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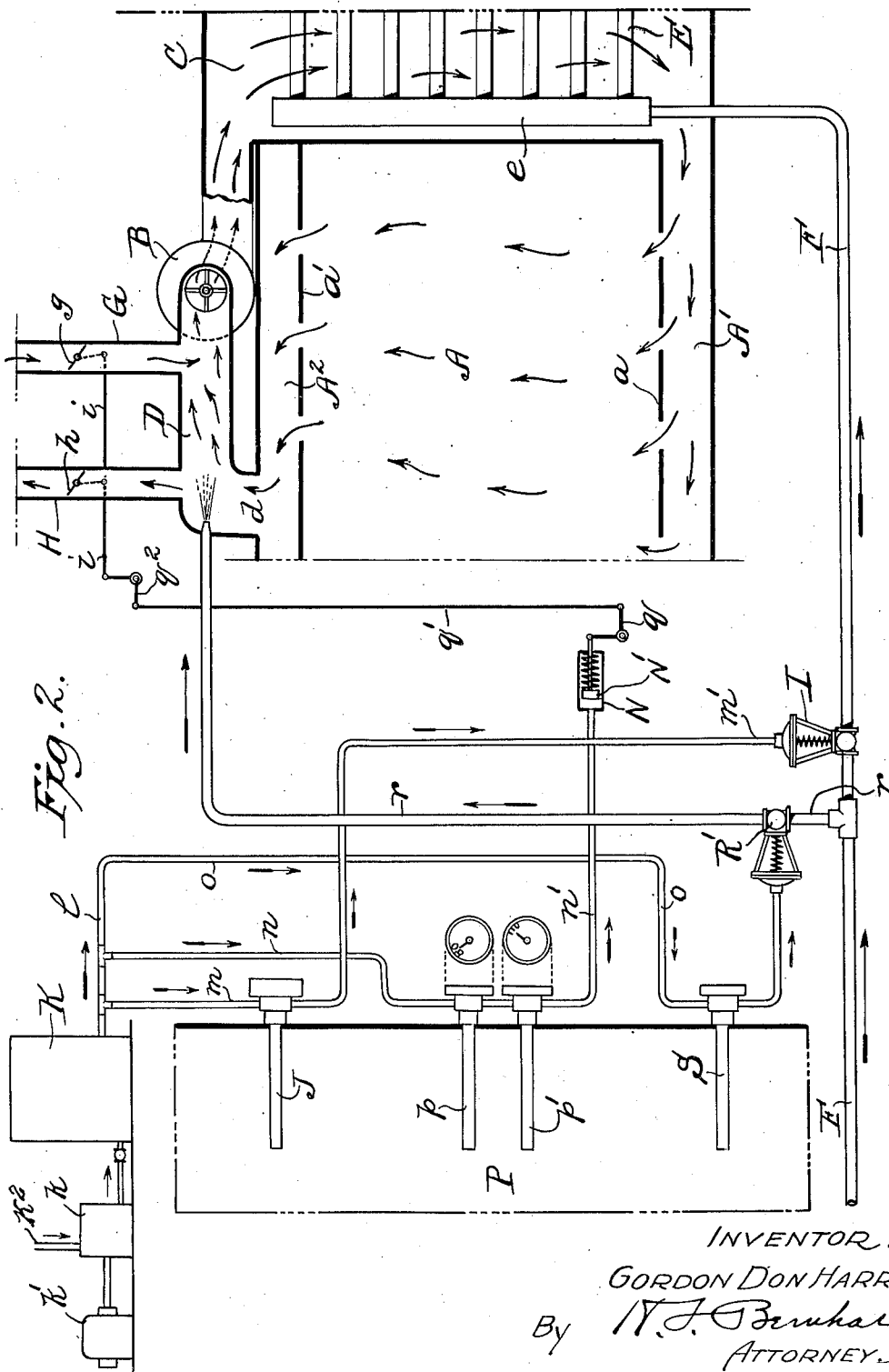
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G. D. HARRIS

ART OF DRYING MATERIALS

Filed Feb. 18, 1924

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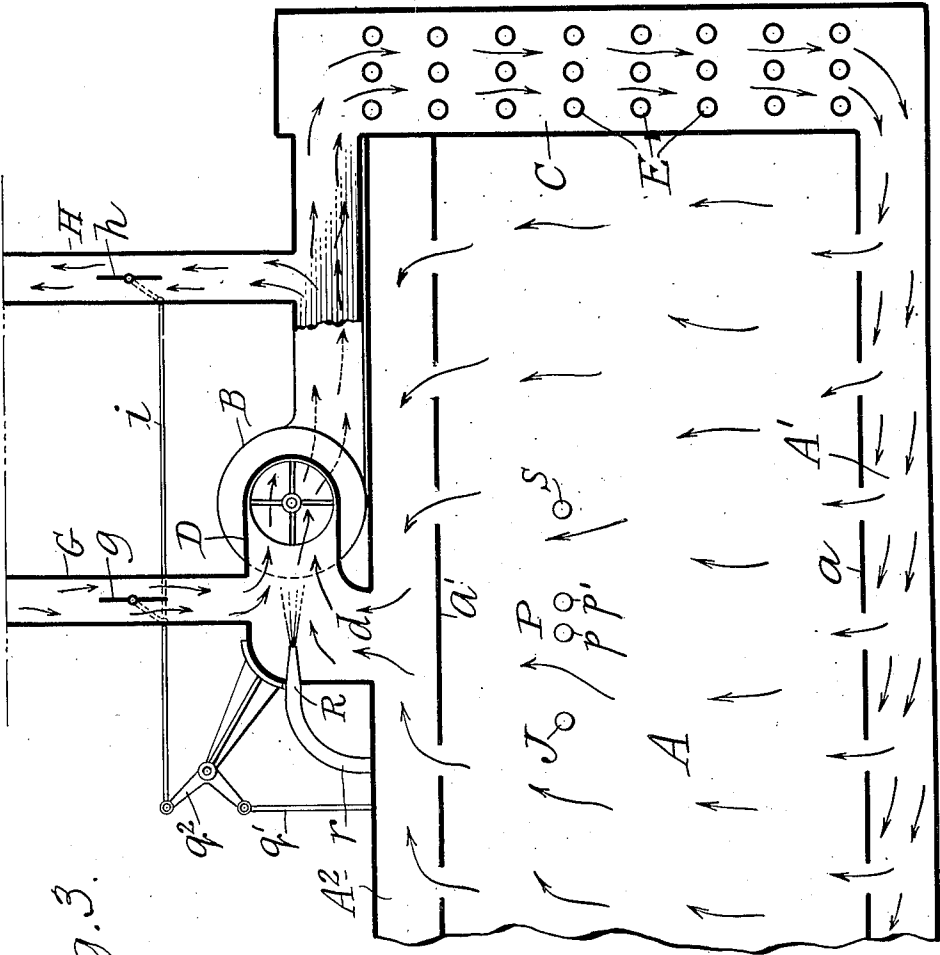


Fig. 3.

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ART OF DRYING MATERIALS.

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To all whom it may concern:

Be it known that I, GORDON DON HARRIS, a citizen of the United States, residing at Freeport, county of Nassau, and State of New York, have invented a certain new and useful Improvement in the Art of Drying Materials, of which the following is a specification.

This invention pertains to the art of drying materials in accordance with a determined or prescribed formula with respect to the conditions of temperature and humidity of the drying atmosphere and also with reference to the moisture content and the character of the material under treatment.

The invention includes both a method and an apparatus, and it is used for the treatment of a wide variety of materials, including leather, ceramic ware, and other products the physical characteristics of which demand that during the drying period there shall be present in the drying atmosphere flowing into contact with the material the required heat units to effect the exchange of heat in the atmosphere for moisture in the material and that such drying atmosphere shall contain, also, a certain humidity the percentage of which is in a definite ratio to the moisture content of the material under treatment.

In the treatment of a certain class of materials, such as leather, it has been determined by experience and investigation that, to attain the required results in conditioning such material, the drying atmosphere shall be maintained at a constant temperature and the moisture content of such drying atmosphere shall, also, be constant, irrespective of a decrease in the ratio of moisture diffusion within the material under treatment, to the end that the heat carried by the drying atmosphere will be exchanged for moisture in the material while the humidity present in the drying atmosphere will also be carried into contact with the material with the object of precluding that condition of such material known as "case hardening", wherein a film on the surface closes the pores against the free exudation of moisture present within the interior of the mass of such material.

Again, in the treatment of other classes of materials, such as ceramic wares, it has been determined by investigation and expe-

rience that the drying atmosphere shall contain the required heat units and a definite moisture content, but as the evaporation of moisture decreases from the material under treatment, the heat units and the percentage of moisture present in the drying atmosphere shall vary as the drying of the material progresses, with the result that the heat units present in the atmosphere will progressively increase and the moisture content of the atmosphere will also progressively increase, or vice versa, the atmosphere will carry heat units in decreasing percentage while the moisture content of such atmosphere will remain constant, or be increased. As an example, in the condition of the drying atmosphere, for evaporating materials such as leather, wherein constant temperature and constant humidity are desirable, the drying atmosphere is heated to a temperature of 100° Fahr., and contains 85% humidity, and these conditions of heat and humidity are rendered constant by boosting the atmosphere and renewing such atmosphere at a more or less frequent interval, determined and controlled by the condition of the atmosphere itself acting through instrumentalities known to the art, whereby an excess of humidity in the atmosphere sets into action certain mechanism that automatically discharges a determined volume of moisture laden air and in like manner replaces the discharged atmosphere with fresh atmospheric air, to the end that the temperature and the humidity of the drying atmosphere will remain constant, or substantially constant, irrespective of the ratio of water diffusion in the product under treatment.

On the other hand, the treatment of materials, such as ceramics, demands that the drying atmosphere shall contain heat units and humidity in varying proportions as the evaporation progresses, to the end that the evaporation from the material shall be carried on under conditions which preclude fractures in and breaking of the material itself. Experience in the treatment of ceramic materials to eliminate moisture therefrom preparatory to firing or baking the materials in order to vitrify the same, shows that a large percentage of breakage is incurred due to the unequal or ununiform evaporation of moisture from areas varying

in cross section of the material itself; thus there is present in each piece of material, such as ceramic ware, certain parts of greater cross section than other parts of such material which are comparatively thin in cross section, and while the drying of the areas of thin cross section is not difficult of accomplishment, the problem is presented of evaporating moisture from the areas of thicker cross section in a definite relation to the evaporation taking place in areas of thin cross section, because the fractures of the material are occasioned by the unequal contraction and expansion of the material itself in the process of eliminating moisture from the areas of thin and thick cross sections. According to my invention, the drying atmosphere itself is conditioned both as concerns the heat carried thereby, and as to its moisture content, and such conditioning of the atmosphere is controllable automatically, to the end that the heat and the humidity shall vary as the evaporation of the materials progresses, such variation including an increase of heat units and an increase in the moisture content of the drying atmosphere. At the initial stage in evaporating moisture from ceramic ware, the drying atmosphere is conditioned by heating it to a temperature of 75° Fahr. and charging or supplying moisture to 95° humidity, but as the evaporation of moisture proceeds from the ceramic ware, it is found that the areas of thin cross section will become dry, or relatively dry, whereas the areas of greater cross section will still contain an appreciable moisture content which it is essential shall be eliminated during the drying process without resulting in fracture of the ware itself and which elimination of moisture shall be effected prior to firing or baking the ware. Accordingly, as the drying progresses the drying atmosphere is conditioned according to the formula or specification by increasing the heat units and by increasing the moisture content present in such atmosphere, to the end that the heat units of the atmosphere will be exchanged for moisture in the areas of thicker cross section of the ceramic ware, whereas the humidity of the atmosphere will so act upon the areas of thin cross section of such ceramic ware as to supply moisture to such thinner areas from the atmosphere itself, as a result of which the ceramic ware is itself conditioned by the drying atmosphere to the end that unequal expansion and contraction of the ceramic ware, and the attendant fracture thereof, is eliminated or minimized, but on the other hand, the evaporation of moisture from such ceramic ware proceeds gradually and steadily in all areas thereof, notwithstanding the variation in the cross sectional areas, and without entailing the breakage so prevalent in the older methods of drying materials of

this character. As in the example hereinbefore mentioned in connection with the evaporation of materials such as leather, the drying atmosphere for treating material such as ceramic ware, is conditioned by heating and reheating such atmosphere to the required temperature or temperatures, and by renewing a definite volume of moisture laden atmosphere with a similar volume of fresh atmospheric air, such conditions of said atmosphere setting into action the temperature and humidity controls whereby the acts of boosting the atmosphere and of renewing the same with fresh atmospheric air are performed automatically, and in case the moisture content of the atmosphere is or becomes too low to conform to the formula or specifications, certain controls act to supply humidity to the atmosphere by feeding thereto a definite volume of live steam from an available source of supply. Provision is thus made for boosting the atmosphere to maintain its temperature constant, or to increase its temperature; again, provision is made for maintaining constant the humidity of the atmosphere, or for increasing the moisture content, and provision is made, also, for increasing the moisture content of such atmosphere by feeding moisture thereto, all such controls being effected to conform with more or less accuracy to the prescribed formula or standard, and to attain such ends usually by automatic mechanism.

Other functions and advantages of the invention will appear from the following description taken in connection with the drawings, wherein—

Figure 1 is a vertical section of a drying apparatus suitable for carrying into practice my invention, and

Figure 2 is a diagrammatic view illustrating one form of controls by which the atmosphere is conditioned automatically both as regards its temperature and humidity and irrespective of the ratio of diffusion of the water content present in the material under treatment.

Figure 3 is a vertical sectional elevation illustrating another arrangement of the air intake and the air outlet with respect to the blower and to other parts of the apparatus.

A is a chamber within which the material to be treated is positioned in a manner to be exposed to the action of a drying atmosphere, the latter being recirculated by the rotative motion of a fan or blower B. As shown, the chamber is provided with perforated floor a and a perforated roof a' , the same being adjacent the bottom and the top, respectively, of the exterior casing so as to produce an intake flue A' and an eduction flue A'' which are in communication with the chamber through the perforations in said floor a and the roof a' , respectively.

At one end of the apparatus is a heater chamber C connected at the bottom with the intake flue A' and at the top with a feeding duct D, and within said heater chamber is a suitable heater or radiator E, the same being shown as a steam coil with a header *e*, to which is connected a steam supply pipe F leading from a source of steam supply, see Figure 2.

The circulating mechanism B for the drying atmosphere is operatively positioned in the feeding duct D, and said circulating mechanism is driven by power of any appropriate kind, so as to drive the blower at the required speed.

The feeding duct is connected at one end through a port *d* to the eduction flue A² of the material chamber, whereas the other end of said feeding duct is in free communication with the heater chamber C. To this feeding duct is coupled an intake duct G open to the atmosphere and operable under certain damper controlled conditions for feeding fresh atmospheric air to the feeding duct and thence through the heater chamber C to the material chamber A.

A discharge duct H is connected to the feeding duct D, the same being at an appreciable distance from the fresh air intake G and the two ducts being wholly independent of each other, although both of them are in communication with the feeding duct. In the fresh air intake is positioned a valve or damper *g*, whereas a similar valve or damper *h* is mounted in the discharge duct H. Said dampers *g*, *h*, are hung for pivotal movement within the respective ducts G H, and as shown, the dampers are conjointly operated by a rod *i* linked to the dampers so as to open and close the dampers whereby the fresh air duct G is opened and closed concurrently with the opening and closing of the moisture laden air discharge duct H. With the dampers *g*, *h*, in closed positions within the ducts G H, and with the blower in motion, said blower draws the drying atmosphere from chamber A through the duct D and blows the atmosphere through chamber C and thence into the chamber A, the effect of which is to recirculate the atmosphere alternately through chambers A C and thus to reheat and boost the atmosphere by contact with the radiator E. By opening the dampers *g*, *h*, in the flues G H, respectively, and with the blower in motion, an outlet is provided through duct H for discharging moist hot air in a definite volume, and at the same time the blower draws in a corresponding volume of fresh atmospheric (new) air to replace the moist air thus discharged from the circulatory path, which latter includes chambers A C and duct D. The fresh air thus drawn into the circulatory path by the blower is mixed with the warm

moist air and thus the drying atmosphere is conditioned by the admixture therewith of new air and by boosting the same through the action of the radiator E.

The flow of steam to the radiator is controlled by a valve I, and this valve is in turn under the control of an automatic temperature regulator J responsive to the temperature of the drying atmosphere and positioned within chamber A, said temperature regulator being of any character suitable for the purpose and adapted to be set manually, so that upon a decrease in the temperature of the drying atmosphere the regulator acts to open the valve I, thus supplying steam to the radiator for heating the drying atmosphere, circulated by blower B, to the required or determined temperature, whereas an increase above the determined temperature in the drying atmosphere influences the regulator J to close the valve I and thereby shut off the steam supply to the radiator F. Any means suitable for the purpose may operatively connect the regulator J with the automatic valve I, but in the drawings there is shown a fluid pressure mechanism which is operatively related not only to the temperature regulator, but is similarly related to the humidity controls, presently referred to. The motive fluid (air in the example shown), is accumulated within a tank K by the action of a compressor *k* driven by a motor *k'*, said compressor having a valved connection *k*² with said tank, and from this tank leads a main *l*, from which is branched a plurality of pipes *m*, *n*, *o*. The pipe *m* is connected with temperature regulator J and leads thence through a branch *m'* to automatic valve I, whereby the action of said regulator J, responsive to a change in the temperature of the drying atmosphere, controls the flow of a motive fluid to the valve I for automatically actuating said valve in feeding and shutting off the flow of steam to the radiator, as the temperature condition of the drying atmosphere may demand.

An excess of humidity in the drying atmosphere, i. e. an increase in the moisture content of said atmosphere above that condition which it is desired to establish and maintain in said atmosphere, influences a control mechanism P which is responsive to an increase or decrease in the moisture content of the drying atmosphere, and which is positioned within chamber A so as to be exposed for contact with the atmosphere circulating into contact with the material. Said humidity control mechanism P includes a wet bulb thermometer *p* and a dry bulb thermometer *p'* with a well known provision for manually setting said thermometers in a manner to insure the action of the control mechanism as a unit when the moisture content of the drying atmosphere exceeds the

limit of the humidity desired. Said humidity responsive control mechanism P is operatively connected with a damper shifting mechanism herein illustrated in the form of a piston cylinder N within which is slidable a spring-actuated piston N' the rod of which is connected to a bell crank q linked by a rod q' to another bell crank q^2 , the latter being pivoted to the damper rod i , see Figure 2. With the humidity control mechanism P co-operates the motive fluid pipe n leading from the main l , said pipe n having a branch leading from the thermometers p p' to and connected with, the damper actuating mechanism. The humidity responsive control P is manually set to become operative when an excess of humidity exists in the drying atmosphere above that limit at which it is desired to maintain said atmosphere, and when this condition is reached, the elements p p' open the path for the flow of motive fluid through pipes n n' to the piston mechanism, whereby the dampers g , h , are opened automatically for the blower to draw in through the intake duct G a supply of fresh atmospheric (new) air, and at the same time to expel through the discharge duct H a corresponding volume of humid hot air. Provision is thus made for conditioning the drying atmosphere by expelling a definite volume of humid air and replacing the expelled air with fresh air, whereupon the control mechanism P is influenced to shut off the flow of motive fluid to piston cylinder N and the dampers g , h , are closed in the intake and exhaust ducts G H, respectively.

Provision is made for automatically feeding moisture into the drying atmosphere should the humidity fall below a determined limit, experience having shown that there are occasions in the service of the machine when the drying atmosphere attains a low humid condition unsuitable for the treatment of a material or materials possessing certain physical properties, as, e. g. in the evaporation of moisture from ceramic ware of ununiform cross sectional dimensions and in the treatment of hides the cross sectional thickness of which varies in different areas. A steam jet nozzle R is positioned for discharging live steam into the feeding duct D for admixture with the drying atmosphere to be recirculated by the blower B, and to this jet nozzle is coupled a feed pipe r branched off the steam main F. The flow of steam is established by opening an automatic valve R' in the pipe r , and this valve is actuated automatically by a control mechanism S responsive to a low moisture content of the drying atmosphere. Said control mechanism S is a thermometer of a known type, positioned in chamber A for exposure to contact with the drying atmosphere, and provided with setting means operable man-

ually to render the thermometer responsive to the moisture content of the atmosphere when it decreases below a desired limit. With this control mechanism S co-operates the motive fluid pipe o having a branch o' leading from the control element S to the automatic valve R' whereby said valve is actuated by the motive fluid supplied by pipe o when the control element S is influenced by low humidity of the drying atmosphere.

In operation, the material to be treated is placed within the chamber A, steam admitted to the radiator, valves g , h , closed, and fan B set in motion for circulating air within the closed path afforded by chambers A, C and duct D. The air is heated to the required temperature by radiator E, and the flow of air into contact with the material effects the exchange of heat for moisture, so that the temperature of the atmosphere will be decreased by such exchange, although the reheating or boosting of such atmosphere during its repeated circulation compensates for the loss of heat units due to such exchange. With the temperature and humidity controls exposed to the drying atmosphere, it follows that the steam supply is cut off from the radiator when the temperature of the atmosphere remains constant, and with the moisture content of the atmosphere at the desired saturation, the dampers g , h , are closed, thus effecting the recirculation by the blower of the atmosphere within the closed path. Where a constant determined humidity and temperature of the drying atmosphere are desired for treatment of the material within chamber A, say at 100° Fahr. and 85 percent humidity, the thermometer control J and humidity control P will influence the radiator E and damper shifting mechanism N N' g q q^2 , so as to supply steam to the radiator at the required intervals and to open and close the dampers g , h , at more or less frequent intervals, so as to discharge a volume of humid atmosphere out of chamber A through exhaust duct H, and at the same time a corresponding volume of fresh atmospheric air is drawn by the blower through the intake G. These operations, either one or all of them, take place whenever the condition of the drying atmosphere changes to such an extent that the temperature and humidity of such atmosphere are not in accordance with the formula or specification determined as desirable for the treatment of a particular material. Obviously, the increase in the moisture content of the atmosphere is due to moisture evaporated from the product, whereas the temperature changes are due to absorption by such atmosphere of the moisture which is exchanged for heat, such changes in the condition of the drying atmosphere taking

place irrespective of a decrease in the ratio of water diffusion in the product or of the decreasing amounts of heat units required for evaporation. As will be apparent, the temperature control J and valve I supply steam to the radiator E by which the heat units are supplied to the drying atmosphere in a definite ratio to evaporation, to maintain the desired operating temperature of the drying atmosphere.

Again, the humidity control P with the damper shifting mechanism act to open and close the dampers g, h, when the drying atmosphere reaches a certain moisture content, whereby the valves are opened for exhausting a definite volume of overcharged humid atmosphere, and to renew the atmosphere by the admission of a proper volume of new air which is mixed with the moist humid atmosphere remaining in the apparatus, so that the drying atmosphere is conditioned in conformity with the formula or specification determined upon as suitable or most desirable for the treatment of a particular product. Furthermore, a decrease in the humidity of the drying atmosphere, as happens in the treatment of certain products, although the temperature may remain constant, or even increase as the evaporation progresses, such decrease affects the low humidity control S so as to actuate the valve R' and provide for the flow of steam to the nozzle R in order to supply moisture to the drying atmosphere until such atmosphere attains the desired moisture content, whereupon the control S closes the valve R' and shuts off the continued supply of steam to the nozzle. In treating materials, such as ceramic ware, with or by a drying atmosphere the temperature and humidity of which will be varied as the drying progresses in conformity with a determined formula or specification, the drying atmosphere initially is, say, at 75° Fahr. and 95 per cent humidity, but at different stages in the progress of the evaporation of moisture from the product, the atmosphere is conditioned to vary the temperature or the humidity, or both temperature and humidity are varied in conformity with the formula through the action of the controls J, P, S, and their associated devices, either independently or conjointly, in a manner to supply steam to the radiator, to open the dampers for the exit of humid atmosphere and for the ingress of new air, and for the addition of moisture to the drying atmosphere to be recirculated within the closed path, whereby the drying atmosphere is itself conditioned both as respects the temperature and moisture content, either as to excess or decreased humidity, so as to attain varying degrees in the temperature and humidity of the atmosphere, and to utilize such conditioned atmosphere in such manner as to constantly main-

tain a proper condition of the product undergoing the drying and conditioning treatment.

In the apparatus shown in Figures 1 and 2, the air intake G and air outlet H are positioned at one side of blower B, i. e. adjacent the suction side of said blower. It may be advantageous to position the outlet H adjacent the pressure side of the blower, and in Figure 3 there is illustrated another form of apparatus, wherein the blower B is positioned intermediate the ends of flue D, the outlet H for the drying atmosphere is connected with flue D adjacent the pressure side of the blower, whereas the air intake G is connected with flue D adjacent the suction side of the blower, it being understood that the purpose is to locate the blower intermediate the air intake G and the air outlet H.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere within a determined circulatory path closed against the admission of outside atmospheric air, heating the drying atmosphere during its recirculation, conditioning the drying atmosphere by the admixture of fresh atmospheric air therewith and by discharging from the circulatory path a definite volume of the atmosphere surcharged with moisture, and controlling the reheating and the renewal of such atmosphere, such control being dependent upon and responsive to a change or changes in the condition of the recirculated atmosphere itself.

2. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere within a definite path closed against the admission of outside atmospheric air, repeatedly heating such atmosphere during its recirculation, conditioning the recirculated atmosphere by discharging from the circulatory path a definite volume of the atmosphere surcharged with moisture and replacing the atmosphere so discharged with fresh atmospheric air, and controlling the reheating and the conditioning of the recirculated atmosphere at stages dependent upon and responsive to changes in the temperature and moisture content of the atmosphere itself.

3. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere within a definite circulatory path closed against the admission of outside atmospheric air, reheating said atmosphere during its recirculation, feeding moisture to said atmosphere to vary the humidity thereof, and controlling the reheating and moisture feed

at stages dependent upon and responsive to a change in the temperature and moisture content of the atmosphere itself.

4. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere within a desired circulatory path, reheating the atmosphere during the recirculation thereof, controlling the periods of such reheating dependent upon changes in the temperature of the atmosphere, conditioning the atmosphere by discharging from the circulatory path a volume of the atmosphere charged with moisture and replacing with fresh air the atmosphere so discharged, and controlling the periods of such conditioning of the atmosphere dependent upon changes in the moisture content of the atmosphere itself.

5. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere within a determined circulatory path, periodically reheating the circulated atmosphere, controlling the periods of such reheating by a decrease in the temperature of the atmosphere during its recirculation, periodically conditioning the atmosphere during its recirculation by discharging a definite volume from the circulatory path and replacing with fresh air the volume so discharged, and controlling the periods of such reconditioning of the atmosphere at stages indicated by the presence of a moisture content in excess of a determined percentage of humidity in such atmosphere.

6. In the art of drying and conditioning materials the cross sectional areas of which vary in thickness, the process which consists in recirculating a drying atmosphere characterized by the presence of a definite moisture and heat content into contact with said material, exchanging heat from the drying atmosphere for moisture in the material at continuous stages in the recirculation of the atmosphere, and at certain stages in the conditioning of said material feeding moisture to the areas of thinner cross section and concurrently therewith evaporating moisture from the areas of thicker cross section, whereby the conditioning of the material areas varying in cross section will progress in definite ratio.

7. In the art of drying and conditioning materials the cross sectional areas of which vary in thickness, the process which consists in recirculating a drying atmosphere characterized by a definite moisture and heat content into contact with said material for exchanging heat for moisture and ultimately attain the supply of moisture to the areas of thin cross section while continuing to evaporate moisture from the areas of thicker cross section, reheating said atmosphere during the recirculation thereof to maintain its

temperature constant, conditioning said atmosphere by discharging a definite volume of humid atmosphere and feeding thereto a like volume of fresh atmospheric air, and controlling the periods of such reheating and such conditioning of the atmosphere at stages which indicate a change in the temperature and moisture content of such atmosphere.

8. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere characterized by a definite heat and moisture content into contact with the material under treatment, reheating said atmosphere during the recirculation thereof, conditioning the atmosphere during recirculation by replacing a definite volume of humid atmosphere with a similar volume of fresh atmospheric air, and controlling such periods of reheating and conditioning of the atmosphere upon a change in the temperature and in the humidity of such atmosphere indicating a drop below a determined limit of heat and moisture content of the atmosphere.

9. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere characterized by a determined heat moisture content into contact with the material, injecting steam into the atmosphere during such recirculation for supplying humidity thereto, reheating the atmosphere during its recirculation, and conditioning the atmosphere as to its moisture content by discharging a definite volume of moist air and replacing the same by a similar volume of fresh air.

10. In the art of drying and conditioning materials, the process which consists in recirculating a drying atmosphere characterized by a determined heat and moisture content into contact with the material, conditioning the atmosphere during recirculation by replacing with fresh atmospheric air a definite volume of such atmospheric air containing an excess of moisture, reheating the atmospheric air during recirculation, and feeding steam into the atmosphere during recirculation to bring the moisture content to a desired limit or limits.

11. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a circulatory path closed to the admission of outside atmospheric air, means for reheating such atmosphere, temperature influenced means for controlling the feed of energy to the reheating means, and humidity responsive means for controlling means operable for conditioning the atmosphere by replacing a definite volume of humid atmosphere with a like volume of fresh atmospheric air.

12. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a circulatory

path closed to the admission of outside atmospheric air, means for reheating such atmosphere, means for conditioning the atmosphere by replacing a definite volume of humid atmosphere with a similar volume of fresh atmospheric air, and humidity-responsive means exposed to the circulating atmosphere and operatively related to said conditioning means to actuate the latter upon a change in the moisture content of the atmosphere.

13. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a circulatory path closed to the admission of outside atmospheric air, means for reheating such atmosphere, means including a damper controlled exhaust and a damper controlled intake for replacing a definite volume of humid atmosphere with a like volume of fresh atmospheric air, and humidity responsive means positioned for contact with the atmosphere and operatively related to said exhaust and intake for shifting the dampers automatically upon an increase above a determined limit in the moisture content of said atmosphere.

14. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a circulatory path closed to the admission of outside air, means for reheating such atmosphere, means for feeding steam to the circulatory path for said atmosphere, and humidity responsive means for controlling the supply of steam upon a decrease below a determined limit in the moisture content of the drying atmosphere.

15. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a circulatory path closed to the admission of outside atmospheric air, means for reheating such atmosphere, temperature controlled means for feeding energy to the reheating means, means for supplying steam to the circulatory path, and humidity responsive means for controlling the feed of steam to said path upon a decrease below a determined limit in the moisture content of the drying atmosphere.

16. In an apparatus for drying and conditioning materials, means for circulating a

drying atmosphere within a circulatory path closed to the admission of outside atmospheric air, means for reheating such atmosphere, temperature controlled means for feeding energy to the reheating means, humidity responsive means influenced by an excess humidity in said atmosphere for replacing a definite volume of humid atmosphere with a like volume of fresh atmospheric air, means for feeding steam to said atmosphere during recirculation thereof, and humidity responsive means influenced by a decrease below a determined limit in the moisture content of the atmosphere for actuating the steam feeding means to supply additional moisture to the atmosphere during recirculation thereof.

17. In an apparatus for drying and conditioning materials, means for recirculating a drying atmosphere within a closed circulatory path, a damper-controlled fresh air intake to said path, a damper controlled moist air outlet connected with said circulatory path, means responsive to an excess of the moisture content of the drying atmosphere for opening the dampers in said fresh air intake and in the moist air outlet for effecting the discharge of a definite volume of moist air from the circulatory path and for feeding to said circulatory path a similar volume of fresh air, means for reheating the air, and temperature controlled means responsive to a drop in temperature of the drying atmosphere for feeding energy to the air reheating means.

18. In an apparatus for drying and conditioning materials, means for circulating a drying atmosphere within a closed circulatory path, a valved fresh air inlet to said circulatory path, a valved moist air outlet from said circulatory path, means responsive to an excess of humidity in the drying atmosphere for opening said moist air outlet and said fresh air inlet, means for reheating the drying atmosphere, temperature controlled means for feeding energy to said reheating means, and means responsive to a low humid condition of the drying atmosphere for feeding steam to said atmosphere.

In testimony whereof I have hereto signed my name this 7th day of February, 1924.

GORDON DON HARRIS,