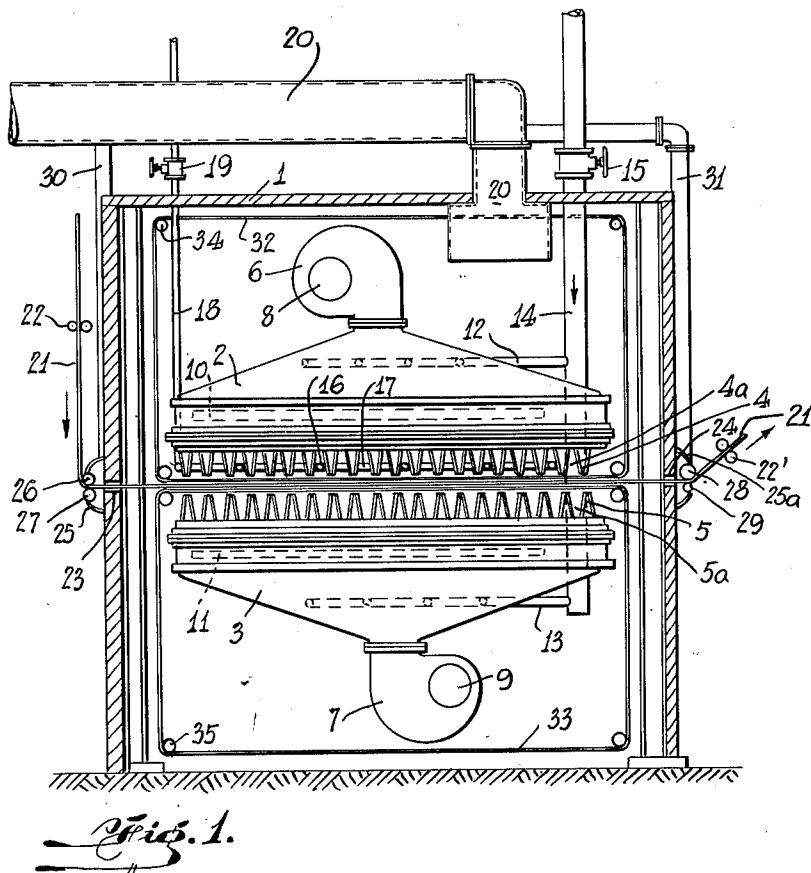
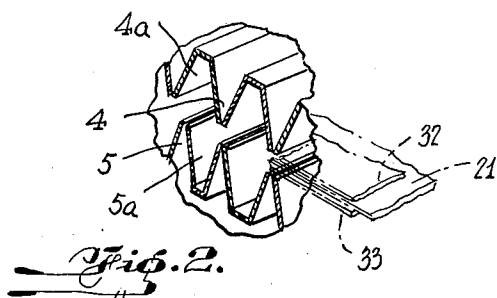


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METHOD OF TREATING SHEET MATERIAL
COATED WITH GELATINE
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METHOD OF TREATING SHEET MATERIAL
COATED WITH GELATINE

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1

The present invention relates generally to a process of treating textile and other cellulosic materials, especially for the removal of liquid therefrom.

Processes of the general character referred to may serve a variety of purposes, such as, for example, the drying of high-quality paper after sizing or impregnation with gelatine, the evaporation of inflammable constituents of substances used for impregnating fabrics, the polymerization of impregnating agent or agents in the manufacture of paper products to render same washable or water resistant, the evaporation of a liquid serving as a vehicle for the agent in a suspension, solution, emulsion and the like to be fixed to and within the fibres of the treated textile or similar product.

In all the aforesaid and like processes, it is important that the desired effect be obtained as rapidly as possible for the following reasons:

From an economic point of view it will be apparent that a shorter duration of the treatment will allow processing of a greater number of units or a greater length of material (where the latter is fed to the installation continuously and in bulk) in a given period of time.

Any prolongation of the treatment under heat beyond the necessary minimum may detrimentally affect the finished product, causing, for instance, the impregnating agent to travel to the surface of the material while the treatment is only to be used to rapidly drive off the liquid vehicle of the suspension, solution, emulsion, etc.

It is clear that the amount of heat (calories) to be applied to the material within a given unit of time is determined by the desired rate of heat treatment, i. e. by the quantity of liquid to be evaporized during such unit of time. If, as heretofore customary, a gaseous fluid is used as the carrier or vehicle of sensible heat which by its contact with the product under treatment progressively raises the temperature of the latter, the amount of heat (calories) made available will depend upon the specific heat of the fluid employed, upon its quantity and upon its temperature. Inasmuch as the specific heat of the gases adapted to be used for this purpose is relatively low, and since their quantity and operating temperature is limited by practical considerations, such as available space and the need for avoiding harmful thermal effects, respectively, the minimum duration of a treatment according to conventional methods is necessarily quite long.

One of the objects of the present invention

2

is to provide a method of and means for treating a fabric and like cellulosic article from which moisture is to be removed, in such manner as to satisfy the above-stated requirements for high-speed operation.

Another object of the invention is to provide a method of and means for thermally treating impregnated fabric and like material from which volatile substances of inflammable character are to be removed, in such manner that all danger of fire or explosion is averted.

A further object of this invention is to provide a method of and means for applying heat to an article of the aforesaid character with sufficient heat impact that the heating effect will substantially instantaneously penetrate deep into the interior or core of the fibres of the aforesaid article under treatment, thereby evaporizing the liquid present therein without necessitating a gradual or preliminary rise to the surface of said article.

Still another object of the invention is to provide a method of utilizing applied and/or the latent heat (e. g. heat of condensation or of chemical reaction) of a suitable carrier medium for purposes of the treatment desired.

Yet a further object of the invention is to provide a method which utilizes as a carrier medium a fluid available in great abundance and at low cost.

A still further object of the invention is to provide a method of removing liquid substance from the surface and the interior of an impregnated article, by the application of a heat carrying fluid, in such manner that the vapors of the liquid thus removed may themselves serve as part of the heat carrying fluid.

According to a further feature of the present invention, the above and other objects are attained by using as heat carrying medium superheated steam or vapor or a mixture of a suitable fluid containing superheated steam, the conditions of heat treatment being chosen or influenced so as to bring about at least partial condensation of the steam or of the aforesaid mixture on and within the fibrous material under treatment.

According to another feature of the invention, the heat carrying fluid is subjected to impingement upon the surface of the aforesaid material through concentrated and repeated jets of superheated steam or vapor, the force of impingement being calculated and of such extent so as to carry the desired heating effect immediately into the interior as well as onto the surface of the

3

material while the latter, for example in the form of lengthy piece material, passes continuously through a substantially closed chamber or defined space.

The invention further contemplates the aforesaid treatment of the material with the exclusion or absence of air, the air being expelled from said chamber by admitting superheated steam into the latter and creating an atmosphere of superheated steam therein at the beginning of the process and operation.

According to the invention superheated vapor may be formed at least in part by moisture expelled from the material (inherent therein or previously added) treated, or by the moisture content of a treatment fluid which is being or was previously applied to the material while the latter is in the heating chamber.

Furthermore, superheated steam or a fluid mixture containing the latter may be admitted to the chamber from therewithout, or superheated vapor or steam may be generated, at least in part, within the substantially air-free chamber.

It is preferred to provide for a continuous exhaust of vapors accumulating within the treatment chamber, so as to maintain the pressure inside the chamber at a predetermined value, the exhausted vapor mixture being subjected, if desired, to fractional distillation for recovery of its constituents.

According to another aspect of the invention, an apparatus for treating fabric and like material in bulk and by a continuous process in the manner set forth above, comprises, in combination, essentially a thermally insulated and substantially closed treatment chamber, conveyor means for continuously advancing the material through said chamber, blower means inside the chamber for directing concentrated and individual jets of superheated fluid, representing a carrier of sensible or effective and/or latent heat, for impingement upon the surface or surfaces of the material to be treated, discharge means allowing for at least partial evacuation of fluid excess from the chamber, and means for impinging a treatment fluid on the material treated.

The above and other features and objects will become apparent from the following description of a preferred embodiment of the invention. In the drawing:

Fig. 1 indicates in section and somewhat schematically an apparatus for the treatment of elongated web or other fibrous, preferably sheet material in a continuous operation.

Fig. 2 is a fragmentary sectional view of a detail of the apparatus referred to in the specification.

As shown in the drawing, a thermally insulated chamber 1 contains an upper blower box 2 and a lower blower box 3 which are equipped with sets of blower nozzles 4 and 5, respectively, these nozzles being separated from one another by respective exhaust channels 4a and 5a. Fluid is supplied to the discharge or blower nozzles by fans 6 and 7, respectively, whose respective intake ports 8 and 9 open into treatment chamber 1. Heaters, schematically indicated at 10 and 11, are disposed inside the blower boxes 2 and 3.

The chamber 1 is furthermore provided with blower nozzles 12 and 13 to which a gaseous treatment fluid is supplied by way of a duct or pipe 14 having a shut-off valve 15. These latter nozzles are preferably disposed intermediate the blowers or fans 6 and 7, respectively, on the one hand, and the heating elements 10 and 11, 75

4

on the other hand; it will be understood, however, that they may also be mounted at some other suitable location within the heating chamber 1.

Additional nozzles 16-17, receiving a treatment liquid by way of a conduit 18 provided with a shut-off valve 19, may be disposed in certain of the exhaust channels 4a between the aforesaid nozzles 4. It will be understood that additional nozzles may be similarly provided at exhaust channels 5a formed between the nozzles 5.

An exhaust conduit 20 opens into the chamber 1 in order to allow for the at least partial evacuation of the treatment fluid.

This exhaust conduit 20 may be connected to any suitable apparatus (not shown) for utilizing the evacuated fluid, such as a condenser, a fractional distillation system, a gas turbine and like consumer unit.

The web material 21 to be treated by this continuous process is introduced into the chamber 1 by way of an inlet slot 23, having previously passed between guide means 22, shown schematically as rollers. The material leaves the chamber 1 through an exit slot 24 and is then directed between similar guide roller means 22'.

The inlet slot 23 is covered by a hood 25 having an inlet slit whose edges are formed by cylindrical elements 26, 27 which allow for the passage of the web 21 while forming a substantially airtight seal against the atmosphere. Analogously, the exit slot or end 24 of the chamber is sealed off against the atmosphere by a similar hood 25a whose outlet slit is formed by cylindrical elements 28 and 29.

The spaces formed between the hoods 25, 25a and the outer wall of the chamber 1 are connected through pipes 30 and 31, respectively, to the exhaust conduit 20 for the purpose of recovering the fluids escaping from the chamber 1 by way of the inlet and exit slots 23 and 24.

Admission of any air through the web material into the treatment chamber may be markedly reduced through suction means (not shown) extending into the space adjacent hood 25.

Within the treatment chamber 1 the material under treatment is moved and displaced within the space defined between the orifices of opposite nozzles 4, 5 by means of endless conveyors 32 and 33, guided on rollers 34, 35, which are sufficiently porous or perforated to offer little resistance to the passage of the fluids.

The operation of the apparatus is now described by way of an example, with reference to the drying of a rubberized fabric. A fabric impregnated with a solution of known rubber composition having a benzene base, is especially delicate and difficult to be treated as the mixture of air and benzene vapors is highly inflammable and there is always present the danger of an explosion where such mixtures are allowed to develop. Actually, accumulation of small electric charges resulting from the rubbing or friction of the fabric against a support may be sufficient to produce a detonation or explosion.

According to the invention, the chamber 1 is heated at the beginning of operations by means of the heating elements 10 and 11, the air being simultaneously agitated by fans 6 and 7. After the temperature has been raised sufficiently to avoid any condensation, superheated steam is admitted through nozzles 12 and 13 by opening valve 15, the steam gradually replacing the air initially present in the chamber 1. In this way, the formation of an explosive mixture during

the subsequent stages of operation will be prevented.

After the air has been driven off or removed from the chamber, or at least sufficiently rarefied, the fabric material 21 impregnated with the aforesaid rubber solution is introduced through the inlet slot 23. Rapid evaporation of the solvent of the rubber composition permeating the fabric material 21 is now brought about by projecting superheated steam at high speed and in the form of individual concentrated jets through nozzles 4 and 5 upon the two faces of the fabric over substantially its entire length within the chamber 1, so that this steam will condense both on the surface and in the core or interior of the fibrous fabric material. Thus, the steam will give up, in addition to its sensible heat, a portion of its latent heat (heat of condensation), resulting in the simultaneous liberation of large calories which in turn will almost instantaneously vaporize the entire solvent present in the portion of the fabric material exposed to the treatment.

This heat impact drives practically immediately the temperature of the material to the boiling point, even within the fiber cores, which causes instantaneous evaporation of the solvent in the very core of the fibrous fabric, in contradistinction to known methods in which the liquid or solvent is vaporized only after it has been brought up from within the material to the surface thereof through capillary action.

After the operation has been initiated in the manner described, the admission of steam by way of the duct 14 may be throttled or completely stopped.

Thus, the liquid evaporated from the treated fabric may now be used to form at least part of the superheated vapor or steam to be projected as a mixture upon the faces of the fabric by the blowers or fans 6 and 7 which draw on the fluid filling the interior of chamber 1, the superheating effect being attained by the action of the heaters 10 and 11.

In order to maintain the atmosphere within the chamber 1 at a predetermined pressure regardless of the continuous influx or supply of fluid, caused by the evaporation of liquid permeating and impregnating the fabric material 21 and by the admission of steam from the duct 14, the fluid is at least partially evacuated or withdrawn from the chamber by means of exhaust conduit 20 which for this purpose is connected to suitable suction means (not shown) such as blowers, condensers and the like.

It is to be mentioned that it is desirable to maintain a pressure slightly higher than atmospheric inside the chamber 1, in order to prevent any entry of air from the outside. The danger of air leakage is, moreover, greatly diminished by the provision of the aforescribed seals 25, 25a at the inlet and outlet ends of the chamber and by the connection between these seals and the exhaust conduit 20 which tends to intercept any air passing through slits 26, 27 and 28, 29.

Since the treatment fluid representing the carrier of sensible and latent heat is a mixture of superheated steam and solvent vapor, the constituents of this mixture may be separated after evacuation by well known means, such as fractional distillation or condensation.

It is important to note that the operation just described takes place in the practically complete absence of air, thereby obviating the pos-

sibility of an explosive mixture forming inside the chamber 1. It should also be noted that the condensation of superheated steam on the surface as well as in the interior of the treated product, together with the amount of sensible heat given off by the fluid, delivers such impact of heat to the material or product under treatment, that the material will be practically instantly brought to the boiling point of the liquid, thereby reducing the drying period very considerably to substantially less than one minute (of the order of not more than a few seconds).

The system described and illustrated may also be used to great advantage in connection with the polymerization of any known polymerizable resinoid-forming substances (synthetic resins) with which fabric is to be impregnated in order to render it wrinkle-proof. It is known that it is difficult in such processes to retain in the fibers the resinous products dissolved in the liquid phase when the latter is being removed from the fabric by conventional methods. Such methods generally cause rising of the liquid to the surface, by capillary action, before vaporization can take place. This rise of the liquid will in turn result in and entail migration of resinous constituents toward the surface where due to the evaporation thereof a crystalline deposit will be formed which causes a hard and unpleasant feel to the fabric.

To effect the desired polymerization in accordance with the method and by means of the apparatus of the present invention as disclosed above, the air is again expelled from the treatment chamber 1 by the admission of superheated steam through the duct 14, as above indicated.

The fabric material impregnated with a suitable and known solution of synthetic resin, is introduced into the chamber. The intensive impact of heat produced by the condensation of superheated steam, impinging upon the fabric and penetrating into the core of the fibrous layers thereof, instantly brings the material with the impregnating liquid to the boiling point of the latter. This, in turn, results in the instantaneous evaporation of the liquid even from the very core of the fibers, thereby causing in the interior thereof precipitation of the resinoid-forming substance, stabilizing same and effectively preventing its migration. At the same time, the supplied heat will effect the desired polymerization of the precipitated resinous or resinoid-forming substances. As in the previously stated example, the operation is extremely rapid and is completed in a few seconds. Also, the quality of the finished and treated material or fibrous product obtained is greatly improved because not only the phenomenon of migration, which characterizes troublesome known forms of treatment, but also the detrimental effects of lengthy exposure to elevated temperatures are avoided. This result is in particular important in connection with the manufacture of paper material sized or impregnated with gelatine, as hereinabove mentioned.

In cases where the treatment involves the sprinkling of the treated material with a particular liquid, the latter may be applied by means of nozzles 16 and 17 fed from the conduit 18. The steaming of fabric material may be mentioned as an example of such a treatment; the steaming operation is greatly enhanced by sprinkling the fabric, for example, with a hydrosulfite solution during its treatment with superheated steam as hereinabove set forth.

Finally, it should be observed that in cases

where the superheated vapor is steam, the water may be directly introduced into the chamber 1 by way of the duct 14; it is also possible, however, to admit only saturated steam or vapor and to superheat same inside the chamber by means of the heating elements 10, 11.

The several treatments mentioned above by way of example will make it plain that the invention is widely applicable to a large number of processes (paper impregnation, fabric drying, etc.), leading now in all cases to various advantages such as increased speed of operation and improvement of the character and quality of the final product, the latter by virtue of the elimination of the detrimental effects due to prolonged exposure to elevated temperatures; all of these advantages being the result of the application and impact of a large quantity of heat resulting from the combined action of the sensible and the latent heat of a superheated vapor allowed to condense on and below the surface of and within the product or material to be treated.

In order to demonstrate the effectiveness of the invention from a comparison between a drying process using conventionally dry air and that employing superheated steam, the following considerations are of interest:

Dry air

1 kg. of dry air heated to 100° C. contains $0.37 \times 100 = 37$ calories, the heat coefficient being 0.37. In order to evaporate 1 kg. water, 100 calories are necessary for heating the same, whereas 540 calories of latent heat bring about evaporation. To this total of 640 calories are to be added losses due to the radiation and losses which are caused on account of the expulsion of saturated air from the heating chamber at the start of the drying process.

Consequently, at least 1280 calories would be needed for each kilogram of water to be evaporated. 1280 calories are, however, for all practical purposes a low estimate. Certain machines necessitate between three to six times the theoretical quantity of 640 calories. Thus, if it is assumed that the expulsion temperature for saturated air leaving the treatment chamber is 50° C., 1 kg. dry air would yield one half of 37 or about 20 calories. Consequently, one would need

$$\frac{1280}{20} = 60.4 \text{ kg. air of } 100^\circ \text{ C.}$$

in order to evaporate 1 kg. water.

Superheated steam

1 kg. of superheated vapor contains approximately 100 calories for heating purposes and 540 calories latent heat for evaporation to which are added further calories which result from overheating according to the formula $Q = 606.5 \times 37 (T - t)$; t being the temperature of the surrounding atmosphere and T the temperature of superheated steam. Consequently, 1 kg. superheated steam of 140° C. contains approximately 640 calories. If one assumes that 15% of the available calories are losses due to radiation, which 15% amount to 96 calories, approximately 736 calories would be available in order to evaporate 1 kg. of water. Thus,

$$\frac{736}{640} = 1.14 \text{ kg. of steam}$$

is required in order to obtain 1 kg. of water to be evaporated. In practice and in order to be on the safe side, approximately 1.3 kg. of steam

should be taken into consideration for each kilogram of water to be evaporated.

From the foregoing it will be seen that there has been disclosed a process of treating lengthy piece of material in continuous operation, comprising the steps of impregnating said material with a reagent in a liquid phase, wherein the reagent may be dissolved or suspended, introducing superheated steam into a chamber, projecting superheated steam upon the surface of said material at a speed sufficiently high to effect penetration of said steam into and below said surface of said material, thereby evaporating at least a portion of said liquid phase, superheating said evaporated portion, and projecting a mixture of said steam and said superheated portion upon the surface of said material, thereby vaporizing a further portion of said liquid phase.

It can thus be seen that there has been provided in accordance with the present invention a method of continuously treating lengthy sheet material to which gelatine containing liquid is applied and which is moved through a substantially air-free enclosure; comprising the steps of maintaining an atmosphere of superheated steam within said enclosure and at a predetermined average pressure slightly higher than atmospheric pressure, directing individual jets of superheated vapor upon spaced surface areas of said material, controlling the velocity of said jets so that the superheated steam is impacted upon the material and partially condenses thereon and sufficient latent heat is removed from the superheated steam to raise the temperature of said material to the boiling point of the liquid contained in said gelatine and substantially immediately vaporized said liquid to force vapor by expansion from said material to the outside thereof, moving the material rapidly through the enclosure at a rate at which the treatment is completed without deleterious effects on the material, evacuating said vapor adjacent and between said surface areas to thereby draw off said vapor therefrom, reheating said evacuated vapor to the conditions of said superheated vapor, and recirculating such superheated vapor for further impact upon said material.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent, is:

The method of continuously treating lengthy sheet material to which gelatine containing liquid is applied and which is moved through a substantially air-free enclosure; comprising the steps of maintaining an atmosphere of superheated steam within said enclosure and at a predetermined average pressure slightly higher than atmospheric pressure, directing individual jets of superheated vapor upon spaced surface areas of said material, controlling the velocity of said jets so that the superheated steam is impacted upon the material and partially condenses thereon and sufficient latent heat is removed from the superheated steam to raise the temperature of said material to the boiling point of the liquid contained in said gelatine and substantially immediately vaporize said liquid to force vapor by expansion from said material to the outside thereof, moving the material rapidly through the enclosure at a rate at which the treatment is completed without deleterious effects on the material, evacuating said vapor adjacent and between said surface areas to thereby draw off said vapor therefrom, reheating said evacuated vapor

9

to the conditions of said superheated vapor, and recirculating such superheated vapor for further impact upon said material.

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