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[72] Inventors **Takuma Katsumata**
Inazawa, Aichi Prefecture;
Tetsuo Ochi, Nagoya, Aichi Prefecture,
both of, Japan
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[73] Assignee **Mitsubishi Jukogyo Kabushiki Kaisha**
Tokyo, Japan

[54] **METHOD OF AND APPARATUS FOR HEATING A ROTARY ROLL**
11 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **219/10.61,** 165/89, 219/469
[51] **Int. Cl.** **H05b 5/00,** B21b 27/06
[50] **Field of Search** 219/469, 470, 471, 10.61, 40.61; 126/400; 165/104

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Primary Examiner—J. V. Truhe
Assistant Examiner—L. H. Bender
Attorney—McGlew and Toren

ABSTRACT: In a rotary roll for heating articles, such as fibers which are to be worked, an annular space is provided within the roll adjacent its outer periphery. A liquid heat transfer medium is placed in the annular space and the roll is heated so that the heat transfer medium is in the boiling state having a liquid phase and a vapor phase. As the roll is rotated centrifugal forces are developed which maintain the liquid phase of the medium against the outer surface defining the annular space. The structure of the roll defining the outer surface of the annular space can be a continuous smooth surface or an undulating surface providing alternate ridges and depressions for improving the effect of the heat transfer medium. The heat medium provides a uniform temperature distribution over the roll.

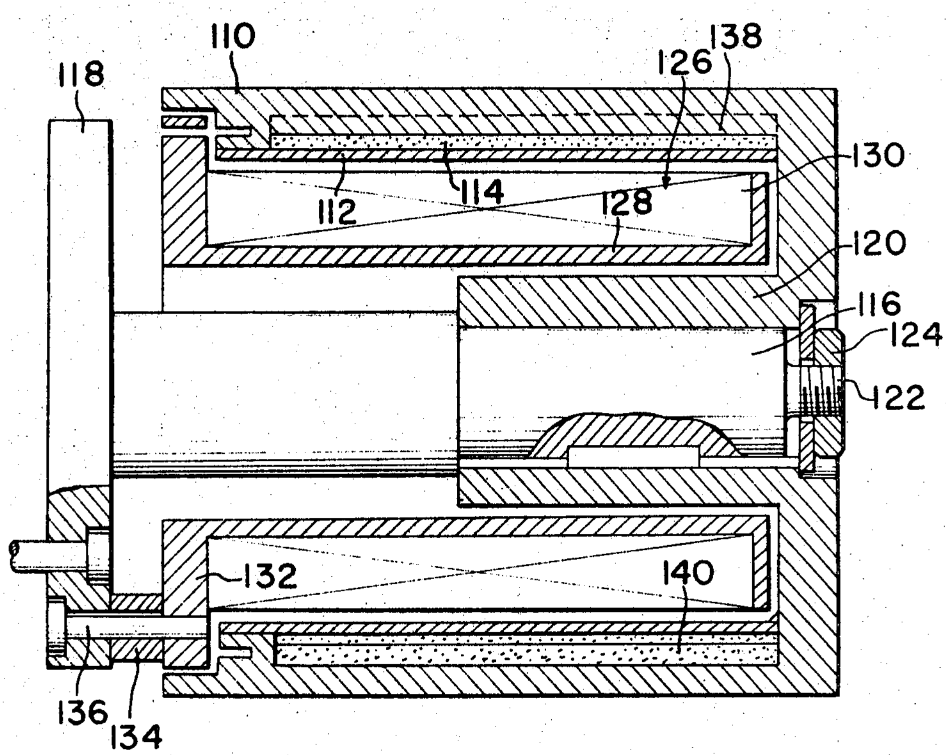
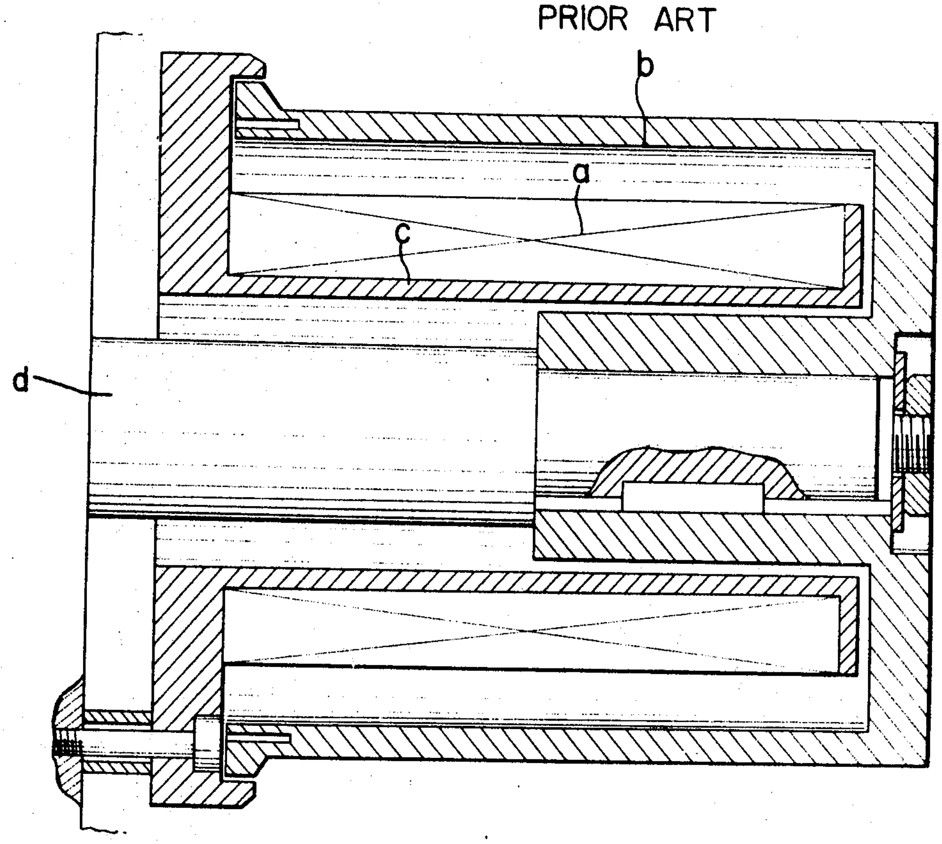


FIG. I
PRIOR ART



INVENTORS
TAKUMA KATSUMATA
TETSUO OCHI

BY McGlew and Toren
ATTORNEYS

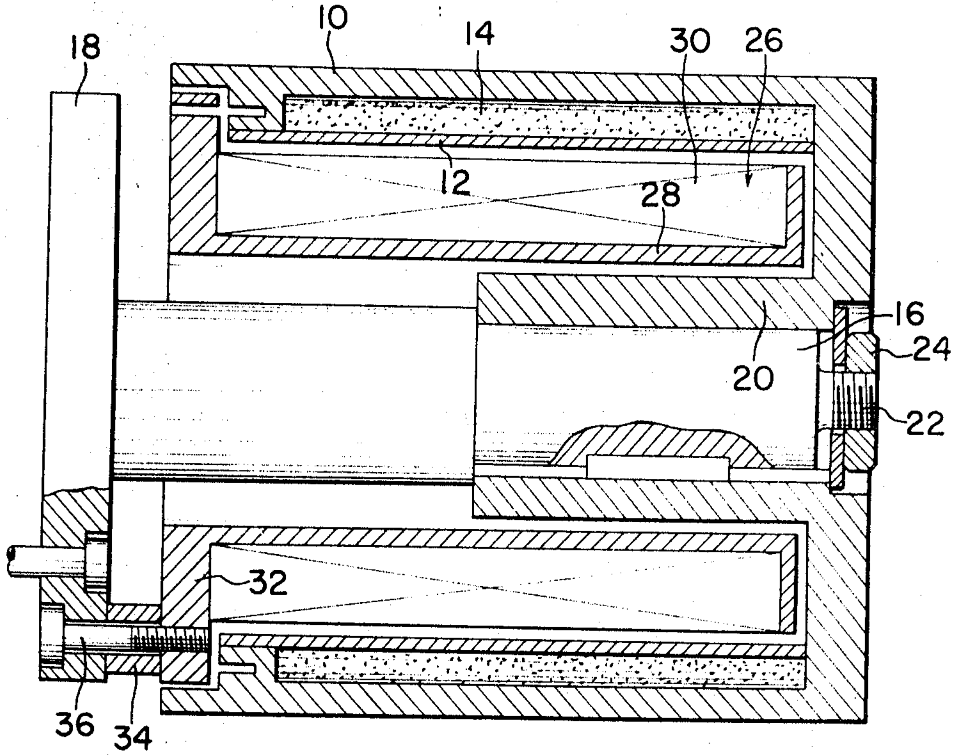


FIG. 2

INVENTORS
TAKUMA KATSUMATA
TETSUO OCHI

BY McGlew and Toren
ATTORNEYS

FIG. 3

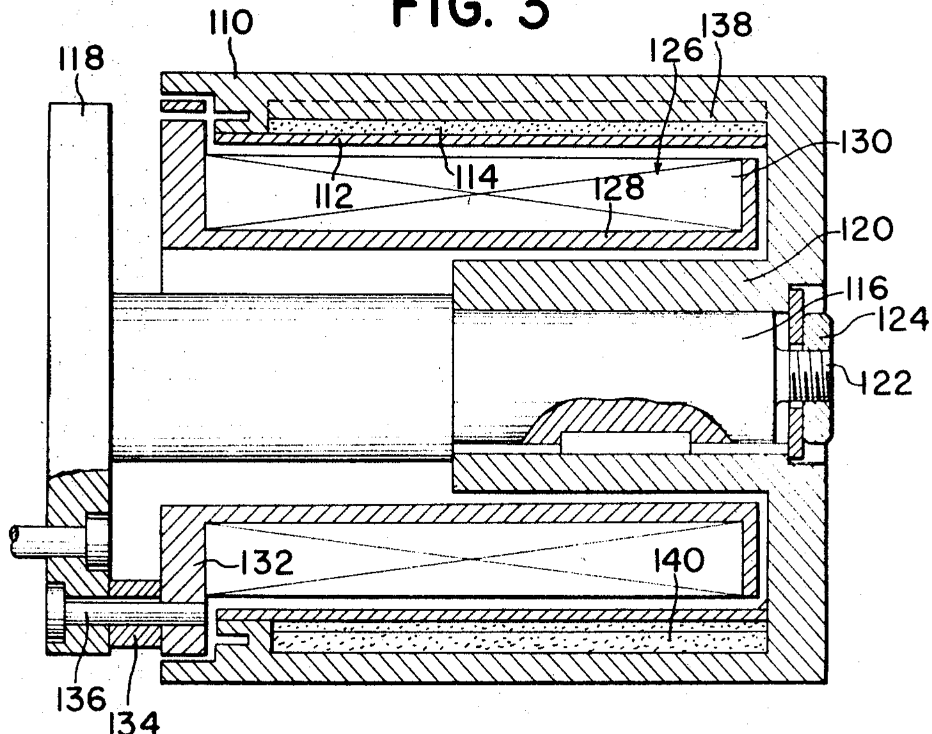
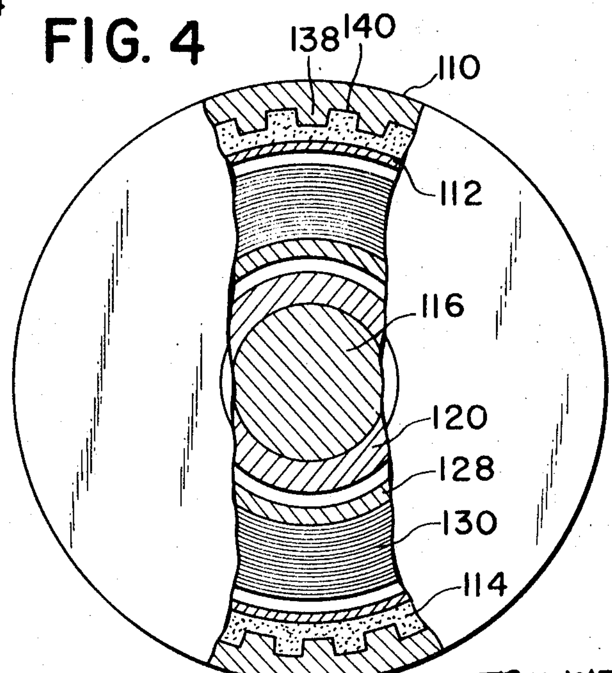


FIG. 4



INVENTORS
TAKUMA KATSUMATA
TETSUO OCHI

BY McGlew and Toren
ATTORNEYS

FIG. 5

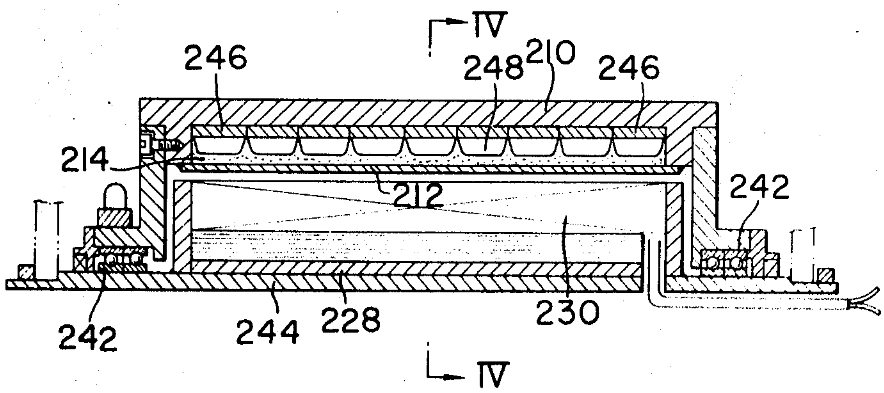
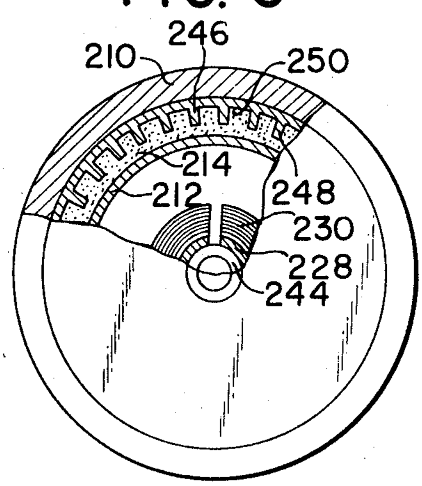


FIG. 6



INVENTORS
TAKUMA KATSUMATA
TETSUO OCHI

BY McGlew and Toren
ATTORNEYS

METHOD OF AND APPARATUS FOR HEATING A ROTARY ROLL

SUMMARY OF THE INVENTION

The present invention is directed to the arrangement of a heated rotary roll for heating articles, such as fibers to be worked, as they pass over the outer surface of the roll and, more particularly, it is directed to the use of a liquid heat transfer medium contained in an annular space within the roll for affording a uniform temperature distribution over the surface of the roll.

In the past, heated rotary rolls have been widely used, such as in thread-stretch-plying machines, in draw-winders and the like. In such rolls, an induction heating coil is positioned within the body of the roll for supplying heat to its outer surface. In such known devices the surface temperature of the roll is maintained relatively uniform when a uniform thermal loading is applied over its entire surface, however, a disadvantage arises if a heavy thermal loading is applied locally at one location on the surface of the roll whereby the temperature at the location of the thermal loading is lowered considerably relative to the remaining surface of the roll. As a result of this nonuniform thermal loading, an extremely unbalanced temperature distribution occurs in the roll, and as a consequence, since the shaft supporting the roll provides a continuous dissipation of heat, the temperature distribution on the roll surface adjacent the rotary shaft is disturbed and the temperature distribution across the surface of the roll becomes nonuniform.

Accordingly, the principal object of the present invention is to provide a heated rotary roll which avoids the disadvantages experienced in the past and is free from any nonuniformity in the surface temperature of the roll in spite of any uneven thermal loadings on the roll, particularly where individual heavy thermal loadings are applied.

Therefore, in accordance with the present invention, an annular space is provided within the roll adjacent its outer periphery and the space is filled with a liquid heat transfer medium. Located radially inwardly from the annular space is a heating member for raising the temperature of the heat transfer medium to its boiling point. The quantity of the heat transfer medium placed within the annular space is sufficient so that the medium is in contact with the entire inner surface of the outer periphery of the roll which defines the outer surface of the annular space.

As the roll is rotated, the centrifugal forces generated throw the heat transfer medium outwardly against the surface of the roll defining the outer surface of the annular space. Since a sufficient quantity of the heat transfer medium is contained within the space, a substantially equal thickness is provided over the outer surface of the space. At the same time, the surface of the roll is heated to a predetermined temperature by the heater located in the roll and the heat transfer medium is raised to the boiling point along the surface of the roll which defines the outer surface of the annular space. Accordingly, if a heavy thermal loading is applied locally on the outer peripheral surface of the roll a considerable amount of heat is dissipated at that location and momentarily a lower temperature portion corresponding to the location of the heavy thermal loading and a higher temperature portion corresponding to the unloaded portion of the roll surface are developed. However, at the location of the heavy thermal loading, the heat transfer medium which is in a boiling condition will condense immediately and supply the heat of condensation to the roll while along the remaining surfaces of the roll where the higher temperature prevails the boiling phenomenon will be promoted further to continue the removal of heat and, as a result, the temperature differential caused by the heavy thermal loading will disappear almost instantaneously. Accordingly, due to the present invention, not only can unevenness in the temperature distribution on the roll surface be compensated where light thermal loadings occur on the roll surface and heat dissipation takes place through the rotary shaft, but also the temperature differentials developed because of local heavy thermal loadings can be removed rapidly with the result that the temperature on the outer surface of the roll is maintained substantially uniform at all times.

The heated rotary roll described above can obtain the desired results as long as the rotational velocity of the roll is maintained below a certain fixed limit which is ascertainable based on the viscosity of the heat transfer medium within the annular space. However, if the velocity of the roll exceeds the fixed limit, a problem arises in that the uniform temperature distribution along the surface of the roll cannot be maintained. By way of example, if a heavy thermal loading is applied to a single location on the roll surface as the roll is rotated at relatively high speeds the heat transfer medium will be strongly urged against the entire outer surface of the annular space due to the centrifugal forces generated and the roll surface and the heat transfer medium will be stripped of their heat. As a result, the vapor phase of the heat transfer medium within the annular space will condense on the surface of the liquid phase adjacent to the outer surface on which the temperature has been lowered due to the local thermal loading with the result that the latent heat of condensation is released. However, the thermal conductivity of the liquid phase is much smaller than that of the metal forming the roll and the latent heat of condensation cannot be conducted efficiently to the portion of the roll whose temperature has been reduced due to the thermal resistance of the liquid phase of the heat transfer medium. Consequently, the surface temperature of the roll cannot be maintained at a uniform level. Therefore, another object of the present invention is to provide a rotary roll which will overcome the above-mentioned problem and maintain the surface temperature of the roll at a uniform level, even if the rotational speed of the roll does not reach the above-mentioned fixed limit.

Accordingly, the surface of the roll defining the outer surface of the annular space containing the heat transfer medium is provided with an undulating surface composed of alternating ridges and depressions. In such a construction, when high-speed rotation of the roll takes place the radially inner portions of the ridged surfaces of the outer surface of the annular space will project radially inwardly through the liquid phase of the heat transfer medium and will be exposed to the vapor phase. In this way, when the roll is subjected to a predetermined high rotational velocity, the centrifugal forces developed drives the liquid phase of the heat transfer medium into the depressions, that is, the radially outermost portion of the annular space while the inner or ridged surfaces of the outer surface extend through the liquid phase and are exposed to the vapor phase. As a result, the evaporation of the heat transfer medium takes place at the higher temperature portions of the roll body within the annular space, that is, on the surfaces exposed through the liquid phase within the recesses and at the same time the condensation of the heat transfer medium at the lower temperature portions of the roll takes place on the surface of the ridges. With this arrangement of the outer surface of the annular space, extremely low thermal resistances will be present adjacent the lower temperature portions of the roll whereby if a heavy local thermal loading is applied to the roll surface the surface temperatures can be equalized effectively.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a longitudinal cross-sectional view of a heated rotary roll as known in the prior art;

FIG. 2 is a longitudinal cross-sectional view, similar to that in FIG. 1, of one embodiment of a heated rotary roll in accordance with the present invention;

FIG. 3 is a longitudinal cross-sectional view of a heated rotary roll, similar to that in FIG. 2, illustrating a second embodiment of the present invention;

FIG. 4 is an end view, partly in cross section, of the embodiment shown in FIG. 3;

FIG. 5 is a partial longitudinal cross-sectional view of a third embodiment of the present invention; and

FIG. 6 is an end view, partly in section, of the embodiment set forth in FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 a heated rotary roll is shown, such as has been known in the prior art, and is composed of an induction heating coil or similar heater *a* mounted in a fixed position within the body of the roll *b* by means of a supporting member *c*, such as an iron core, for heating the outer surface of the roll. The roll *b* is mounted for rotation on a shaft *d*. When a uniform thermal loading is applied to the outer surface of the roll *b* the surface temperature of the roll is maintained relatively uniform. However, if a heavy thermal loading is applied at a single location on the outer surface the temperature at that location is lowered very considerably and, as a result, the surface temperature of the roll becomes unbalanced. Further, a continuous dissipation of the heat in the roll *b* takes place through the shaft *d* which serves as the support member for the roll and this characteristic also contributes to an uneven temperature distribution in the surface of the roll *b*.

In FIG. 2, one embodiment of the present invention is illustrated which solves the problem of uneven temperature distribution in the surface of the roll as has been experienced in the prior art. The roll is formed of an outer hollow cylindrical member **10** which is made of a magnetic material having a good thermal conductivity. Within the hollow member a cylindrical jacket **12** is positioned closely inwardly from the inner surface of the hollow member and forming an annular space **14** therebetween. A suitable heat transfer medium, such as DOWTHERM (a trade name of a product of the Dow Chemical Corporation) which is a mixture of 26.5 percent diphenyl and 73.5 percent diphenyl oxide, or a medium principally consisting of diphenyl chloride, alkyl napthalene and the like, is enclosed within the space under a predetermined temperature such that at the desired operating temperature of the roll surface, the heat transfer medium being in the boiling state.

Disposed centrally within the roll cylinder or body **10** is a rotary shaft **16** which extends laterally from a bearing box **18**. At the end of the rotary shaft spaced from the bearing box, a hub **20** on the roll cylinder **10** is secured to the shaft **16** by a nut **24** in threaded engagement with a screw portion **22** of the shaft. The roll cylinder **10** is arranged to rotate with the shaft **16**. In the space between the radially inner surface of the sleeve **12** and the shaft **16** a heater **26** is provided for heating the outer surface of the roll. The heater is comprised of a cylindrical iron core **28** extending about the shaft and a coil **30** is mounted around the iron core with a predetermined gap provided between the inner surface of the sleeve **12** and the outer surface of the coil. At the end of the core **28** adjacent the bearing box **18**, a flange **32** extends radially outwardly relative to the axially extending portion of the core and is fixed in its radially outer region to the bearing box **18** by bolts **36** and a heat insulating sleeve or spacer **34** encloses the portion of each bolt extending between the bearing box **18** and the juxtaposed surface of the flange **32**.

In operation, as the shaft **16** is driven by a suitable driving means, not shown, the roll cylinder **10**, the sleeve **12**, and the heat transfer medium within the annular space **14** rotate as a unit so that the medium in the annular space is forced outwardly against the inner surface of the roll cylinder **10** by centrifugal force. The quantity of the heat transfer medium filled into the annular space is sufficient to assure that a substantially equal thickness of the medium is formed over the entire inner surface of the roll cylinder. Simultaneously, an alternating magnetic flux is produced through the iron core **28** and the roll cylinder **10** by an alternating current flowing in the coil **30** and this magnetic flux heats the roll cylinder in a uniform manner. The heating operation is continued until the outer surface temperature of the roll cylinder reaches a preset temperature, at which temperature the heat transfer medium being rotated within the annular space reaches its boiling point with a liquid phase and a vapor phase being established within the annular space **14**.

With the outer roll surface at the desired temperature and the heat transfer medium in the boiling state, if a heavy thermal loading is applied to the surface of the roll cylinder, particularly when the loading is limited to a local or individual section of the surface, a considerable amount of heat is removed from that individual section while the temperature from the remainder of the surface of the roll cylinder is raised with the result that a momentary condition exists with a lower temperature portion and a higher temperature portion on the surface of the roll cylinder. However, at the local section where the lower temperature exists the boiling heat transfer medium condenses and releases the heat of condensation to that section while at the remainder of the surface experiencing the higher temperatures, the boiling phenomenon is promoted further to remove heat and reduce the higher temperature of the roll cylinder surface. As a result, the temperature differential between the heavily thermally loaded surface and the remaining surface of the roll body can be rapidly equalized by the heat transfer effected by the heat transfer medium.

The above-mentioned relation may be generally represented by the following equation:

$$\lambda\Lambda\frac{d_\theta^2}{dX^2}+\beta_1(\theta_1-\theta_0)+\beta_2\left(\frac{1}{l}\int_0^l\theta dx-\theta_1\right)$$

$$=\alpha_1(\theta_1-\theta_o)+\alpha_2(\theta-\theta_2)$$

where

λ: a thermal conductivity of the rotary heating roll,

Λ: a cross section area of the rotary heating roll,

β_1: heat generation per unit length of the rotary heating roll,

β_2: a heat of evaporation or condensation per unit length of the rotary heating roll,

X: a lengthwise coordinate of an arbitrary point on the rotary heating roll,

l: a total length of the rotary heating roll,

θ: a temperature at an arbitrary point on the rotary heating roll,

θ_1: an ambient temperature,

θ_o: a preset temperature,

α_1: a heat dissipation factor due to rotation,

α_2: a heat dissipation factor due to thermal loading.

In the above equation, the surface temperature of the rotary heating roll is determined by the values of λ and β_2. However, since the latter is far larger than the former in value, when a temperature difference is caused on the surface of the roll, only the heat transfer through the medium in the annular space serves to eliminate the difference and equalize the temperature distribution.

By way of example, the distribution of surface temperatures on the roll *b* in the prior art, as shown in FIG. 1, and the roll **10** according to the present invention, as shown in FIG. 2, where both have the same diameter of 180 mm. and the same length of 100 mm., it indicated in the following table:

Lengthwise position on the roll, mm.	Surface temperature of the prior art roll in FIG. 1, ° C.	Surface temperature of the roll of the present invention in FIG. 2, ° C.	Position of thermal load
0	182.5	172.6	Region of passing thermal load.
10	181.0	172.5	Do.
20	180.0	172.0	Do.
30	174.0	171.0	Do.
40	170.0	170.5	Do.
50	170.0	170.0	Do.
60	170.0	170.2	Do.
70	170.5	170.5	Do.
80	171.0	170.9	Do.
90	172.0	170.3	Do.
100	171.0	170.0	Do.

Another embodiment of the invention is shown in FIGS. 3 and 4 in which similar elements of the roll have the same reference numeral with the addition of the prefix 100. Since the structure of the roll in FIG. 3 is similar to that illustrated in FIG. 2, a detailed description of its arrangement is not considered necessary. The roll is comprised of a roll cylinder **110** which is mounted by means of a hub **120** on the end of a rotary shaft **116** which is mounted within a bearing box **118**. In the annular space between the shaft **116** and the inner surface of the roll **110** a sleeve **112** is provided closely adjacent the inner surface of the roll **110** and forming in combination therewith an annular space **114** within which a heat transfer medium is filled. Between the sleeve **112** and the shaft **116** a heater **126** is provided comprising a cylindrical iron core **128** and a coil **130** positioned between the core and the sleeve **112** with a space or gap provided between the inner surface of the sleeve **112** and the juxtaposed surface of the coil **130**. Adjacent the bearing box **118** a flange **132** is provided on the core **128** and is secured to the bearing box by means of bolts **126** and insulating spacer tubes **134**.

The difference between the structure of the roll in FIGS. 3 and 4, as compared to the roll illustrated in FIG. 2, is the alternating longitudinally extending groove and land construction on the inner surface of the roll cylinder **110**. As is shown in FIG. 4, lands **138** alternate with grooves **140** around the inner periphery of the roll cylinder **110**. In FIG. 2, the inner surface of the cylinder **10** had a continuously circular construction. In this second embodiment of the invention, if a suitable amount of the heat transfer medium is placed within the annular space **114** and the roll cylinder is rotated at a sufficiently high speed while it is being heated, the surface temperature of the cylinder **110** reaches a predetermined temperature and the heat transfer medium is in a boiling condition. The boiling condition of the heat transfer medium can be assured by pressurizing the medium in accordance with the predetermined temperature of the roll surface. Due to the high rotational speed of the cylinder **110** the heat transfer medium within the annular space is urged against the inner peripheral surface of the roll cylinder by centrifugal force, and the amount of the heat transfer medium and the dimensions of the lands **138** and grooves **140** are determined in such a manner that the liquid phase of the heat transfer medium is contained within the grooves **140** while the surfaces of the lands **138** are exposed to the vapor portion of the medium.

If it is assumed that a local or isolated thermal loading is applied to the surface of the roll cylinder **110**, its surface will momentarily undergo an uneven temperature distribution. However, at the portions of the surface of the cylinder where a higher temperature exists the liquid phase of the medium contained within the grooves **140** will boil more intensely and the heat required for such action will be absorbed from the roll surface to thereby lower its temperature. However, at the location of the local thermal loading the lower temperature which exists on the surface will be raised as the vapor contacting the lands **138** within the annular space condenses releasing the latent heat of condensation to the surface of the roll cylinder at that location. As a result, the temperature of the roll cylinder is raised in one location while the remainder of the roll cylinder is cooled by the different actions of the heat transfer medium within the annular space and, in particular, due to the construction of the lands and grooves formed in the interior surface of the cylinder. As a consequence, a uniform temperature distribution is maintained even where local heavy thermal loadings are applied to the roll. Where the condensation of the vapor phase of the medium takes place, because it condenses onto the lands **138**, a much better thermal conductivity is obtained than through the liquid phase portion of the medium with the heat transfer being achieved more quickly so that the temperature distribution is equalized in an effective and efficient manner.

In FIGS. 5 and 6, a third embodiment of the present invention is illustrated in which similar elements of the roll are identified by the same reference numerals, however, with the addition of the prefix 200. In FIG. 5, the roll cylinder **210** is rotatably supported at its opposite ends on a sleeve **244** by means of bearings **242**. Integrally attached to the sleeve **244** is an iron core **228** within which a coil **230** is mounted with its radially outer surface spaced from the adjacent inner surface of the sleeve **212** which combines with the inner surface of the cylinder **210** to provide an annular space **214**.

Around the inner peripheral surface of the cylinder **210**, a number of nonmagnetic conductive rings **246** are provided having a uniform length in the axial direction of the cylinder. As can be seen in FIG. 6, the radially inner surface of the rings **246** are provided with alternating lands **248** and grooves **250**.

In view of the above description of the invention, it is believed that it will be easy for persons skilled in the art to understand the manner in which this third embodiment operates. The rotation of the roll supported by the bearings **242** affords the required centrifugal forces for distributing the heated heat transfer medium in the boiling state with its liquid phase being contained within the grooves **250** and its vapor phase contacting the surfaces of the lands **248**. Therefore, the embodiment in FIGS. 5 and 6 will operate in the same manner as described for the embodiment disclosed in FIGS. 3 and 4 in achieving the desired uniform temperature distribution across the surface of the roll cylinder.

Additionally, since the rings **246** which line the inner surface of the cylinder **210** are made of a nonmagnetic conductive material, they serve as secondary conductors in the induction heating operation and thereby considerably improve the electric power factor in heating the surface of the roll cylinder **210**. Moreover, since the rings **246** are manufactured separately from the cylinder **210** it is possible to produce a large size assembly of the roll and rings at a considerably lower cost than would be possible if a single unit grooved about its interior surface were to be employed.

What we claim is:

1. A method of heating a rotating roll structure comprising forming a radially shallow sealed annular space within the roll structure at the circumferential wall of the roll, filling a liquid heat transfer medium in the annular space in a sufficient quantity for providing the heat transfer medium in contact with the entire surface of the roll adjacent to its exterior surface, heating the roll structure to a temperature sufficient to bring the heat transfer medium to a boiling state and providing a liquid phase and a vapor phase in the sealed annular space, rotating the roll structure for generating centrifugal forces for directing the liquid phase of the heat transfer medium against the interior surface of the roll adjacent its exterior surface with the vapor phase being spaced from the interior surface, in the annular space, by the liquid phase so that when a thermal loading is applied to the exterior surface of the roll structure the arrangement of the heat transfer medium effects uniform distribution of the temperature of the exterior surface of the roll structure.

2. A method, as set forth in claim 1, including providing alternating grooves and lands on the roll surface within the an-

nular space adjacent the exterior surface of the roll structure, and supplying the heat transfer medium within the annular space in such a quantity that in the boiling state the liquid phase of the heat transfer medium can be disposed within the grooves with the vapor phase contacting the lands located between the grooves.

3. A rotary roll for heating an article, such as a fiber, as it is worked, comprising a centrally disposed support member, a cylindrically shaped member concentrically disposed about and spaced radially outwardly from said support member and forming the outer surface of the roll, wall means, including said member, forming a sealed annular space spaced closely inwardly from the outer surface of the roll, said member being arranged to rotate about the axis of said support member, the sealed annular space within said member being arranged to contain a liquid heat transfer medium capable of being maintained in the boiling state to provide a liquid phase and a vapor phase and so that the liquid phase is sufficient to cover the entire surface of the member defining the outer surface of the annular space, and heating means disposed between said wall means and said support member and heating the heat transfer medium to the boiling state for heating the outer surface of said member.

4. A rotary roll, as set forth in claim **3**, wherein said member comprises an outer cylinder forming the outer surface of the roll, and a cylindrically shaped sleeve disposed concentrically about said support member and spaced closely radially inwardly from the inner surface of said cylinder for cooperating therewith to form the annular space for receiving the heat transfer medium.

5. A rotary roll, as set forth in claim **4**, wherein the inner surface of said cylinder forming the outer surface of said annular space has a sinuous surface providing alternating grooves and lands extending in the axial direction of said support member.

6. A rotary roll, as set forth in claim **4**, including a hub member integrally secured to said cylinder for mounting said cylinder on said support member, said support member comprising a rotary shaft, and means for fixing said hub to said shaft.

7. A rotary roll, as set forth in claim **6**, wherein said heating means comprises an iron core concentrically disposed about said shaft and spaced radially inwardly from said sleeve, and a coil mounted about said iron core and spaced radially inwardly from the inner surface of said sleeve for forming a predetermined gap therebetween.

8. A rotary roll, as set forth in claim **4**, wherein the interior surface of said cylinder is provided with alternating longitudinally extending lands and grooves with the grooves extending radially outwardly away from said support member, the surfaces of said lands being disposed in spaced relationship from the radially outer surface of said sleeve.

9. A rotary roll for heating an article, such as a fiber, as it is worked, comprising a centrally disposed support member, a cylindrically shaped member concentrically disposed about and spaced radially outwardly from said support member and forming the outer surface of the roll, said member forming an annular space spaced closely inwardly from the outer surface of the roll, said member being arranged to rotate about the axis of said support member, the annular space within said member being arranged to contain a liquid heat transfer medium capable of being maintained in the boiling state to provide a liquid phase and a vapor phase and so that the liquid phase is sufficient to cover the entire surface of the member defining the outer surface of the annular space, and heating means disposed between said member and said support member for heating the outer surface of said member and heating the heat transfer medium to the boiling state, wherein said member comprises an outer cylinder forming the outer surface of the roll, a cylindrically shaped sleeve disposed concentrically about said support member and spaced closely radially inwardly from the inner surface of said cylinder for cooperating therewith to form the annular space for receiving the heat transfer medium, a hub member integrally secured to said cylinder for mounting said cylinder on said support member, said support member comprising a rotary shaft, and means for fixing said hub to said shaft, said heating means comprising an iron core concentrically disposed about said shaft and spaced radially inwardly from said sleeve, a coil mounted about said iron core and spaced radially inwardly from the inner surface of said sleeve for forming a predetermined gap therebetween, a bearing box positioned at one end of said shaft for rotatably supporting said shaft, said bearing box being laterally spaced from the adjacent surface of said core, a bolt assembly for securing said core to said bearing box, said bolt assembly comprising a plurality of bolts extending between said bearing box and said core, and an insulating sleeve enclosing each said bolt for the extent of the space between said bearing box and said core.

10. A rotary roll for heating an article, such as a fiber, as it is worked, comprising a centrally disposed support member, a cylindrically shaped member concentrically disposed about and spaced radially outwardly from said support member and forming the outer surface of the roll, said member forming an annular space spaced closely inwardly from the outer surface of the roll, said member being arranged to rotate about the axis of said support member, the annular space within said member being arranged to contain a liquid heat transfer medium capable of being maintained in the boiling state to provide a liquid phase and a vapor phase and so that the liquid phase is sufficient to cover the entire surface of the member defining the outer surface of the annular space, and heating means disposed between said member and said support member for heating the outer surface of said member and heating the heat transfer medium to the boiling state, wherein said member comprises an outer cylinder forming the outer surface of the roll, a cylindrically shaped sleeve disposed concentrically about said support member and spaced closely radially inwardly from the inner surface of said cylinder for cooperating therewith to form the annular space for receiving the heat transfer medium, a plurality of concentric rings of the same outside diameter disposed within said cylinder and the outer surfaces of said rings being in surface contact with the inner surface of said cylinder, said rings being concentrically disposed about said support member, and the inner surfaces of said rings being arranged to provide alternating axially extending lands and grooves with the grooves extending radially outwardly from said lands in the direction of the outer surface of said cylinder, and the surfaces of said lands being spaced radially outwardly from the outer surfaces of said sleeve.

11. A rotary roll, as set forth in claim **10**, wherein said support member comprises a tubular member, bearing means being mounted on said tubular member at axially spaced positions, and said cylinder being mounted on said bearing means for rotating about said tubular member.