

- [54] **MOISTURE MEASURING AND CONTROL APPARATUS**
- [75] Inventors: **Charles F. Strandberg, Jr.; Robert C. Strandberg**, both of Greensboro, N.C.
- [73] Assignee: **Strandberg Engineering Laboratories, Inc.**, Greensboro, N.C.
- [22] Filed: **Mar. 27, 1972**
- [21] Appl. No.: **238,114**
- [52] U.S. Cl. **307/118, 34/52**
- [51] Int. Cl. **F26b 13/12**
- [58] Field of Search **34/43, 52; 307/118; 324/65**

- [56] **References Cited**
- UNITED STATES PATENTS**
- | | | | |
|-----------|--------|-----------------|-------|
| 2,702,948 | 3/1955 | Seney | 34/52 |
| 2,942,352 | 6/1960 | Eicken-Estienne | 34/52 |

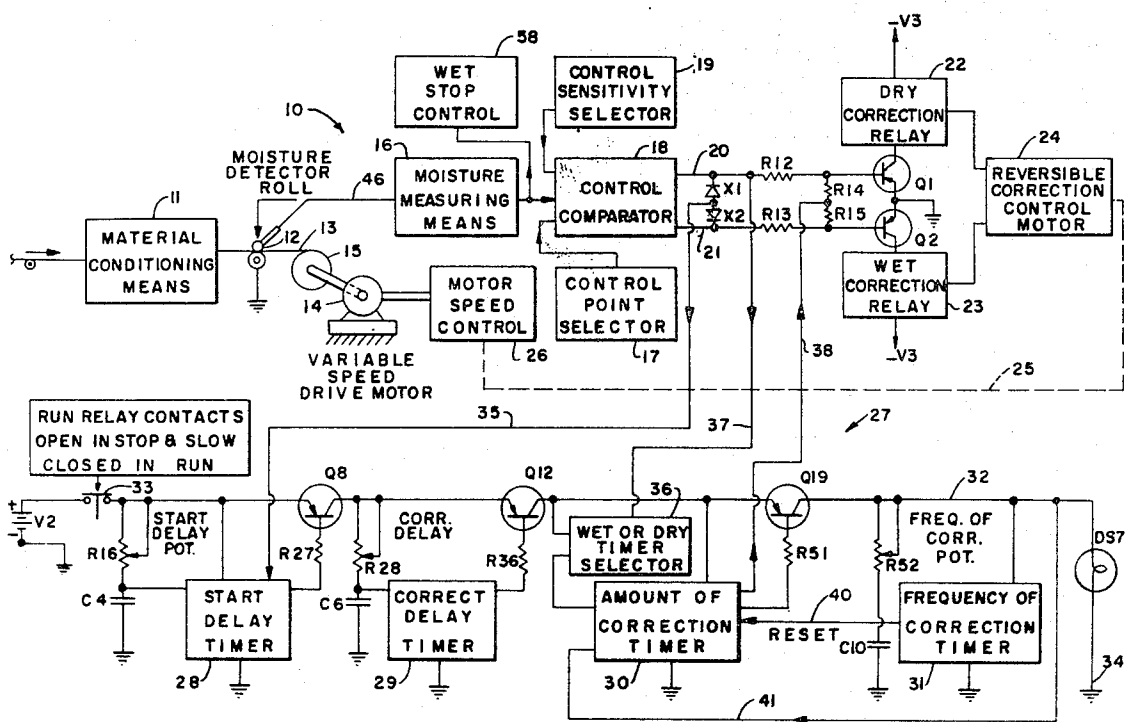
- FOREIGN PATENTS OR APPLICATIONS**
- | | | | |
|-----------|--------|---------------|---------|
| 1,102,062 | 1/1965 | Great Britain | 307/118 |
|-----------|--------|---------------|---------|
- Primary Examiner—Robert K. Schaefer
Assistant Examiner—William J. Smith
Attorney—Munson H. Lane et al.

[57] **ABSTRACT**

An apparatus for measuring the moisture content of material being conveyed through a machine for conditioning the material to achieve a selected moisture content, and for controlling the speed at which the material is conveyed through the machine in order to subject the material to longer or shorter periods of exposure to the conditioner for the purpose of achieving

the selected moisture content for the material. The apparatus includes: a moisture meter for measuring the moisture content of the material and producing an electric voltage signal which is related to the moisture content of the material, a reference signal generator which produces a reference voltage which is related to a selected moisture standard, a comparator which compares the measured moisture signal with the standard moisture signal and generates a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount and generates a wet condition signal when the measured moisture content exceeds the standard moisture content by a predetermined amount. Controls are provided which respond to the dry and wet condition signals in order to increase the speed or decrease the speed at which the material is conveyed through the machine. Timers are provided by which the dry and wet condition signals are prevented from actuating the speed controls except after a start time delay sufficient to permit the material in the machine when the machine is started to clear the machine, and a correction time delay which insures that a condition requiring correction persists long enough to warrant correction. An amount of correction timer is actuated after the time delays which unblocks the controls and permits them to respond to the dry and wet condition signals for a predetermined time period. A frequency of correction timer is provided which is actuated at the end of the time period established by the amount of correction timer to recycle the amount of correction timer at reoccurring intervals of predetermined frequency. The timers are all connected to a common power source and are energized in sequence by plural series connected switches. A wet stop control is provided to shut down the machine in case an excessive moisture condition is measured which cannot properly be corrected by the automatic controls.

20 Claims, 8 Drawing Figures



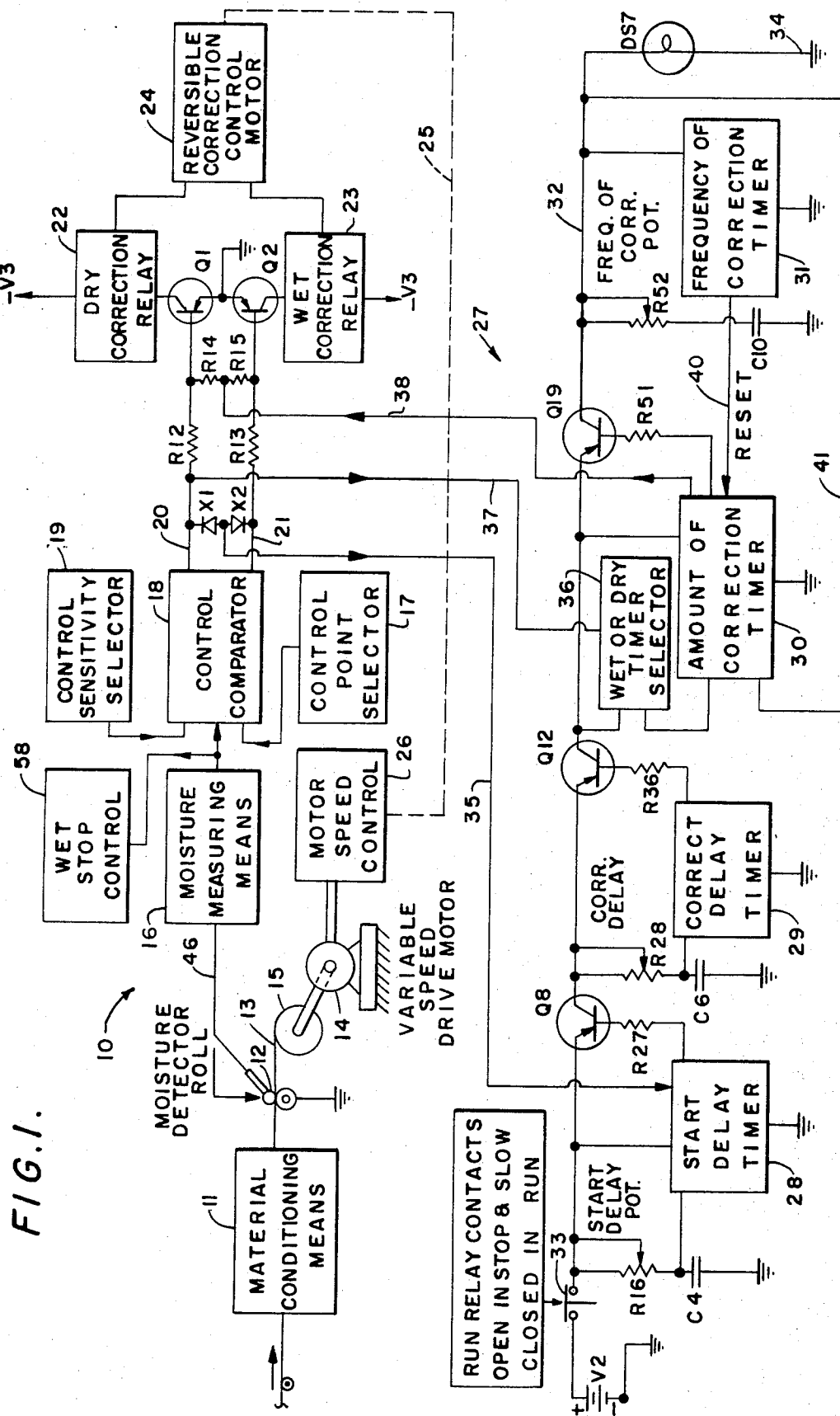


FIG. 2A.

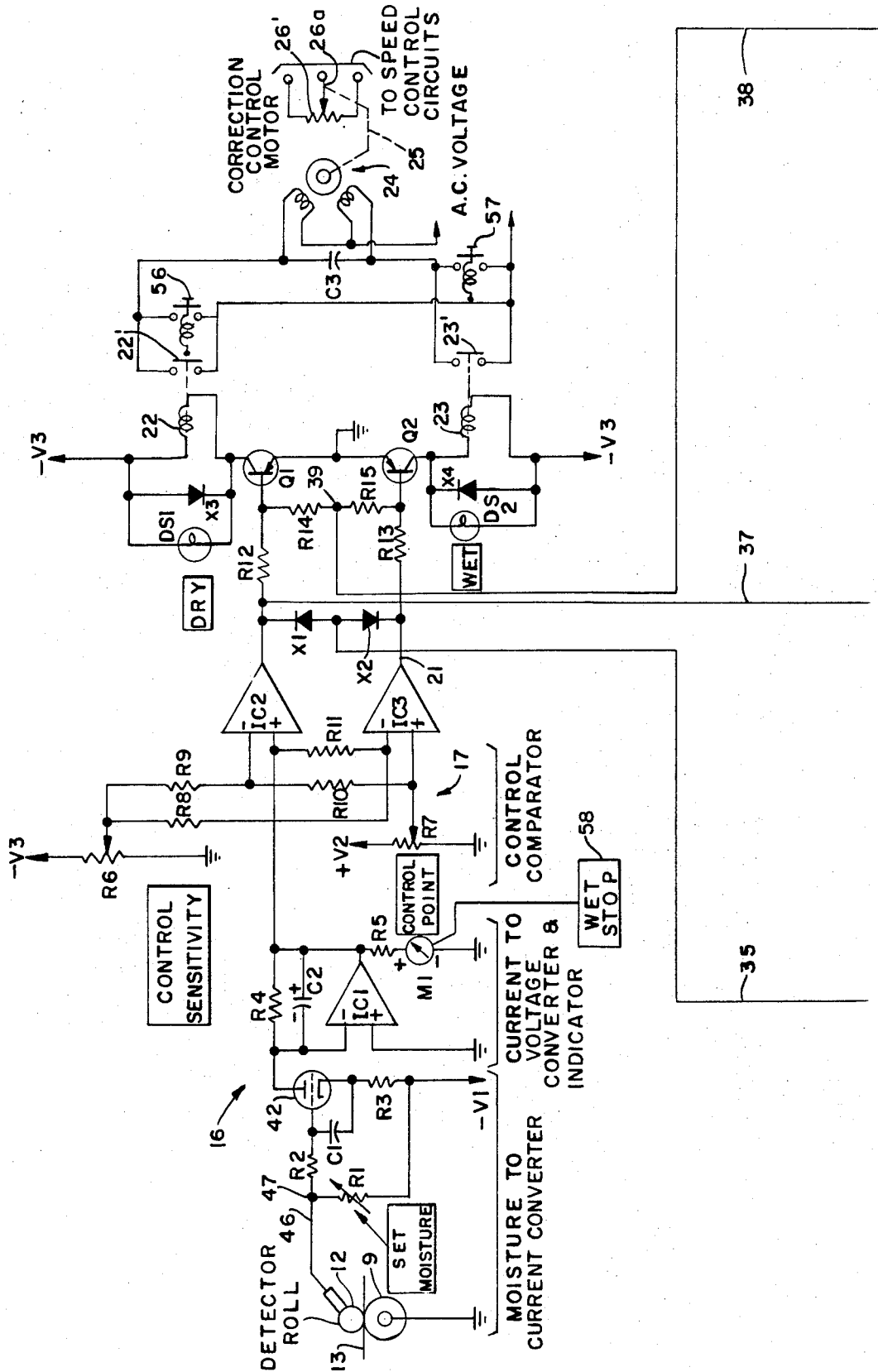


FIG. 2B.

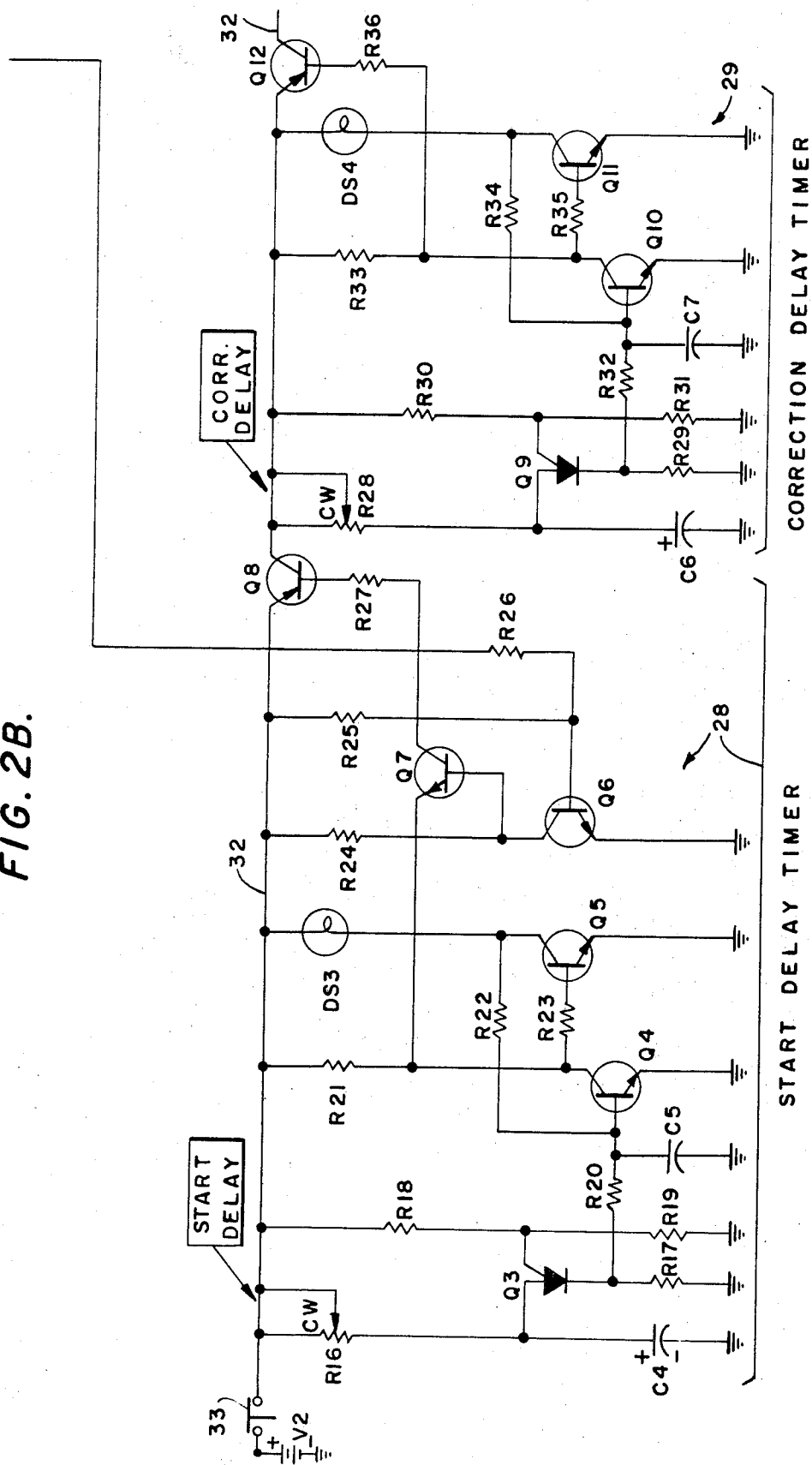


FIG. 2C.

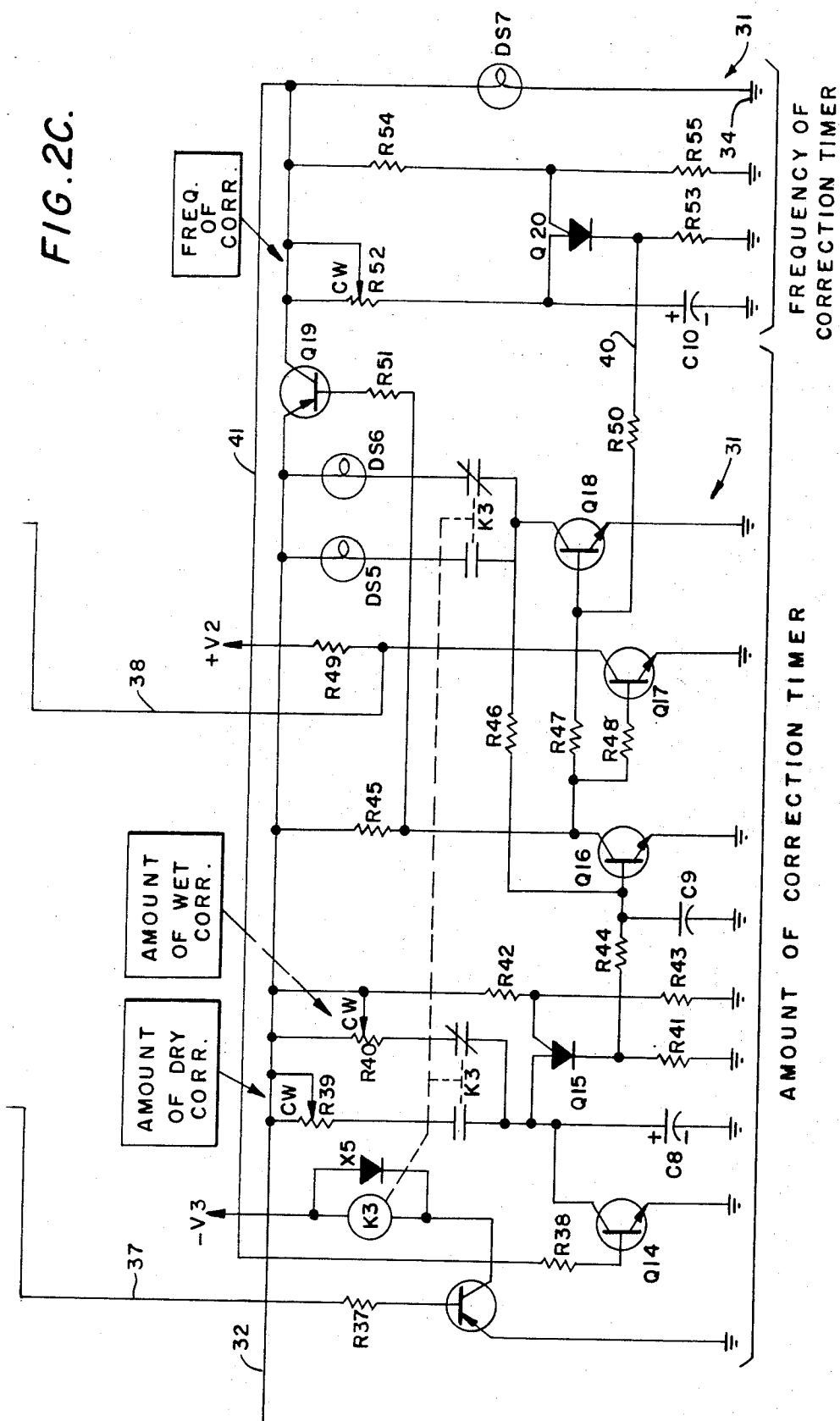


FIG. 4.

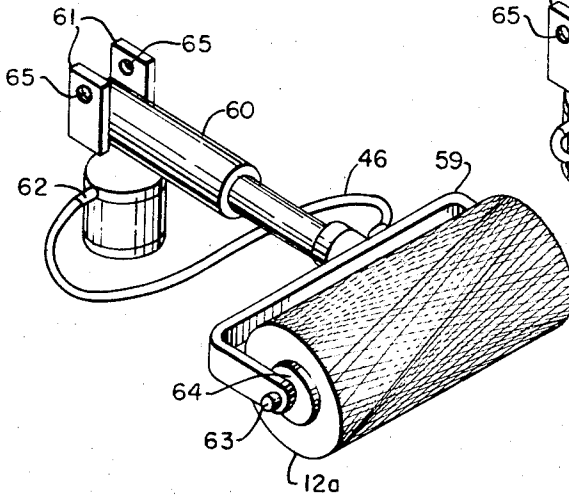


FIG. 5.

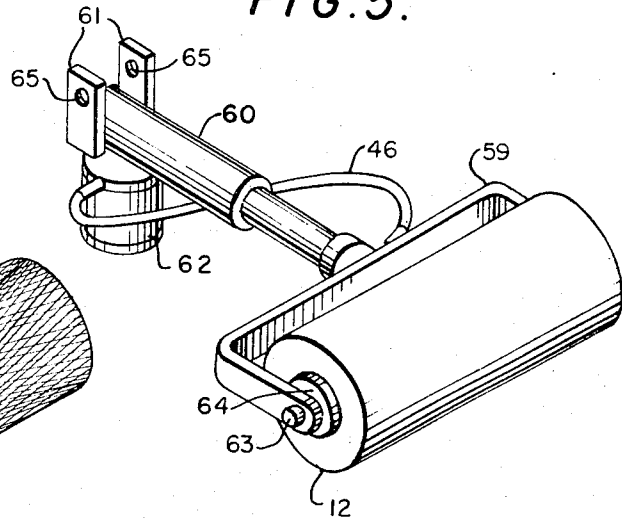


FIG. 6.

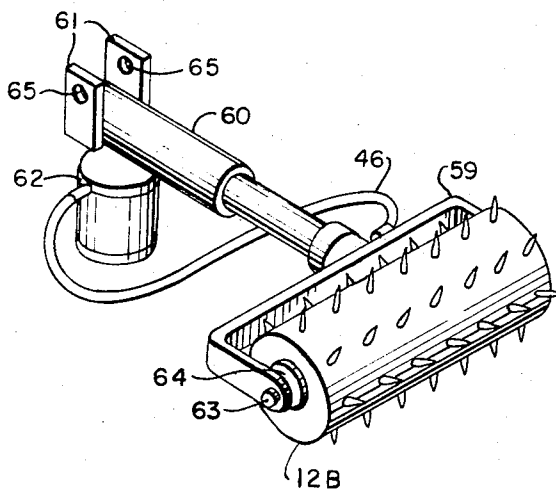
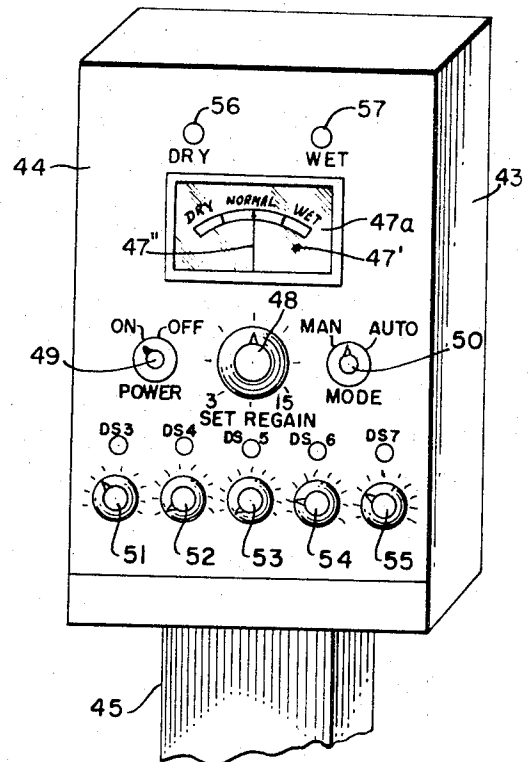


FIG. 3.



MOISTURE MEASURING AND CONTROL APPARATUS

The invention relates to an improved continuous type moisture measuring and controlling instrument for measuring the moisture content of material treated in a moisture conditioning machine and for controlling the machine speed so as to hold the moisture in the finished product relatively constant.

One particular moisture conditioning machine with which the invention is adapted is a web dryer having variable speed conveying means for moving the web through the dryer. The invention measures the moisture content of the web having the drier, compares the measured moisture content with a selected moisture standard and controls the speed of the conveying means moving the web in response to signals indicating the deviation of the measured moisture content from the selected standard moisture content by predetermined amounts. The controls decrease the speed of the web conveying means when the web condition is too wet and increase the speed of the web conveying means when the web is too dry.

It is an object of this invention to provide improved control means for correcting abnormal moisture conditions in the web without excessive hunting so as to hold the moisture in the finished product relatively constant.

It is another object of the invention to provide improved timing means for permitting the controls to respond to dry and wet correction signals (obtained by comparing a measured material moisture content with a selected standard material moisture content) only during periods of predetermined time duration at reoccurring intervals of predetermined frequency and only after a time delay period.

It is an object of the invention to include a start delay timer for establishing a start time delay period sufficient to allow material in the conditioning machine at the time it is started to clear the machine, a correction delay timer for establishing a correction delay period sufficient to ascertain that the abnormal moisture condition persists long enough to warrant corrective action, an amount of correction timer for establishing the time period during which the controls are permitted to take corrective action, and a frequency of correction timer which is energized at the end of the time period established by the amount of correction timer to prevent the controls from making another speed correction until sufficient time has elapsed to allow the initial speed correction to influence the moisture. The frequency of correction timer resets the amount of correction timer after a predetermined time period and continues to operate alternately with the amount of correction timer as long as the machine is running and abnormal moisture signals are being produced. When the measured moisture condition returns to within a normal moisture condition zone centered with respect to a selected standard moisture condition, all of the timers except the start delay timer will be deenergized and put in readiness to begin a new timing interval upon the reoccurrence of persisting abnormal moisture condition signals.

It is another object of this invention to provide an amount of correction timer which includes separate timing circuits, one a dry correction timing circuit for timing a dry correction period, and the other a wet cor-

rection timing circuit for timing a wet correction period, and means for selecting which timer is operative in accordance with whether a wet or dry abnormal moisture condition signal is being generated. The separate timing circuits are provided so that the amount of wet correction time may be selected to be longer than the amount of dry correction time in order to better assure adequate drying.

It is another object of the invention to connect the start delay timer, the correction delay timer, the amount of correction timer, and the frequency of correction timer so that they may be energized in sequence when the conditioning machine is put in run condition. The timers are preferably solid state devices and solid state switches are preferably provide between the respective timers in series circuit with a power source, which switches control the sequence of operation of the timers.

It is another object of the invention to provide a wet stop control which will shut down the moisture conditioning machine when an excessive wet moisture condition occurs.

With the foregoing objects and features in view and such other objects and features which may become apparent as this specification proceeds the invention will be understood from the following description taken in conjunction with the accompanying drawings, wherein like characters of reference designate like parts and wherein:

FIG. 1 is a partial block and partial schematic diagram showing the invention as adapted for one particular use;

FIGS. 2A, 2B and 2C are schematic diagrams of sections of the invention and when put together with FIG. 2A above and FIGS. 2B and 2C positioned in horizontal alignment below FIG. 2A, they together form the complete schematic diagram of the invention;

FIG. 3 is an elevational view showing the front control and display panel provided on the main housing for the invention;

FIG. 4 is a perspective view showing a knurled detector roll forming a component of the invention;

FIG. 5 is a perspective view showing a detector roll which is smooth surfaced forming an alternate component of the invention, and

FIG. 6 is a perspective view showing a spiked detector roll forming another alternate component of the invention.

Referring now to the accompanying drawings and to FIG. 1 in particular, the invention 10 is illustrated as adapted to one particular use for continuously measuring the moisture content of web material 13 after it passes through a material conditioning means 11, such as a dryer, and for controlling the speed of a variable speed drive means 14, such as a variable speed electric motor, which drives the material conveyor means 15. Measuring means 16 is provided for continuously measuring the moisture content of the material and for producing an electrical output signal which is related to the moisture content of the material. A control point selector means 17 is provided for generating a reference signal related to a standard moisture content desired for the material being treated. The measured moisture content signal from the moisture measuring means is compared with the selected standard moisture

signal from the control point selector 17 in a control comparator means 18. The control comparator means 18 has two output channels 20 and 21 which may be designated a dry condition signal channel, and a wet condition signal channel respectively. The control comparator means generates a normal condition signal when the measured moisture content is within a predetermined range centered with respect to the selected standard moisture content. The normal signal comprises like and equal outputs in channels 20 and 21. The control comparator means 18 generates a wet condition signal when the measured moisture content exceeds the standard moisture content by a predetermined amount, and it generates a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount. A control sensitivity selector which provides means for adjusting the comparator to determine the limits of the predetermined range by which the measured moisture content may vary from the standard moisture content so that the comparator means will produce a normal signal is designated at 19. The dry signal condition channel 20, including a resistor R12 is connected to the base of transistor Q1 which provides means responsive to the dry condition signal for producing dry correction control signals. The transistor Q1 is connected between ground and the negative side of a grounded voltage source V3 in series with the energizing coil of a dry correction relay 22. The wet condition signal channel 21, including a resistor R13 is connected to the base of transistor Q2 which provides means responsive to the wet condition signal for producing wet correction control signals. The transistor Q2 is connected between ground and the negative side of a grounded voltage source V3 in series with the energizing coil of a wet correction relay 23. The transistors Q1 and Q2 function like normally open switches which are responsive to dry or wet condition signals respectively for closing. Closing of the switch Q1 energizes the dry correction relay 22 while closing of the switch Q2 energizes the wet correction relay 23. The dry correction relay 22 and the wet correction relay 23 have contacts in a reversing circuit supplying energy to the reversible correction control motor 24 which is suitably connected by drive means 25 to adjust speed control means 26 for controlling the variable speed drive means 14. When the dry correction relay 22 is energized the reversible correction control motor is rotated in a direction which adjusts the speed control means 26 to increase the speed of the variable speed drive means 14, and when the wet correction relay 23 is energized the reversible correction control motor is rotated in a direction which adjusts the speed control means 26 to decrease the speed of the variable speed drive means 14.

While the invention as described thus far has been described particularly with application to drying web material it should be recognized that the invention is adaptable for providing other moisture conditioning functions for the material. For example, the material conditioning means could conceivably be means for adding moisture to the material being treated, in which case a dry condition signal would indicate that the material should remain in the conditioning means for a longer time, and a wet condition signal would indicate that the material should remain in the conditioning

means for a shorter period. It would thus be necessary to connect the reversible control motor so that a dry correction control signal would cause the reversible control motor to move in a direction to adjust the motor speed control to decrease the speed of the variable speed drive means, and a wet correction control signal would cause the reversible control motor to move in a direction to adjust the motor speed control to increase the speed of the variable speed drive means.

The system so far described with respect to FIG. 1 if used by itself would produce undesired hunting by the correction control motor. In order to improve the system response the invention includes timing means generally indicated by the reference numeral 27 in the bottom half of FIG. 1. The timing means 27 permits the transistors Q1 and Q2 to respond to dry and wet condition signals respectively only during periods of predetermined time duration at reoccurring intervals of predetermined frequency while the dry or wet condition signals as the case may be continue to be generated by the comparator 18 and only after a time delay period initiated when the moisture conditioning means begins to run at normal speed.

The timing means 27 includes a start delay timer means 28, a correction delay timer means 29, an amount of correction delay timer means 30 and a frequency of correction timer 31 which are connected in parallel with a d.c. voltage source V2 at spaced intervals along the line 32 in the order named from the positive side of V2 toward ground 34. The conducting line 32 includes a plurality of switches 33, Q8, Q12 and Q19, and an indicator lamp DS7. The switch 33 is actuated by the run relay or other switch means which turns on the material conveyor drive motor. The switch 33 is positioned between the positive side of V2 and the start delay timer 28. The switches Q8, Q12 and Q19 are solid state switches. Q8 is positioned between the start delay timer 28 and the correction delay timer 29, Q12 is positioned between the correction delay timer 29 and the amount of correction timer 30, and Q19 is positioned between the amount of correction timer 30 and the frequency of correction timer 31.

The start delay timer begins its timing cycle when the switch 33 is closed. After a predetermined time period which may be adjusted by the start delay potentiometer R16, the start delay timer will close the switch Q8 provided a wet or dry condition signal is present on the line 35 taken from the common junction between oppositely directed diodes X1 and X2 which are connected to the dry condition channel 20 and the wet condition channel 21 respectively. The time delay for which the start delay timer is adjusted is the time required to allow all the dry material in the dryer at the time the dryer is started to be delivered out of the dryer. If an abnormal (dry or wet) condition signal is present on the line 35 at the end of the start time delay period the switch Q8 will close and the correction delay timer 29 will be energized to begin a correction time delay period which is provided to assure that the abnormal moisture condition persists long enough to warrant action. The correction delay timer is initiated each time the control comparator senses an abnormal condition. The correction delay timer is adjustable for different time delay periods by means of the correction delay potentiometer R28.

At the end of the correction delay period the correction delay timer closes the transistor switch Q12 and the amount of correction timer 30 is energized to initiate an amount of correction time period. As will be subsequently explained in more detail the amount of correction timer 30 is actually two timers, a wet correction timer and a dry correction timer which are selectively actuated by a wet or dry timer selector means 36. The wet correction timer is normally selected by the selector means 36 unless a dry signal appears on the control line 37 connected between the dry condition signal channel 20 and the wet or dry selector means 36 in which event the dry correction timer will be selected. The wet correction timer is set for a longer time period than the dry correction timer to better assure adequate drying of the web material 13.

The amount of correction timer 30 normally provides a hold off bias voltage on the line 38 connected between the amount of correction timer and the common junction 39 between resistors R14 and R15 which are connected to the dry condition channel 20 and the wet condition channel 21 respectively. The hold off bias voltage on line 38 is sufficient to prevent a dry condition signal on channel 20 from closing the transistor switch Q1 and to prevent a wet condition signal on channel 21 from closing the transistor switch Q2. However, during the time that the amount of correction timer is timing a correction time period, which may be either a dry or wet correction, the hold off bias voltage is removed from the line 38 permitting Q1 and Q2 to respond to abnormal condition signals appearing in channels 20 and 21 respectively.

At the end of the amount of correction time period the hold off voltage is again applied to the line 38 to open the switches Q1 and Q2 depending on which one is not already open. Also at the end of the amount of correction time period the timer 30 closes the transistor switch Q19 thus energizing the frequency of correction timer 31. When the switch Q19 is closed a bias voltage is applied through control line 41 to prevent the amount of correction timer from beginning a new cycle. The frequency of correction timer once energized times for a predetermined period selected by the setting of the frequency of correction potentiometer R52. When the time interval of the frequency of correction timer 31 ends an output reset pulse is fed over the reset line 40 to the amount of correction timer 30. The reset pulse over line 40 causes the transistor switch Q19 to open and the amount of correction timer to begin a new timing cycle. The alternate operation of the amount of correction timer 30 and the frequency of correction timer 31 will continue as long as abnormal signals (wet or dry) are generated by the control comparator 18 and for as long as the material conveying and conditioning machinery remains in run. When the measured moisture content of the material returns to the normal zone the switch Q8 will open and the correction delay timer, the amount of correction timer and the frequency of correction timer will all be de-energized. When the measured moisture content once again deviates from the normal zone each of these timers will again be energized in sequence to again provide the necessary operation of the correction control motor to effect the necessary compensation in the speed of the

variable speed drive means to achieve the desired moisture content in the material 13.

CIRCUIT ANALYSIS

FIGS. 2A, 2B and 2C show the complete electrical schematic of the invention with the exception of power supplies, switches, and terminal strips. Aside from the a.c. voltage required for operation of the reversible two-phase correction control motor 24, the circuit operates from three independent regulated d.c. supplies, -V1, +V2 and -V3. Typical values for these supplies are -V1 (-150V), +V2 (+12V), and -V3 (+12V).

The circuit elements, shown as triangles on the schematic and labeled IC1, IC2 and IC3 are general purpose, integrated circuit, operational amplifiers. No specific type is required. A suitable device, utilized in the instrument is a UA741, manufactured by Fairchild Semiconductor.

The circuit elements, labeled Q3, Q9, Q15 and Q20 are programmable unijunction transistors, such as 2N6028, manufactured by General Electric Co.

All other circuit elements are readily identifiable from their symbols and no specific types are required.

The schematic is broadly sub-divided into major circuit functions for clarity. The theory of operation of each is described below.

The moisture to current converter provides means for sensing the moisture in the web and converting the resistance characteristic, inversely related to the moisture, into a meaningful electrical signal. With the detector roll 12 contacting the web 13 directly opposite the grounded machine roll 9, the resistance of the web is directly in series with the set moisture control R1 from ground to -V1. The vacuum tube 42 is connected as a cathode-follower to provide a very high input-impedance voltage measurement of the voltage drop across R1, which is directly related to the moisture in the web. As the moisture in the web 13 increases, the resistance decreases. Therefore, the voltage drop across R1 increases. Conversely, as the moisture in the web decreases, the resistance of the web increases and the voltage drop across R1 decreases.

The value of the set moisture control R1 can be varied to allow for calibration of the instrument for different web materials. Generally the value of R1 is set to be equivalent to the resistance of the web at the desired moisture level.

The voltage drop across R1 causes a proportional current to flow through the tube 42. The plate of vacuum tube 42 is connected directly to the inverting input of IC1. This point is a virtual ground since it is the summing node for the amplifier.

The current to voltage converter and indicator is a standard inverting amplifier used to convert and properly scale the current from the vacuum tube 42 into a ground-referred voltage for operation of the indicating meter M1 and subsequent control circuits. Resistor R4 determines the output voltage of IC1 and capacitor C2 provides the required damping for both the indicator M1 and control circuits.

The control comparator 18 consists of two operational amplifiers operating open loop for maximum sensitivity. A reference voltage is set on the control point control R7. This voltage is connected to the in-

verting input of IC2 and to the non-inverting input of IC3. The output of IC1 is connected in reverse manner to the non-inverting input of IC2 and to the inverting input of IC3.

To provide a center-scale dead zone (normal), a separate control sensitivity control R6 is included. This control provides means for calibrating the control circuitry to the limits of the green, normal zone on the indicating meter.

Once properly calibrated, the output of both IC2 and IC3 will be positive so long as the meter indication remains in the normal zone. Should the meter indication fall into the dry zone, the output of IC2 will go negative. In similar manner, should the meter indication rise into the wet zone, the output of IC3 will go negative. Subsequent operation of the dry correction relay 22 or the wet correction relay 23 is conditional upon the status of the various timers in the timing means 27.

Prior to describing the operation of each of the timers it is to be pointed out that the power supply connection to all of the timer circuitry is via the run relay contacts 33. This is a spare set of normally open run relay contacts on the machine. Only when the machine is placed in the run position will these contacts close, thereby providing power from +V2 to the timers. Also, note that transistor Q17, in the amount of correction timer, is connected, via R49 at all times to +V2. Therefore at any time that Q17 is off, a positive voltage will be applied via resistors R14 and R15 to the bases of transistors Q1 and Q2, respectively. This positive signal is of sufficient magnitude to override any negative signal from the outputs of IC2 and IC3. Consequently it is necessary that transistor Q17 be on before any operation of either the dry correction relay 22 or wet correction relay 23 is possible. Also note that transistor Q13 is connected via R37 to the output of IC2. At any time that the output of IC2 goes negative (meter indication in the dry zone), Q13 will turn on, thereby energizing relay K3. The two sets of contacts of K3 are connected to select either potentiometer R39 or potentiometer R40 and also either lamp DS5 or lamp DS6. This permits one amount of correction timer circuit to actually provide two separate timing functions — amount of dry correction and amount of wet correction. The lamps DS5 and DS6, as well as lamps DS3, DS4 and DS7 simply serve to identify which timer is on.

Each of the four timers is basically the same. However additional transistors have been added to certain timers to provide appropriate input or output control of each. Description of the basic timing means of one will serve for all. All of the additional circuit elements will be described in detail as to their particular function.

The start delay timer 28 is included to delay all correction control for a preset time after the machine has started. When the run relay contacts close, capacitor C4 begins to charge via the start delay control R16. Resistors R18 and R19 set the intrinsic stand-off ratio of the programmable unijunction transistor Q3. Transistors Q4 and Q5 are connected in a bi-stable arrangement so as to provide a continuous output after the start time delay. Simultaneously with the closure of the run relay contacts 33, Q5 turns on and Q4 remains off. Capacitor C5 ensures that Q4 remains off long enough for Q5 to turn on via base drive from R23. With

Q5 on, Q4 will remain off until the start time delay has expired, then being turned on as C4 discharges through Q3 into R17. Once Q4 turns on, Q5 will turn off and Q4 will remain on via base drive from R22. Note that while the start delay timer 28 was in the timing state, with Q5 on, the lamp DS3 was on, thereby providing visual identification that the start delay timer was on.

Similar bi-stable circuits are employed in both the correction delay timer 29 and the amount of correction timer 30. No such circuit is included in the frequency of correction timer 31 however. Since the amount of correction timer 30 and the frequency of correction timer 31 operate together in tandem, the bi-stable circuit is not necessary in the frequency of correction timer 31, and the output of the frequency of correction timer, at the junction of Q20 and R53, is connected, via R50, back to the amount of correction timer 30 to reset its bi-stable circuit and, thereby re-start the amount of correction timer.

However prior to a detailed explanation of these two timers consider again the start delay timer 28. After the start time delay has expired, no further timer operation will ensue until and unless either the output of IC2 or IC3 goes negative, indicating either a dry or wet condition on the meter M1. As long as the meter indication remains in the normal zone, the outputs of both IC2 and IC3 remain positive. Steering diodes X1 and X2 are reverse biased and block the positive signals. Transistor Q6 is held on via base drive from R25. This effectively grounds the base of Q7, holding it off. With Q7 off, Q8 is off and since this transistor acts as a series switch for controlling the application of +V2 to the remaining timers, each of the three remaining timers is de-energized.

Now, assume that the output of IC2 goes negative, indicating a dry condition on the meter M1. Diode X1 is now forward biased and this negative signal is fed, via R26 to the base of Q6. The magnitude of this signal is sufficient to override the positive base drive from R25 and Q6 turns off. With the base of Q7 now positive with respect to its effectively grounded emitter (Q4 on), Q7 turns on thereby turning on Q8 and applying +V2 to the correction delay timer 29.

Operation of the correction delay timer is identical to that of the start delay timer 28. During the interval that the timer is timing, Q11 is on, Q10 is off, and the next series switch Q12 is also off, blocking +V2 from the amount of correction timer 30 and the frequency of correction timer 31. When the correction delay ends, Q10 turns on and Q11 turns off. With Q10 on, Q12 turns on and +V2 is now applied to the amount of correction timer 30.

Operation of the amount of correction timer 30 is also identical to that of the previous timer except for the addition of Q14 and R38. However during the timing interval of the amount of correction timer 30, Q14 is off since the next series switch Q19 is off. Therefore C8 is charged via the amount of dry correction control R39 since the output of IC2 is negative, thereby energizing K3. Transistor Q18 is on, DS5 is on, Q16 is off, and Q19 is off. With Q16 off, Q17 is turned on. This removes the positive hold-off voltage from the base of Q1 and the negative output from IC2 turns Q1 on via R12. The dry correction relay 22 is now energized and the correction control motor 24 rotates in the proper

direction to affect an increase in the machine speed. When the amount of dry correction time interval ends, Q16 turns on, Q17 turns off, and the positive hold-off voltage is once again applied to the base of Q1 and Q1 turns off, de-energizing dry correction relay 22 and terminating rotation of the correction control motor 24. Also when Q16 turns on, Q19 turns on, applying +V2 to the frequency of correction timer 31. As the timer 31 begins its timing interval, Q14 is turned on via R38. With Q14 now on C8 cannot be charged again via R39. This assures that the next timing interval of the amount of correction timer 30 is accurate.

When the time interval of the frequency of correction timer 31 ends, the output pulse from Q20 via R50 causes Q18 to turn on, thereby removing the base drive to Q16 via R46. As Q16 turns off, Q19 also turns off, Q14 turns off, and another amount of dry correction time interval begins. This tandem operation of these two timers 30 and 31 will continue as long as the meter M1 indication remains in the dry zone for as long as the machine remains in run. When the meter M1 indication returns to the normal zone, Q8 will turn off, and the correction delay timer 29, the amount of correction timer 30, and the frequency of correction timer 31 will all be de-energized. When the meter M1 indication once again deviates from the normal zone, each of these timers 29, 30 and 31 will again be energized, in sequence, to again provide the necessary operation of the correction control motor 24 to affect the necessary compensation in machine speed to achieve the desired moisture level set on the set moisture control R1.

While electronic timers and switches are described in the specification and drawings, suitable electro-mechanical timers and various types of switches may be substituted which will perform the timing and switching functions described and fall within the spirit and scope of the invention as claimed.

Referring now to FIG. 3 the instrument housing 43 mounted on stand 45 and provided with a front display and control panel 44 is shown. The housing 43 will normally contain all of the instrument components shown in FIGS. 2A, 2B and 2C with the exception of the detector roll 12 and grounded roll 9. The detector roll 12 is preferably located at the delivery end of the material conditioner as near as possible to the point at which the web 13 is rolled or folded. If one detector roll is used, it should be mounted in the center of the web. If more than one detector roll is used, they should be connected together. The detector roll 12 is connected by high dielectric wire 46 to a junction 47 inside of the housing 43 between R1 and R2 in the moisture to current converter circuit (see FIG. 2A). The correction control motor 24 and the speed control potentiometer 26' are preferably housed in housing 43 but they may be mounted externally in proximity to the variable speed drive motor 14 for the material conveyor if desired. If the correction control motor 24, and the speed control potentiometer 26' are mounted in housing 43 suitable wiring connections are provided to connect the speed control potentiometer 26' in the speed control circuit for the variable speed drive motor 14. The speed control for the variable speed drive motor 14 is of conventional design for which reason it is shown only by block 26 in FIG. 1. It will be understood that the speed control potentiometer 26' is connected

in the energizing circuits for the variable speed drive motor 14 in such a way that varying the position of the potentiometer movable contact 26a will cause a variation in speed of the drive motor 14.

On the front panel 44 is positioned the indicator dial 47a for the moisture meter M1. The indicator dial is divided into three zones of moisture condition: dry, normal and wet. The dry and wet zones, colored red, indicate conditions that are abnormal. The center normal zone, colored green, indicates that the moisture in the material is normal. It should be mentioned at this point that the meter M1 may be a meter relay type which is provided with a circuit contact 47' which when engaged by the pointer 47'' at the extreme end of the wet zone will operate a relay or other wet stop control 58 to shut down the moisture conditioning machine. Such wet stop control 58 is desirable when the moisture content of the material reaches a predetermined high level beyond which the conditioning machine and the controls therefor will not operate satisfactorily. Instead of a meter relay other wet stop controls may be used. Another suitable wet stop control would include a wet stop comparator and a wet stop control point selector like comparator 18 and control point selector 17 which would be connected to the output of the moisture measuring means 16 in parallel with comparator 18. The wet stop set point selector would be set to a selected high moisture standard which if exceeded by the measured moisture content would cause the wet stop comparator to provide a signal which turns the moisture conditioning machine off.

Beneath the meter indicating dial 47a is a selector 48, marked "Set Regain." The knob for selector 48 turns the set moisture resistor R1 in the moisture meter circuit shown in FIG. 2A. The "Set Regain" selector is calibrated in units from 3 to 15 which correspond directly to the moisture in cotton expressed as a percentage of its dry weight. The units also correspond in precisely known relationships to moisture in other natural and man-made fibers as well as to any blends of these. To the left of the "Set Regain" selector is a power on-off switch 49 which turns the moisture conditioning machine and the measuring and control apparatus of this invention on and off. To the right of the set regain selector is a mode selector switch control knob 50 which enables the operator to put the machine speed control in manual or automatic. When in manual position the reversible correction control motor may be actuated to increase machine speed by manually pressing the "dry" manual switch button 56, or to decrease machine speed by pressing the "wet" manual switch button 57. The contacts of the "dry" switch button 56 are positioned across the contacts 22' of the dry correction relay 22 and the contacts of the wet switch button are positioned across the contacts 23' of the wet correction relay 23.

At the bottom of the panel 44 are selector knobs 51, 52, 53, 54 and 55 which actuate the start delay potentiometer R16, the correction delay potentiometer R28, the amount of dry correction potentiometer R39, the amount of wet correction potentiometer R40, and the frequency of correction potentiometer R52, respectively. The dial for the start delay selector 51 is calibrated in minutes from 0 to 3.0, while the dials for the remaining four selectors 52-55 are calibrated in

seconds from 0 to 60. Directly above the selector knobs 51-55 are indicator lamps DS3-DS7 which when lighted indicate that their associated timer is timing.

MOISTURE SENSORS

The moisture sensors used with this invention are electric devices which sense the moisture content in the material being tested and they are of different types depending on the type of moisture meter being used, and the nature of the material being tested. For a resistance type moisture meter which passes an electric current through the material, and senses the variation of electric current in relationship to the electrical resistance of the material and in turn as a function of moisture content, the moisture sensors are electric conductors in the form of rollers, bars and the like. When the moisture content of a fabric web is being sensed the moisture sensors are preferably detector rolls as illustrated at 12 in FIGS. 1 and 2A of the drawings. The detector rolls 12 may be selected as to weight and contact surface for different materials.

For use with sizing machine, i.e., slashers, a single medium-weight roll 12 is usually mounted over the nip roll 9 in the center of the warp at the delivery end of the machine. Heavy detector rolls are needed on heavy yarn which may be damp. For yarn counts under 20 a heavy, knurled roll is recommended. Wet warps can result from using light-weight rolls on heavy warps, because the moisture control will sense a dry surface and cause the machine speed to be increased. In these instances the warp surface on the loom beam may even feel hot and dry. If the slasher is allowed to stand for a few minutes, the surface may become cold and damp. Considerable warp losses have resulted from this condition, confusing both the moisture control and the operator.

Continuous filament yarns, such as Nylon, of low denier are susceptible to damage from detector rolls. Special, light-weight rolls are recommended for these applications to prevent the roll from permanently flattening the yarn.

It is not advisable to locate detector rolls before the leasing section immediately after drying. The reason for this is that the latent heat contained in the yarn immediately after drying can cause rapid and continued drying as the yarn passes through the open and exposed leasing section. This is generally true for all fibers, both natural and man-made, except at extremely low speeds. At these low speeds, it is possible for overdried yarn to pickup moisture when it is exposed in the leasing section.

It is generally unnecessary to employ more than one centrally located detector roll on modern slashers. However, additional rolls can be employed for the purpose of assuring even size pickup and moisture across the warp. A selector position is available to combine all of the rolls together. The moisture control will be influenced largely by the detector roll which is in contact with the dampest part of the warp.

Full-span detectors, such as a pair of closely spaced rolls, can be employed. Although this arrangement is seldom used, it offers the advantage of permitting the wet stop device to respond to a few wet ends anywhere in the warp. The wet condition can result from lapped yarn or dents on one of the squeeze rolls. When full-

span detectors are used, it is recommended that a single short detector roll be located in the center of the warp to provide better control consistency. The two detectors should be connected together.

The use of predryers in both dye-beam and double-dip systems brings about a size pickup problem as a result of variations in the residual moisture in the yarn before it enters a size box. The moisture in dry yarn is very consistent, so no significant variations in pickup result. Damp yarn emerging from a predryer will provide increased pickup due to its higher moisture, but, if the moisture is variable, the pickup will be variable.

Detector rolls can be located at the exits of predryers, and moisture controls can be employed to regulate the predryer temperature to obtain more consistent moisture and more consistent size pickup.

Much of what has been said about the use of detector rolls on slashers also applies to fabric dryers.

Single, medium-weight detector rolls are usually employed without regard to fabric density. The effects of size penetration experienced with sizing heavy yarns is generally not experienced on fabric, but light-weight rolls may be necessary to avoid damage to hot fabrics.

It is generally advisable to locate detector rolls at the delivery end as near as possible to the point at which the fabric will be rolled or folded. As in the case of slashers, considerable moisture evaporation can occur in the threading section after drying as a result of the latent heat contained in the fabric.

The effect of latent heat in fabric can be utilized in curing operations by intentionally locating detector rolls at dryer exits. Although the moisture control will not ascertain the complete absence of moisture, it will accurately ascertain extremely low levels of moisture. By setting the moisture control for the lowest moisture level and by locating the detector roll at the dryer exit, the complete absence of moisture can generally be assured at the entrance to the curing oven or section. Substantial increases in production can often be accomplished by this method.

Full-span detector rolls or bars are useful on multi-strand dryers. The moisture control will be influenced largely by the dampest strand.

Teflon insulated detector roll wire is recommended when detector rolls are located on very hot fabric or when they are installed inside dryers.

Spiked detector rolls are available for penetrating through the pile side of carpet to the base. A pair of these rolls, one behind the other, can be employed. Smooth-surface rolls, can be used on the back side of carpet in the same manner.

A single or double probe is available for mounting inside the air duct of raw stock dryers. Although the probe may not consistently contact the stock as it moves through the duct, the moisture control will seek an average value of the contacts and can be used to control the apron speed, the feed rate, or both.

Special detectors can be made for new or unusual applications. The primary requisites are contact consistency and high insulation resistance. Good insulation materials include Teflon, which is capable of withstanding very high temperatures, and polyvinylchloride (PVC), which performs well as an electrical insulator but is limited to use at fairly low temperatures.

FIGS. 4 to 6 are illustrative of different detector rolls 12, 12a and 12b, which may be used with the invention. Detector roll 12 shown in FIG. 5 is a smooth surface conductive roll, roll 12a (FIG. 4) is a knurled surface conductive roll, and roll 12b is a spiked surface conductive roll. Each of the rolls have opposite shaft ends 63 (only one shown) which are journaled in bearings at the ends of the parallel arms of the conductive yoke 59. The yoke 59 is supported by a rearwardly extending handle 60, preferably insulated, to which support brackets 61 are secured. The brackets 61 have aligned holes 65 through which a pivot pin may be positioned for pivotally attaching the handle 60 to a suitable support at the site where the detector roll is to be used. An insulated conductor 46 which is electrically connected to the yoke 59 extends to a connector 62 from which a cable connection may be made extending to the moisture measuring means 16 contained in the housing 43 (see FIG. 3). Conductive spacers 64 are provided between the ends of rolls 12, 12a and 12b and the yokes if required to insure adequate conductive contact between the rolls and the arms of yoke 59.

CALIBRATION - TIMER SETTINGS

The start delay timer 28, adjustable from 0 to 3 minutes, serves to disable the control during the time the dryer 11 is standing or operating at low speed as well as for an adjustable, preset time after starting or returning to normal, run speed. Without the start delay provided by the timer 28 the control would sense an excessively dry condition in the standing or slowly moving material and gradually increase the run speed setting. When the dryer 11 is returned to run speed, the speed setting would have been advanced too far for adequate drying of the material that had not yet entered the dryer while it was standing or operating at low speed. Wet material would, of course, be produced before the control could reduce the speed sufficiently to dry it.

A good rule, concerning the start delay timer is to set it to a length of time long enough to permit all dry material to reach the dryer exit at the lowest expected operating speed. This should correspond with the heaviest material to be dried.

With the start delay properly set and its time expired after the machine has begun to operate at normal, run speed, the control will begin to make speed adjustments depending upon the moisture condition it senses.

If the moisture is normal, which means it is in agreement with the amount set on the set regain selector, no control action will occur.

When the moisture varies from the normal zone, whether the departure is toward dry or wet, the correction delay timer 29 functions. This timer 29 which is adjustable from 0 to 60 seconds, determines how long an abnormal condition may exist before the control will act to correct it. It will, for instance, permit temporary wet spots and cut marks on warps to pass through without causing the control to change speed. Without the correction delay, many needless changes, mostly reductions, in speed will be made, only to require the control to make a compensating change later, but usually at an accumulating loss in production. This would be the case if the correction delay timer were set to zero time. On the other hand, if the correction delay timer is set too long, the control will be slow to act,

bringing on the likelihood of both overdried (loss in production and quality) and underdried (loss in quality) material. Obviously, some setting between zero and some excessive length of time should be ideal. There is no specific rule for setting the correction delay potentiometer; settings found to be best from actual experience are in the neighborhood of 5 seconds. The general rule is to set the correction delay timer long for drying applications in which the moisture is not stable, that is, the moisture variations are constantly causing the control to vary in and out of the normal zone. Such long settings tend to cause the control to stabilize the speed for the preset average moisture desired and to make speed changes only as the departures in moisture from the normal zone tend to become permanent. Conversely, if the application is one in which stable and consistent moisture is obtained, there is little justification for any more than a very small amount of time to be allowed to pass occasional wet spots, cut marks, and the like. The control is then able to make step by step changes in speed from time to time to maintain constant moisture at the maximum possible rate of production.

The correction delay timer 29 then functions each time the moisture becomes abnormal, and it prevents the control from changing the speed until there is reasonable certainty that a change should be made. The moisture must remain abnormal constantly without even momentarily becoming normal again until the full time set on the correction delay timer has expired.

Once a dry or wet condition has proved to be sufficiently permanent to justify a change in speed, a corresponding speed change is made instantly. Separate amount of correction timers determine the amount of correction. The amount of dry correction timer determines the length of time the control motor 24 will run to increase the speed. The amount of wet correction timer determines the length of time the control motor will run to decrease the speed. These timers are adjustable from 0 to 6 seconds. The amount of time is directly related to the change in speed in yards or meters per minute, but this depends upon the response of the particular drive system, whether electrical or mechanical.

Separate dry and wet correction timers are provided to facilitate making slightly larger corrections from a wet condition than from a dry condition. Since abnormally wet conditions generally affect material quality more adversely than abnormally dry conditions, it is possible to run safely at higher average moisture levels by setting the amount of wet correction timer somewhat higher than the amount of dry correction timer.

The remaining timer 31, frequency of correction, adjustable from 0 to 60 seconds, follows after a change in speed has been made. This timer 31 will allow a time to elapse so that the change in speed can actually influence the moisture. If the influence is insufficient to cause the moisture to become normal, a second change in speed will be made, and so on until the abnormal moisture condition is fully corrected.

The two timers, amount of dry correction or amount of wet correction and the frequency of correction work together in a tandem "off-on" manner. Their action

stops whenever the moisture returns to normal, after which a new, abnormal condition must first exist longer than the time set on the correction delay before another correction will be made.

It would appear that the frequency of correction timer 31 should be set to a time approximately as long as the start delay, since this is very nearly equal the time required for complete travel of the material through the dryer. In practice, however, this approach does not provide the best performance. After a change is made in the speed, the moisture will begin to be influenced almost immediately, the full effect being realized after full passage of the material through the dryer. Sufficient change in moisture to depart from the normal zone generally occurs after about one third the full passage has been made. Since it is desirable to limit the delay between corrections as much as possible, the frequency of correction timer 31 should be set to about one-third the time required for complete passage. In actual sizing applications which require a start delay period of 60 seconds, the frequency of correction timer 31 is usually set to 15 to 20 seconds for best performance.

With the frequency of correction timer 31 set only long enough to permit a departure out of the normal zone upon a given speed change, the two amount of correction timers should be set to the highest amount possible without excessive hunting. It is not good practice to employ small amounts of correction simply to avoid overshooting the normal zone. It is better to allow a tolerable amount of overshoot, provided, of course, the changes are not so great and so often that the control cannot reach equilibrium soon after the corrections are made.

Important advantages of the new moisture control are:

1. The invention may be calibrated for use on most popular textile fibers being processed throughout the world. All competitive instruments that we are aware of do not offer this advantage. Instead, it is necessary to make bone dry tests in a laboratory on samples to determine the actual amount of moisture in the material.

2. The invention provides means for presetting the control to get any desired amount of moisture in material blends as well as in single fiber materials. Tests are made to determine the relationship between moisture and electrical resistance of the various popular textile fibers and tables are supplied with the invention showing such relationships. The "Set Regain" selector 48 is calibrated in units from 3 to 15 which correspond with values of electrical resistance. At a setting of 3, the resistance is in the neighborhood of 12,000 megohms. As the selector is rotated toward 15, the resistance decreases to a low of about 12,000 ohms. Since the selector dial 48 is calibrated particularly for cotton, a setting of 7 indicates that cotton must contain 7 percent moisture regain for the control to be satisfied under which condition the meter M1 will indicate the center of the green normal zone. At the same setting rayon must have 12.9 percent moisture regain and other fibers will have other moisture regain values which can be determined from tables provided with the invention. The setting of the "Set Regain" selector 48 for various materials at specific moisture regain values will be obtained from the proper tables.

In this specification moisture regain is defined as the amount of moisture in the material expressed as a percentage of its dry weight, i.e.,

5 Percent moisture regain

$$= \frac{\text{gross weight} - \text{bone dry weight}}{\text{bone dry weight}} \times 100\%$$

10 While the invention has been described in connection with a specific material condition correcting means (i.e., a dryer for correcting the measured moisture condition of web material to conform to a standard moisture condition) it is not intended that the invention be limited to one specific utility. Various uses and modifications may become apparent to those skilled in the art to which the invention relates. Accordingly, it is not desired to limit the invention to this disclosure, and various modifications and equivalents may be resorted to, falling within the spirit and scope of the invention as claimed.

What is claimed is:

1. Moisture measuring and control apparatus for use with a material moisture conditioning means having conveyor means for conveying the material through the material moisture conditioning means and a variable speed drive means for driving the conveyor means at different speeds as determined by said moisture measuring and control apparatus, said moisture measuring and control apparatus comprising means for continuously measuring the moisture content of material conveyed through the material moisture conditioning means and producing an electrical output signal related to the moisture in the material, a control point selector means for generating a reference signal related to a selected standard moisture content, a control comparator means for comparing the measured moisture signal with the reference signal, said control comparator means generating a wet condition signal when said measured moisture content exceeds the standard moisture content by a predetermined amount, generating a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount and generating a normal signal when the measured moisture content is within a predetermined range centered with respect to said standard moisture content, means responsive to said dry condition signal for producing dry correction control signals, means responsive to said wet condition signal for producing wet correction control signals, means responsive alternatively to said dry and wet correction control signals for increasing and decreasing respectively the speed of said variable speed conveyor drive means, and timing means for permitting said means for producing dry correction control signals to respond to said dry condition signals and for permitting said means for producing wet correction control signals to respond to said wet condition signals only during periods of predetermined time duration at reoccurring intervals of predetermined frequency while said dry and wet condition signals continue, said timing means including an amount of correction timer means which determines the length of the time periods during which the dry and wet condition signals may be applied to said means for producing dry correction control signals and to said means for producing wet correction control signals respectively, and a frequency of correction

timer means for periodically resetting said amount of correction timer at a predetermined frequency.

2. The apparatus set forth in claim 1 wherein said time delay period includes a start time delay initiated when the material conveying means begins to move material through the material moisture conditioning means and a correction time delay initiated at the end of said start time delay and only when said comparator is generating a dry or wet condition signal.

3. The apparatus set forth in claim 1 wherein said moisture measuring means is an electrical resistance type moisture meter which includes a substantially constant d.c. voltage source, a pair of electrodes for continuously bridging a portion of the material to be measured and a set moisture control resistor in series circuit with said voltage source and said electrodes, said set moisture control resistor being adjustable and being normally set so that its resistance value is equivalent to the resistance of the material to be measured at the desired moisture level, high input impedance voltage to current converter means for sensing the voltage across the set moisture resistor and producing an output current which is directly proportional to the voltage drop across the set moisture control resistor, a current to voltage converter responsive to said output current from said voltage to current converter for converting and scaling said output current into a ground-referred voltage, a moisture indicator means responsive to said ground-referred voltage for indicating the moisture content of said material, and circuit means for applying said ground-referred voltage to said control comparator.

4. The apparatus set forth in claim 3 wherein said moisture indicator has an indicator dial including a central normal zone, a wet zone and a dry zone, said wet zone and dry zone being on opposite sides of said normal zone.

5. Moisture measuring and control apparatus for use with a material moisture conditioning means having conveyor means for conveying the material through the material moisture conditioning means and a variable speed drive means for driving the conveyor means at different speeds as determined by said moisture measuring and control apparatus, said moisture measuring and control apparatus comprising means for continuously measuring the moisture content of material conveyed through the material moisture conditioning means and producing an electrical output signal related to the moisture in the material, a control point selector means for generating a reference signal related to a selected standard moisture content, a control comparator means for comparing the measured moisture signal with the reference signal, said control comparator means generating a wet condition signal when said measured moisture content exceeds the standard moisture content by a predetermined amount, generating a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount and generating a normal signal when the measured moisture content is within a predetermined range centered with respect to said standard moisture content, means responsive to said dry condition signal for producing dry correction control signals, means responsive to said wet condition signal for producing wet correction control signals,

means responsive alternatively to said dry and wet correction control signals for increasing and decreasing respectively the speed of said variable speed conveyor drive means, and timing means for permitting said means for producing dry correction control signals to respond to said dry condition signals and for permitting said means for producing wet correction control signals to respond to said wet condition signals only during periods of predetermined time duration at reoccurring intervals of predetermined frequency while said dry and wet condition signals continue and only after a time delay period, said moisture measuring means being an electrical resistance type moisture meter which includes a substantially constant d.c. voltage source, a pair of electrodes for continuously bridging a portion of the material to be measured and a set moisture control resistor in series circuit with said voltage source and said electrodes, said set moisture control resistor being adjustable and being normally set so that its resistance value is equivalent to the resistance of the material to be measured at the desired moisture level, high input impedance voltage to current converter means for sensing the voltage across the set moisture resistor and producing an output current which is directly proportional to the voltage drop across the set moisture control resistor, a current to voltage converter responsive to said output current from said voltage to current converter for converting and scaling said output current into a ground-referred voltage, a moisture indicator means responsive to said ground-referred voltage for indicating the moisture content of said material, and circuit means for applying said ground-referred voltage to said control comparator, said moisture indicator having an indicator dial including a central normal zone, a wet zone and a dry zone, said wet zone and dry zone being on opposite sides of said normal zone, and said control comparator consisting of two operational amplifiers operating open loop for maximum sensitivity, each operational amplifier having an inverting input, a non-inverting input and an output terminal, one operational amplifier having its non-inverting input connected to receive the output voltage from said current to voltage converter while the other operational amplifier has its inverting input connected to receive the output voltage from said current to voltage converter, the one operational amplifier having its inverting input connected to receive said reference signal from said control point selector and the other operational amplifier having its non-inverting input connected to receive said reference signal from said control point selector, and a control sensitivity adjusting means for said comparator whereby the operational amplifiers are caused to produce said normal output signal when the moisture indicator reads within said normal zone.

6. The apparatus set forth in claim 5 wherein said means responsive to said dry condition signal for producing dry correction control signals includes a normally open, dry condition signal responsive switch in series circuit with a voltage source and the energizing coil of a dry correction relay, and wherein said means responsive to said wet condition signal for producing wet correction control signals includes a normally open wet condition signal responsive switch in series circuit with a voltage source and the energizing coil of a wet correction relay.

7. The apparatus set forth in claim 6 wherein said normally open dry condition signal responsive switch and said normally open wet condition signal responsive switch are solid state switches which are normally biased to cut off.

8. The apparatus set forth in claim 6 wherein said timing means provides bias for maintaining said normally open dry condition signal responsive switch and said normally open wet condition signal responsive switch open even when dry and wet condition signals are present, and removes said bias for periods of predetermined time duration at reoccurring intervals of predetermined frequency while said dry and wet condition signals continue thus permitting said dry and wet condition signal responsive switches to respond to said dry and wet condition signals respectively while said bias is removed.

9. The apparatus set forth in claim 6 wherein said means alternatively responsive to said dry and wet correction control signals includes a reversible correction control motor, a speed control potentiometer driven by said reversible correction control motor for adjusting the speed of said variable speed conveyor drive, and reversing circuit means for energizing said reversible correction control motor selectively in opposite directions, said reversing circuit means being controlled by said dry correction relay when energized to cause said correction control motor to move said speed control potentiometer in a direction to increase the speed of said variable speed conveyor drive means and said reversing circuit means being controlled by said wet correction relay when energized to cause said correction control motor to move said speed control potentiometer in a direction to decrease the speed of said variable speed conveyor drive means.

10. Moisture measuring and control apparatus for use with a material moisture conditioning means having conveyor means for conveying the material through the material moisture conditioning means and a variable speed drive means for driving the conveyor means at different speeds as determined by said moisture measuring and control apparatus, said moisture measuring and control apparatus comprising means for continuously measuring the moisture content of material conveyed through the material moisture conditioning means and producing an electrical output signal related to the moisture in the material, a control point selector means for generating a reference signal related to a selected standard moisture content, a control comparator means for comparing the measured moisture signal with the reference signal, said control comparator means generating a wet condition signal when said measured moisture content exceeds the standard moisture content by a predetermined amount, generating a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount and generating a normal signal when the measured moisture content is within a predetermined range centered with respect to said standard moisture content, means responsive to said dry condition signal for producing dry correction control signals, means responsive to said wet condition signal for producing wet correction control signals, means responsive alternatively to said dry and wet correction control signals for increasing and decreasing respectively the speed of said variable speed conveyor

drive means and timing means for blocking said dry and wet condition signals from said means for producing dry correction control signals and said means for producing wet correction control signals respectively and for unblocking said dry and wet condition signals during time periods of predetermined length at reoccurring intervals, said timing means including an amount of correction timer means which determines the length of the time periods during which the dry and wet condition signals are applied to said means for producing dry correction control signals and to said means for producing wet correction control signals respectively, and a frequency of correction timer means for periodically resetting said amount of correction timer at a predetermined frequency.

11. The apparatus set forth in claim 10 wherein said amount of correction timer means includes an amount of dry correction timer means for unblocking the means for producing dry correction signals and an amount of wet correction timer means for unblocking the means for producing wet correction signals, and means for selecting the amount of dry correction timer means to operate only when a dry condition signal is being generated, and for selecting the amount of wet correction timer means to operate when said wet condition signal is being generated.

12. The apparatus set forth in claim 11 wherein said amount of dry correction timer means and said amount of wet correction timer means are adjustable for operating over time periods of different length.

13. The apparatus set forth in claim 12 wherein said amount of wet correction timer means is adjusted to operate over a longer time period than said amount of dry correction timer means.

14. The apparatus set forth in claim 13 wherein said timing means further includes a correction delay timer means for delaying the operation of said amount of correction timer means a predetermined time period after said comparator begins to generate wet or dry condition signals to assure that an abnormal signal persists long enough to warrant correction.

15. The apparatus set forth in claim 14 wherein said timing means further includes a start delay timer means for delaying the operation of said correction delay timer for a predetermined time period after the material conveying means begins to move material through the material moisture conditioning means.

16. Moisture measuring and control apparatus for use with a material moisture conditioning means having conveyor means for conveying the material through the material moisture conditioning means and a variable speed drive means for driving the conveyor means at different speeds as determined by said moisture measuring and control apparatus, said moisture measuring and control apparatus comprising means for continuously measuring the moisture content of material conveyed through the material moisture conditioning means and producing an electrical output signal related to the moisture in the material, a control point selector means for generating a reference signal related to a selected standard moisture content, a control comparator means for comparing the measured moisture signal with the reference signal, said control comparator means generating a wet condition signal when said measured moisture content exceeds the standard

moisture content by a predetermined amount, generating a dry condition signal when the measured moisture content is less than the standard moisture content by a predetermined amount and generating a normal signal when the measured moisture content is within a predetermined range centered with respect to said standard moisture content, means responsive to said dry condition signal for producing dry correction control signals, means responsive to said wet condition signal for producing wet correction control signals, means responsive alternatively to said dry and wet correction control signals for increasing and decreasing respectively the speed of said variable speed conveyor drive means and timing means for blocking said dry and wet condition signals from said means for producing dry correction control signals and said means for producing wet correction control signals respectively and for unblocking said dry and wet condition signals during time periods of predetermined length at reoccurring intervals, said timing means including a start delay timer for establishing a start time delay sufficient to permit the material in the conditioning means at the time it is started to clear the machine, a correction delay timer which establishes a time delay period after the start time delay which insures that a condition requiring correction persists long enough to warrant correction, an amount of correction timer which is actuated after the correction delay period to establish a time period during which time said means responsive to said wet and dry condition signals for producing wet and dry correction control signals respectively are unblocked and permitted to respond to said wet and dry condition signals respectively, and a frequency of correction timer which is actuated at the end of the time period established by the amount of correction timer to recycle the amount of correction timer at reoccurring intervals of predetermined frequency for as long as an abnormal condition signal is being generated.

17. The apparatus set forth in claim 16 wherein said timers are energized from the same power source, and sequencing means are provided for energizing said start delay timer when the conditioning means is turned on, for energizing said correction delay timer after the start delay period and when an abnormal condition signal is being generated, for energizing said amount of correction timer at the end of said correction time delay, for energizing said frequency of correction timer at the end of the time period established by the amount of correction timer.

18. The apparatus set forth in claim 17 wherein said sequencing means includes a plurality of series switches separating the respective timers from said power source, said series switches including a first normally open switch connected in a sequencing circuit between said power source and said start delay timer which is closed when said moisture conditioning means is turned on, a second normally open switch connected in said sequencing circuit between said start delay timer and said correction delay timer which is closed at the end of said start delay when an abnormal condition signal is being generated, a third normally open switch connected in said sequencing circuit between said correction delay timer and said amount of correction timer which is closed at the end of said correction delay period, and a fourth normally open switch connected in said sequencing circuit between said amount of correction timer and said frequency of correction timer which is closed at the end of said amount of correction time period.

19. The apparatus set forth in claim 18 wherein said switches are solid state switches and said timers are solid state timers.

20. The apparatus set forth in claim 16 wherein all of said timers have means for adjusting their respective time periods.

* * * * *

40

45

50

55

60

65