

June 30, 1953

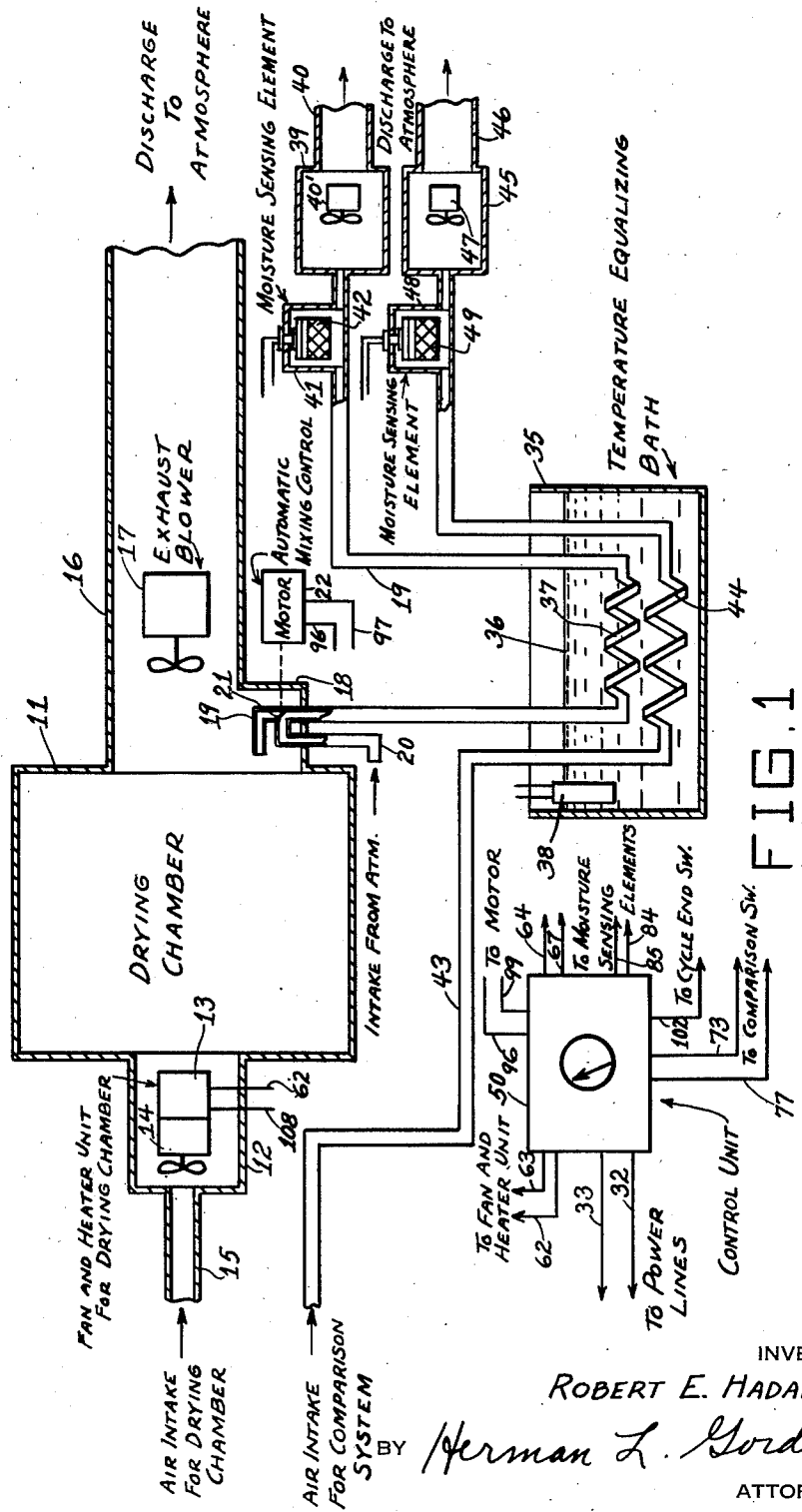
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2,643,464

AUTOMATIC DRYING CONTROL SYSTEM

Filed March 7, 1949

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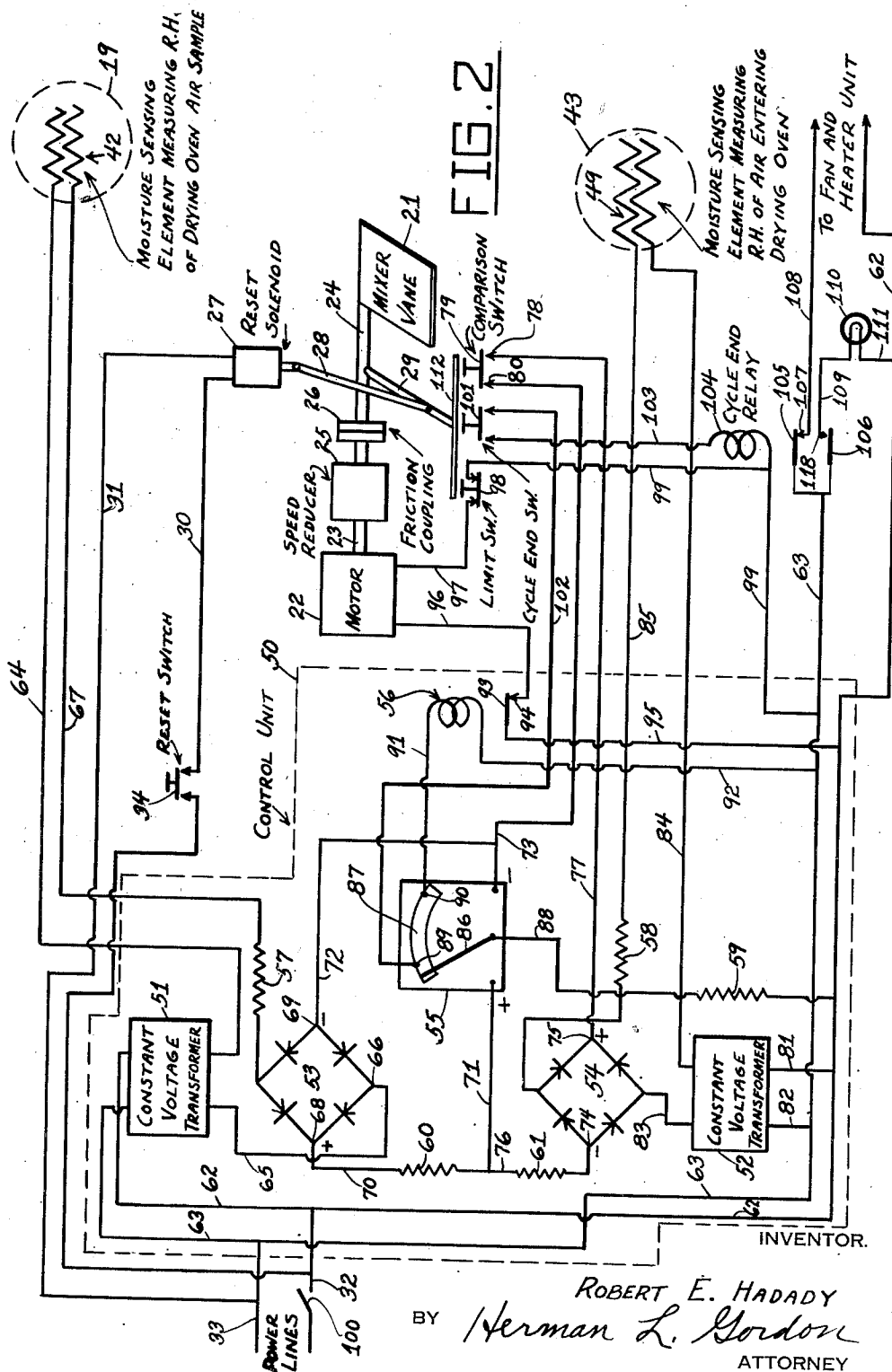
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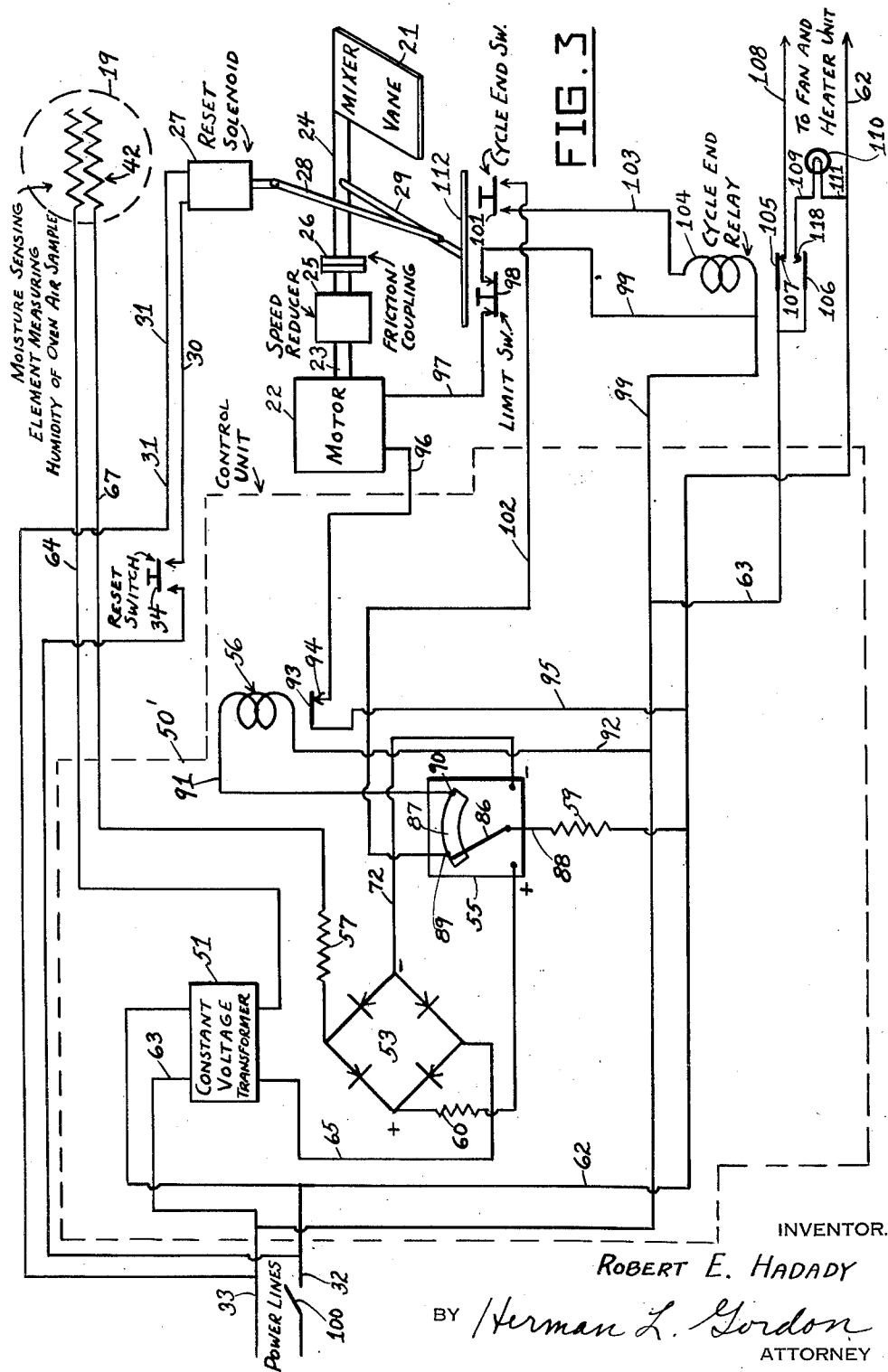
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AUTOMATIC DRYING CONTROL SYSTEM

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UNITED STATES PATENT OFFICE

2,643,464

AUTOMATIC DRYING CONTROL SYSTEM

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Application March 7, 1949, Serial No. 79,949

15 Claims. (Cl. 34—48)

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This invention relates to drying apparatus, and more particularly to a drying apparatus of the hot air automatic type.

A main object of the invention is to provide a novel and improved drying apparatus which is simple in construction, automatic in operation, and which is very reliable in performance.

A further object of the invention is to provide an improved drying system of the hot air automatic type wherein the moisture content of the air leaving the drying chamber is compared with that of the atmosphere and wherein the source of drying heat is automatically controlled in accordance with the results of such comparison, whereby no human supervision of the heat source is required and whereby uniformity of drying of the material to be dehydrated is obtained.

A still further object of the invention is to provide an improved automatic drying system of the hot air type employing the principle of comparing the moisture content of a sample of the air leaving the drying chamber with that of atmospheric air at a common temperature, and wherein means are provided for preventing condensation of the moisture in the sample of air leaving the drying chamber, whereby inaccurate operation of the system due to such condensation is prevented, and whereby the reliability of operation of the system is greatly increased.

A still further object of the invention is to provide an improved automatic drying system of the hot air type wherein a sample of the air leaving the drying chamber is compared as to moisture content with atmospheric air at a common temperature and wherein automatic means are provided for mixing the hot air sample with atmospheric air and maintaining the mixture at all times in a condition below saturation as to moisture content, whereby condensation in the system is prevented and whereby inaccurate operation of the system is avoided.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a schematic drawing illustrating the conduit connections of an automatic drying system constructed in accordance with the present invention.

Figure 2 is a schematic wiring diagram showing the electrical connections of one form of automatic drying system constructed in accordance with the present invention.

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Figure 3 is a schematic wiring diagram illustrating the electrical connections of a second form of the invention wherein control of the system in terms of the absolute moisture content of the material being dried is obtained.

Referring to the drawings, 11 designates a suitable chamber or oven in which the articles to be dried are placed. Chamber 11 is provided with an air intake section 12 in which is mounted an electric heater 13 or other electrically controlled heater. Said heater may be equipped with a conventional blower unit 14 for moving air past the heating coils of heater 13 into the drying chamber 11. Designated at 15 is the air intake duct which communicates with the atmosphere. The exhaust duct leading from drying chamber 11 is shown at 16. A conventional exhaust blower 17 may be mounted within exhaust duct 16 if so desired.

At its connection to drying chamber 11 the exhaust duct 16 is formed with an enlarged portion 18, and projecting into said enlarged portion through its wall is an air sampling conduit 19. Designated at 20 is an air intake conduit which also extends through the wall of said enlarged portion 18 adjacent conduit 19 and connects with conduit 19 inside said enlarged portion. Pivoted within conduit 19 at its junction with conduit 20 is a flap valve 21. Valve 21 may be rotated from a normal position, wherein the upper portion of conduit 19 is closed off and conduit 20 connects the remainder of conduit 19 to atmosphere, toward a position wherein conduit 20 is closed off with respect to conduit 19 and the upper portion of conduit 19 is in unrestricted communication with the lower portion of conduit 19. Flap valve 21 is connected in a suitable manner to the shaft of an external motor 22 so that when motor 22 is energized the valve 21 is rotated from its normal position, shown in Figure 1, toward the position wherein the conduit 20 is closed off with respect to conduit 19 and conduit 19 is unrestricted. During such periods wherein flap valve 21 is in an intermediate position, the lower portion of conduit 19 may receive air from both the drying chamber 11 and from the atmosphere.

As shown in Figures 2 and 3, the shaft of motor 22, shown at 23, is connected to the shaft of flap valve 21, shown at 24, through a speed reducing unit 25 and a friction coupling 26. Friction coupling 26 transmits driving torque to shaft 24 in one direction but allows shaft 24 to be rotated in the opposite direction without requiring motor 22 to be reversed. This reversal of shaft 24 may be

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accomplished by means of a reset solenoid, shown at 27, whose plunger is connected by a link 28 to an arm 29 secured to shaft 24. The winding of solenoid 27 is connected by conductors 30 and 31 to the power lines, shown respectively at 32 and 33. A normally open push button reset switch 34 is interposed in conductor 30, whereby solenoid 27 is normally deenergized.

Designated at 35 is a suitable tank or container having liquid 36 therein maintained by suitable thermostatic means 38 at a substantially constant temperature. The precise value of this temperature is unimportant except that it must be above the ambient temperature of the atmosphere and below the maximum operating temperature within the drying chamber. For practical reasons, a preferred value would be within the range between 100° and 130° Fahrenheit, since this would place the measured relative humidity within the working range of present relative humidity measuring equipment.

The lower portion of conduit 19 is formed with coils 37 which are immersed in the temperature-controlled liquid 36. From the coils 37 the conduit extends to a blower housing 39 which is connected to a discharge duct 40. Housing 39 contains a conventional exhaust blower 40'. Preceding housing 39, conduit 19 is formed with an enlarged portion 41 containing a humidity sensing element 42 of the bifilar type, such as is disclosed in United States Patent No. 2,285,421 to Francis W. Dunmore, issued June 9, 1942, or any other suitable humidity sensing element of the current-modifying type.

Designated at 43 is a conduit formed with coils 44 which are immersed in the temperature-controlled liquid 36 adjacent coils 37. One end of conduit 43 is open to the atmosphere. The other end of said conduit is connected through a blower housing 45 to a discharge duct 46. Housing 45 contains a conventional exhaust blower 47. Preceding housing 45, conduit 43 is formed with an enlarged portion 48 containing a humidity sensing element 49 similar to element 42.

From Figure 1 it will be apparent that humidity sensing element 42 is exposed to the air exhausting from conduit 19 after passing through the coils 37. Similarly, humidity sensing element 49 is exposed to the atmospheric air exhausting from conduit 43 after passing through the coils 44. Since coils 37 and 44 are maintained at the same temperature by liquid 36, the air engaging element 42 is at the same temperature as the air engaging element 49, whereby the relative resistances of elements 42 and 49 provide a direct comparison of the percentage moisture content of the air exhausting from conduit 19 and the atmospheric air exhausting from conduit 43, without requiring any correction for difference in temperature.

Designated at 50 is a control unit containing various electrical components, shown schematically in Figure 2. Referring now to Figure 2, it will be seen that control unit 50 includes the respective constant voltage transformers 51 and 52, respective full-wave rectifiers 53 and 54, an ammeter-relay 55, a motor control relay 56, and the respective resistors shown at 57, 58, 59, 60 and 61. The primary of transformer 51 is connected to the line wires 32 and 33 by respective wires 62 and 63. One secondary terminal of transformer 51 is connected to one terminal of humidity sensing element 42 by a wire 64. The other terminal of the transformer secondary is connected by a wire 65 to one side of the full wave bridge recti-

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fier 53 at 66. The opposite side of the rectifier is connected through the current-limiting resistor 57 to the remaining terminal of element 42 by a wire 67. The elements of the bridge rectifier 53 are arranged so that the output terminal shown at 68 will be positive in polarity and the output terminal shown at 69 will be negative. Positive terminal 68 is connected by a wire 70 through the resistor 60 to a wire 71, which in turn is connected to the positive terminal of the ammeter-relay 55. The negative terminal 69 is connected by a wire 72 to a wire 73 connected to the negative terminal of ammeter-relay 55. The elements of bridge rectifier 54 are arranged so that the output terminal shown at 74 will be negative and the output terminal shown at 75 will be positive in polarity. Terminal 74 is connected by a wire 76 through resistor 61 to wire 71. Terminal 75 is connected by a wire 77 to one stationary contact 78 of a normally open push button switch 79 located adjacent motor 22. The other stationary contact of the switch, shown at 80, is connected to the wire 73.

The primary of constant voltage transformer 52 is connected by respective wires 81 and 82 to the wires 62 and 63. One terminal of the secondary of said transformer is connected by a wire 83 to one side of rectifier 54. The other secondary terminal is connected by a wire 84 to one terminal of humidity sensing element 49. The remaining terminal of element 49 is connected by a wire 85 through current limiting resistor 58 to the opposite side of rectifier 54.

Ammeter-relay 55 is provided with a pivoted pointer 86 swingable over an arcuate scale 87 in response to a flow of current through the energizing coil of the ammeter-relay. As will be subsequently explained, such a flow of current takes place when an appreciable potential exists across the output terminals of rectifier 53 with switch 79 open, or when switch 79 is closed and the humidity of the air sample from the drying oven contacting the moisture sensing element 42 is greater than the humidity of the atmospheric air adjacent the oven sampled at humidity sensing element 49.

Pointer 86 is connected by a wire 88 through current limiting resistor 59 to the wire 62. Ammeter-relay 55 is provided on scale 87 with a first adjustable stationary contact 89, located adjacent the zero end of the scale, and with a second adjustable stationary contact 90 located adjacent the high end of the scale. The pointer 86 is engageable with the respective contacts 89 and 90 as said pointer swings over the scale. Contact 90 is connected by a wire 91 to one terminal of the winding of relay 56. The other terminal of said winding is connected by a wire 92 to wire 63. Relay 56 has an armature 93 normally engaging a stationary contact 94. Armature 93 is connected by a wire 95 to wire 62. Contact 94 is connected by a wire 96 to one terminal of motor 22. The other terminal of the motor is connected by a wire 97 to one stationary contact of a normally closed push button switch 98 located adjacent said motor. The other stationary contact of said switch 98 is connected by a wire 99 to wire 63. It will be seen from Figures 2 and 3, that motor 22 is normally energized by a circuit comprising wire 32, wire 62, wire 95, armature 93, contact 94, wire 96, the motor winding, wire 97, normally closed switch 98, wire 99, wire 63, and wire 33, assuming the main control switch, shown at 100, to be closed.

Also located adjacent motor 22 is another normally open push button switch 101. One of the stationary contacts of switch 101 is connected by a wire 102 to the contact 89 of the ammeter-relay 55. The other stationary contact of said switch is connected by a wire 103 to one terminal of the winding of a relay 104. The other terminal of said relay winding is connected to wire 99.

Relay 104 has two armatures, shown respectively at 105 and 106. Both of said armatures are connected to wire 63. Armature 105 normally engages a contact 107 which is connected by a wire 108 to one terminal of the fan and heater unit 14. The other terminal of said fan and heater unit is connected to the wire 62. From Figures 2 and 3, it will be seen that the fan and heater unit is normally energized through a circuit comprising wire 33, wire 63, armature 105, contact 107, wire 108, the fan and heater unit, wire 62, and wire 32. The fan and heater unit becomes deenergized when armature 105 is lifted out of engagement with contact 107 responsive to the energization of relay 104. Designated at 118 is a contact engaged by armature 106 when relay 104 becomes energized. Contact 118 is connected by a wire 109 to one terminal of a signal lamp 110. The other terminal of said signal lamp is connected by a wire 111 to wire 62. When relay 104 becomes energized, lamp 110 becomes energized by a circuit comprising wire 32, wire 62, wire 111, the signal lamp, wire 109, contact 118, armature 106, wire 63, and wire 33.

Arm 29 carries a bar 112 which simultaneously engages the push buttons of the three switches 79, 101 and 98 as vane 21 reaches a position closing off conduit 20 with respect to conduit 19. This opens switch 98 and closes switches 79 and 101.

The automatic mixing control device comprising the motor 22 and its associated elements functions to prevent condensation in the sampling conduit 19. If this control device were not provided, condensation would occur when the sampled exhaust air had a dewpoint higher than the temperature of the piping and/or the bath 36. The effect of condensation would be to cause inaccurate and unreliable response until all of the condensate had evaporated. The automatic mixing control device mixes the sample of air exhausted from the drying chamber with atmospheric air so as to always keep the moisture content of the air in conduit 19 below saturation.

Figure 1 illustrates the starting position of the mixing control vane 21. In this position, conduit 19 is fully open for atmospheric air and fully closed for drying chamber exhaust air. As soon as the system is placed in operation, as by closing switch 100, motor 22 becomes energized and starts driving vane 21 toward a position wherein conduit 19 is fully closed for atmospheric air and fully open for drying chamber exhaust air. The vane is driven at a very low speed because of the speed reducer 25.

In the starting position of the system, both of the moisture sensing elements 42 and 49 are contacted by atmospheric air whose temperature is equalized by the bath 36. The voltage across the output terminals of rectifier 53 will therefore have a value corresponding to the percentage moisture content of atmospheric air at the temperature of equalization, this value being substantially below saturation. Pointer 86

will therefore swing to a relatively low reading on scale 87.

The motor continues to drive vane 21, gradually admitting more and more exhaust air from the drying chamber into conduit 19. Since this exhaust air contains an appreciable amount of moisture at the beginning of the drying cycle, pointer 86 begins to swing further up on the scale 87 until it reaches a point corresponding to just below saturation. At this point, pointer 86 engages contact 90. Relay 56 becomes energized through a circuit comprising wire 32, wire 62, resistor 59, wire 88, pointer 86, contact 90, wire 91, the winding of relay 56, wire 92, wire 62, and wire 33. This raises armature 93 and opens the energizing circuit of motor 22 at contact 94. The motor stops, and remains deenergized until the moisture content of the air mixture in conduit 19 drops below the scale value at which contact 90 is located, due to the drying of the product in the chamber 11. As pointer 86 retreats from this scale value, it disengages from contact 90, causing relay 56 to become deenergized, and allowing armature 93 to re-engage contact 94, whereby the motor 22 again becomes energized. The motor starts driving again and opens vane 21 further, to allow a greater percentage of exhaust air from drying chamber 11 to be present in conduit 19. As the percentage of moisture in the air contacting sensing element 42 reaches the scale value corresponding to the location of contact 90, pointer 86 again engages said contact, stopping the motor. This procedure is repeated over and over again until vane 21 is fully closed for atmospheric air and fully open for drying chamber exhaust air. At this point, bar 112 engages the push buttons of the switches 98, 101 and 79. Switch 98 is thereby opened, breaking the motor circuit and stopping the motor. As above explained, switches 79 and 101 are now closed.

The closure of switch 79 connects the output of rectifier 54 across the terminals of ammeter-relay 55 in opposition to the output of rectifier 53. Since the output voltage of rectifier 54 is controlled by the percentage moisture content in the atmospheric air contacting humidity sensing element 49 at the equalization temperature of bath 36, the position of pointer 86 on scale 87 will show a comparison of or difference between the moisture content of the subsequent samples of air from the drying chamber with respect to the moisture content of atmospheric air.

The drying of the product continues until the moisture contents of the two air samples respectively contacting the sensing elements 42 and 49 are equal or have a specified difference. At this time, pointer 86 engages contact 89. This energizes relay 104 through a circuit comprising wire 32, wire 62, resistor 59, wire 88, pointer 86, contact 89, wire 102, switch 101 in its closed position, wire 103, the winding of relay 104, wire 99, wire 63, and wire 32. Armature 105 is therefore lifted out of engagement with contact 107, deenergizing the fan and heater unit. At the same time, armature 106 engages contact 118, causing the signal lamp 110 to be energized and signalling that the drying cycle is at an end.

To reset the system for the next run, reset switch 34 is closed, energizing reset solenoid 27, and causing the plunger of the solenoid, acting through link 28 and arm 29, to return shaft 24 and vane 21 to the starting position. Bar 112 is disengaged from the push buttons of switches 98,

101 and 79, allowing switch 98 to close and switches 101 and 79 to open.

The values of resistances 57 and 58 are preferably of the order of 1 megohm. These resistances are employed to limit the amount of current flowing in the circuits of the respective sensing elements 42 and 49 to very small values. Resistor 59 is employed to limit the amount of current flowing through the windings of the respective relays 56 and 104 and through the contacts 89 and 90. Resistor 61 is employed to prevent rectifier 54 from acting as a shunt across ammeter 55 when switch 79 closes. Similarly, resistor 60 is employed to prevent rectifier 53 from acting as a shunt across ammeter 55 with respect to the potential available at the output terminals of rectifier 54. Resistors 60 and 61 are preferably of the order of 10,000 ohms.

It should be noted that the system is arranged so that neither of the humidity sensing elements 42 or 49 may be contacted by saturated air at any time. This prevents damage to the hygroscopic coatings on the elements and substantially reduces the possibility of inadvertently changing the calibrations of these elements.

Figure 3 shows schematically a simplified form of the invention wherein the apparatus is adapted to dry a product in terms of its absolute moisture content. The modified form shown in Figure 3 employs substantially the same arrangement of elements shown in Figures 1 and 2, except that the structure whereby a comparison with moisture content in the atmosphere is obtained is eliminated, that is, the conduit 43, coil 44, sensing element 49, exhaust blower 47, etc., are omitted. The control unit, shown at 50' in Figure 3, includes the constant voltage transformer 51, the full wave rectifier 53, the ammeter-relay 55, the relay 56, and the respective resistors 57, 59 and 60, connected in the manner as in Figure 2. Since no comparison switch is required in the system of Figure 3, only the limit switch 98 and the cycle end switch 101 are provided adjacent motor 22. The moisture sensing element 42 is located in the sampling conduit 19 in the same manner as illustrated in Figure 1.

In the starting position of the apparatus of Figure 3, conduit 19 is fully open for atmospheric air and fully closed for drying chamber exhaust air. As soon as the system is placed in operation, as by closing switch 100, motor 22 becomes energized and starts driving vane 21 toward a position wherein conduit 19 is fully closed for atmospheric air and fully open for drying chamber exhaust air. Moisture sensing element 42 is contacted by atmospheric air taken in through conduit 20. Pointer 86 will therefore swing to a relatively low reading on scale 87.

As the motor continues to drive vane 21, more and more exhaust air from the drying chamber is admitted into conduit 19. Since this exhaust air contains an appreciable amount of moisture at the beginning of the drying cycle, pointer 86 begins to swing further up on the scale 87 until it engages contact 90. Relay 56 becomes energized and opens the energizing circuit of motor 22 at contact 94. The motor stops, and remains deenergized until the moisture content of the air mixture in conduit 19 drops due to drying of the product. Pointer 86 disengages from contact 90, deenergizing relay 56, whereby motor 22 again becomes energized, allowing a greater percentage of exhaust air from the drying chamber to be present in conduit 19. As pointer 86 again engages contact 90, the motor is again stopped.

This procedure is repeated over and over again until vane 21 is fully closed for atmospheric air and fully open for drying chamber exhaust air. At this point bar 112 engages the push buttons of switches 98 and 101. Switch 98 is thereby opened, breaking the motor circuit and stopping the motor. Switch 101 is now closed.

From this point on, pointer 86 indicates on scale 87 the absolute moisture content of the subsequent samples of air from the drying chamber at the temperature of the bath 36.

The drying of the product continues until the moisture content of the exhaust air decreases to a specified value (determined by test and depending upon the size of the product, the material thereof, the air velocity, etc.) corresponding to the position of contact 89 on scale 87. At this value, pointer 86 engages contact 89, energizing relay 104 and causing the fan and heater unit to be deenergized by the raising of armature 105. At the same time, signal lamp 110 becomes energized by the engagement of armature 106 with contact 118, signalling that the drying cycle is at an end.

To reset the system for the next run, reset switch 34 is closed, energizing solenoid 27 and causing vane 21 and bar 112 to return to their starting positions.

It will be apparent that in either of the systems illustrated in Figures 2 and 3, a moist article may be automatically dehydrated to a desired degree of dryness by placing same in the drying chamber 11, closing the main power switch 100, and setting vane 21 to starting position by means of push button switch 34. In the latter stages of the drying cycle, the moisture content of the air leaving the drying chamber will be indicated by pointer 86 on the scale 87 of the ammeter-relay 55. As soon as the article reaches the desired degree of dryness, the fan and heater unit will be automatically deenergized and the signal lamp 110 will become energized, indicating that the article is ready to be removed from the drying chamber.

While certain specific embodiments of automatic drying systems have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, a sampling conduit connected to said chamber, an atmospheric air intake duct connected to said sampling conduit, valve means at the connection of said duct to said conduit regulating the amount of atmospheric air admitted into said conduit, a moisture-sensitive element in said sampling conduit, a control device connected to said source, and a control circuit connected to said control device, said control circuit including the moisture-sensitive element.

2. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, valve means at the connection of said duct to said sampling conduit regulating the amount of atmospheric air admitted into said sampling conduit, a moisture-sensitive element in said sampling conduit, a control device connected to said source, and

a control circuit connected to said control device and said valve means, said control circuit including the moisture-sensitive element.

3. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, a sampling conduit connected to said chamber, an atmospheric air intake duct connected to said sampling conduit, valve means regulating the amount of atmospheric air admitted into said sampling conduit from said intake duct, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, means regulating said valve means in accordance with the response of said moisture-sensitive element, control means for the source, and means operating said control means in response to the movement of the valve means to a predetermined position.

4. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, electrically operated valve means at the connection of said duct to said sampling conduit regulating the amount of atmospheric air admitted into said sampling conduit, a current-responsive control device, a moisture-sensitive resistance element in said sampling conduit, a control circuit including said resistance element connected to said current-responsive control device, first switch means associated with said current-responsive device, circuit means connecting said electrically operated valve means to said first switch means, a control circuit associated with said source, second switch means associated with said current-responsive control device, and circuit means connecting said second switch means to said latter control circuit.

5. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, electrically operated valve means at the connection of said duct to said sampling conduit regulating the amount of atmospheric air admitted into said sampling conduit, a current-responsive control device, a moisture-sensitive resistance element in said sampling conduit, a control circuit including said resistance element connected to said current-responsive control device, first switch means operated by said current responsive device in response to a relatively high current therein, circuit means connecting said electrically operated valve means to said first switch means, a control circuit associated with said source, second switch means operated by said current-responsive device in response to a relatively low current therein, and circuit means controlled by said electrically operated valve means at times connecting said second switch means to said latter control circuit.

6. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, electrically operated valve means at the connection of said duct to said sampling conduit, means controlling the temperature of said sampling conduit, a current-responsive control device, a mois-

ture-sensitive resistance element in said sampling conduit, a control circuit including said resistance element connected to said current-responsive control device, first switch means operated by said current-responsive device in response to a relatively high current therein, circuit means connecting said electrically operated valve means to said first switch means, a control circuit associated with said source, second switch means operated by said current-responsive device in response to a relatively low current therein, and circuit means controlled by said electrically operated valve means at times connecting said second switch means to said latter control circuit.

7. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, electrically operated valve means at the connection of said duct to said sampling conduit regulating the amount of atmospheric air admitted into said sampling conduit, a current-responsive control device, a first moisture-sensitive resistance element in said sampling conduit, a second moisture-sensitive resistance element exposed to atmospheric air adjacent said chamber, respective energizing circuits including the respective moisture-sensitive elements connected in opposition to said current-responsive control device, means associated with said valve means controlling the energizing circuit containing the second resistance element, first switch means operated by said current-responsive device in response to a relatively high current therein, circuit means connecting said electrically operated valve means to said first switch means, a control circuit associated with said source, second switch means operated by said current-responsive control device in response to a relatively low current therein, and circuit means controlled by said electrically operated valve means at times connecting said second switch means to said latter control circuit.

8. The structure of claim 10, and wherein an additional atmospheric air duct is provided adjacent the chamber, the second moisture-sensitive element being located within said additional atmospheric air duct, and wherein means are provided maintaining the sampling conduit and said additional atmospheric air duct at a common temperature.

9. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an exhaust conduit connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct connected to said sampling conduit, a constant temperature bath, a portion of the sampling conduit beyond the connection thereof to said atmospheric air intake duct being immersed in said bath, electrically operated valve means at the connection of said duct to said sampling conduit regulating the amount of atmospheric air admitted into said sampling conduit, a current-responsive control device, a first moisture-sensitive resistance element in said sampling conduit beyond the portion immersed in the bath, an additional atmospheric air duct also having a portion thereof immersed in the bath, a second moisture-sensitive resistance element in said additional duct beyond the immersed portion thereof, respective energizing circuits including the respective moisture-sensitive resistance elements

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connected in opposition to said current-responsive control device, means associated with said valve means controlling the energizing circuit containing the second resistance element, first switch means operated by said current-responsive device in response to a relatively high current therein, circuit means connecting said electrically operated valve means to said first switch means, a control circuit associated with said source, second switch means operated by said current-responsive control device in response to a relatively low current therein, and circuit means controlled by said electrically operated valve means at times connecting said second switch means to said latter control circuit.

10. An automatic drying system comprising a chamber, a source of heated air connected to said chamber, an outlet conduit connected to said chamber, a constant-temperature bath, a sampling conduit connected to said outlet conduit, a substantial portion of said sampling conduit being immersed in said bath, a moisture-sensitive element in said sampling conduit, a control device connected to said source, and a control circuit connected to said control device, said control circuit including the moisture-sensitive element.

11. In an automatic drying system, the combination of a chamber, a source of heated air connected to said chamber, an exhaust conduit communicating with the atmosphere and connected to said chamber, a relatively small sampling conduit connected to said exhaust conduit, an atmospheric air intake duct communicating with the atmosphere and connected directly to said sampling conduit, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, and means regulating the amount of atmospheric air admitted into said sampling conduit in accordance with the response of said moisture-sensitive element.

12. In an automatic drying system, the combination of a chamber, a source of heated air connected to said chamber, an exhaust conduit communicating with the atmosphere and connected to said chamber, a relatively small sampling conduit connected to said exhaust conduit, means controlling the temperature of said sampling conduit, an atmospheric air intake duct communicating with the atmosphere and connected directly to said sampling conduit, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, and means regulating the amount of atmospheric air admitted into said sampling conduit in accordance with the response of said moisture-sensitive element.

13. In an automatic drying system, the combination of a chamber, a source of heated air

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connected to said chamber, an outlet conduit connected to said chamber, a sampling conduit connected to said outlet conduit, a constant-temperature bath, a substantial portion of said sampling conduit being immersed in said bath, an atmospheric air intake duct connected directly to said sampling conduit ahead of said constant-temperature bath, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, and means regulating the amount of atmospheric air admitted into said sampling conduit in accordance with the response of said moisture-sensitive element.

14. In an automatic drying system, the combination of a chamber, a source of heated air connected to said chamber, an exhaust duct communicating with the atmosphere and connected to said chamber, a sampling conduit connected to said exhaust duct, an atmospheric air intake duct communicating with the atmosphere and connected directly to said sampling conduit, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, and means regulating the amount of atmospheric air admitted into said sampling conduit in accordance with the response of said moisture-sensitive element.

15. In an automatic drying system, the combination of a chamber, a source of heated air connected to said chamber, an exhaust conduit communicating with the atmosphere and connected to said chamber, a sampling conduit connected to said exhaust conduit, an atmospheric air intake duct communicating with the atmosphere and connected directly to said sampling conduit, valve means regulating the amount of atmospheric air admitted into said sampling conduit from said duct, a moisture-sensitive element in said sampling conduit beyond the connection of the air intake duct thereto, and means operating said valve means in accordance with the response of said moisture-sensitive element.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,167,740	Carrier	Jan. 11, 1916
1,467,306	Carrier	Sept. 11, 1923
1,539,230	Anderson	May 26, 1925
1,707,547	Adams	Apr. 2, 1929
2,037,695	Brownlee et al.	Apr. 21, 1936
2,080,059	Peebles	May 11, 1937
2,333,000	Gayring	Oct. 26, 1943
2,347,601	Jackson	Apr. 25, 1944
2,548,939	Brion	Apr. 17, 1951