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3,273,101

HEATING APPARATUS FOR USE IN ELECTRICALLY HEATED ROLLS

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FIG. 1.

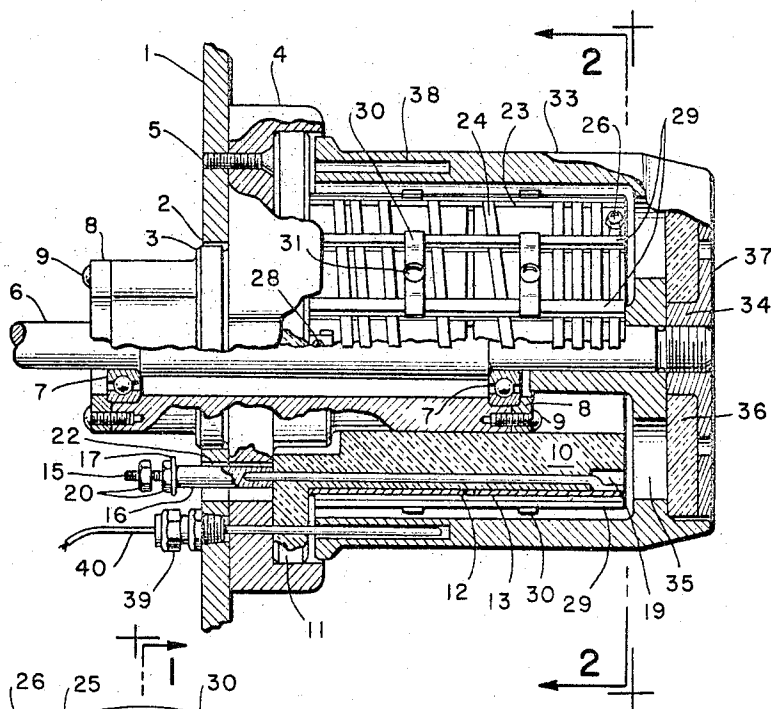
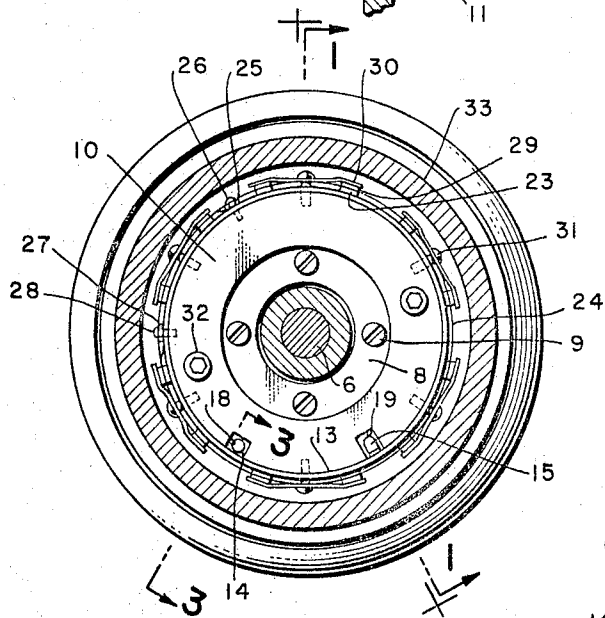


FIG. 2.

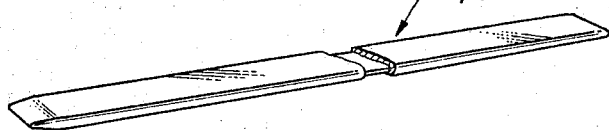
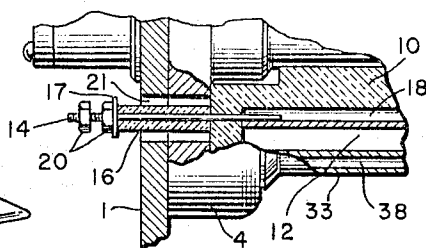


FIG. 4.

FIG. 3.



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This invention relates generally to heating devices and, more particularly, to improved heated roll assemblies which incorporate a novel and beneficial heater construction for general applications requiring rotatably mounted, heated rolls, e.g. draw rolls and drying rolls.

Heretofore, considerable effort has been expended in developing heated roll devices for use in diverse applications, such as paper-making and yarn and film treatments. As evidenced by the prior art, some workers have resorted to heated rolls for such and related purposes by introducing a liquid or gaseous media into a roll interior via a hollow shaft and rotating joint combination, as shown, for example, in U.S. Patent 2,162,727 to Kline. Such a construction, however, has the disadvantage of a limited rotational speed of the roll and early failure of the mechanical joint or seal employed to effect the transfer of the media from a stationary source to the rotating interior of the roll, with an attendant loss of heat to the atmosphere. Other workers have utilized a liquid heat transfer media contained within one or more cavities of the roll and heating this media with an electrical means, usually employing a slip ring in cooperation with the rotating roll shaft. Still other workers have utilized electrical heating elements mounted interiorly in the rotating roll and supplying power thereto by slip-ring constructions that inherently are subject to wear and early mechanical failure under high speed rotation, accompanied by undesirable electrical noise and subsequent electrical failure. Still other devices employ stationary electrical means mounted interiorly of the rotating roll, which heating means may be designed to operate on the principle of electromagnetic induction, as taught in U.S. Patent 2,273,423 to Somes. A common objection to all of these various heated roll devices resides in the fact that they are subject to unduly long delays in heat-up time from ambient to process operating temperatures and slow response to temperature changes it may be desired to effect during the execution of a given process utilizing such rolls. Even electrically powered radiant heaters, which inherently possess a capability of a relatively fast response, leave something to be desired, the primary obstacle being that of the air gap that normally exists between the heater surface and the surface of the roll to be heated thereby. The inordinate size of such an air gap is necessitated by the fact that the thermal expansion normally experienced by prior art radiant-type heaters in many instances results in grounding of the heater element against the surface to be heated, i.e. the interior roll surface, in cases where a sufficiently large size air gap has not been provided. A further objection to many of the existing roll heater designs lies in their difficulty of inspection, maintenance and repair, normally due to the fact that the heater construction is one of encapsulation, usually in some heat-resistant bonding medium, which encapsulation renders it impossible to make any major adjustments or repairs and usually results in discard of the heater should break-down occur. Also, there has been a wide and long recognized need for a heated roll design capable of precise control and adjustment of the temperature gradient along the roll surface. In many applications, it is desired to establish a precise gradient of temperature along the roll and, in others, to establish a zero gradient therealong. To our knowledge, there is not

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presently available a roll construction that would enable such control, no matter the precautions taken.

In general, the utilization of a stationary electrical resistance radiant heater to heat rotating roll assemblies to a desired temperature gradient along the length of the roll surface is known in the prior art, as evidenced by U.S. Patent Number 2,244,745, and we do not, therefore, profess that such a general construction comprises a part of our inventive contribution; we do, however, believe ourselves to be the first inventors of major refinements and improvements in the construction of such generally characterized heated roll assemblies.

It is therefore one object of our invention to provide a stationary electrical resistance element heater that utilizes radiant heat energy and is of such design as to provide accurate control of the temperature gradient as measured along the surface of a roll or roller associated therewith.

Another object of this invention is to devise a heated roll construction capable of rapidly responding to required process temperature changes.

A further object is to devise a heated roll combination having an improved radiant heater construction which cooperates with its associated roll in such fashion that the roll surface may be elevated from ambient to process operating temperature conditions in minimum time.

Still another object is to devise a heater construction capable of being easily fabricated in such a manner as to provide either a uniform or variable temperature gradient along the roll surface, depending upon the process requirements.

A still further object is to provide such a heater construction wherein either a flat, ribbon-like, or small diameter, continuous wire resistance element may be employed as the heating source without encountering short-circuiting problems where minimum air gaps are desired for quick response.

Yet another object is to provide a stationary electrical resistance element heater for rotating roll assemblies that is economical in construction and operation, easily fabricated and maintained, and one that can be utilized in many applications.

A further object is a method of wrapping and securing an electrical resistance heater element about a stationary core assembly in such a fashion that a minimum air gap between the heater and the roll surface may be employed without suffering the risk of grounding the heater element against the associated roll.

It is another object of our invention to provide a combination stationary-core-radiant-heater and roll assembly, the core construction being characterized by a substantially helically wrapped electrical resistance heater element secured in a novel fashion so as to effect a segmentation and substantially uniform distribution of thermal expansion effects throughout the length of the heater element to thereby minimize the possibility of short-circuiting such element against roll surrounding structure.

According to our invention, the foregoing and other objects are attained by providing a heated roll construction wherein the heater takes the form of a stationary mounted core, helically enwrapped by an electrical resistant, radiant heater element which is secured to the core assembly at axially and circumferentially spaced points, relative to the core so as to effect a segmentation and distribution of the thermal expansion experienced by such element at the elevated temperatures to which it must be subjected. A major significance in such a novel fashion of securing a ribbon-like electrical resistant heater element lies in the fact that it enables one to employ a minimum air gap between the heater element and the roll heretofore unattainable without introducing the hazard of grounding the heater element. The roll is of

hollow construction enclosing the core heater assembly, the roll being affixed to a rotatable shaft extending axially through the heater core and mounted in anti-friction bearings supported in a stationary housing which comprises the inner element of the core construction, the housing being affixed to any desired machine frame. Enveloping the stationary housing, and affixed thereto, is a cylindrical, spool-shaped insulating member possessing good thermal and electrical insulating properties. Enveloping said cylindrical insulator are two cylindrical sleeve members, each isolated from the other so that they may also serve as a series element in the electrical circuit of the heater. Affixed to said sleeve members are the electrical terminal connections which project through the machine frame for simplicity in connecting the heater to an electrical power source. Around the periphery of said cylindrical sleeves are affixed a plurality of insulating strips extending axially of the roll shaft, which strips, in combination with others, provide the means of affixing and electrically isolating the continuous electrical resistance heater element in a manner to segment its thermal expansion. The insulator strips are affixed to the cylindrical sleeves in a novel fashion by suitably placed clamps, as are the terminal ends of the electrical heater element. Provision is also made for accurately sensing the roll surface temperature for control and recordation purposes, the sensing element projecting into an annular cavity formed at the inboard end of the roll and consisting of a stationary combination thermistor-thermo-couple probe, commercially available.

A better understanding of the invention may be had from the following detailed description of an illustrative embodiment thereof, when read in conjunction with the appended drawings, in which:

FIG. 1 is a fully assembled, axial view, partially sectionalized, showing a typical embodiment of our heated roll assembly and details of the novel stationary heater construction mounted internally of the hollow, rotatable roll;

FIG. 2 is an outboard end view of the roll assembly, partially sectionalized, taken along line 2—2 of FIG. 1;

FIG. 3 is a partially sectionalized detailed view of the lower left hand portion of FIG. 1 taken along line 3—3 of FIG. 2 and showing the details of the electrical terminal construction, and

FIG. 4 is a partially sectionalized, detailed view of a typical insulating strip, all such strips being substantially identical.

Referring, in detail, to the drawings, in which like numbers of reference indicate like or similar parts, reference numeral 1 indicates the machine frame which has formed therein a pilot hole 2 through which the pilot 3 of roll shaft support housing 4 projects. Extending through the bore of roll shaft support housing 4 is rotatably mounted roll drive shaft 6 mounted in anti-friction bearings 7 supported by the shaft support housing. Drive shaft 6 is driven by any suitable variable or fixed speed driving means, not shown. Anti-friction bearings 7 are retained in shaft support housing 4 by bearing caps 8 and machine screws 9. Suitable lubrication may be supplied to bearing 7 by means of, for example, an automatic mist lubrication system, not illustrated, or any similar arrangement.

Coaxially surrounding and enveloping the roll shaft support housing 4 is a cylindrical, spool-shaped insulation member 10 fabricated from a good thermal and electrical insulating material, such as a blend of asbestos fiber and diatomaceous silica locked in an inorganic binder. The insulating member 10 is formed to have a sliding fit over support 4 to assure concentricity between the rotating drive shaft 6, support 4, the electrical heater components and the rotatable roll 33. Integral with insulating member 10 there is provided a radially outwardly extending flange 11 which serves to reduce thermal con-

duction from the electrical heater to the machine frame 1 and roll shaft support housing 4.

A pair of metal cylindrical sleeves or sheaths 12, 13, preferably constructed of steel having a low coefficient of thermal expansion and serving as electrical conducting and heater element mounting surfaces have a tight sliding fit engagement over insulating member 10. Affixed to sleeves 12, 13 are electrical power terminals 14, 15, respectively. Provision for these terminals is made in the spool-shaped cylindrical insulator 10 by means of slots 18, 19, respectively, extending axially of the insulator. Slot 18 runs the full length of the insulator up to flange 11, while slot 19 runs to a depth sufficient to permit the mounting of outboard sleeve 13 flush with the insulator surface on the right hand end, as shown in FIG. 1. With the configuration illustrated, an air gap of approximately $\frac{1}{8}$ inch remains between sleeves or sheaths 12, 13 serving to isolate one from the other, this being necessary in that both such sleeves serve as electrical conductors in series relationship with the heater element 24.

Electrical power terminals 14, 15 project through holes 21, 22, respectively, in the machine frame 1 and shaft support housing 4. A small terminal insulator 16 surrounds the protruding extremities of terminals 14, 15 to isolate such terminals from the machine frame 1 and shaft support housing 4. These insulators 16 also serve as spacer members to maintain the desired relationship between washer 17 and nuts 20, to which the electrical leads are attached, and the machine frame 1.

Turning now to another important feature of our invention, there shall now be described a novel and most advantageous way of wrapping and securing the heating element 24 to the above described core-insulator assembly in such fashion as to segment and uniformly distribute heating element elongations due to thermal expansion to thereby avoid excessive concentrated buckling and consequent grounding of the heating element. From the drawing, it is seen that a plurality of insulating strips 23 envelope the cylindrical sleeve members 12, 13 and are arranged to extend axially of the core assembly and spaced circumferentially thereabout. As more clearly seen in FIG. 4, these strips comprise a steel core, preferably of a low coefficient of expansion, and an overlay or outer coating of aluminum oxide applied over a nickel-aluminide bonding medium. Though our invention is not limited to this particular construction of the insulating strips, it has been found particularly resistant to the high temperatures encountered. It is over these strips, so placed, that the ribbon-like electrical resistance heating element 24 is wound about the core assembly under a small amount of tension, the strips serving to electrically insulate the heating element from sleeve members 12, 13. Strips 23 may be affixed to either of the cylindrical sleeves 12, 13, or they may be simply retained in place during the winding of the heater element 24 and not permanently affixed to either of said sleeves, the proper positioning of the strips being maintained by the tension in the heater element imparted during the winding operation.

Heater element 24 is affixed to outboard cylindrical sleeve 13 by means of clamp 25 and machine screw 26, whereby the sleeve serves as an electrical terminus for the heater element at its outboard end, as viewed in FIG. 1. Having anchored the heater element 24 in such fashion, it is thence wound over the sleeve and the previously positioned insulating strips 23 in any suitable configuration that will produce the desired heat distribution along the surface of the roll 33. It is visualized that a given heater made according to the present invention may be repeatedly rewound in varying configurations and spacing to generate any desired temperature gradient, although the most common requirement will be that of a zero gradient throughout the extremities of the roll surface. Depending upon the particular size and capacity of heater

and roll construction it is desired to employ, it will be found a simple and quickly executed matter of trial and error in determining the particular configuration of the helical winding that is productive of the desired result, whether it be a zero or varying temperature gradient along the roll surface. The remaining end of heater element 24 is then clamped to the inboard cylindrical sleeve 12 by means of clamp 27 and machine screw 28. It is preferred that the heater element 24 be wrapped under a tension of from about 5 to 10 pounds to insure against slack and, in the case where the strips are not otherwise maintained in their proper position, to insure against their slippage. After heater element 24 is fully wrapped and its respective ends affixed to the cylindrical sleeves 12, 13, upper or outer insulating strips 29, which are of the same general construction as the inner or lower strips 23, are placed, one above each of the lower strips 23 and clamped into position by means of clamps or clip bars 30, machine screws 31 serving to detachably fasten the mid-points of the bars and, consequently, insulating strips 23, 29 to the sleeve surfaces. Each clip bar 30 spans two adjacent pairs of insulating strips 23, 29 and it is preferred that two axial spaced clamps be used for each adjacent pair of strips, as depicted in FIG. 1. Cap screws 32 affix the heater assembly to the shaft support housing 4 to thereby maintain the proper relationship therebetween. These pairs of insulating strips, each comprising an upper and lower strip, so spaced as to envelop cylindrical sleeves 12, 13 in substantially equal circumferential increments, serve to support and clamp the heating element 24 at substantially equal segments along its continuous length. The result is that, upon subjection to extremely high temperatures, any thermal expansion of the heating element will be segmented into nearly equal increments throughout the length of the element. Thus, when power is applied to the heater element, it is free only to expand between the clamped pairs of insulating strips retaining it in place. Such expansion, so permitted, has been found to be less than the thickness of the clamping strips which, in the embodiment illustrated, is about 1/16 inch. Consequently, electrical shorting cannot occur between heater element 24, roll 33 or cylindrical sleeves 12, 13, even where air gaps of heretofore intolerably small dimension are employed. This ability to operate with a small air gap is extremely important in that the rate of response of the heated roll surface to induced changes in temperature, as a consequence of changes in the power supplied to the element, varies inversely as the size of the air gap.

Rotatably roll 33 is affixed to shaft 6 by means of a force-fitted taper 34. Holes 35 are integral with the web of roll 33 to reduce the rotating mass and also to reduce the capacity of the conductive path for heat to shaft 6 and bearings 7. Roll-end thermal insulation member 36 nests within a cavity provided in the outboard end of roll 33 to reduce heat losses through the end of the roll by way of roll retaining nut and cover cap 37.

An annular slot is provided in roll 33 for the insertion of a combination thermistor-thermocouple probe 39 which is mounted in machine frame 1. Electrical lead 40 extends from probe 39 to any suitable temperature control and recording means, not illustrated. An annular groove 38 is provided along the inboard portion of the wall of roll 33 to accommodate the sensing probe 39 to better insure that it indicates and controls the surface temperature of the roll 33 rather than the temperature of the electrical heater element 24. The combination probe 39 has been found to suffice for roll surface temperatures up to 300° C. For higher roll surface temperatures, a radiation pyrometer serves as an excellent indicating and controlling means.

To further aid a clear understanding and appreciation of the significance of our inventive contributions, reference may be had to the following examples.

Example I

A roll having an outside circumference of 1.50 feet and a No. 3 matte finish, weighing 7.1 pounds exhibited the below tabulated heat-up times when heated from an ambient temperature of 22° C. to various desired operating temperatures.

The stationary electrical heater unit utilized consumed 2225 watts at 117 volts A.C. when drawing full voltage. The maximum voltage applied to the heater in obtaining the following data was 100 volts A.C., this voltage limitation being due solely to a limiting feature of the particular controller employed.

Roll surface temperature was measured with a radiation pyrometer. The maximum temperature differential over the face of the roll in the examples is seen to be 3° C., a differential heretofore unattained in prior art heater rolls.

Roll Speed, F.P.M.	Roll Surface, Temp., ° C.	Heat-up Time, Min.
250.....	22	0
250.....	200	6.5
250.....	250	7.0
250.....	285	7.5
250.....	300	8.25

Example II

Roll Speed, F.P.M.	Roll Surface, Temp., ° C.	Heat-up Time, Min.
5,225.....	22	0
5,225.....	200	10.0
5,225.....	250	17.5
5,225.....	275	27.0
5,225.....	285	40.0

It may now be appreciated that the above described invention offers particular advantages and benefits to those engaged in the manufacture of synthetic fibers, plastic, film, paper, etc. where the processing of materials of a continuous nature must be accomplished.

Present day economics dictate that process equipment operate at higher and higher speeds in order to achieve increased production from a smaller capital investment. At the same time, product quality must be continually improved to remain competitive. In the particular case of drawing, drying, etc. synthetic fibers, the present invention has been found to fulfill both desires in that high speed, heated rolls, in cooperation with stationary electric core heaters, overcome the disadvantages of existing means known in the art, roll speed limitation being now only dependent on process demands or the type of anti-friction bearings employed. Similarly, the quality of product capable of being realized with this invention is greatly enhanced because the roll surface temperatures are easily controlled within extremely narrow limits and the product contacting such rolls may therefore be processed at more uniform temperatures.

Obviously, numerous modifications and variations of the present invention, both as to its apparatus and method aspects, are possible in the light of the above teachings. It is, therefore, to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

What is claimed is:

1. A radiant heating apparatus for use in heated roll assemblies comprising a non-rotatably mounted, spool-shaped core assembly of thermal and electrical insulating properties, a first plurality of electrical insulating strips spaced circumferentially of and extending longitudinally along the outer surface of said core assembly, an electrical resistance element wrapped in a substantially helical fashion about said thermal insulator and overlying said electrical insulating strips, a second plurality of insulating strips overlying said resistance element, each coinciding with one of said first plurality of insulating strips, clamp means engaging adjacent pairs of insulating strips with

said core assembly, where thermal expansion of said electrical resistance element is effectively segmented and caused to be uniformly distributed about the entire circumference of said core assembly.

2. A heating apparatus for use in electrically heated rolls comprising a spool-shaped core assembly, electrical resistance heater means wound in a substantially helical fashion about said core assembly, fastening means operative to maintain substantially equi-spaced points along said heater means fixed relative to said core assembly, said fastening means comprising pairs of superposed electrical insulating strips spaced circumferentially about said core assembly and extending axially thereof, said heater means extending between the member strips of each of said pairs, means to clamp said strips to said core assembly, whereby thermal expansion of said heater element is effectively and uniformly segmented and caused to be uniformly distributed about the entire circumference of said core assembly.

3. The apparatus as defined in claim 2 wherein said spool-shaped core assembly comprises a hollow cylindrical support member, an intermediate layer of electrically and thermally resistant material surrounding said support member and a metallic sheath surrounding said intermediate layer.

4. The apparatus as defined in claim 2 wherein each of said strips is characterized by an outer coating of aluminum oxide bonded to a metallic core.

5. The apparatus as defined in claim 2 wherein said

clamping means comprises a plurality of clip bars, each said clip bar being attached at its midpoint to said core assembly to extend circumferentially thereof and transversely to said pairs of strips, each end of each clip bar engaging and clamping an adjacent pair of said strips against the surface of said core assembly.

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