

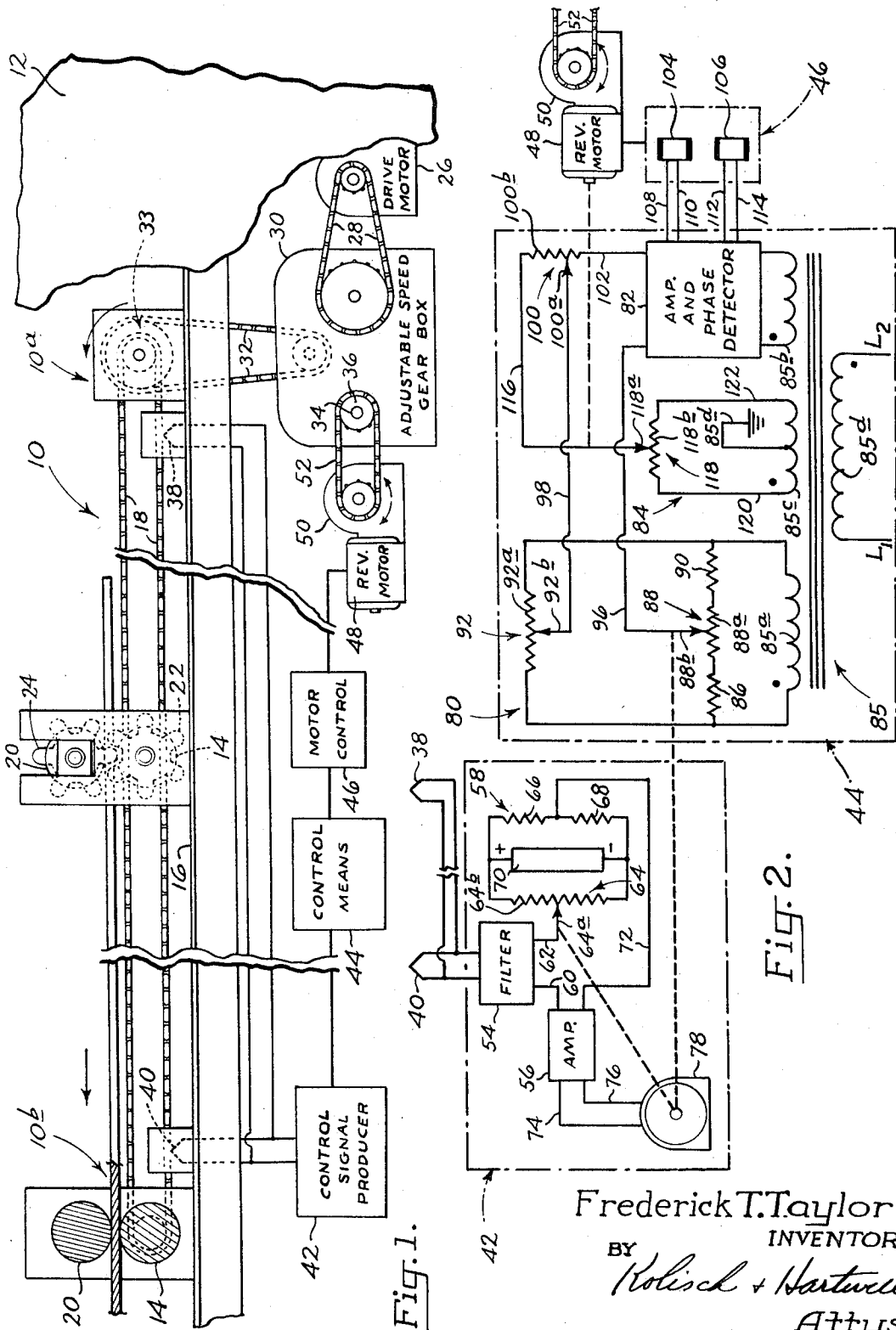
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TEMPERATURE-SENSITIVE SPEED-ADJUSTABLE CONVEYOR-TYPE DRYER

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TEMPERATURE-SENSITIVE SPEED-ADJUSTABLE CONVEYOR-TYPE DRYER

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ABSTRACT OF THE DISCLOSURE

A dryer having a power-driven conveyor deck for transporting articles to be dried, and including temperature-responsive apparatus for adjusting the speed of the conveyor deck to compensate for variations in dryer temperature.

This invention relates to conveyor-type dryers, and more particularly, to means in such a dryer for adjusting the speed of conveyor decks therein automatically with variations in dryer temperature. While a specific embodiment of the invention is disclosed herein with reference to veneer dryers, it is appreciated that the invention is applicable as well to other types of dryer apparatus.

In the usual veneer dryer, sheets of veneer are moved through the dryer on multiple conveyor decks, and hot air is passed over the sheets to remove moisture therefrom. Since veneer sheets often have different drying characteristics requiring that they spend a greater or a lesser amount of time in the dryer in order to be properly dried, the sheets are typically first separated into batches with the sheets in each batch having similar characteristics, and fed into the dryer in such batches. For a given batch of sheets, it has been the customary practice to adjust the speed of the conveyor decks whereby, with a known temperature existing inside the dryer, the sheets spend enough time in the dryer so that about 90% of them emerge with proper dryness. If a greater percentage is dried, there results a waste in dryer time and too many overdried sheets, whereas if a lesser percentage is dried, too many sheets must be rerun.

In the past, in order to control the uniformity of sheets treated in a dryer, it has been the practice to measure the moisture of sheets leaving the dryer, and to adjust the speed of the conveyor decks whenever for a given batch of sheets a too great or too small percentage of the sheets have the proper dryness. A problem with this system, however, is that it fails to respond directly to variations in dryer temperature which normally occur, and which substantially affect the rate at which sheets are dried. This invention contemplates novel apparatus whereby it is temperature variations that are detected rather than moisture variations, and such detections are utilized to adjust the speed of the conveyor decks immediately in a manner compensating for the variations. A considerably faster response is possible, since it is internal dryer conditions that are controlling.

Thus, a general object of the invention is to provide, in a conveyor-type dryer, novel means for controlling, in a highly practical and efficient manner, the uniformity of articles emerging from the dryer after treatment therein.

Another object is to provide in such a dryer novel means which responds rapidly to changed conditions within the dryer affecting the drying rate of articles, whereby adjustments are made to assure that with such altered conditions the articles remain inside the dryer long enough so that a known desired percentage of the articles attain the proper dryness.

More particularly, an object of this invention is to provide such means whereby dryer temperature is continually monitored to detect any variations therein above and

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below an optimum temperature established for a given class of articles being treated, and the speed of conveyor decks carrying such articles through the dryer is automatically adjusted to compensate for such detected variations.

Thus, the invention features a novel temperature sensor which detects temperature variations in the dryer, variable drive means adjustable to speed up and slow down the movement of conveyor decks in the dryer, and control means responsive to the temperature sensor connecting the sensor and drive means producing automatic adjustment of the drive means to compensate for temperature variations detected. The temperature sensor and control means herein each employ an electrical bridge circuit functioning to maintain an electrical balance condition whereby, for a given class of articles being treated by the dryer, the speed of the conveyor decks is that required for the dryer temperature then existing.

A further object of the invention is the provision, in apparatus of the type so far described, of a novel proportioning device which is operable to make an adjustment in the speed of the conveyor decks for a given temperature variation which changes in proportion depending upon the particular drying characteristics of the articles being treated. This is of special utility where, as in the case of veneer sheets, the dryer is likely to be employed to dry articles in different runs which have widely varying drying characteristics.

Yet another object of the invention is to provide such apparatus which readily enables manual adjustment to be made in the speed of the conveyor decks without impairing the features of automatic operation of the apparatus.

These and other objects and advantages attained by the invention will become more fully apparent as the description which follows is read in conjunction with the accompanying drawings, wherein:

FIG. 1 illustrates, somewhat schematically, portions of a conveyor in a deck of a conventional veneer dryer, portions of power-operated variable drive means for moving the conveyor, portions of a temperature sensor for monitoring the temperature inside the dryer, and portions of a control means provided for controlling the speed of the conveyor through adjustment of the variable drive means; and

FIG. 2 illustrates, diagrammatically, electrical circuits employed in the temperature sensor and control means of FIG. 1.

Turning now to the drawings, and with reference first to FIG. 1, 10 indicates portions of an elongated conveyor in one of the decks of a conventional veneer dryer 12. The conveyor shown has an infeed end 10a adjacent the front of the dryer where veneer sheets are deposited on the conveyor, and an off bearing end 10b located adjacent the discharge end of the dryer. During operation of the dryer, veneer sheets deposited on conveyor 10 (and upon other like decks which are typically provided in such a dryer) move from the front to the discharge end of the dryer through an enclosed heated chamber where moisture is removed from the sheets.

The conveyor deck shown comprises a lower set of rolls 14 journaled on a frame 16 which are rotated under power by means of a chain 18. The chain is trained over suitable sprockets secured to one set of ends of rolls 14. The conveyor deck also includes an upper set of rolls 20, which are gravity rolls, and which press veneer sheets downwardly on lower rolls 14. Drive is transmitted from the lower to the upper rolls by gears, such as star gears 22, 24.

Power-drive means for rotating the rolls of the conveyor comprises a drive motor 26 with its output shaft operatively connected by means of a chain 28 to the

input shaft of an adjustable speed gear box 30. The output shaft of the gear box is connected through a chain 32 and a sprocket assembly 33 to chain 18. Gear box 30 includes an adjusting shaft 34 equipped with a sprocket 36. Shaft 34 may be rotated in one direction to increase the ratio of the speed at which chain 28 moves to the speed at which chain 32 moves. Rotation of shaft 34 in the opposite direction decreases the ratio of the speed at which the two chains move.

Mounted on frame 16 adjacent the front and discharge ends of the dryer are thermocouple devices 38, 40, respectively. The thermocouple devices are electrically connected together in parallel, and are connected to apparatus referred to herein as a control signal producer, indicated generally in block form at 42. The thermocouple devices together with signal producer 42 comprises collectively what is designated as a temperature sensor herein. In the operation of the dryer according to this invention, the thermocouple devices monitor the temperature in the dryer and the temperature sensor functions to detect temperature variations above and below a certain pre-established temperature in the dryer, and to produce one of two kinds of control signals, depending upon whether the variation detected is a temperature rise or a temperature drop below the pre-established temperature.

Indicated in block form at 44 is control means as contemplated herein operatively connected to signal producer 42, responsive to control signals produced by the temperature sensor. Control means 44 is also operatively connected to motor control equipment indicated generally in block form at 46, and control equipment 46 is in turn connected to a reversible electric motor 48. Motor 48 is connected through a gear box 50 and a chain 52 to sprocket 36. Motor 48, together with gear box 30, comprise variable drive means as contemplated herein.

In general terms, with the dryer operating, upon control means 44 receiving a control signal of one type it causes motor control 46 to operate motor 48 in one direction, whereupon gear box 30 is adjusted to speed up the conveyor, and upon receiving a control signal of the other type, it causes the motor control to operate motor 48 in the opposite direction whereby gear box 30 is adjusted to slow down the conveyor.

Considering the construction of apparatus 42 forming part of the temperature sensor, and referring to FIG. 2, it includes a conventional filter shown in block form at 54 operable to pass DC and filter out AC variations, a power supply amplifier 56, and a bridge circuit shown generally at 58.

Thermocouple devices 38, 40 are connected to the input of filter 54. One of the output terminals of filter 54 is connected by a conductor 60 to one of the input terminals of amplifier 56. The other output terminal of the filter is connected by a conductor 62 to sliding contact 64a of a variable resistor 64 which also includes a resistive winding 64b.

Winding 64b forms one part of bridge circuit 58, and is connected in parallel with a pair of series-connected resistors 66, 68 which also form part of the bridge. Bridge 58 further includes a suitable DC voltage supply 70 which is connected in parallel both with winding 64b and with resistors 66, 68. Connecting the bridge to the other input terminal of amplifier 56 is a conductor 72 which is connected to the bridge at the junction between resistors 66, 68.

The output terminals of amplifier 56 are connected by means of conductors 74, 76 to a reversible motor, or motor means, 78. The output shaft of motor 78 is suitably ganged to sliding contact 64a.

Explaining briefly the operation of the temperature sensor, thermocouple devices 38, 40 each monitor the temperature inside the dryer in the respective regions where they are located. The devices each produce a DC

output voltage which is proportional to the temperature measured, and with the two devices connected in parallel, a DC voltage is applied to the input of filter 54 having a magnitude which is proportional to the average mean temperature in the dryer at a given time.

Bridge circuit 58 functions in such a manner that sliding contact 64a has a null position on winding 64b where no voltage difference exists between conductors 62, 72. With contact 64a moved in one direction away from its null position, a DC voltage occurs with one polarity between conductors 62, 72, and when the contact is moved in the opposite direction away from the null position, a DC voltage occurs with the opposite polarity between the conductors.

The sum of the voltages existing between conductors 60, 62 and conductors 62, 72 is applied to the input of amplifier 56. For a given temperature condition in the dryer, if this sum results in a net voltage being applied to the input of the amplifier, the amplifier supplies power to motor 78 causing the motor to operate. The direction in which the motor operates depends upon the polarity of such a net voltage, and this direction is such that the motor causes wiper 64a to move on winding 64b to a position wherein the net voltage applied to the amplifier is reduced to zero. When this occurs, the motor stops.

If any variation occurs in the temperature inside the dryer from the aforementioned given temperature condition, such variation will result in a change in the voltage applied to the input of filter 54, and hence the application of some net voltage again to the input of amplifier 56. Motor 78 will then operate to eliminate again such net voltage.

Turning now to a description of control means 44, the control means includes a bridge circuit 80, or first voltage source means, an amplifier and phase detector, or electrical circuit means, shown in block form at 82, a second voltage source means 84, and an AC transformer 85.

Bridge circuit 80 includes, in one branch thereof, and connected in series, a resistor 86, a variable resistor 88 including a winding 88a and a sliding contact 88b, and a resistor 90. Connected in parallel with this branch of the bridge circuit is a variable resistor 92, having a winding 92a and a sliding contact 92b, and an output winding 85a of transformer 85. Transformer 85 also includes output windings 85b, 85c, and an input winding 85d which is connected to a suitable source of AC power. In FIG. 2, dots are placed adjacent one end of each of the windings of the transformer to indicate electrically corresponding ends of the windings. When the polarity of voltage across the input winding is such that the dotted end of the winding is positive with respect to the other end of the winding, then the polarities of voltages across the output windings are such that the dotted ends of those windings are positive relative to the other ends of the windings.

Sliding contact 88b is suitably ganged to the output shaft of previously-described motor 78 which forms part of the temperature sensor, and is connected by means of a conductor 96 to one of the input terminals of amplifier and phase detector 82. Sliding contact 92b is connected through a conductor 98 to the sliding contact or adjustable means 100a of a variable resistor, or proportioning device, 100 which also includes a resistive winding 100b. One end of winding 100b is connected by a conductor 102 to the other input terminal of amplifier and phase detector 82, and the amplifier and phase detector is also connected to previously-mentioned output winding 85b of transformer 85.

Forming part of motor control 46, which is a conventional motor control unit, are a pair of solenoids 104, 106 connected to the amplifier and phase detector by means of conductors 108, 110 and 112 and 114, respectively. The motor control unit operates in such a manner that upon energizing of solenoid 104 power is supplied

to reversible motor 48 to operate the motor in one direction, and upon energizing of solenoid 106, power is supplied to operate motor 48 in the opposite direction.

The other end of previously-mentioned winding 100b of the proportioning device is connected by means of a conductor 116 to the sliding contact 118a of a variable resistor 118 which also includes a winding 118b. Contact 118a is suitably ganged to the output shaft of reversible motor 48, and winding 118b has its opposite ends connected by means of conductors 120, 122 to opposite ends of winding 85c of transformer 85. The center of winding 85c is connected to ground at 85d. Contact 118a has a null position on winding 118b where no voltage difference exists between conductor 116 and ground.

Considering the operation of control means 44, sliding contacts 88b, 92b may be adjusted to various positions on windings 88a, 92a, respectively, to change the net AC voltage appearing between conductors 96, 98, or to eliminate such net voltage. Sliding contact 118a of source means 84 may be adjusted to various positions on winding 118b to produce a net AC voltage, or to eliminate such net voltage, between conductor 116 and ground. In addition to the ground connection for conductor 116 provided through voltage source means 84 by ground 85d, the conductor is additionally connected to ground through winding 100b, and amplifier and phase detector 82 which is provided with the usual ground connection (not shown). The input voltage to amplifier 82 has two components, namely, as one component, the AC voltage occurring between conductors 96, 98, and as the other component, that portion of the voltage existing between conductor 116 and ground which appears across winding 100b between the connection of conductor 98 with sliding contact 100a and conductor 102. The input voltage to amplifier 82 may, as a consequence, be varied by changing the relative positions of sliding contacts 88b, 92b on windings 88a, 92a, the position of sliding contact 118a on winding 118b, and the position of sliding contact 100a on winding 100b.

The amplifier and phase detector is a conventional unit, and merely functions, upon a net AC voltage being applied to its input terminals through conductors 96, 102, to compare the phase of the voltage between these conductors with the phase of the voltage across winding 85b. This comparison is made after amplification of the voltage appearing between conductors 96, 102.

With no net voltage existing between conductors 96, 102, the phase detector produces no energizing current for solenoids 104, 106. With a net voltage applied between conductors 96, 102 which is in phase with the voltage across winding 85b, the phase detector supplies power to energize solenoid 104, and upon energizing of this solenoid, motor control unit 46 causes reversible motor 48 to operate in such a direction whereby an adjustment takes place in gear box 30 speeding up conveyor 10. Simultaneously with operation of motor 48, the motor slides contact 118a on winding 118b to produce a voltage between conductor 116 and ground of such a phase and magnitude that the portion of such voltage appearing between conductors 98, 102 exactly equals and opposes the voltage between conductors 96, 98. With these two voltages equal and opposite, no net voltage is applied to the input of the phase detector, solenoid 104 de-energizes, and reversible motor 48 stops. During the operation of motor 48, gear box 30 is adjusted to cause speeding up of conveyor 10.

If the compared voltages are out of phase with one another, the amplifier and phase detector supplies power to energize solenoid 106. Upon energizing of this solenoid, the motor control unit causes reversible motor 48 to operate in the opposite direction, to produce adjustment in gear box 30 whereby conveyor 10 is slowed down. Simultaneously with operation of motor 48, sliding contact 118a is moved on winding 118b to reduce the net voltage applied to the input of the phase detector to zero.

When this occurs, solenoid 106 de-energizes and motor 48 stops, with conveyor 10 now moving at a slower speed than it had prior to operation of the motor.

Considering the operation of proportioning device 100, which in the circuit constitutes a voltage divider, it has already been described how the net voltage applied to amplifier 82 between conductors 96, 102 comprises, as a component, the voltage appearing across winding 100b between the point of engagement of sliding contact 100a and conductor 102. The position of sliding contact 100a of the proportioning device may be adjusted manually by the operator of the dryer, such adjustment permitting the operator to control the amount of change in dryer speed which occurs on a given net voltage appearing between conductors 96, 102. Should the operator adjust sliding contact 100a to place it near the top of winding 100b in FIG. 2, a relatively small change in the position of sliding contact 118a on winding 118b will produce a relatively large voltage change in the portion of winding 100b providing a part of the input voltage to phase detector 82. Hence, on a given net voltage occurring between conductors 96, 102 reversible motor 48 will run for a relatively short time in eliminating any net voltage to the input of phase detector 82. With a short running period relatively little change takes place in conveyor speed. On the other hand, if sliding contact 100a is adjusted to place it near the bottom of winding 100b, the reversible motor must run for a considerably longer time before eliminating the net voltage applied to the phase detector, and with a longer running time a greater change in dryer speed takes place.

Generally speaking, articles which, for a given dryer temperature, take a relatively long time to dry require a greater change in conveyor speed for a particular change in dryer temperature, than those which take a relatively short time to dry. Thus, thick veneer sheets require a substantial change in dryer speed for a given variation in temperature, while thin sheets a relatively small speed change.

Describing now the operation of the apparatus as a whole let it be assumed for purposes of illustration that relatively thin, quickly dried veneer sheets are the articles being handled, and that with a temperature ordinarily available in a dryer of 350° F., a dryer speed is required which will produce a drying time of eight minutes for the sheets. With such sheets, where a change in dryer temperature requires a relatively small compensating change in dryer speed, proportioning device 100 is adjusted to place its sliding contact 100a near the top of winding 100b in FIG. 2. Charts compiled from data obtained on past experimentation enable the operator to select fairly precisely the exact position for the sliding contact.

With the position of the contact in proportioning device 100 set, and with the temperature in the dryer at the desired 350° F., thermocouple devices 38, 40 produce a voltage applied to amplifier 56 in control signal producer 42 causing operation of motor 78. The motor runs until such time as contact 64a (which is ganged to the motor) moves to a position on winding 64b reducing the net voltage applied to amplifier 56. With running of motor 78, sliding contact 88b is moved to some adjusted position on winding 88a.

The operator now adjusts manually the position of sliding contact 92b of variable resistor 92 to obtain a conveyor speed in the dryer resulting in the desired eight minute drying time. With adjustment of contact 92b, an unbalanced condition is produced resulting in a net AC voltage being applied to phase detector 82, such as will cause operation of reversible motor 48 producing adjustment of gear box 30. The phase of such voltage will depend upon whether the operator wishes the conveyor to speed up or to slow down, which determines whether he adjusts the sliding contact to the right or to the left on

winding 92a in FIG. 2. Ultimately, when the desired conveyor speed is reached the circuit in control means 44 will be in balance with the application of no net voltage to phase detector 82.

If the conveyor of the dryer is now loaded with veneer, and assuming that no temperature change occurs in the dryer, the speed of the conveyor will remain constant with eight minutes being required for sheets to travel through the dryer. Should, however, a temperature change occur in the dryer, such as a rise in temperature, a change will take place in dryer speed which results in the same type of drying for the type of sheets handled as would have occurred had no temperature change taken place. Thus, with the increase in temperature, the thermocouple devices produce an increase in volume resulting in a net voltage being applied to amplifier 56. Motor 78 runs for a short time period until such net voltage is cancelled by adjustment of wiper 64a on winding 64b, and adjustment also takes place in sliding contact 88b resulting in a net voltage being applied to phase detector 82 of such phase as to cause reversible motor 48 to produce adjustment of gear box 30 to increase the running speed of the conveyor. By reason of the initial adjustment made in the proportioning device, which results in a relatively short operating period for reversible motor 48 for a slight imbalance occurring in bridge circuit 80, there will be a relatively small speeding up of the conveyor.

Should a temperature drop occur in the dryer, the conveyor in the dryer is slowed down by reason of a net voltage of opposite phase being supplied to phase detector 82 from bridge circuit 80.

With thick sheets requiring longer drying time, where a substantial change in dryer speed is required to compensate for a given temperature variation in the dryer, proportioning device 100 is adjusted to place its sliding contact 100a closer to the bottom of winding 100b in FIG. 2. This means that for a given net voltage applied to the input of phase detector 82, the operating period of reversible motor 48 is considerably longer than the operating period which takes place with the first-described adjustment for the proportioning device.

Thus, it will be appreciated that the apparatus disclosed herein responds substantially immediately to any temperature variation occurring inside a dryer. The apparatus operates continuously and automatically without requiring the constant attention of an operator. By employing bridge circuits in the temperature sensor and in the control means, the apparatus readily and accurately produces the proper adjustment in dryer speed which is required for each temperature variation. The proportioning device enables the apparatus to produce the correct compensation in dryer speed for articles having widely varying drying characteristics.

It should be apparent that while only a single conveyor deck of a dryer has been illustrated herein, the apparatus shown is readily adaptable to control the speeds of all conveyors in a dryer. Additionally, while certain drying temperatures and times have been specified, and the drying of veneer has been specifically described, it should be understood that this has been for the purpose of illustration only. Obviously, other temperature conditions and conveyor speeds are possible, and the apparatus of the invention is suitable for the drying of other articles than veneer.

While an embodiment of the invention has been disclosed herein, it is appreciated that variations and modifications are possible without departing from the spirit of the invention. It is desired to cover all such variations and modifications that would be apparent to one skilled in the art, and which come within the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In a heated dryer having a conveyor deck for moving articles to be dried through the dryer,
a temperature sensor for detecting temperature varia-

tions operable to produce a related control signal on detecting such a variation,

power-operated variable drive means connected to said conveyor deck for operating the deck and to produce movement of articles through the dryer, adjustable to speed up and slow down such movement of articles, and

control means connecting said sensor and said variable drive means producing automatic adjustment of said drive means and related change in the speed of movement of articles through the dryer compensating for temperature variations detected by said sensor, said control means comprising a proportioning device including means which may be adjusted to change the amount of adjustment of said drive means produced by said control means for a given temperature variation occurring in the dryer.

2. The apparatus of claim 1, wherein said temperature sensor produces one type of control signal upon detecting a temperature rise above a given pre-established temperature and another type of control signal upon detecting a temperature drop below the pre-established temperature, and said control means operates, upon said sensor producing said one type of control signal, to produce adjustment of said drive means to speed up the movement of articles through the dryer, and upon said sensor producing said other type of control signal, to produce adjustment of said drive means to slow down the movement of articles through the dryer.

3. The apparatus of claim 2, wherein said control means further comprises electrical circuit means including an input, said circuit means being adapted, upon a voltage being applied to its said input, to effect the supply of power to said drive means whereby adjustment of the drive means occurs, first voltage source means operatively connected to said input operable, upon a control signal being produced by said temperature sensor, to apply a voltage to said input, and second voltage source means operatively connected to said input in series with said first voltage source means operable, with a voltage applied to said input by said first voltage source means, and upon adjustment of said drive means, to produce a voltage compensating for the voltage produced by said first voltage source means thereby to reduce the net voltage applied to said input to zero.

4. The apparatus of claim 3, wherein said second voltage source means includes a variable resistor operatively connected to said drive means operable, upon adjustment of said drive means, to adjust the voltage output of said second voltage source means.

5. The apparatus of claim 3, wherein said proportioning device comprises a variable resistor operatively connected between said second voltage source means and said input.

6. The apparatus of claim 3, wherein said first voltage source means comprises a bridge circuit including a first variable resistor operatively connected to said temperature sensor adjustable, upon said sensor producing a control signal, to produce a corresponding voltage for said first voltage source means applied to said input.

7. The apparatus of claim 6, wherein said bridge circuit further includes a second variable resistor manually operable independently of said first variable resistor to vary the voltage applied by said first source means to said input.

8. The apparatus of claim 6, wherein said temperature sensor includes power-operated motor means operatively connected to said first variable resistor operable, upon being supplied with power, to produce adjustment of said device, power-supply amplifier means having an input operable, upon a voltage being applied to its said input, to supply operating power to said motor means, thermocouple means mounted on the dryer monitoring the temperatures therein operatively connected to the input of said amplifier, means adapted to apply a voltage to said input of said amplifier means with such voltage corresponding to the temperature in the dryer, and a bridge

circuit operatively connected to the input of said amplifier means operable, with voltage applied by said thermocouple means to said input, and upon operation of said motor means, to apply a voltage to said input compensating for the voltage produced by said thermocouple means reducing the net voltage applied to the input of said amplifier means to zero.

9. The apparatus of claim 8, wherein the bridge circuit of said temperature sensor includes a variable resistor operatively connected to said motor means adjustable, upon operation of said motor means, to vary the voltage

applied by the bridge circuit to the input of said amplifier means.

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