United States Patent [19]

Wilkening et al.

[11] **3,739,484**

[45] **June 19, 1973**

[54] **PRESSURE REGULATING SYSTEM FOR A DRYER APPARATUS**

[75] Inventors: **Gail A. Wilkening**, Beaverton; **Ervin R. Hefley**, both of Portland, Oreg.

[73] Assignee: **E. V. Prentice Co.**, Portland, Oreg.

[22] Filed: **Apr. 24, 1972**

[21] Appl. No.: **247,033**

[52] **U.S. Cl.** ..... **34/51**, 236/15 C, 98/1.5, 34/54

[51] **Int. Cl.** **F26b 21/06**

[58] **Field of Search** 34/54, 51, 50, 15, 34/72, 16, 16.5; 98/1.5; 137/487.5

[56] **References Cited**

UNITED STATES PATENTS

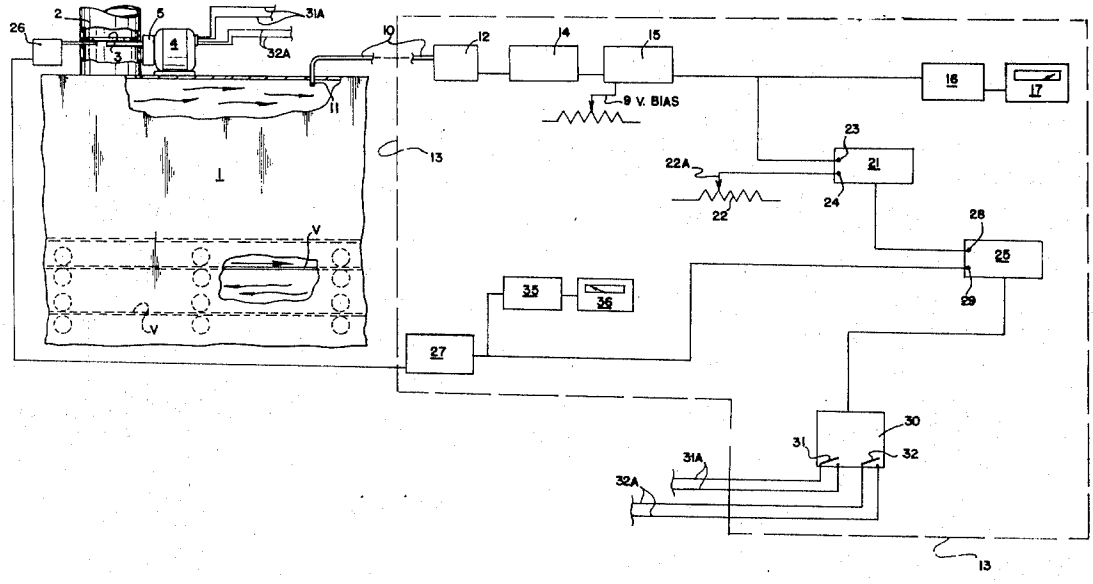
3,527,241	9/1970	Bristow et al.	137/487.5
3,324,566	6/1967	Dietert	34/54

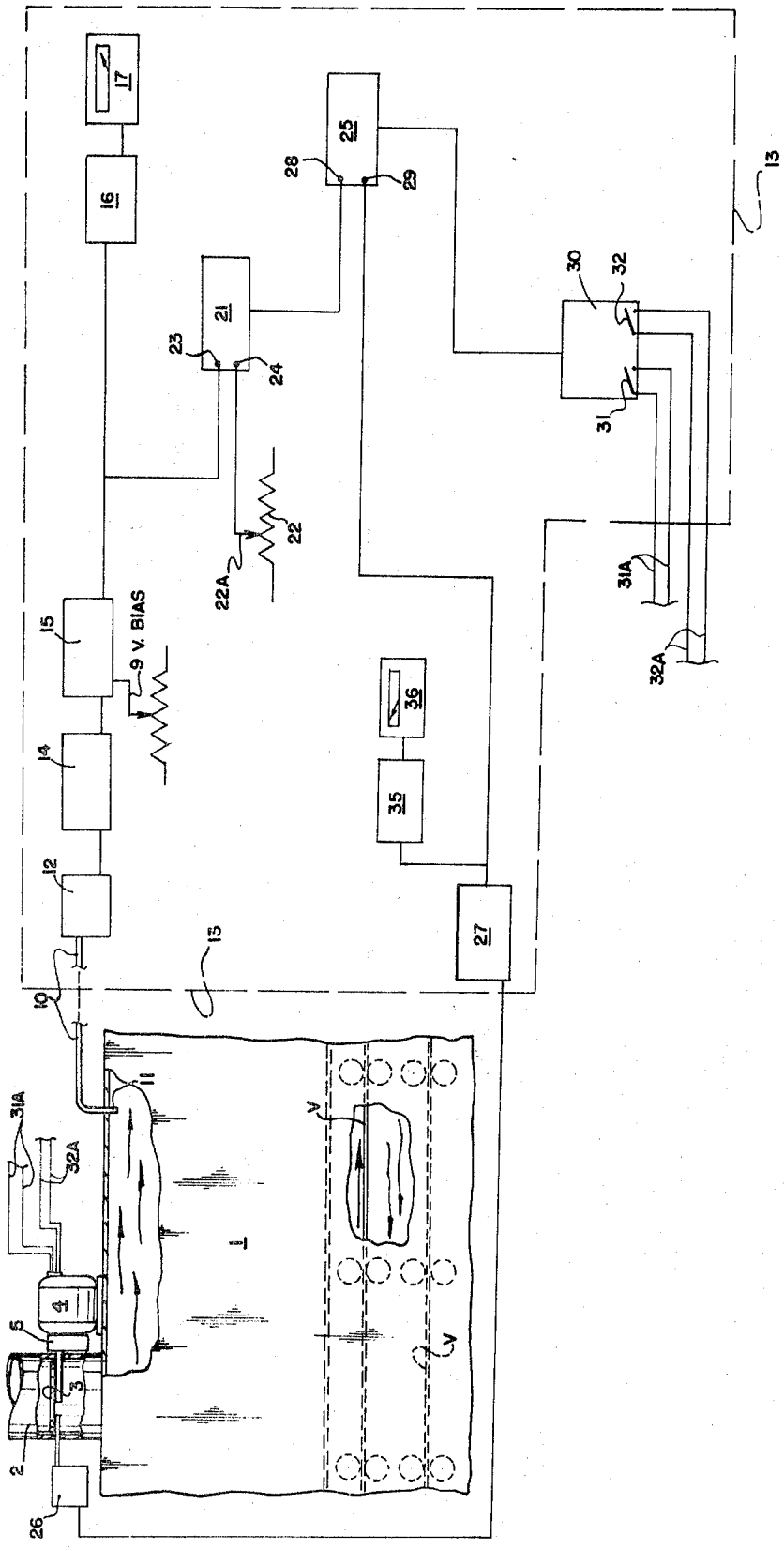
Primary Examiner—William F. O'Dea
Assistant Examiner—Paul Devinsky
Attorney—James D. Givnan, Jr.

[57] **ABSTRACT**

A system for regulating internal dryer vapor pressure to provide a continuous, optimum pressure for the wood veneer being dried. A voltage proportional to dryer pressure is compared with a settable voltage corresponding to optimum dryer pressure with the potential difference therebetween being detected by a first differential amplifier. The output signal of said amplifier constitutes an error signal to a second differential amplifier. Said second differential amplifier compares said error signal with a voltage proportional to the position of a power operated damper. Switch means in circuit with said second amplifier includes high and low voltage actuated relays which energize a damper motor for operation in opposite directions for opening and closing the damper to decrease or increase dryer pressure. In a balanced condition wherein the dryer is operating within an optimum pressure range the output of said second amplifier is such as to cause the high and low relays to remain open and hence the damper and dryer pressure being static.

10 Claims, 1 Drawing Figure




17
16
25
28
29
13
30
32
21
23
24
31
22
22A
31A
32A
9 V. BIAS
15
14
12
36
35
27
10
11
V
V
1
4
5
3
2
26

PRESSURE REGULATING SYSTEM FOR A DRYER APPARATUS

BACKGROUND OF THE INVENTION

The present invention concerns dryers for the drying of wood veneer sheets as they are conveyed therethrough and particularly to a system for regulating internal dryer pressure to achieve the drying action desired.

Wood veneer dryers serve to reduce the moisture content of peeled wood veneer sheets prior to the sheets being further utilized as for example being joined as laminates of a plywood panel. Drying of veneer is critical in that over drying causes excessive sheet shrinkage and can depreciate the sheet surface to prevent later satisfactory bonding to other laminates. Under drying can also result in unsatisfactory bonds and, at the least, requires a re-cycling of the under dried sheets back through the dryer apparatus.

In an effort to monitor veneer sheet drying, prior improvements have included means sensing both temperature and moisture content of moving veneer sheets during and after passage through a dryer. Said means operates in conjunction with dryer speed and/or temperature controls for changing the conveyor speed and hence duration of a sheet drying time within a dryer or the dryer operating temperature. Dryers so equipped represent an advance over early dryers but do not, however, provide a direct, fast response to internal dryer conditions.

For the most part regulation of air or vapor pressure within a dryer has been left to the individual talents of the dryer operator. Damper controls, often as not, were set and then infrequently checked by the operator. Internal dryer pressure accordingly has not been utilized as an important dryer control factor.

SUMMARY OF THE PRESENT INVENTION

The instant invention is embodied within a system for regulating the air, or more accurately vapor pressure within a drying apparatus. Such an apparatus characteristically provides a heated flow of pressurized vapor about the articles passing therethrough. Regulation of the vapor pressure importantly results in the control of dryer air humidity not heretofore continuously monitored for optimum dryer operation. Since vapor pressure may be readily correlated to dryer humidity the present system enables control of the latter.

In the present system a vapor pressure value, taken from the internal airflow of the dryer, is converted into an amplified electrical signal proportional to the pressure. Such pressure commonly ranges from 3 to 10 inches of water depending on the dryer make and whereat in the dryer the pressure is taken.

A first fixed-gain, differential amplifier serves to compare the amplified signal with an adjustable set point voltage which has a value corresponding to the optimum dryer pressure desired to be maintained. The differential amplifier generates an error signal any time said amplified pressure signal input varies from the set point voltage. The error signal is applied to a second fixed-gain, differential amplifier which additionally receives a second voltage signal corresponding to the present position of dryer damper means. In a balanced condition (both inputs being of equal voltage) the second differential amplifier emits a medial voltage while an unbalanced condition results in a higher or lower

switch actuating voltage which in turn ultimately controls a reversible damper control motor. The repositioning of the damper results in a change in the dryers internal pressure returning same to that desired at which time the error signal is cancelled. Accordingly, the present system seeks at all times to provide a desired pressure within the dryer by positioning of the dryers damper, the desired pressure being correlative with optimum dryer humidity.

As dryers may have multiple zones each including burners and damper controlled exhaust stacks, it will be appreciated that the present apparatus may be used therewith in a multiple manner for controlling all of said zones.

Operator controlled pressure changes are provided for to achieve optimum drying of different veneer batches with varying moisture content and of the same or different thicknesses. For example, and assuming temperature and drying duration are constant, veneer sheets of ¼inch thickness will require a dryer environment of lower humidity than that required for drying ⅛ inch thick veneer sheets. Convenient adjustment of the set point voltage by the operator provides for such a pressure change (and humidity change) without interfering with subsequent automatic operation of the system.

Accordingly, an important object of the present system is the provision of a system for automatically regulating vapor pressure of a dryer structure to, in turn, achieve optimum dryer humidity which otherwise would not be possible other than by use of elaborate, costly test apparatus not suitable to the typical dryer installation.

A further object of the present invention is the provision of a system readily adaptable for use with existing dryer structures and requiring the addition of but damper associated components and a pressure lead to the dryer. Accordingly, no costly modification of the dryers burners or of the sheet conveying means are required.

BRIEF DESCRIPTION OF THE DRAWING

With attention to the accompanying drawing, the single FIGURE thereof illustrates, in block form, electrical components of the present system with a fragment of the dryer structure including a damper equipped dryer stack in venting communication with a dryer housing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With continuing reference to the accompanying drawing wherein applied reference numerals indicate parts similarly identified in the following specification, the reference numeral 1 indicates a fragment of a wall of a dryer apparatus. The particular dryer shown and described is for the drying of wood veneer and includes horizontal conveyor means termed decks which are provided in multiple, stacked fashion with each deck including conveyor components for movement of veneer panels V along vertically spaced courses through the dryer.

A dryer heat source in the form of multiple burners, in combination with blowers, discharge a pressurized flow of heated air into the circulation type dryer shown while fans circulate said flow within the dryer enclosure. Accordingly, a flow of heated air is directed into

contact with the moving veneer sheets normally in a direction opposite to that of sheet travel as per applied arrows. In the past, the drying effect of the airflow has been dependent on the variables of duration of sheet exposure and internal dryer temperature.

The present system provides an additional variable, i.e., dryer pressure which heretofore has been fully utilized as a dryer controlling factor.

Circulating dryers typically include exhaust stacks as at **2** which include a damper at **3** for controlling vapor exhaust. A reversible damper control motor is indicated at **4** which drives the damper **3** in opposite directions through a reduction drive **5.** A gear reduction drive providing for 90° of damper movement per 60 seconds of motor operation has provided satisfactory.

The application of the present system to dryers known in the trade as jet dryers with multiple drying zones and heating and exhaust means associated with each zone is equally feasible with the present system.

PRESSURE SIGNALING MEANS

Indicated at **10** is a pressure line having an inlet end **11** located desirably within a relatively high pressure area of the dryer the location of which area will vary in different makes and types of dryers. The pressure line **10** terminates exteriorly of the dryer within a pressure transducer **12** located within a control panel represented by a dashed line **13** which may be removed from the dryer structure. Pressure transducer **12** converts a normal operating pressure of 0 to 10 inches of water column pressure within the dryer to a proportional electrical signal. A first amplifier at **14** proportionally increases the signal received to between three to fifteen volts DC representing a dryer operating pressure of from 0 to 10 inches water. For ease of understanding a specific embodiment of the present apparatus will be described without any intention of so restricting the invention.

A second amplifier at **15** compares this 3 to 15 volt signal to a fixed voltage reference, for example, 9 volts DC constituting a bias which inhibits the output of the second amplifier. Accordingly, a 3 volt output of amplifier **15** may correspond to 5 inches water column pressure within the dryer with a 15 volt output corresponding to 10 inches of pressure. This adjustment of amplifier **15** is with reference to a particular dryer, one having a pressure operating range of from 5 to 10 inches pressure. In those dryers where operating pressures range from 0 to 10 inches water column pressure the second amplifier **15** may be dispensed with as no suppression is required.

The signal from the second amplifier drives voltage-to-current conversion means at **16** which produces a proportional 0–500 current signal to drive a meter **17** calibrated to read inches of water.

DIFFERENTIAL AMPLIFIERS

The signal from amplifier **15** (3 to 15volts) additionally constitutes one input voltage into a differential, fixed-gain amplifier **21** referred to hereinafter occasionally as first differential amplifier means. A second voltage input into said amplifier means, for comparison thereby with said one input voltage, originates within a variable resistor **22** having a positionable wiper contact **22A** to provide a desired set point voltage. The set point voltage is set manually to correspond to the vapor pressure desired for example, 8 inches water column, to be maintained in the dryer as read from meter **17.** In the installation and calibration of the present system the adjustment of voltage output of the varible resistor **22** will be such as to provide a voltage to differential amplifier **21** equal to that from amplifier **15** when the dryer is at optimum operating pressure for the specific batch of veneer sheets being dried. From prior operating information the set point voltage from resistor **22** may be set which voltage will result in the dryer pressure desired.

Differential amplifier **21** compares the two input voltages by measuring the signals ' potential difference and producing an output signal comprised of the amplifiers normal output voltage increased or decreased by the amplified differential. Such an output from amplifier **21** is termed an error signal and will range from 3 to 15 volts DC in the described embodiment. For example, assuming the input signals applied to terminals **23–24** are equal, differential amplifier **21** will have a normal output of 9 volts while a voltage increase at terminal **23** exceeding the set point voltage at terminal **24** will result in an increased voltage output (above 9 volts) of differential amplifier **21.** A voltage decrease at terminal **23,** below the set point voltage applied at **24,** will result in a voltage drop in the output of differential amplifier **21.** This lower or higher output signal during unbalanced conditions is termed the error signal and constitutes an input to second differential amplifier means at **25** also of the differential, fixed-gain type. The origin of the remaining input into differential amplifier **25** will now be described.

A potentiometer **26** is suitably coupled to the stack damper **3** with the resistance of the potentiometer varying with movement of the potentiometers wiper contact during powered damper movement. Sensing the changes in the resistance of potentiometer **26** is a voltage source **27** having an output range of from 3 to 15 volts DC proportional to the range of potentiometer resistance values. The damper position voltage output of voltage source **27** constitutes the other or second voltage input into differential amplifier **25** at its terminal **29** for comparison therein with the error signal voltage applied at terminal **28** from amplifier **21**

Potentiometer **26** and voltage source **27** constitute damper signal producing means.

The second differential amplifier **25,** in similarity to the first described, has a normal output voltage altered by the amplification of the voltage potential difference applied at its terminals **28–29.** An output signal range of from 3 to 15 volts DC is accordingly provided which is applied to motor controlling switch means **30** having self-contained high-low relays **31–32** with the high relay switch contacts set to close at a preset voltage above 9 volts and the low relay set to close at a preset voltage below 9 volts. In a balanced condition of amplifier **25** its normal output voltage of 9 volts is applied to the switch means **30** resulting in neither relay being actuated and hence the damper remaining static. A typical calibration of switch means **30** may include the setting of a high limit relay **31** to close at 65% of maximum signal to drive the damper motor **4,** via leads **31A,** in a damper opening direction. The low limit relay **32,** in switch means **30,** may be set to close at 35% of maximum signal to drive the damper motor, via leads **32A,** in an opposite or closing direction. Voltage outputs intermediate 35% – 65% of maximum signal are ineffec-

tual. The above percentage relay set points are typical and may be varied to prevent excessive cycling.

For the purpose of providing an indication of the damper position a meter **36** is provided while voltage-to-current means at **35** which converts the 3 to 15 volt output of the voltage generator **27** to a proportional current level for said meter.

One entirely satisfactory embodiment of the invention utilizes the following components which is set forth by way of example and is not intended to imply any limitations as to use of equivalent components in the present system:

pressure transducer **12**; Autocon differential pressure transducer **2101**DA;

amplifiers **14** and **15**; Auto-Mod amplifier **8202**VF;

voltage-to-current means **16** and **35**; Auto-Mod meter interface module **8203**CA;

differential, fixed-gain amplifiers **21** and **25**; Auto-Mod comparator **8208**CA;

switch means **30**; Auto-Mod limit/alarm card **8204**AA;

voltage source **27**; Auto-Mod level input **8202**MA.

The Auto-Mod prefix is used to idenfity module components manufactured by Autocon Industries,Inc., of St. Paul, Minnesota. Further, the above components are powered by a power supply identified as Auto-Mod Power Supply **8201**PB with system voltage of 24 volts DC provided by a common power supply including a transformer for reduction of line power.

In the initial calibration of the system, the position of wiper contact **22**A may be adjusted along resistor **22** until the meter **17** indicates the dryer operating pressure desired for the veneer batch being dried. Operating records will provide about what resistor output is required for a desired dryer pressure.

In operation, a higher than optimum dryer pressure for example will result in the input voltage at terminal **23** of amplifier **21** exceeding the settable voltage input from resistor **22.** Accordingly, the error signal applied at terminal **28** to the second differential amplifier will exceed the voltage applied at terminal **29** representing the position of damper **3.** Depending on the potential difference therebetween the normal voltage output of amplifier **25** will be altered, in the present example increased above 65% of maximum signal resulting in the closure of the high limit relay **31** in switch means **30** causing opening movement of damper **3.** With damper **3** moving slowly towards an open position the internal dryer pressure slowly recedes and eventually the voltage input at terminal **23** is reduced to the preset voltage input applied at terminal **24.** Accordingly, the error signal therefrom is reduced to the amplifiers normal output of for example 9 volts. Damper motor **4** wll stop damper opening movement upon the high limit relay **31** opening which occurs when the output signal from amplifier **25** drops below 65% of maximum signal (15volts DC). This voltage drop is achieved by the damper signal voltage at terminal **29** decreasing to approximately the normal output voltage of amplifier **21** applied at terminal **28.** The amplified differential signal applied to switch **30** is accordingly reduced below 65% (of 15 volts, or 9 and ¾ volts) to open relay **31.** The operation of the system to remedy a lower than desired dryer pressure is believed obvious from the above.

While the foregoing is rendered with regard to a typical embodiment of the present invention it is not intended to restrict the scope of protection sought as obvious changes will be readily apparent to those skilled in the art with such changes coming within the scope of the appended claims.

What we desire to secure under a United States Letters Patent is:

1. A system for regulating the internal vapor pressure and humidity of a veneer drying apparatus having adjustable damper means, said system comprising,

pressure signaling means responsive to dryer pressure and providing an electrical input signal proportional to said pressure,

first differential amplifier means having a normal output voltage and amplifying the voltage difference between two input signals one of which being the amplified pressure signal, the voltage difference detected causing an increase or decrease from the amplifiers normal output voltage to constitute an error signal,

means providing a second voltage input to said differential amplifier means and being adjustable to provide a variable voltage input signal equal to the signal of said pressure signaling means when the dryer is operating at a desired pressure, the desired pressure being different for batches of veneer having different thicknesses and moisture content,

second differential amplifier means having a normal output voltage and comparing voltage inputs and having an amplified output proportional to the voltage difference therebetween when inputs are unbalanced,

damper signal producing means associated with a damper for the dryer and providing an electrical input signal the voltage of which varies with the damper position,

said second amplifier means comparing the error signal from the first amplifier means and the damper position signal input and providing an output proportional to the voltage difference therebetween,

switch means in circuit with said second amplifier means and responsive to voltage inputs above and below preset values to close high and low voltage switch contacts therein,

power driven dampener means in circuit with said switch contacts and positioning said damper toward open or closed positions in response to the closing of said high or low switch contacts, and

the operation of the power driven damper means automatically terminating when the output of said second amplifier returns to a voltage intermediate the preset voltage values of said high and low switch contacts.

2. The system as claimed in claim **1** additionally including a meter calibrated to indicate internal dryer vapor pressure, means for converting the dryer pressure signal into meter driving amperage.

3. The system as claimed in claim **2** wherein said pressure signalling means includes a pressure transducer in communication with the dryer interior and amplifier means.

4. The system as claimed in claim **3** wherein said pressure transducer is in communication with an internal area of the dryer having relatively high vapor pressure.

5. The system as claimed in claim **1** additionally including a meter calibrated to indicate damper position, means converting the damper position signal into meter driving amperage.

6. In combination with a veneer dryer apparatus having an internal heated airflow for the drying of veneer conveyed therethrough, said apparatus having one or more air outlets regulated by power operated damper means, the improvement comprising a system for regulating internal dryer vapor pressure and humidity including,

a pressure responsive device providing an electrical signal proportional to internal dryer pressure,

means amplifying said signal,

first differential amplifier means having a normal output voltage and amplifying the voltage difference between two input signals one of which being the amplified dryer pressure signal, the remaining input signal being a settable voltage, the voltage difference detected causing an increase or decrease from the amplifiers normal output voltage to constitute an error signal,

means providing said remaining input signal and being adjustable to provide a variable voltage input signal, said input signals being substantially equal when the dryer is operating at a desired pressure, the desired pressure being different for batches of veneer having different thicknesses and moisture content,

second differential amplifier means having a normal output voltage and amplifying the voltage difference between two signal inputs one of which being the error signal from said first differential amplifier,

damper signal producing means providing the second signal input into said second amplifier means with the last mentioned input increasing and decreasing with changes in the position of the dryers damper means,

said second differential amplifier means producing, during an unbalanced signal input condition, an output signal proportional to the difference between the voltage of its two input signals, the voltage difference detected causing an increase or decrease from the second amplifier normal output voltage,

switch means including high and low voltage switch contacts closeable in response to the increase or decrease away from the normal voltage output of said second amplifier means, said switch contacts in circuit with the power operated damper means of the dryer apparatus for movement of the damper toward an open or closed position to respectively lower or raise internal dryer pressure toward the desired dryer pressure, and

the operation of the power driven damper means automatically terminating when the output of said second amplifier returns to a voltage intermediate the preset voltage values of said high and low switch contacts.

7. The system as claimed in claim 6 additionally including a meter calibrated to indicate internal dryer pressure, means for converting the dryer pressure signal into meter driving amperage.

8. The system as claimed in claim 7 wherein said pressure responsive device is a pressure transducer in pressure communication with the dryer interior.

9. The system as claimed in claim 8 wherein said pressure transducer is in communication with an internal area of the dryer having relatively high vapor pressure.

10. The system as claimed in claim 9 additionally including a meter calibrated to indicate damper position, means converting the damper position signal into meter driving amperage.

* * * * *