United States Patent

Wallsten

[15] **3,659,347**

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[54] METHOD AND MEANS FOR DRYING MOIST MATERIAL, SUCH AS PAPER, CELLULOSE, OTHER FIBRES OR THE LIKE

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Aug. 13, 1969 Sweden.....11294/69

[52] **U.S. Cl.**.....**34/9,** 34/124

[51] **Int. Cl.**.....**F26b 3/00**

[58] **Field of Search**.....34/9, 110, 111, 115, 118, 122, 34/124, 125

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Primary Examiner—John J. Camby

Attorney—Brooks, Haidt & Hoffner

[57] **ABSTRACT**

A method and means for drying moist material in which heat from a source of heat is supplied at least partially to one side of a porous layer, the pores of which are capable of conducting vapor. The moist material is in contact with the opposite side of the porous layer, so that due to the heat from the source of heat the moisture in said moist material is vaporized to vapor which thus is generated as a result of evaporation of moisture in said moist material and is at least partially forced into and through said porous layer in a direction opposite to that of the temperature gradient caused by heat supplied mainly by means of thermal conductivity from the source of heat to the porous layer through a homogeneous, heat-conducting wall. The wall is arranged in at least partial heat-conducting contact with the porous layer and defines a partition between the porous layer and the source of heat, blocking the passage of steam through said porous layer. The generated vapor is discharged in direction mainly perpendicular to said temperature gradient.

10 Claims, 14 Drawing Figures

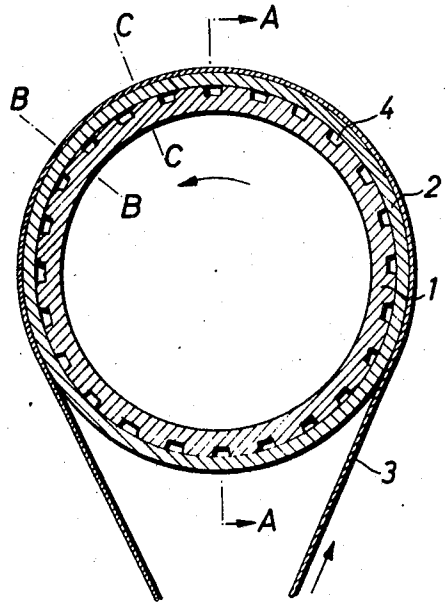

Fig.1

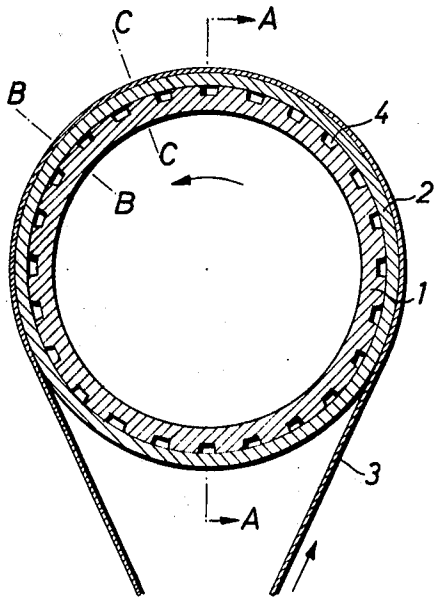

Fig.2

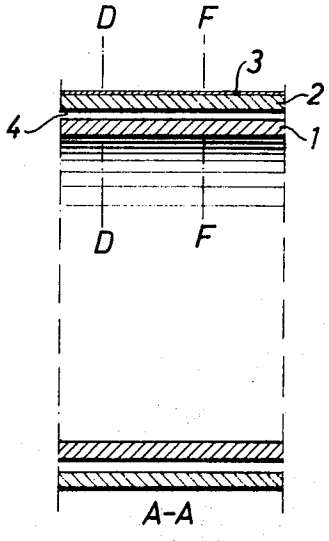

Fig.4

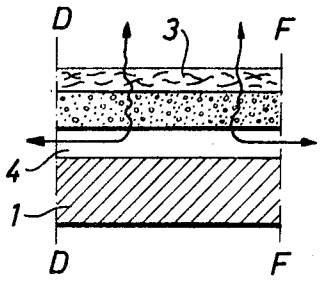

Fig.5

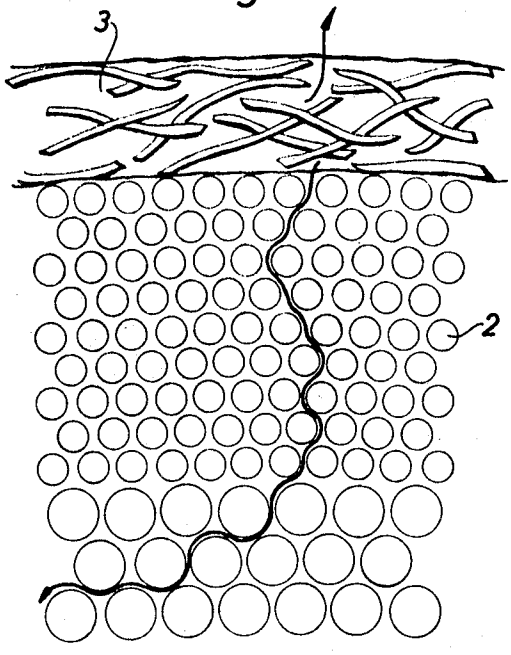

Fig.3

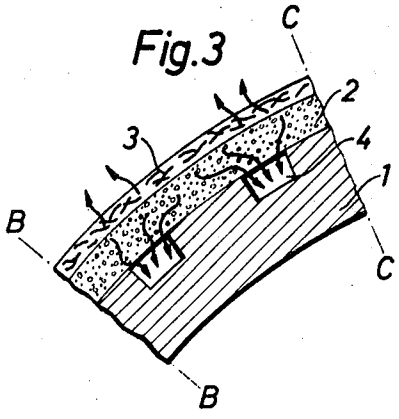

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Fig.6

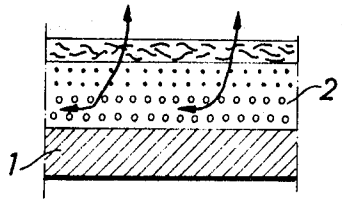

Fig.7

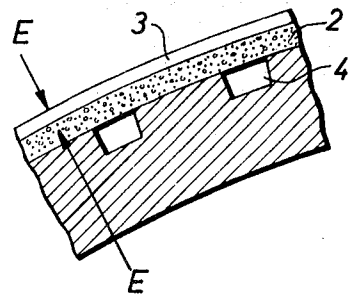

Fig.8

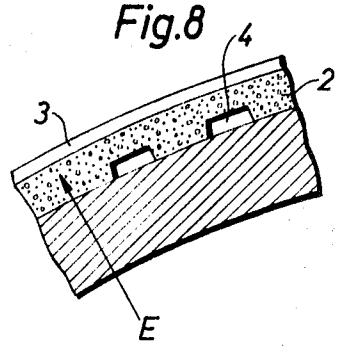

Fig.9

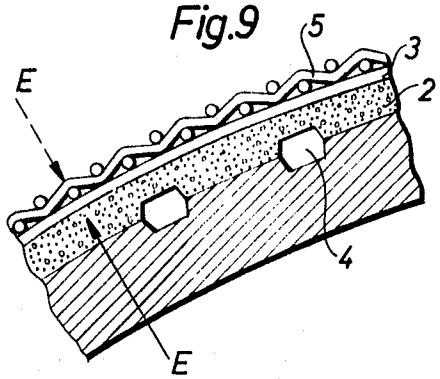

Fig.10

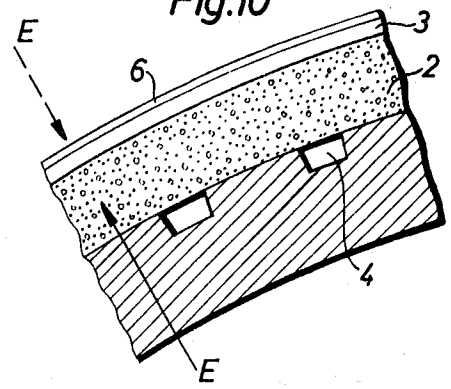

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Fig.11

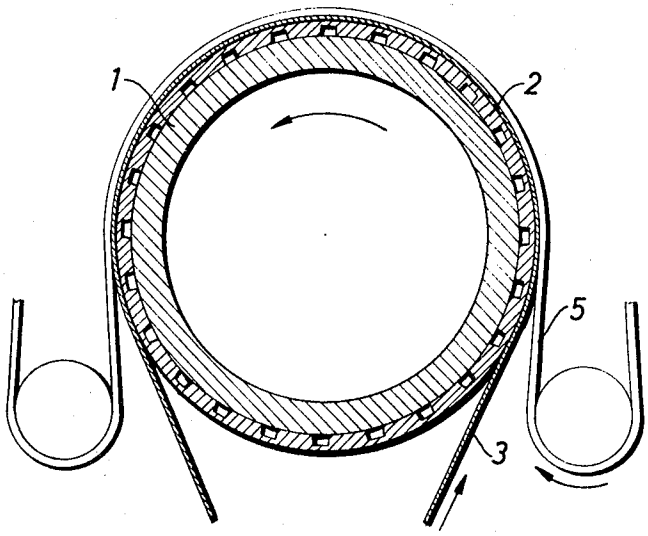

Fig.12

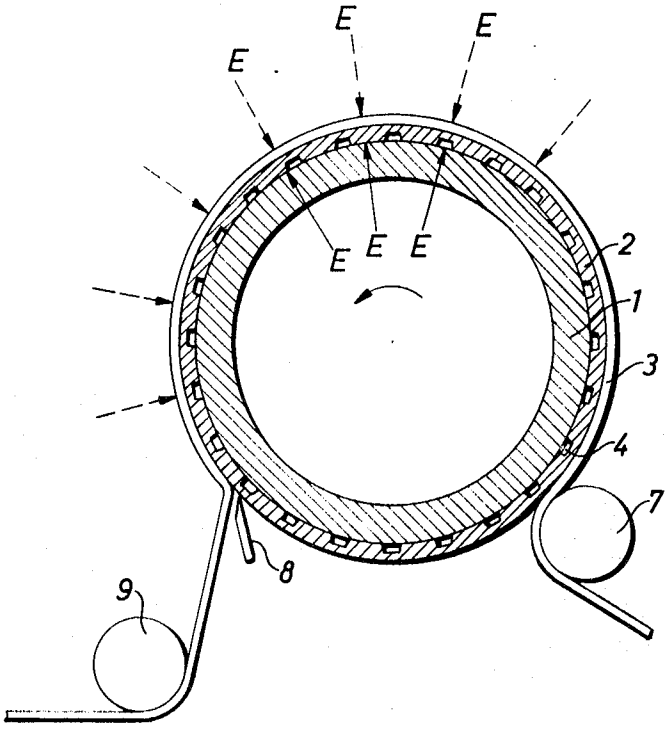

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Fig.13

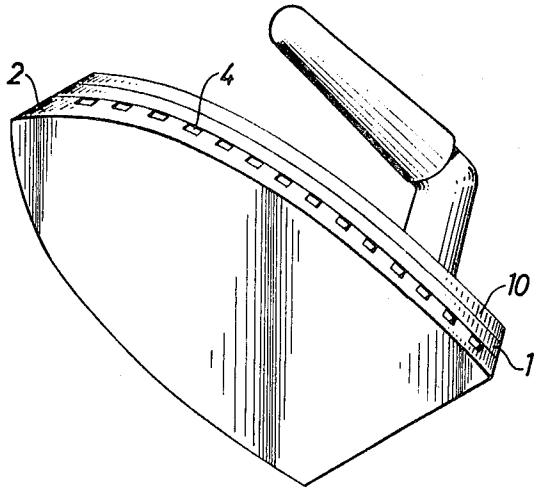
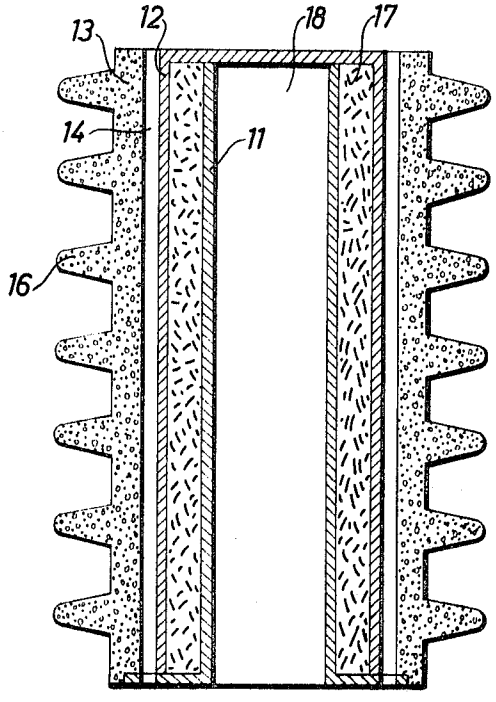


Fig.14



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METHOD AND MEANS FOR DRYING MOIST MATERIAL, SUCH AS PAPER, CELLULOSE, OTHER FIBRES OR THE LIKE

The present invention relates to drying sheets or webs of material, such as paper, cellulose, other fibers, board, textiles and the like. The invention aims at effecting extremely rapid and effective drying, that is to say removal of water or the like, and in this way enables a considerably increased rate of drying in comparison with other types of drying systems. If, for example, the invention is used in connection with the manufacture of paper in a paper machine, either a considerable increase in the speed of the paper machine is achieved or the so-called drying section of the machine can be made considerably shorter, which means that the drying section will require less space than in conventional systems.

First of all some examples will now be given of the application of the invention in connection with the manufacture of paper and cellulose. In no way, however, is the invention limited to only this application. Thus, it has been found that the invention can be used with success for drying textiles, hair, etc. Examples of suitable applications will be given at the end of this description.

As is known, paper or board is manufactured by first introducing the formed wet sheet or web of fiber material through a so-called press section, in which the water is squeezed or pressed out as much as possible according to the desired quality of the paper or board. The moist paper web is then passed through the so-called drying section which substantially consists of a number of heated rotating cylinders. Normally, these cylinders are heated by means of super-heated steam or water vapor under pressure and are normally arranged in two rows, one arranged above the other. The paper web is carried through the drying section so as alternately to come into contact with a lower cylinder and an upper cylinder. Upon contacting the rotating cylinder surface the paper web usually will be urged towards this surface by means of drying felts or drying screens. In this embodiment, therefore, the paper web will be dried alternately on one side and on the opposite side when travelling through the drying section.

In another embodiment of a conventional drying section the wet paper web when leaving the press section is transferred to a single, large rotating heated cylinder. When the cylinder has completed the major portion of its revolution the paper web will be dry and is removed from the surface of the cylinder.

It is easily understood that the disadvantage of the drying methods described above is that the water which during the drying process is to be evaporated from the paper web, has to pass through the surface of the paper facing away from the heated surface of the cylinder. This is because the steam generated cannot penetrate through a solid, homogeneous surface of the cylinder. The alternate drying by means of a series of heated cylinders also has the disadvantage that, when the paper web is transferred to the next cylinder in succession, a film of steam produced on the surface facing away from the heated cylinder will be facing the said next cylinder so as to impede satisfactory heat transfer from the cylinder surface to the paper web.

In order to achieve increased drying effect many different methods have been suggested. For example, the web of material may be dried by replacing the drying cylinders by perforated drums over which the web of material is led, heat being supplied from the outside by means of hot air for example, whereupon the steam produced is withdrawn from the interior of the drums by means of vacuum.

According to another method the moist web of material is dried by means of hollow cylinders, the cylindrical surfaces of which consist of porous material and comprising a large number of passages extending from outer surface to inner surface, by heat being transferred radially from a source of dry heat in the interior of the cylinder in an inwards/outwards direction through the porous material to the moist web of material so that the water vapor produced by the heat will be

forced in the opposite direction through holes in the walls of the cylinder into the cavity of the cylinder. By keeping the atmosphere in the interior of the cylinders dry by suitable choice of source of heat (for example electricity, dry gas or oil) the entering steam is prevented from condensing and may be removed from the interior of the cylinders in some suitable manner. In another arrangement use is made of solid cylinder surfaces, for example of stainless steel which are perforated with holes in order to achieve a similar result.

The latter method, however, has certain disadvantages. For example, this method limits the type of heat source which can be used and for this reason super-heated water vapor or steam cannot be used. This is partly because of the moist atmosphere and partly because of the super-atmospheric pressure which would prevail in the interior of the cylinder when using super-heated water vapor. Such a super-atmospheric pressure would cause leakage outwards of water vapor and prevent or restrict the possibility of steam derived from the moist web of material from penetrating from the outside, inwardly from the porous surface. Furthermore, difficulties would arise in obtaining a porous cylindrical surface which has sufficient strength to withstand the inner steam pressure of super-heated water vapor. The arrangement using a solid cylindrical surface with perforated holes also has the disadvantage that such holes, which for practical reasons have to be relatively large, tend to cause marks on the web of material and to become clogged since various particles of material easily can catch in the holes.

The present invention eliminates the above mentioned disadvantages. According to the invention heat is transferred from a suitable heat source through a solid, homogeneous, heat conducting wall to one side of a porous layer which is wholly or partially in heat-conducting contact with the wall. The moist material is pressed against the opposite side of the porous layer from the side of the porous layer which faces the wall. Although the solid, homogeneous wall serves to provide good heat conduction from any suitable heat source including such heat sources as a body of super-heated water vapor, the wall also acts as a barrier or sealing partition to prevent the flow of fluids such as steam therethrough. Since the porous layer has pores which conduct steam, but the homogeneous wall is so arranged that steam cannot pass therethrough, any steam generated in the porous layer will be removed in a plane which is substantially perpendicular to the direction of the temperature gradient caused by the supply of heat through the homogeneous wall. Because of the arrangement of a homogeneous, heat-conducting wall as sealing partition for the generated water vapor, the drying means can be made independent of the type of source of heat. Thus, no particular dry atmosphere is required so that, for example, super-heated water vapor is suitable as a source of heat. Furthermore, use can be made of sources of heat which are sensitive to moist atmosphere, for example electric resistance elements. In cylindrical drying means the homogeneous wall can also be designed to withstand the pressure if super-heated water vapor is used as source of heat and thus may serve as the supporting sheath surface of the pressure vessel.

The invention will be described in the following with reference to the accompanying drawings. FIG. **1** shows a cross-section of a drying cylinder according to one embodiment of the invention. FIGS. **2**, **3**, **4** and **5** show, on a larger scale, parts of the means according to FIG. **1**. FIG. **6** shows, on a larger scale, a special embodiment and FIGS. **7** to **10** show, on a larger scale, suitable parts of a drying cylinder in various embodiments, inter alia with respect to supply of heat, removal of steam and arrangements for effecting an extra high contact pressure between the web of material and the drying surface.

In the embodiment according to FIG. **1** the drying means consists of a supporting cylinder or sheath (separating wall or partition) **1**, which is heated in a suitable manner, for example by supplying super-heated water vapor into the interior of the cylinder. This cylinder is provided with ends, shafts for its rotation and for the supply and removal of steam and also of

condensate. The novelty of the invention is that the homogeneous sheath 1 consisting of heat-conducting material, for example cast iron, is surrounded by an outer sheath 2 which is heated by means of heat-conduction from sheath 1. The web of material 3 to be dried engages the outer sheath 2. This is made of porous material having fine pores which can conduct steam, a suitable porous material being so-called sintered material, for example sintered iron or some other sintered metal. The outer sheath 2 of porous material is made in such a manner that its outer surface is so uniform that it will cause no marks whatsoever on the surface of the paper web and no fibers from the paper web will catch in any recesses. By a suitable choice of sintered material, this requirement of a smooth surface of the sheath 2 is fulfilled while maintaining the necessary good porosity and strength. Furthermore, the surface can be made hard while still retaining these properties. Due to the properties of the sheath 2 evaporation of steam can also take place through the porous layer on heating of the paper webs 3. This fact is illustrated schematically in FIG. 5. The two arrows indicate the two main paths of the steam flowing on evaporation, that is to say, both from the layer 2 and into this layer, the steam seeking to flow through the path having the least flow resistance. The porous layer 2 is indicated schematically by circles which in practice do not have such a regular appearance. In accordance with one embodiment of the invention (FIG. 1), the steam penetrating into the porous layer 2 subsequently will be withdrawn through a number of parallel passages 4 extending in axial direction of the cylinder. These passages are considerably wider than the fine pores of layer 2.

In this way the steam is removed with the least possible flow-resistance towards one or both ends of the cylinder. Since the heat supply completely or partly is effected through the porous layer 2, there is no condensation of steam passing through this layer. According to FIGS. 1, 2 and 4 the passages 4 in the homogeneous sheath 1 are in the form of parallel grooves. Of course, the passages may also be made in the porous layer 2; see FIG. 8.

The supply of heat for drying the web 3 of material can be arranged in many different ways. Some embodiments are shown in FIGS. 7 – 10. FIG. 7 shows simultaneous supply of heat from the outside and from the inside as shown by the arrows E. The supply of heat from the outside may of course take place in various ways, such as by radiation and/or convection. This can be achieved by infrared radiation, by burning gas, heated air or gas. For example the supply of internal heat may be effected by means of super-heated water vapor, burning gas, hot oil or other liquid. In the example shown the passages 4 for discharge of steam have been arranged in the homogeneous inner sheath. The heating medium, for example super-heated water vapor, may be supplied and discharged for example through the shaft or shafts about which the cylinder is rotatable.

FIG. 8 shows an arrangement with internal supply of heat only, for example by means of super-heated water vapor. The passages 4 for removing steam are in this case made in the porous material 2.

FIG. 9 shows an embodiment in which an outer porous surface 5, for example a drying felt or drying screen presses the material web 3 against the porous layer 2. In this way there will be obtained an improved heat-transfer. The heat may be supplied either externally or internally, or by a combination of these two alternatives. Steam removal will take place both through the material 5 and through the material 2. In this case the passages 4 for steam withdrawal are arranged both in the porous material 2 and in the homogeneous inner sheath.

FIG. 10 illustrates an outer surface 6 which is tight (for example a steel belt) acting to press the web 3 against the porous layer 2. The heat supply can of course be arranged in various ways. In this case the steam removal takes place only inwardly towards the porous material. This embodiment is of interest since in certain cases it will facilitate production of paper material having a very uniform surface on both sides.

FIG. 11 shows how a paper web 3 is led around a drying means corresponding to that shown in FIG. 1, but in which an outer surface corresponding to the layers 5 or 6 in FIGS. 9 and 10, respectively, will press the paper against the porous layer 2.

As has already been mentioned, paper webs, for example, are also dried by pressing the wet web of paper against a single rotating cylinder surface. According to the invention, such a cylinder may also be provided with a porous outer casing and passages for the removal of steam. FIG. 12 illustrates such a drying method with a press roll 7 which transfers the web of paper 3 to the porous layer 2 having steam-removal passages 4. The heat is supplied both from the inside through the supporting inner sheath surface 1 and from the outside as shown by the arrows E. A doctor knife 8 and a doctor roll 9 may be arranged to remove the dried paper web from the cylinder. Of course an additional supply of heat may also take place from the outside against the porous surface directly in the region of the drying cylinder which is not covered by the paper web. This feature also applies to the embodiments shown in FIGS. 1 and 11.

As porous material we prefer sintered metal, for example of copper, copper alloys such as brass, sintered iron, steel or alloys of iron or steel. It is important for the invention that the material is sufficiently porous to permit satisfactory passage of steam as well as being of sufficient strength and that the external surface is sufficiently smooth to avoid causing of marks on the web of paper. It is also important that the surface be so uniform that no deposits, such as fiber fragments or the like, clog the pores. Preferably the porous surface is kept clean, for example free of synthetic fibers, by scraping it by means of a doctor knife. In order to produce such sintered metals the material chosen for the sintering must have a suitable grain size. In practice it has been found that for a so-called 10 percent bronze a suitable grain size is less than 75 microns, with an average grain size of about 40 microns. This is mentioned only by way of example and in fact both coarser and finer particle sizes may be used depending on the other conditions during the manufacture of the sintered material.

In order to combine the requirement of good uniformity and strength of the surface with a low flow-resistance to the steam produced, the porous material according to the invention may be composed of several various layers having different characteristics. Thus, the outer layer of the porous material may be manufactured with a plurality of fine pores and with a smooth surface, whereas one or more inner layers may consist of considerably coarser sintered material, in order to give the least possible flow-resistance for the steam. The various layers may be compacted prior to sintering. The outer shell may possibly be chromium-plated or provided with some other surface coating or finish in order to achieve the desired surface hardness. The circles of different sizes in FIG. 5 are intended to illustrate different layers of sintered material. By means of the arrangement described above a low flow-resistance can be achieved in some cases in the direction towards the ends of the cylinder so that, at least for comparatively narrow drying cylinders it will not be necessary to arrange special passages 4 to remove the steam. See FIG. 6 which illustrates a cross-section through a drying cylinder without any special passages for removing the steam. In order to achieve good drying effect it has also been found to be advantageous to provide the outer layer of the porous material with extremely fine passages. Within certain temperature ranges the fine pores will draw in water in the liquid phase or liquid condition by capillary action and this water is subsequently evaporated further in in the porous material.

Of course the steam flowing through the sintered material and/or through the steam discharging passages may be collected at the ends of the cylinder in some suitable manner and possibly be withdrawn for use in preheating air, or the like, in the drying system of the paper machine, for example.

Some results of evaporation obtained in a device according to the invention compared with conventional means for drying

a web of paper have been mentioned previously. A comparison has been made with a few various qualities of paper. Initially, the paper web had a dry content of 40 percent and was finally dried to a dry content of 95 percent. The following table shows how the drying times have been reduced at some different qualities of paper. In all cases the surface temperature was 120° C.

Quality	Drying time in secs. when being dried by a heated homogeneous surface	porous surface	Reduction of time in %
Kraft paper, 80 grs/sqm	6.5	3.7	43
Fluting, 127 grs/sqm	20.5	15.5	24
Writing paper, 70 grs/sqm	5.7	3.5	39
Sack paper, 90 grs/sqm	9.7	5.6	42

The invention can also be used for drying flat surfaces. FIG. 13 illustrates a flat iron made in accordance with the invention. It has a porous layer 2, a homogeneous, heat-conducting wall 1, source of heat 10, for example in the form of electric resistance elements, and steam discharge passages 4. Flat irons or ironing surfaces for ironing by machine which are designed in accordance with the invention, for example as shown in FIG. 13, are characterized by a considerably increased working capacity in comparison with devices of conventional design.

The invention can also be used in drying appliances for curling (permanent waving) hair. For a long time curlers have been used having coils with heated central cores around which the hair is wound in moist condition to be dried by the heat supplied to the hair from the inside.

In order to simplify handling, the coils or curlers are preferably heated prior to use in separate heating means in which, for example, heat is transferred by means of conduction for example through electrically heated cylindrical or conical pins, each fitting into a corresponding hole in the center of the coil or curler. In order to be able to supply the greatest possible amount of heat without the curlers becoming too heavy, the center of the curler should have the greatest possible heat capacity. Various embodiments are known in one of which there is used a center filled with a material which is particularly heat-absorbing since it melts or solidifies, respectively, within the desired temperature range for the drying process whereby it will be possible to utilize the heat of fusion emitted during the solidification process. Normally such curlers have an outer casing of a material with relatively low heat-conductivity in order to avoid too high a surface temperature in the surface layer, since such a high temperature might damage the hair.

Such curlers for setting hair can be manufactured within the scope of the invention in which the outer casing is sintered of, for example, plastic material so that steam can be conducted through the pores of the sintered material. The steam is removed in a plane perpendicular to the temperature gradients and possibly the steam-removal may be facilitated by means of special steam-removal passages provided in the plastic material or in the outer layer of the core.

FIG. 14 shows one embodiment of a hair curler according to the invention, substantially in accordance with claims 11 or 12. The porous outer casing 13 may also be provided with projecting spikes 16 in order to facilitate rolling up the hair. The inner, homogeneous wall 11 contacts the heat-conducting pins which are fitted into the hole 18 while the curler is being heated. Outside the cavity of the wall is a material 17 having high fusion heat and melting on being heated as described previously. A homogeneous heat-conducting wall 12 forms a blocking layer between the porous material 13 and the heated core 18. Passages 14 to remove the steam may possibly be provided in the porous material 13. However, these passages are not necessary if the porous material is sufficiently porous. FIG. 14 is intended only to illustrate one type of hair curler according to the invention. Thus, for example, the invention may of course be used for hair curlers without a melting core. When a curler having a melting core is used, the homogeneous wall 12 also prevents the source of heat, i.e., molten material, from penetrating out into the porous outer casing 13.

When curlers according to the invention are being used the hair should preferably be moistened before being dried by means of the stored heat. However, if the porous material, which should preferably be of a non-moisture-absorbant material, for example plastic, is adjusted as far as volume, structure and porosity are concerned so that due to capillary action it will absorb water in suitable quantities in relation to the heat capacity of the core, the hair may be rolled around the curlers in dry condition, after the curlers have been moistened with water. In this way the moistened and heated curlers emit steam from the porous layer so as to moisten the hair. When the moisture has been removed from the capillaries of the porous layer and partly absorbed by the hair, the heat remaining in the core and the porous casing of the curlers will contribute to drying the hair. This method provides an extremely uniform and suitable degree of moisture in the hair which greatly will assist in performing the curling process.

Instead of or in addition to the axial passages 4 shown in FIGS. 1, 2, 3, 4, 7, 8, 9, 10, 11, 12 there may be provided steam drawing passages extending around the periphery of the cylinder 1 and/or of the porous layer 2, possibly in a helical track, but still perpendicular to the temperature gradient. Such additional passages may interconnect adjacent passages 4.

What I claim is:

1. A process of drying or dewatering moist webs of paper, cellulose or the like comprising the steps of:
   a. supplying heat from a heat source via a homogeneous, heat conducting wall to one side of a porous layer having pores capable of deviating moisture;
   b. applying said web against a side of said layer opposite the side to which heat is supplied;
   c. continuously deviating, through said porous layer, steam generated between said moist web and said porous layer, whereby the steam is essentially forced into channels arranged between said wall and said porous layer, which channels extend below a contact surface of said porous layer with said web.

2. Drying means comprising a porous layer supported by a homogeneous blocking wall, said blocking wall being arranged to transfer heat from a heating source to said porous layer, and steam passages extending below the outer surface of said porous layer.

3. Drying means according to claim 2, wherein said porous layer and blocking wall are arranged as an outer cover on a rotatably mounted cylinder.

4. Drying means according to claim 2 wherein said passages have a larger cross-sectional area than the pores of said porous layer.

5. Means according to claim 2 wherein the porous layer is adapted for contact with a moist web to be dried and comprises sintered material, the composition of the porous layer being such that a surface facing the moist web consists of fine sintered material providing a smooth surface, whereas the interior of said porous layer consists of coarse sintered material to give less flow resistance to steam than said fine sintered material.

6. Means according to claim 2 wherein said means is used in combination with a flat ironing surface.

7. Drying means according to claim 2 comprising a cylinder for continuous drying of a moist web of material, said cylinder being journalled rotatably on shafts at least one of which shafts is arranged to supply heating medium, and wherein said

passages are arranged to discharge water vapor generated from the moist web in a direction substantially perpendicular to a temperature gradient resulting from heat transfer.

8. Drying means according to claim 7 wherein at least portions of said passages are arranged to discharge the water vapor mainly in a direction parallel to the generatrix of the cylinder towards at least one end thereof.

9. Drying means according to claim 7 wherein at least portions of said passages are arranged to discharge the water vapor around the periphery of said cylinder.

10. Drying means according to claim 6 wherein some of said passages are arranged to discharge the water vapor in the direction of the generatrix of said cylinder and others of said passages are arranged to discharge the water vapor around the periphery of said cylinder.

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