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VAPOR HEATED ROLL

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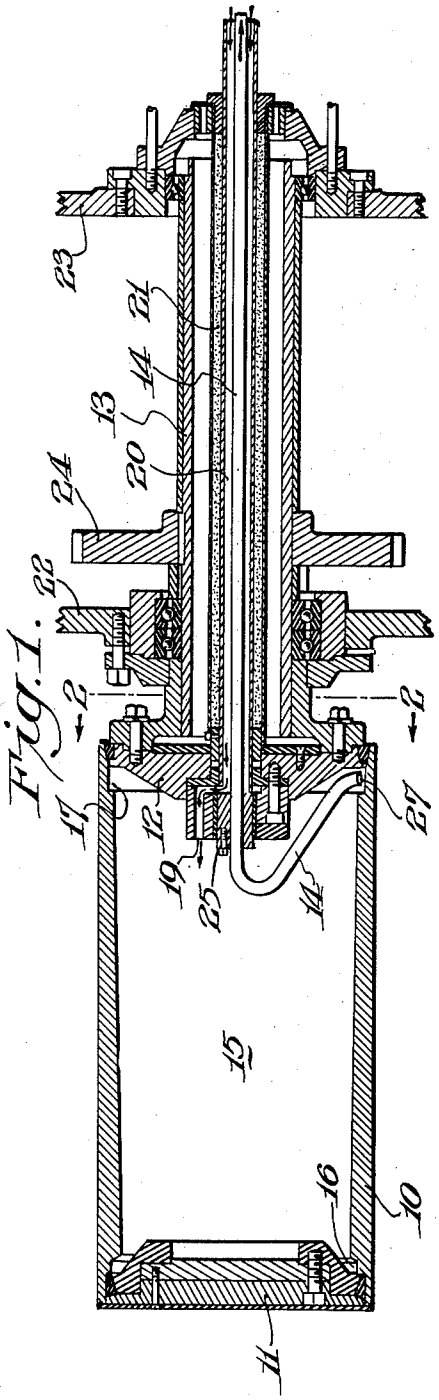


Fig. 1.

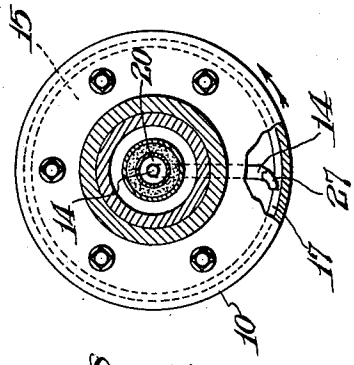


Fig. 2.

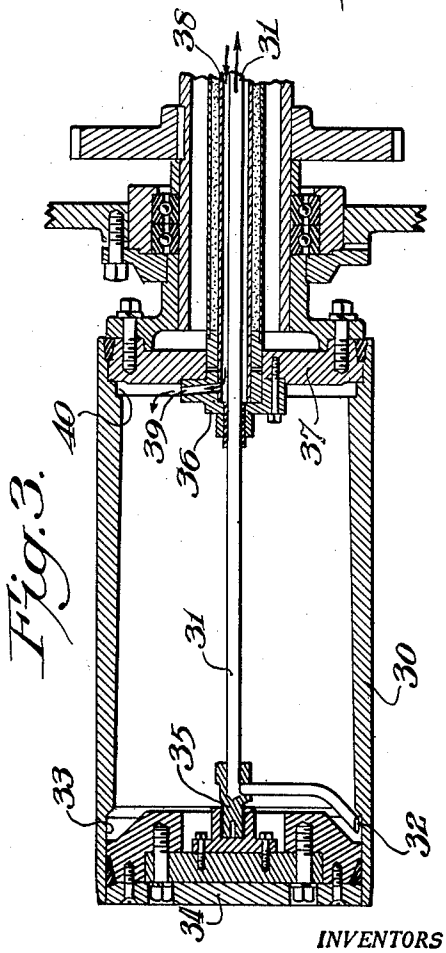


Fig. 3.

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VAPOR HEATED ROLL

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1 Claim. (Cl. 257—95)

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This invention relates to vapor-heated rolls suitably for drying or heating material passing thereover, and is more particularly concerned with rolls adapted for high speed continuous treatment of material requiring close control of temperature.

Rapidly rotating heated rolls are extensively used in continuous drying operations. A typical large industrial application is the drying of wet pulp webs in paper-making. A number of heated rolls are arranged in the drier section of the paper machine and pass the wet pulp continously from roll to roll along a serpentine path. The rolls must be maintained at a sufficiently high temperature to dry the web during passage through the drier, but the temperature should not be so high that the quality of the paper is impaired. However, the permissible temperature range is relatively wide.

Steam is the usual heating medium because of the convenience and ready control of the temperature at which heat is supplied to the roll. The temperature at which the heat of condensation of the steam is given up is controlled by regulating the pressure of the steam supply. The steam condenses at constant temperature within the hollow roll and the temperature drops occurring during heat transfer to the outer roll surface need be of concern if the saturated steam temperature is a suitable number of degrees above the minimum effective temperature for the roll. Other vapors, such as paracymene vapor, may be used when condensation temperatures above 200° C. are required, in order to avoid the excessive pressures which would be required with steam.

The drying of some types of textile fibers and fabrics requires more careful temperature control because the maximum temperature which can be used without injuring the material is lower than that of paper. However, drying can still be performed successfully over a fairly wide range of temperatures, and ordinary steam-heated rolls can be used.

A much more difficult heating problem arises when material is subjected to special treatment within a narrow temperature range. For example, the properties of certain types of synthetic yarns are greatly improved by stretching the yarn in a moist condition, drying under tension, and then conditioning the yarn at an elevated temperature to eliminate all or most of the residual shrinkage. The stretching, drying and conditioning must all be performed within relatively narrow temperature ranges in order

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to obtain optimum properties, and temperature uniformity within the optimum range is necessary to obtain uniform yarn properties.

The continuous aftertreatment of synthetic yarns is accomplished conveniently and economically on a plurality of running ends of yarn in the form of a warp. Drawing, drying, relaxing, and heat treatments of various sorts are performed customarily by passing the yarn around one or more heated rolls driven at the proper speed. One difficulty with processing a plurality of running ends of yarn in warp form is in maintaining uniformity of treatment of each individual running end. Consequently, in hot roll processing, yarn uniformity necessitates that the temperature of roll surfaces contacting the yarn be maintained within stringent limits in order to keep the individual ends of yarn at the same temperature. The roll surface should be maintained within plus or minus 4° C. of the optimum temperature at all points of contact, with loads varying from a few yarn ends to as many as 1000 or more, and at surface speeds up to 1000 yards per minute or higher.

It has been found to be impossible to achieve such close control of temperature with ordinary steam-heated rolls having cylindrical walls of uniform thickness. The outside surface temperature of a typical 12½ inch diameter steel roll having walls ½ inch thick varied under even moderate loads by 13° C. across the working surface, was also uneven in temperature under no load conditions, and a change in temperature of 13° C. occurred at some places on the roll when the loading conditions were changed from no load to moderate load.

Non-uniformity of temperature in the case of ordinary rolls has beeen found to be caused principally by the insulating effect of a layer of water of unequal thickness formed by the condensing steam. Water is a much poorer conductor of heat than the metal of the roll. The condensate is thrown off of the end plates of the rolls by the rapid rotation of the rolls and flows over the inside of the cylindrical surface to the condensate removal pipe, where the water is removed. The layer is thinnest on the end plates and at the point or points of removal, and the temperature of the outside of the roll will most nearly approach the steam temperature at these places. The temperature at other places on the outside of the roll will be lower and will vary depending upon the thickness of the condensate layer. This thickness will vary not only with the location but, to an even greater

extent, with the load on the roll, as this determines the rate at which condensation occurs.

It is an object of the present invention to provide a roll heated by steam or other vapor which, when rotated at sufficient speed to prevent condensate from accumulating in a pool at the bottom of the vapor chamber, has substantially uniform temperature characteristics at all points on the outside working surface under all conditions of operation. Other objects of the invention will become apparent from the following description and the drawing.

The objects of the invention are accomplished by forming the vapor chamber with a taper, so that the chamber tapers along the axis of the roll from a larger diameter at one end to a smaller diameter at the other end, and providing a condensate collection trough at the larger end of the chamber and means for removing condensate out of the chamber from the trough. Preferably a cooling trough is located at the opposite end of the chamber from the condensate collection trough.

Specific embodiments of the invention will now be described with reference to the drawing, in which,

Figure 1 is a sectional elevation of one form of roll, the section being taken along the axis of the roll,

Figure 2 is a transverse section taken on line 2—2 of Figure 1, and

Figure 3 is a sectional elevation, corresponding to Fig. 1, showing a modified form of the invention.

The roll shown in Fig. 1 comprises a cylindrical wall 10, a circular front end 11, a circular rear end 12 attached to a hollow supporting axle 13, and a condensate pipe 14 passing through the axle. The wall 10 decreases uniformly in thickness from the front end to the rear end to provide an axial taper to the vapor chamber 15 formed by the cylindrical wall 10 and the ends 11 and 12. A condensate trough 16 is provided in the wall 10 adjacent to the front end 11. This trough rings the inside of the wall to trap condensate and reduce heat transfer from the end 11 to the wall. Another similar trough 17 is cut into the inside of the wall adjacent to the rear end 12. The trough forms a receptacle for and collects condensate carried along the sloping inside surface of wall 10 by centrifugal forces resulting from rotation of the roll. Condensate pipe 14 is bent downward into trough 17 to remove condensate collected therein.

Steam or other vapor is introduced into chamber 15 through passageway 19 and annular space 20 surrounding condensate pipe 14 inside of hollow axle 13. It is desirable to surround this steam passage with insulation 21. The axle is supported on bearings 22 and 23, and is rotated by suitable means engaging a gear 24 mounted on the axle between the two bearings.

In the embodiments shown in the drawings the the condensate pipe is stationary, and a suitable bearing 25 is arranged to support it at the inner end of the axle. As shown in Fig. 2, the end 27 of condensate pipe 14 is preferably bent in the opposite direction from the direction of rotation of the roll to form a scoop which helps to remove condensate from the collection trough 17. Of course the condensate pipe could be arranged to rotate with the roll, which would simplify the construction, but this is less desirable from the standpoint of condensate removal.

A modified form of the invention is shown in Fig. 3 in which the cylindrical walls 30 of the vapor chamber decrease in thickness from the rear of the chamber and are thinnest at the front. With this arrangement condensate is carried to the front end of the chamber, in a direction opposite to that of the embodiment shown in Fig. 1. Hence the condensate pipe 31 must extend to the front of the roll with the end 32 projecting into a condensate collection trough 33 to remove the condensate. The circular front end 34 of the roll is provided on the inside with a bearing 35 to support the condensate pipe. Another bearing 36 is arranged to support the condensate pipe where it passes into the vapor chamber of the roll through the circular rear end 37. This bearing also supports the end of vapor pipe 38 surrounding the condensate pipe. Steam or other vapor is admitted into the chamber through this pipe 38 and passageway 39 through the bearing 36. A condensate trough 40 is preferably provided to reduce heat transfer from the end 37 to the cylindrical walls 30. In other respects this embodiment of the invention is similar to the one shown in Fig. 1.

Suitable means for lubricating the various bearings and for providing vapor-tight joints have been shown in the drawing. Since these are well-known in the art and form no part of the invention, they have not been described.

The advantages of rolls in accordance with this invention over ordinary steam-heated rolls, having a simple cylindrical steam chamber, are as follows:

(1) The tapered or frusto-conical shape of the vapor chamber, and the collection trough, greatly reduce the condensate build-up on heat-transfer surfaces, required in the case of ordinary rolls to cause condensate to flow to the point of removal. As soon as condensate forms on the interior heat-transfer surface, the centrifugal forces resulting from rotation of the roll cause the condensate to move toward the larger end of the chamber and into the trough. This keeps the condensate film on the heat-transfer surface thin, so that the insulating effect is kept low. As a result, the outside roll temperature is only slightly affected in going from no load or partial load to full load.

(2) The condensate layer is also more uniform in thickness and is thinnest where the metal wall is thickest. The volume of flowing condensate increases as the point of removal is approached, but the wall is simultaneously decreasing in thickness. The decreasing resistance to heat transfer of the wall offsets the increasing resistance of the condensate layer and provides for uniform heat transfer to the outside working surface. The temperature has been found to be substantially uniform over the whole working surface under both no load and full load conditions.

(3) Condensate collecting in the troughs at each end of the chamber reduces heat conduction from the end plates of the roll to the ends of the outside working surface and avoids non-uniformity of temperature from this source.

The temperature uniformity achieved in actual operation with a steam-heated steel roll in accordance with this invention, 12½ inches in diameter and 25½ inches long, is shown in the table. The temperatures were measured on the outside surface of the rotating roll with a special instrument developed for the purpose. "No load" means that no material was being treated and heat losses from the rotating roll were ap-

proximately 3000 B. t. u. per hour from convection and radiation. The roll was then used to evaporate moisture at a total load of 29,430 B. t. u. per hour.

Inches from end	5	10	15	20
No Load ° C.	165	165	165	165
Full Load ° C.	158	158	158	158

The cylindrical wall of the roll used in the above test tapered from 1⅛ inch thick at the thick end to ⅞ inch thick at the thin end, and the roll speed was approximately 800 rotations per minute. It is seen that excellent uniformity of surface temperature was obtained at both no load and full load conditions. At considerably lower roll speeds it might be desirable to increase the taper. The temperature difference between no load and full load conditions (7° C.) can be reduced appreciably by reducing the wall thickness or by using a metal of higher conductivity than steel, such as copper or aluminum.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claim.

What is claimed is:

A rotatable, vapor-heated, cylindrical roll roll adapted for high speed continuous treatment of material at a uniform temperature within plus or minus 4° C. of an optimum temperature over the entire working surface of the roll which comprises a wall having a cylindrical outer surface constituting the working surface of the roll, circular end plates attached to each end of said cylindrical wall and enclosing a vapor-heating chamber within said wall, a hollow supporting axle attached to one only of said end plates in axial alignment with said roll, bearings supporting said axle in horizontal position for rotation of said roll, said cylindrical wall being tapered uniformly in thickness from end to end to provide a vapor chamber having a gradually increasing diameter from one of said end plates to the other end plate, condensate collection troughs ringing the inner side of said wall adjacent to each of said end plates, an a stationary condensate removal pipe passing axially through said supporting axle into said chamber with the chamber end of the pipe located in the condensate trough at the larger diameter end of said chamber, said pipe end being bent in the opposite direction from the direction of rotation of the roll to act as a scoop for removing condensate.

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