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METHOD FOR CONDITIONING WEB-LIKE MATERIALS IN A CLOSED CHAMBER

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FIG. 2.

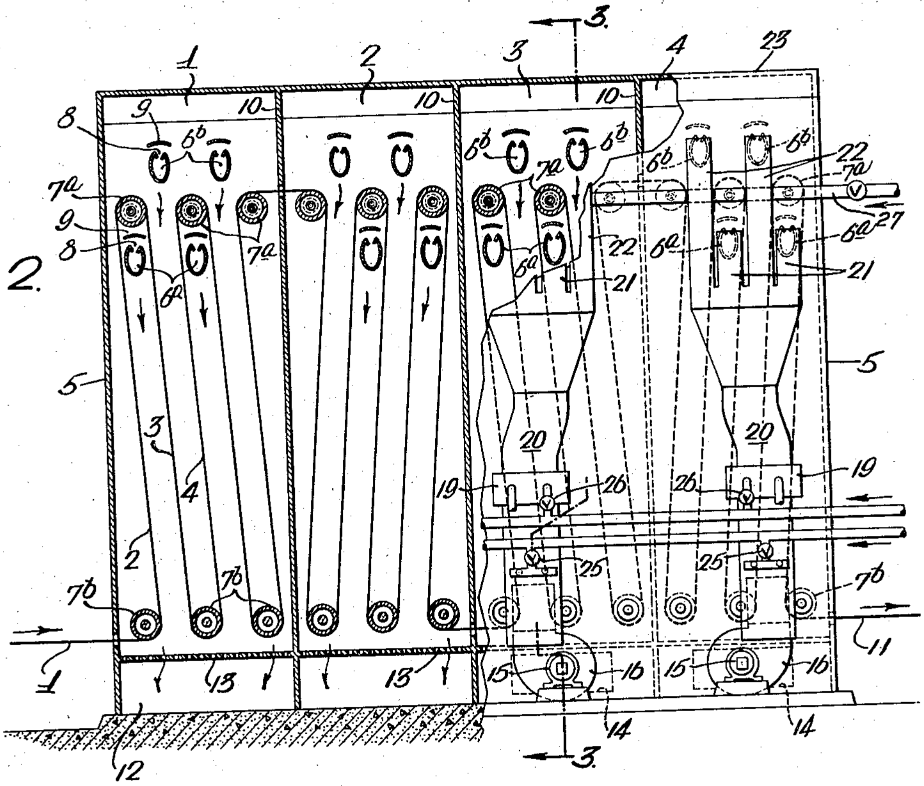


FIG. 3.

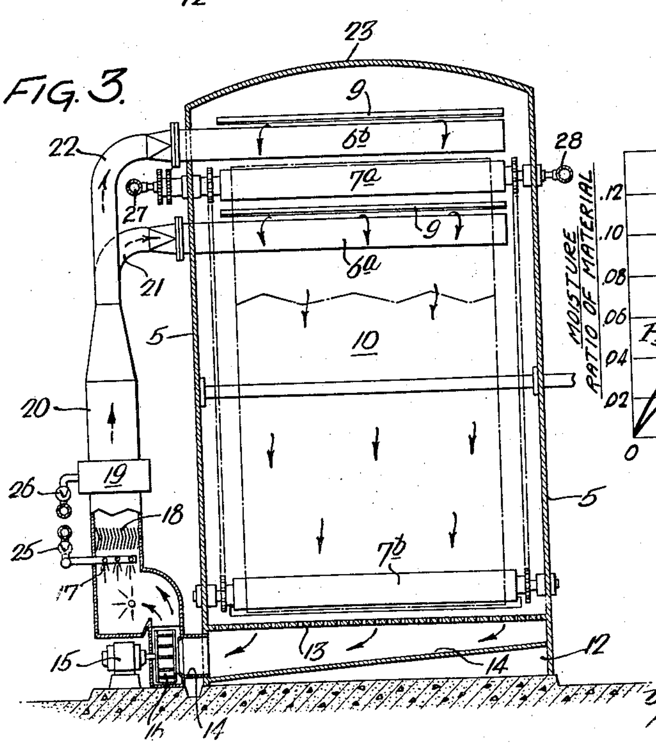
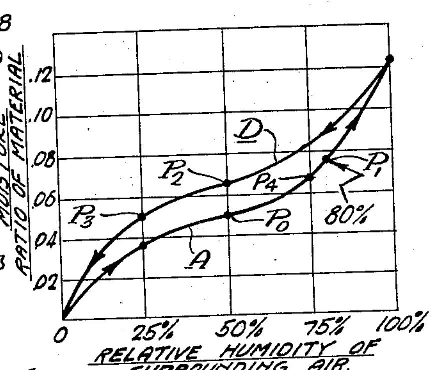


FIG. 1.



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METHOD FOR CONDITIONING WEB-LIKE MATERIALS IN A CLOSED CHAMBER

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4 Claims. (Cl. 34—23)

The present invention relates to a method for conditioning web-like materials in a closed chamber by means of a gaseous medium containing vaporized liquid. When conditioning web-like hygroscopic materials, the treatment is primarily for causing the moisture ratio of the material to balance with normal storing atmosphere. "Moisture ratio" is the weight of moisture in the material divided by the bone dry weight of the material. For special kinds of paper such conditioning is furthermore necessary because of the demand for stability during printing or the like. The conditioning can be performed in several manners, for instance by supplying finely divided moisture by means of spray nozzles or by conducting the web through a space with vapor atmosphere.

In the first case it is often difficult to distribute the moisture evenly and there is also a risk of staining or marking the material surface. When conditioning in vapor atmosphere there is a risk of marking by partial condensation. Furthermore, it is difficult to perform the conditioning without an undesired rise of temperature. The best method for conditioning hitherto known is the method where the material is caused to pass through a closed space, in which the material is exposed to the influence of wet air having a suitable moisture ratio. This method however—because of the rise in temperature by condensation of moisture in the material and the resulting reduction of the relative humidity of the air—necessitates a rather long treatment time.

It is an object of the present invention to eliminate said drawbacks and the invention is mainly characterized in that the conditioning is divided in a number of separate effective treatment steps and in that the material is cooled between said steps to a lower temperature than the temperature prevailing in the preceding treatment step for the purpose of maintaining the greatest possible difference in said effective treatment steps between the vapor pressure of the conditioning medium and that of the material.

Other characteristics of the inventive method will be evident from the claims and the following description.

In the accompanying drawing:

Fig. 1 illustrates a diagram for the hygroscopic equilibrium, for instance for paper.

Fig. 2 is a vertical longitudinal section through a conditioning apparatus suitable for the performance of the method.

Fig. 3 is a vertical transverse section through said apparatus.

For any given material, there is a curve which plots the moisture ratio of the material against the relative humidity of the surrounding moist air at equilibrium. These curves of the hygroscopic properties of various materials are available in the "International Critical Tables." For example, in the volumes published for the National Research Counsel by McGraw-Hill Book Company in 1933, these curves appear in volume 2 at pages 321 et seq.

In Fig. 1 the curves A and D represent the equilibrium

state for a material having a moisture ratio indicated in the ordinate in relation to the surrounding air, having a relative humidity indicated in the abscissa. A is the so-called absorption curve, i.e. this curve shows that equilibrium moisture ratio which a material reaches when being moistened, and D is the desorption curve, i.e., this curve shows that equilibrium moisture ratio which a material reaches when being dehumidified. For example, if material is being moistened, when the relative humidity of the surrounding atmosphere is 50%, the material will reach equilibrium with the atmosphere when it has a moisture ratio of 0.050 (see point *Po* on curve A in Fig. 1). However, if the material is being dehumidified, or dried, when the relative humidity of the surrounding atmosphere is 50%, the material reaches equilibrium with the atmosphere when it has a moisture ratio of 0.065 (see point P2 on curve D in Fig. 1). Thus, if the material has a moisture ratio of 0.050 and the relative humidity of the surrounding air drops, the material will not be dehumidified to a substantial extent until the relative humidity drops below 25% (see point P3 on curve D). Conversely, if the material has a moisture ratio of 0.065 and the relative humidity of the surrounding air rises, the material will not be moistened to a substantial extent until the relative humidity rises above 75% (see point P4 on Curve A). P_1 represents the moisture ratio to which the material in accordance with the invention should be moistened to reach a moisture ratio P_2 in equilibrium with normal atmosphere after the material in the last treatment step has been dehumidified. The distance O—P_1 thus illustrates the moistening period and the distance P_1—P_2 illustrates in corresponding manner the dehumidifying period.

As stated above, the treatment is carried out by a plurality of moistening steps with a cooling step between successive moistening steps. The relative humidity of the treating medium, for example moist air, is in the first step held at 20%. If permitted to reach equilibrium, referring to curve A of Fig. 1, the material could only attain a moisture ratio of 0.030. At the end of the first treatment step, the material is cooled to remove the heat of moistening imparted in the first step. In the subsequent steps, the relative humidity of the treating air is increased, for example in 10 percent increments. At 50% relative humidity, the material may only attain a moisture ratio of 0.050, and would be in equilibrium with air ranging in relative humidity from 25% to 50%. However, moistening is continued by increasing the relative humidity above 75% to the point P1. Then the material is dehumidified by reducing the relative humidity to 50%, so that the material attains a moisture ratio of 0.065, as indicated at point P2 on the curve D.

In Figs. 2 and 3, reference number **1** designates the entering run of the web-like material. Reference numbers **2**, **3** and **4** designate a number of vertical runs of the web which leaves the apparatus at the point **11**. The outer walls of the apparatus are designated **5** and the apparatus is by means of partitions **10** divided into a number of zones I, II, III and IV. Reference numbers *7a* and *7b* respectively designate the upper and lower rolls for the web. Reference numbers *6a* and *6b* designate distributing means for the supply of the conditioning medium which means are arranged between the different runs of web. The supplying means are in the illustrated apparatus oval shaped tubes equipped with a longitudinal slot **8** along the upper side of the tube. The slot is covered by a deflector plate **9** arranged at some distance from the slot. Reference number **13** designates a perforated intermediate bottom wall arranged below the lower rolls *7b*. Reference number **12** designates a space below said bottom wall, which is used for the discharge of the conditioning medium. Said space **12** is by means of the openings **14** connected to a channel **20** situated outside the apparatus, in which means for preparing and circulating the conditioning medium are arranged in form of spray nozzles **17** controlled by a valve **25** and a circulating fan **16** having a motor **15**. In the channel **20** eliminator plates **18** and a heat exchanger **19** controlled by a valve **26** are also arranged. The channel **20** is by means of the branch ducts **21** and **22** connected to the above mentioned distributing means *6a*, *6b*. **23** designates the roof of the apparatus which roof in the illustrated apparatus is arched for the purpose of discharging towards the sides of the apparatus the liquid drops caused by condensation of the upwardly rising vapor.

In performing the method of the invention in the apparatus shown in Figs. 2 and 3, the web **1** is threaded through the four sections or zones of the apparatus. The web is moistened in Section I, cooled in Section II, moistened in Section III, and dehumidified in Section IV. To accomplish this, the valves **25** and **26** for the first section are adjusted to provide a relative humidity in the first section of, for example, 40%. In the second section, the valves **25** and **26** are regulated to cool the web and remove the heat imparted by the absorption of moisture in the first section. In the third section, the valves **25** and **26** are regulated to provide a relative humidity, of, for example, 80% to thereby moisten the web in this section, and in the fourth section, the valves **25** and **26** are regulated to provide a relative humidity of, for example, 50% to dehumidify the web. Instead of cooling by a gaseous medium in Section II, the rolls in this section may be cooled for example by a coolant introduced and extracted by pipes **27** and **28** to effect cooling of the material. In the alternative, the Sections I, II, and III may all be moistening sections and the web may be passed over a cooled roll mounted intermediate the successive sections (not shown in Fig. 2).

What we claim:

1. A method for moistening paper, fabric, and similar hygroscopic web-like materials to a given moisture ratio which is in balance with atmosphere of a predetermined relative humidity, said method being effected in a closed space by means of a gaseous medium containing vaporized liquid; comprising moistening the material in a plurality of separate moistening steps, by maintaining the relative humidity of the conditioning medium in the first moistening step at a value below said predetermined relative humidity and raising the relative humidity in each succeeding moistening step so that in the final moistening step, the relative humidity is above said predetermined relative humidity, maintaining in each moistening step the vapor pressure of the medium above that of the material, cooling the material between said moistening steps to temperatures just below the dry bulb temperature of the medium in the preceding moistening step, and preventing condensation on the material by maintaining the dew point of said conditioning medium in each step below the temperature of the material.

2. A method according to claim 1 wherein material is cooled indirectly by contact with a conditioning medium of a suitable low temperature.

3. A method according to claim 1 wherein the material is cooled directly by contact with a cooled surface.

4. A method according to claim 1 wherein the relative humidity of the medium in said final moistening step is substantially above said predetermined relative humidity, said method including the step of dehumidifying the material following said final moistening step to said given moisture ratio by a medium having a relative humidity slightly below said predetermined relative humidity.

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