, these electrical connections being such as to effect corrective action of the valve-regulating and controlling mechanism as will later appear. These periodic connections are effected whenever a conical roller 60 carried by and insulated from the needle 52 is brought into contact with the upper face of the sector 55. Means for bringing the needle down against the sector periodically have therefore been provided. As shown, this means comprises a curved depressor bar 61, which is arranged in the arc of a circle about the axis of the rotor 50 as a

center. This bar is mounted at opposite ends so that it moves vertically, being carried by the parallel motion mechanism comprising opposite pairs of parallel arms 65, 66 and 67, 68. The arms 65 and 67 are fixed to a shaft 70 journaled in suitable extensions 71 in the frame of the instrument, while the arms 66 and 68 are journaled at points beneath the shaft 70. The outer or forward ends of the arms have pivotally connected thereto, brackets 72, to which the depressor bar 61 is fixed. The parallel motion bars are rocked downwardly and then upwardly at intervals. For this purpose the shaft 70 has fixed thereon an arm 75 to which is pivotally connected a link 76, the lower end of which has a cam follower 77 riding on a cam 78 on a clock motor shaft 79, this clock motor being of any suitable description. As herein shown, it is a well known single phase synchronous motor which derives its power supply from a single phase alternating current source through the wires 80 and 81.

Each time the needle 52 is brought down by the depressor bar it may also be caused to make a mark on a record paper. For this purpose, outwardly of the depressor bar 61 a striker bar 85 extends over the needle 52, this striker bar being so carried by the depressor mechanism as to impart a downward blow on the needle whenever the depressor bar is depressed to snap the needle down against a printing strip 86 which may well be a strip of carbon paper which extends across a paper record strip 88. This paper record strip is shown as extending over a feed roller 89, which is shown as driven continuously as through its shaft 90, sprocket wheel 91 and chain 92 from the clock motor 78. The marking strip may be fed laterally across the record strip to insure a fresh marking surface presented to the paper on each stroke of the needle. For this purpose the strip 86 is shown as passing about rollers, such as 95, which may be rotated from the shaft 90 as by means of the spiral gears 96 and 97 on the shaft 90 and the roller carrying shaft 98 of the marking strip. Means by which the snapping action of the bar 85 is produced is shown at one end in Figure 5. Journaled to the outer end of the parallel motion arm 65 is a bell crank lever 100 having one arm 101 connected through a spring 102 with one end of the bar 85. The other arm 103 of this bell crank is resiliently pulled backwardly by a spring 104, thus tending to rock the bar 85 downwardly. A pin 105 extending laterally from the arm 100 is caused to ride on the edge of a ratchet wheel 106 which is prevented from rotation in one direction by a holding dog 107 spring-pressed thereagainst. The pin 105 rides over the inclined tooth face of the ratchet wheel 106 whenever the depressor bar is moved downwardly, this causing the bell crank lever 100 to be so rocked as to hold the bar 85

slightly elevated. As soon as the depressor bar has moved downwardly to such a point that the pin 105 rides over the apex of a tooth of the wheel 106, the spring 104 acts immediately to pull the arm 100 rearwardly, thus snapping the arm 101 sharply downwardly and giving a sudden snap to the bar 85, bringing the needle down with a sharp quick blow onto the printing strip 86 and causing a mark to be made on the record sheet 88. There is immediately a rebound of the bar 85 due to the resiliency of the springs 102, the last portion of its downward stroke being effected by momentum, so that the bar 85 immediately rises somewhat, permitting the needle 52 to spring upwardly from the marking strip. At each actuation of the depressor bar, therefore, it is seen that a record of the position of the needle 85 is made on the record sheet 88.

Whenever the depressor bar when depressed finds the needle deflected from its central position, so that the roll 60 bridges across between the strip 56 and one or the other of the strips 57 and 58, an electric circuit is completed through one of the other coils 115, 116 of a relay G. Adjacent ends of the windings of the coils 115 and 116 are connected together and through the wire 117 with one side 118 of a source of current, which may well be the single phase alternating current which is used to excite the transformer 30 of the oscillatory circuit mechanism M. The opposite ends of the coils 115 and 116 are connected respectively to the strips 58 and 57, the strip 56 being connected to the opposite side of the energy source. Resistances such as 120 are shown as employed to reduce the line voltage to a suitable small value for the rather delicate contact mechanism which includes the roller 60 and the contact strips 56, 57 and 58.

The energization of either of the coils 115, 116 takes place only on depression of the depressor bar when the needle 85 has been moved relative to the sector 55 so as to bring the roller out from the space between the strips 57 and 58. The relay G is normally in a central neutral position, a lever element 130 thereof which is normally biased to central position, as by means of a spring 131, carrying a switch arm 132 which may connect the wire 117 to either of the wires 133 or 134 when one or the other of the coils 115 and 116 is energized. When neither of these coils is energized, the wire 117 is out of electrical connection with both the wires 133 and 134. These wires 133 and 134 lead to the mechanism H, which controls the position of the valve.

As shown in Figure 1, the mechanism H has connected also thereto direct lines 140 and 141 leading to the power lines 118 and 119. These lines 140 and 141 lead directly to a constantly rotating motor 145 shown in Figures 2 and 3. This motor is connected

through a reduction gearing to a crank disk 146 which is connected through a connecting rod 147 to a lever 148 journaled on a shaft 149. The constant rotation of the motor 145 thus imparts a continuous oscillation to the lever 148. This lever 148 carries a pair of solenoids 150 and 151. The outer end portions of the solenoids 150 and 151 are connected respectively to the wires 133 and 134 leading from the relay G, while the inner ends of these coils are connected to the wire 140 leading to one service wire. Whenever the relay G is operated, therefore, to energize the wires 133 or 134, corresponding solenoids 150 and 151 are energized. When the relay is in its neutral central position, neither of the coils 150 or 151 being energized, a double-ended pawl 155, pivoted at 156 to a lever 148, is in its central position with both end portions 157 and 158 out of contact with the teeth of a reversible ratchet wheel 160 fixed to the shaft 149, as shown in Figure 2. This double pawl 155 has a stem portion 161 extending between oppositely disposed centering springs 162 carried by a lever 163 fulcrumed at 156 and having operative connection to the cores 165 of the solenoids 150 and 151. When the solenoid 150 is energized, the arm 163 is moved to the left, thus to bring the pawl end 157 into operative relation to the ratchet wheel 160, whereupon oscillation of the lever 148 by means of the motor 145 rotates the ratchet wheel 160 step by step in a counterclockwise direction. Should the solenoid 151 be energized, the pawl end 158 becomes active and the oscillation of the lever 148 then causes the ratchet wheel 160 to rotate in the opposite direction step by step. The shaft 149, as shown in Figures 1 and 3, carries at its lower end a sprocket wheel 170 about which passes a chain 171, this chain also passing about a sprocket wheel 172 journaled on a stud shaft 173 at the end of the long arm of the lever 176. One stretch of this chain is fixed to the weight 145. Thus rotation of the shaft 149 in either direction will then cause the weight 145 to be moved lengthwise of the lever 146 thus to change its effective lever arm on the valve 42 which thus controls the opening of the valve and consequently the amount of steam supplied to the driers.

In order that the weight 145 may not be moved too far in either direction, automatic cut-off mechanism may be employed to open the circuit to that one of the coils 150 and 151 which is energized whenever the weight is moved to the desired limit. Such a mechanism is shown more particularly in Figure 4. The shaft 149 as there shown has a threaded upper extremity on which is carried a nut 175. This nut 175 is held between a pair of jaws 176 on the arm 177 of a bell crank lever 178. The other arm 179 of this lever carries a pair of spaced contact arms 180 and 181

which normally bridge pairs of spring contacts 182 and 183, respectively. Continued motion of the weight 45 in either direction is thus accompanied by an axial motion of the nut 175 on the shaft 149 and the parts are so arranged that whenever the weight approaches its desired limit, the corresponding switch arm 180 or 181 is brought out from bridging relation between the corresponding contacts 182 and 183, these contacts being interposed in series with wires 133 and 134, respectively. It is preferable that these contacts be of the quick break type and they are so shown in Figure 4. In the particular construction there shown, each of the contacts 180 and 181 comprises a bar 185 to which is pivoted near its lower end, a jaw member 186, these jaw members on the two contacts facing each other. The outer end portions of each of the jaw members 186 is spring-pressed into facial contact with its corresponding bar 180 but may be separated therefrom, rocking about its pivotal connection therewith until its lower extremity 187 contacts the face of the bar. With such a construction whenever one of the contacts 180 or 181 passes beyond the mating spring contacts 182 or 183 the jaw member is held therebetween until its lower end 147 contacts with the bar portion 180. Further motion then causes the jaw to be positively pulled away from the spring contacts whereupon the upper ends of the jaws are snapped back into contact with the bar portions 180 so that a quick final break is made between the arms and the spring contacts.

In order that the amount of actuation of the valve-controlling mechanism H shall be proportional to the amount by which the needle 52 is displaced from its normal central position denoting the desired moisture content, a follow-up mechanism should be employed. In the construction shown in Figure 5 this follow-up mechanism comprises means by which on motion of the needle 52 from its mid-position in either direction, the sector 55 is moved in the same direction, thus to bring the space between the strips 57 and 58 toward the needle at a uniform rate such that this space reaches the needle within a period of time dependent on the distance the needle has traveled away from the desired mid-position and thus proportional to the amount of deviation of the moisture content from that desired.

This follow-up motion is shown as effected by the rotation of the worm 200 fixed to a shaft 201, this shaft 201 carrying at one end a sprocket wheel 202 over which passes a chain 203 engaging over a sprocket wheel 204 on a reversible clock motor 205. This motor may be of the general type of that shown at 77 except that it is reversible. For this purpose it may be provided with two separate field windings, one of which being

energized causes the motor to rotate in one direction and the other being energized causing it to rotate in the opposite direction. At 210 is shown a field terminal common to the two windings, while at 211 and 212 are shown the separate terminals for the two field windings. The terminal 210 may be connected to one side of the source of electrical power, while the terminals 211 and 212 are connected respectively to the relay terminals 133 and 134. Thus whenever the depressor bar acts to bring the contact roller 60 on to the upper face of the sector 50, bridging the strip 56 with either of the strips 57 and 58, actuation of the valve-regulating and controlling mechanism H also actuates the motor 205 in a direction to bring the space between the strips 57 and 58 beneath the needle so that the total time during which the valve mechanism is moved is proportional to the deviation of the needle from its normal central position. By this means the proportionality between the movement of the valve and the error of moisture content is preserved.

Prior to putting the paper machine on automatic control for the first time, it is preferable to disconnect the automatic controller F which may be done by opening the switch shown at 225 in Figure 1, whereupon the relay G may be actuated by hand to close the contacts with the wires 133 and 134, whereupon the position of the weight may be caused to move as desired. For hand actuation of the relay G, the pivotal axis of the member 130 may be extended and provided with an actuating knob 226. The moisture is brought by hand operation of this relay to a point located as exactly as possible to the desired moisture as determined by tear-outs and weighings from the paper. The needle 52 is then brought to mid-position by adjustment of the relative degree of tuning between the oscillatory circuits M and N to give the central deflection for the desired moisture content. The sensitiveness of the apparatus may be adjusted by adjusting the spacing between the plates 12 and 14 of the book condenser when the desired moisture content is obtained. The relay G may then be let alone and the switch at 225 closed, whereupon the paper machine is under automatic control.

It has been found in practice that due to lack of exact synchronism between the mechanism at F and the valve-controlling mechanism H, there are small errors of response which may be cumulative, resulting after a time in departures from the exact relationship between valve settings and indicator needle positions which obtained on the first adjustment, so that after a time the mechanism will tend to hold the paper at a moisture content different from that for which the mechanism was originally set.

With the mechanism just described, therefore, it is necessary to re-set the apparatus occasionally whenever it becomes apparent that the machine is tending to establish a moisture different from that desired. To obviate this inconvenience in some instances a direct mechanical inter-connection may be made between the mechanism at F and the valve-controlling mechanism. Where this is possible the two mechanisms may be kept in exact synchronism so that no "wandering" or "drift" results. Such a mechanism is shown in Figure 8. Referring to this figure, it will be seen that the shaft 149a of the mechanism H which carries the sprocket wheel 170 over which the weight-controlling chain 171 passes is connected through the bevel gears 230 and 231 to a shaft 232 extending to the instrument F. At this instrument the shaft 232 is shown as provided with a sprocket wheel 233 over which passes a chain 234 engaging about a sprocket wheel 235 journaled on a shaft 236. Carried on this shaft is a clutch 237 by which the sprocket wheel 235 may be clutched to rotate the shaft 236. This shaft 236 carries a gear 238 meshing with a pinion 239 on the follow-up actuating shaft 201a. Through this connection the movement of the weight 45 is directly proportional to the movement of the follow-up mechanism so that no "wandering" of the control from that for which it was originally set can take place. By throwing out the clutch, the automatic control may be disconnected whenever this is desired.

In most commercial plants the valve for controlling the steam supply to the driers is so situated that it can not be readily connected up to the mechanism F through a positive mechanical drive. A modified electrical control mechanism shown in Figures 9 and 10 has therefore been devised by which much less "wandering" or "drift" is permitted than in the mechanism first described, so that it does not require to be set so often. It may not, however, be quite as effective in this respect as the direct mechanical drive, and it is somewhat more complicated than the electrical connection first shown. Referring to these figures, at the valve-controlling mechanism is a continuously operating synchronous motor 300 which is connected through the beveled pinion 301 to continuously rotate in opposite directions a pair of mitre gears 302 and 303. These mitre gears are journaled on a shaft 304 to which either may be connected selectively by a friction clutch 305 or 306. The shaft 304 is connected through the reduction gearing at 310 to rotate the sprocket wheel 311 about which the weight-controlling chain 312 for the valve controller passes. The clutches at 305 and 306 are arranged to be controlled as by means of the levers 315 and 316 with their outer ends engaging the clutch-actuating spools

317 and 318, respectively. These levers are controlled by a T-shaped lever 320 having its stem portion 321 engaging the balanced core 322 which passes into upper and lower solenoids 323 and 324. These solenoids 323 and 324 are preferably arranged vertically so that the core may float freely therein without frictional drag, and the weight of the core is supported as by the spring 325. By this construction energization of either of the solenoids 323 or 324 is immediately effective in throwing the corresponding clutches into and out of action. When the solenoid 323 is energized the clutch 306 is thrown into operative relation and when the solenoid 324 is energized the clutch 305 is thrown into clutching relation. The selective energization of the coils 323 and 324, therefore, determine the direction of motion of the chain 312 and thus the direction of operation of the steam valve.

Similarly at the instrument F is a constantly rotating synchronous motor 330 which drives in opposite directions through a beveled pinion 331 a pair of oppositely disposed beveled gears 332 and 333. These gears are journaled on the follow-up shaft 334 and may be selectively clutched thereto by clutches similar to those shown at 305 and 306, one of these clutches being carried on an arm 338 which is a portion of a bell crank lever 339. The upper ends of the arms 335 and 338 are connected together as by the link 340. The arm 341 of the bell crank lever 339 carries at its other end a core 342 extending vertically through a pair of solenoids 343 and 344. The weight of this core and the arm 341 is balanced as by means of a spring 345 positioned between the support 327 and an arm 346 extending laterally from the arm 335. Energization of either of the solenoids 343 or 344 thus acts to throw one or the other of the arms 335 or 338 so as to clutch the corresponding bevel gears 332 or 333 to the shaft 334, the parts being so counterbalanced that the clutching action is exceedingly prompt, in this respect being similar to the clutching connections for the weight-moving mechanism. Energization of the solenoids 343 and 344 is controlled from the relay 350, while the energization of the solenoids 323 and 324 is controlled from the relay 352. The coils 354 and 355 of the relay 350 are arranged in parallel with the similar coils 356 and 357 of the relay 352 and both these are so connected to the strips 56, 57 and 58 of the sector 55, similarly to the coils 115 and 116 shown in Figure 5, that whenever the valve-actuating mechanism is operated to change the setting of the valve, the follow-up mechanism is also actuated to produce the follow-up motion.

By the employment of an electrically controlled actuating device for the follow-up and for the valve-moving mechanism which

are exceedingly prompt in response, and which run at fixed proportional speeds, the possibility of their drifting out of exact synchronism with each other is minimized so that the apparatus will continue to tend to control the moisture within substantially the same limits for a very considerable period after its initial adjustment.

Having thus described certain embodiments of this invention, it should be evident to those skilled in the art that various changes and modifications might be made therein without departing from its spirit or scope as defined by the appended claims.

We claim:

1. In combination with a drier, and a valve for controlling the supply of steam to said drier, of a lever movable to open and close said valve, a weight movable along said lever to control by its position thereon the angular position of said lever, and a device responsive to the moisture content of said material coming from said drier for controlling the position of said weight.

2. In a machine of the class described, a drier, a permanently located hygrometric body responsive in its moisture content to the moisture content of the material coming from such drier, means for indicating such response, means for regulating the drying action of said drier, and means controlled by said indicating means for controlling said regulating means.

3. In a machine of the class described, a permanently located hygrometric body responsive in its moisture content to the moisture content of material coming from said drier, means for regulating the drying effort of said drier, means for indicating the response of said body, and means acting in response to indications different from a predetermined amount and in amount proportional to the extent of deviation of such indication therefrom for imparting corrective action to said regulating means.

4. In combination, a drying mechanism, means for controlling said mechanism, a permanently located hygrometric body responsive in its moisture content to moisture of material delivered from said mechanism, and means controlled by variations of response of said body from that response corresponding to a desired normal moisture content of said material for actuating said controlling mechanism.

5. In combination, a drier, a valve for controlling the supply of a drying agent to said drier, a permanently located hygrometric body responsive in its moisture content to moisture content of material coming from said drier, and means controlled by variations in the response of said body from that corresponding to a desired normal moisture content of such material to change the opening of said valve in a correcting direction.

6. In combination, drying mechanism, a device responsive to moisture content of material coming from said mechanism, means for varying the drying effect of said mechanism, means for controlling said varying mechanism, said controlling means having a movable element the position of which is controlled by the response of said device and follow-up means relative to which said device moves, means for actuating said varying means in correcting direction on departure of said element from a determined point of said follow-up means, and means actuable on each such departure to move said follow-up means in a direction to bring said point toward said element.

In testimony whereof we have affixed our signatures.

ALBERT ALLEN.
JOHN G. CALLAN.