Feb. 13, 1940. A. MELLOR ET AL 2,189,915

DRYING OF LAYERS OR SHEETS OF MATERIAL

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FIG. 1

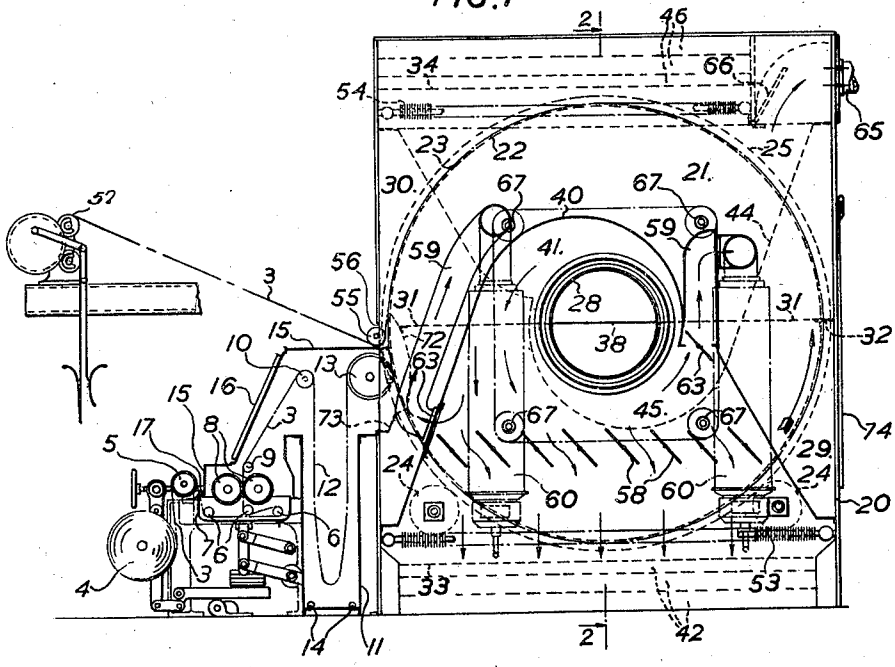
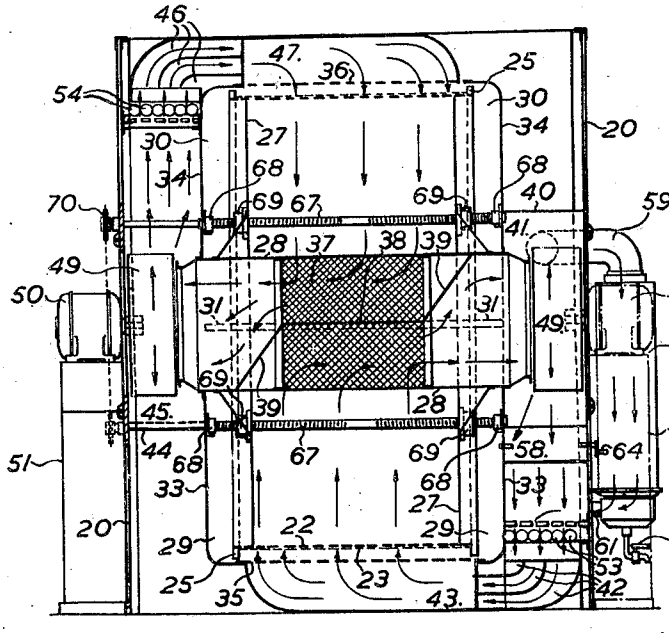


FIG. 2



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DRYING OF LAYERS OR SHEETS OF MATERIAL

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11 Claims. (Cl. 34—24)

This invention relates to the drying of layers, sheets, or webs of material containing a volatile liquid.

According to the invention a layer, sheet, or web of material containing a volatile liquid is dried in a plurality of stages, in at least one of which super-heated vapour of the liquid is applied to the material, and in at least one other stage, including the final stage, a gas is applied to the material to complete the extraction of the liquid.

The invention is particularly applicable to the drying of layers or sheets of permeable materials such as fabrics, e. g., fabrics which have been impregnated with a liquid containing a substance dissolved in a volatile solvent, since in this case the drying currents may be caused to pass through the material. In the following description, the invention will be explained principally with reference to the treatment of a fabric. Thus, in accordance with one method of carrying out the invention super-heated vapour of the solvent is passed through the fabric in one stage conveniently as an operation involving circulation of the vapour with part of the vapour being continuously withdrawn from the circuit and condensed to liquid, while the remainder is returned for circulation through the fabric. In another drying stage, including the final stage, a gas, such as air, preferably heated, is passed through the fabric to complete the extraction of the solvent. The solvent-laden gas may, where necessary, be led to suitable recovery means, e. g., a carbon recovery plant.

The circulation of the super-heated vapour and the gas through the fabric may conveniently, though not necessarily be carried out while the fabric is travelling in contact with an endless support, e. g., an endless band of permeable fabric or other material, receiving the fabric at one point of its travel and, after passing through a plurality of drying chambers, delivering it dry or substantially so at another point. Thus, the fabric may be led round the surface of a drum formed of perforated metal or the like and covered, if desired, with fabric. The drum is arranged to revolve, e. g., about a horizontal axis, in a chamber divided both externally and internally of the drum into a plurality of smaller chambers or compartments. A compartment inside the drum registers with a compartment outside, and a fan is disposed so as to produce a suction inwardly through the fabric from an exterior to an interior compartment.

Heating means are provided in an exterior compartment so as to provide for the super-heating of vapour contained in the circuit by evaporation from the fabric. A by-pass is provided for diversion of part of the circulating vapour to one or more condensers, the remainder of the vapour remaining in circulation.

In the portion or portions of the chamber in which gas is applied to the fabric to complete the extraction of the solvent, suitable means may be provided for heating of the gas, and a fan may be provided to circulate the heated gas through the fabric. Solvent-laden gas may be carried away by suitable suction means, substantially dry gas being admitted to the chamber at a rate suitable to complete the drying.

In order to provide for efficient recovery of solvent, pressure inside the apparatus is maintained somewhat below atmospheric pressure, so that in the main solvent cannot leak outwards but only air inwards, this air being ultimately carried away to the recovery plant.

For many purposes two-stage drying is sufficient, but some other number of drying stages, with the necessary condensers or recovery plants, may be provided if the nature of the material under treatment and/or of the solvent employed or the rate of operation render it desirable.

The rate of travel of the surface on which the layer or sheet web is carried is so adjusted as to allow for any shrinkage that may take place during the drying operation.

A form of apparatus according to the invention will now be described in greater detail with reference to the accompanying diagrammatic drawing of which—

Fig. 1 is a part cross-sectional side elevation of a two-stage drying machine adapted for operation in conjunction with fabric impregnating and treating apparatus of the types described in U. S. application S. Nos. 123,102 filed January 30, 1937 and 124,138 filed February 4, 1937.

Fig. 2 is a part cross-sectional front elevation of the drying machine viewed along the line 2—2 of Fig. 1.

Referring to Fig. 1 fabric 3 unwinding from a roll 4 passes upwardly to and around a roller 5 and downwardly from the roller to guide rollers 6 which are rotatably mounted in a trough 7 containing a solution of a dyestuff in a volatile solvent. The fabric 3 passes round the guide rollers 6 in the manner shown and is directed upwardly from the last of the rollers to the nip of a pad mangle comprising a pair of rubber-covered rollers 8. In this passage round the submerged guide rollers 6 the fabric 3 becomes thoroughly impreg-

nated with dye liquor and free liquor is expressed from the fabric by the rollers 8.

From the rollers 8 the fabric 3 passes over guide rollers 9, 10 to a vapour chamber 11 through which the fabric travels in the form of a running loop 12 and passes over a roller 13 into the drying machine, which will be described later. The vapour chamber 11 may be heated by steam pipes 14.

The trough 7, mangle rollers 8, rollers 9 and 10 and the vapour chamber 11 are covered by a shield 15 which fits closely around the apparatus and assists in reducing evaporation into the atmosphere of solvent from the trough 7 and from the fabric as it proceeds to and passes through the vapour tank 11. The shield 15 is provided with a window 16 through which the dyed fabric may be inspected during its travel, and is formed with a narrow slot 17 to allow of the passage of the fabric from the roller 5 to the trough 7.

The drying machine comprises a chamber 20 which houses a rotatable hollow drum indicated generally at 21. The drum consists of a peripheral shell of perforated metal 22 which is covered with loosely woven air-permeable fabric 23 and is supported and rotated by rollers 24 which engage and drive raised tracks 25 formed around the edges of the drum. The side plates 27 of the drum do not rotate, and are mounted about a centrally-disposed stationary hollow cylinder 28, the plates fitting closely between the cylinder and the periphery 22 of the drum.

The chamber 20 is formed into two separate compartments 29, 30 both internally and externally of the drum 21, a stationary plate 31 horizontally mounted inside the drum and a lip 32 in registry with the plate outside the drum, dividing the two compartments, the lower (29) of which is enclosed within a casing 33 while the upper compartment is enclosed within a complementary casing 34.

The bottom of the casing 33 comprises a perforated metal plate 35 and the top of casing 34 comprises a similar plate 36. A plate 38 is disposed within the cylinder 28 in registry with the plate 31 and thus completes the division of the two compartments 29, 30 internally of the drum. The ends 39 of the plate 38 are bent so as to fit against opposite sides of the cylinder 28, and the middle portion of the cylinder comprises a wide belt of wire gauze 37, for reasons which will be apparent from the following description.

The space between the right-hand sides of the casings 33, 34 and the right-hand wall of the chamber 20 (as seen in Fig. 2) is divided by a curved shield 40 which forms a chamber 41, the chamber being connected by conduits 42 to a chamber 43, the upper side of which is open to the perforated plate 35 of the casing 33. The space between the left-hand side of the casings 33, 34 and the left-hand wall of the chamber 20 is similarly divided by a curved shield 44 which forms a chamber 45, the chamber being connected by conduits 46 to a chamber 47, the lower side of which is open to the perforated plate 36 of the casing 34.

The chambers 41, 45 contain fans 49 directly driven by electric motors 50 which are supported on raised mountings 51 at opposite ends of and in registry with the cylinders 28. The extremities of the cylinder protrude beyond the casings 33, 34 to a point close to each fan 49 so as to concentrate the suction of the fans in the respective ends of the cylinder.

The suction created by the fan 49 in the chamber 41 causes a current to circulate through the compartment 29, the current passing from the chamber 41 past heating pipes 53 (to be described later), through the conduits 42 and chamber 43 and into the lower portion of the drum 21 through the perforated plate 35 and the permeable periphery of the drum, the current then passing through the lower portion of the gauze band 37 and along the cylinder 28 to the right (as seen in Fig. 2) and finally back to the fan 49, as indicated by arrows in the drawing.

Similarly, the fan 49 in the chamber 45 causes a current to circulate through the compartment 30, the current passing from the chamber 45 past heating pipes 54, through the conduits 46 and chamber 47 and into the upper portion of the drum through the perforated plate 36 and the permeable periphery of the drum, the current then passing through the upper portion of the gauze band 37 and along the cylinder 28 to the left, and finally back to the fan as indicated by the arrows.

In this manner, two separate circulations are set up within the chamber 20, each being isolated from the other within its chambers 41, 43, 29 (or 45, 47, 30) and each creating suction on substantially one half of the periphery of the drum 21.

In operation, the fans 49 are started, the drum is rotated by the rollers 24 in the direction shown by the arrow in Fig. 1, and the pipes 53, 54 are heated. The vapour-charged fabric 3 passes over the roller 13 from the vapour chamber 11 and is laid on the fabric surface 23 of the drum 21. The drum carries the fabric through the compartments 29, 30 in turn and eventually delivers it in dried form to a guide roller 55 which operates in an opening 56 formed in the chamber 20, the fabric passing from the roller to a collecting device indicated generally at 57. The rate of rotation of the drum 21 is controlled in accordance with the rate of shrinkage of the fabric being dried, and in this manner the length of the running loop 12 in the vapour chamber 11 is maintained substantially constant. The collecting device 57 is shown for convenience close to the chamber 20 but is preferably disposed some distance from the chamber so as to be clear of the pad mangle apparatus.

On entering the compartment 29 the fabric 3 is subjected to suction through the permeable periphery of the drum 21 and vapour is sucked from the fabric and passed into circulation. The temperature of the heating pipes 53 is such that the circulating vapour becomes superheated and in this manner a drying current of superheated solvent vapour is continually applied to and passed through the fabric 3 during its passage through the compartment 29.

The rate of circulation of the drying current may be regulated by louver blades 58 arranged in the chamber 41 and controlled as to position by a handle 64 outside the chamber 20. Thus at the commencement of the drying operation the louver blades 58 may be set with their edges close together in order to retard the circulating current and to enable the current to become quickly charged with vapour to the desired degree, and when such condition is reached the blades may be opened to accelerate the circulation.

Part of the circulating vapour may continuously be withdrawn from the chamber 41 for condensation to liquid through by-pass conduits 59 which lead from the chamber to cooling con-

densers 60 disposed outside the chamber 20. The vapour passes downwardly through the condensers, as indicated by the arrows, and uncondensed vapour passes back from the condensers through conduits 61 to the lower portion of the chamber 41 for recirculation. The condensed liquid may be withdrawn from the lower portion of each condenser by means of a cock 62. While two by-pass conduits 59 leading to two condensers 60 are shown in the drawing it will be understood that one conduit of suitable size and one condenser of suitable capacity, only could be employed if desired.

The quantity of vapour by-passed through the condensers 60 may be regulated by blades 63 disposed at the entrances to the conduits 59. In this manner the degree of concentration of the solvent vapour in the circulating current (and consequently the rate of drying of the fabric 3) can be controlled. Continuous withdrawal of vapour from the chamber 41 results in the pressure within the chamber 29 being maintained somewhat below atmospheric pressure. In the main, therefore, vapour cannot leak outwards but only air inwards, this air being ultimately charged with solvent vapour.

On passing from the compartment 29 to the compartment 30 the fabric 3 is subjected to the second stage of the drying operation, warm air being sucked through the fabric to complete the extraction of solvent. Thus the fan 49 in the chamber 45 forces air past the heating pipes 54 and into circulation, in the manner described above. Solvent-laden air is withdrawn from circulation through a conduit 65 leading to a solvent recovery plant, e. g., a carbon recovery plant, the quantity of air so withdrawn being regulated by a hinged flap 66 disposed near the entrance to the conduit. Fresh air is drawn into circulation through the opening 56 in the wall of the chamber 20. With a solvent recovery plant which itself exercises suction in its supply pipe the suction may be strong enough to assist the operation of the fan 49 in the chamber 45 and, if very strong, may render such fan unnecessary. With a continuous withdrawal of quantities of air from the chamber 45 larger than the quantities admitted to the chamber the pressure within the chamber is maintained somewhat below atmospheric pressure, as with chamber 29, and leakage of solvent vapour into the atmosphere is prevented.

In order to reduce undesirable leakage of air into the interior of the drum 21 near the opening 56 in the chamber 20, and to minimise the amount of vapour drawn into the chamber from the vapour chamber 11, the edge of the plate 31 adjacent to the periphery of the drum near the opening is somewhat foreshortened and a curved shield 72 is fitted to the edge of the plate across the width of the drum, in the manner shown in Fig. 1. The shield 72 co-operates with a further shield 73 mounted inside the chamber 20 and extending from the lower edge of the opening 56 to a point near the periphery of the drum in registry with the edge of the shield 72.

The side plates 27 of the drum though fitting closely to the cylinder 28 and the periphery of the drum may be moved towards or away from each other in accordance with the width of the fabric being dried. Thus the plates are supported by four threaded shafts 67 each of which is rotatably mounted in bearings 68 formed in the casings 33, 34, and engages an internally threaded boss 69 secured to each side plate 27. The shafts 67 are synchronously rotatable by chain and sprocket gearing 70 and are threaded in reverse directions at their right- and left-hand ends so that rotation of the shafts causes the plates either to draw together or move away from each other in accordance with the direction of rotation of the shafts. In this manner the machine can quickly be adapted to dry fabrics of different widths, the movable plates ensuring that substantially the whole of the suction is concentrated on the fabric. The chamber 20 is provided with a sliding door 74 which may be opened to allow of entry into the chamber for cleaning or other purposes.

The invention is particularly useful in connection with the dyeing of cellulose acetate or other cellulose ester or ether textile materials with the aid of volatile organic solvents, and enables the drying of such materials to be carried out in a rapid and continuous manner.

Having described our invention, what we desire to secure by Letters Paent is:

1. A method of drying a layer, sheet, or web of permeable material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, in at least one of which super-heated vapour of the solvent substantially free from other gas is passed through the material, and in at least one other stage, including the final stage, another gas is passed through the material to complete the extraction of the solvent.

2. A method of drying a layer, sheet, or web of permeable material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, and in at least one of said stages passing through the material a circulating current of super-heated vapour of the solvent substantially free from other gas, and regulating the concentration of the solvent in said vapour, and in at least one other stage, including the final stage, passing air through the material to complete the extraction of the solvent.

3. A method of drying a layer, sheet, or web of permeable material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, and in at least one of said stages passing through the material a circulating current of super-heated vapour of the solvent substantially free from other gas, and continuously withdrawing from the circuit part of the vapour, and in at least one other stage, including the final stage, passing air through the material to complete the extraction of the solvent.

4. A method of drying a layer, sheet, or web of permeable material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, and in at least one of said stages passing through the material a circulating current of super-heated vapour of the solvent substantially free from other gas continuously withdrawing from the circuit part of the vapour, and recovering solvent from said withdrawn vapour, and in at least one other stage, including the final stage, passing air through the material to complete the extraction of the solvent.

5. A method of drying a layer, sheet, or web

of material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, and in at least one of said stages passing through the material a circulating current of super-heated vapour of the solvent substantially free from other gas, and regulating the concentration of the solvent in said vapour, and in at least one other stage, including the final stage, passing through the material a circulating current of warm air to complete the extraction of the solvent, continuously withdrawing solvent-laden air from said current, and recovering solvent from said withdrawn air.

6. A method of drying a layer, sheet, or web of permeable material impregnated with a liquid containing a substance dissolved in a volatile solvent, which comprises extracting solvent from the material in a plurality of stages, and in at least one of said stages passing through the material a circulating current of super-heated vapor of the solvent substantially free from other gas, continuously withdrawing from the circuit part of the vapor, and recovering solvent from the vapor by condensation, and in at least one other stage, including the final stage, passing air through the material to complete the extraction of the solvent.

7. Apparatus for drying a layer, sheet, or web of material, comprising an endless permeable support for the material, a plurality of chambers, means for moving the support progressively through the chambers in succession, means for circulating a gaseous current through the first chamber so as to cause the current to pass through the support in that chamber, means for super-heating such circulating current, means for removing part of such current, a condenser adapted to receive the removed part of the current, and means for directing a gaseous current to pass through the support in another of the chambers.

8. Apparatus according to claim 7, comprising means to return the removed part of the current from the condenser into circulation.

9. Apparatus for drying a layer, sheet, or web of material, comprising a chamber, a drum rotatably mounted within the chamber and having a permeable periphery adapted to support the material, means dividing the chamber into two compartments internally and externally of the drum, means for rotating the drum so that the material is carried progressively through the compartments in succession, means for circulating a gaseous current through the first compartment and through the periphery of the drum in that compartment, means for heating said current, a condenser adapted to receive part of the current from the first compartment, and means for passing a gaseous current through the other compartment and through the periphery of the drum in said compartment.

10. Apparatus for drying a layer, sheet, or web of material, comprising a chamber, a drum rotatably mounted within the chamber and having a permeable periphery adapted to support the material, means dividing the chamber into two compartments internally and externally of the drum, means for rotating the drum so that the material is carried progressively through the compartments in succession, means for circulating a gaseous current through the first compartment and through the periphery of the drum in that compartment, means for heating said current, a condenser adapted to receive part of the current from the first compartment, means for controlling the quantity of current passed to the condenser, and means for passing a gaseous current through the other compartment and through the periphery of the drum in said compartment.

11. Apparatus for drying a layer, sheet, or web of material, comprising a chamber, a drum rotatably mounted within the chamber and having a permeable periphery adapted to support the material, means dividing the chamber into two compartments internally and externally of the drum, means for rotating the drum so that the material is carried progressively through the compartments in succession, means for circulating a gaseous current through the first compartment and through the periphery of the drum in that compartment, means for heating said current, means for regulating the velocity of said current, a condenser adapted to receive part of the current from the first compartment, and means for passing a gaseous current through the other compartment and through the periphery of the drum in said compartment.

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