

Aug. 16, 1966

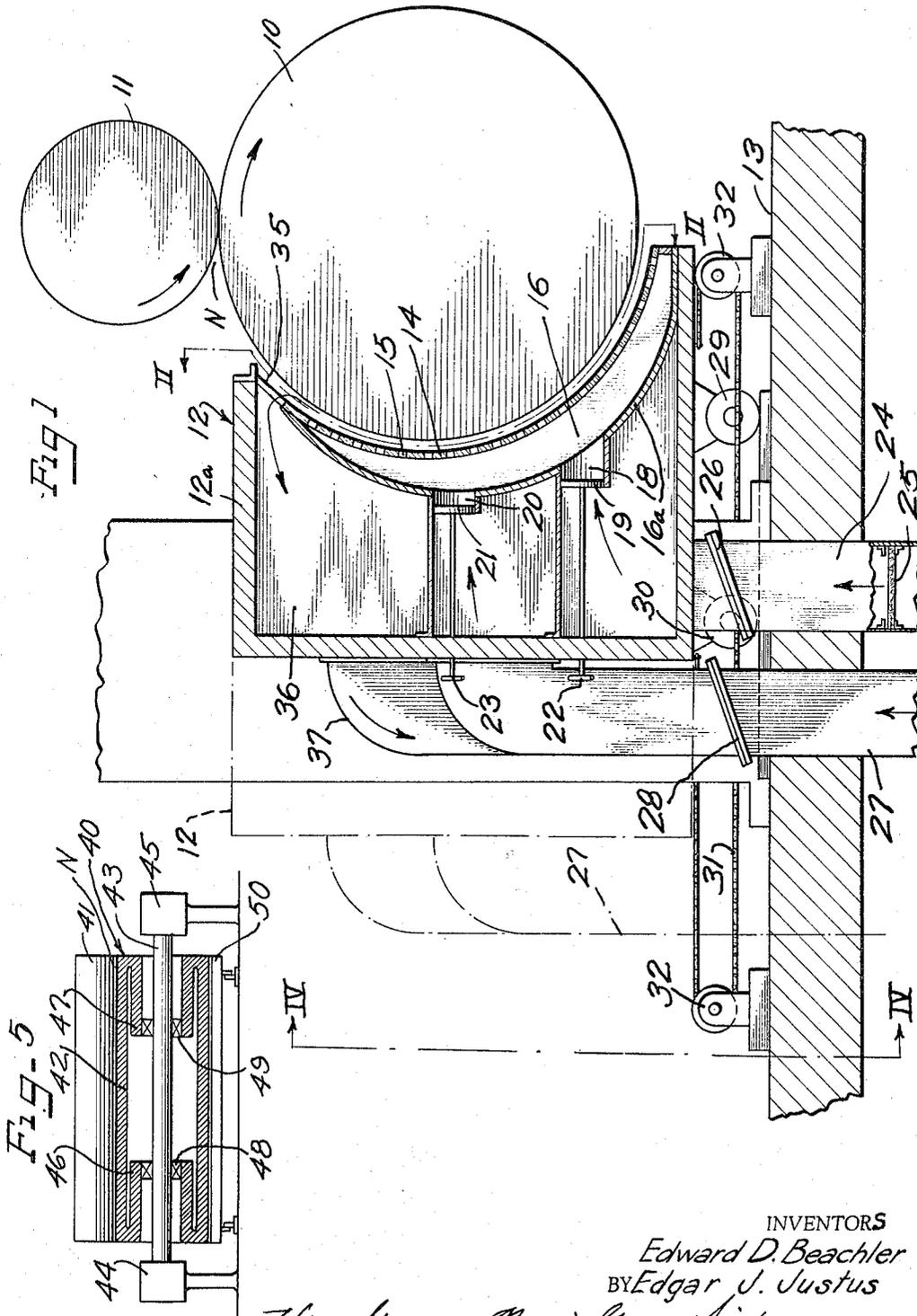
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3,266,561

METHOD AND MEANS FOR CORRECTING THE CROWN OF A ROLL

Filed Dec. 23, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

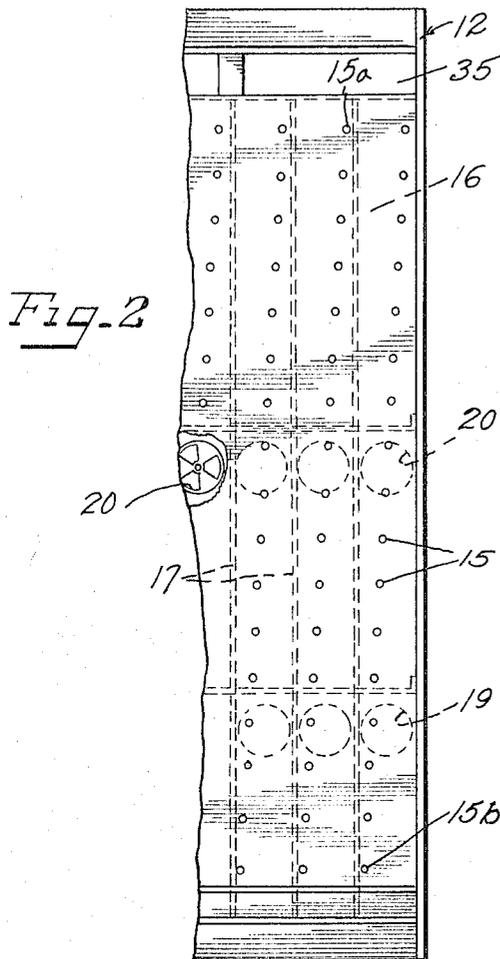


Fig. 2

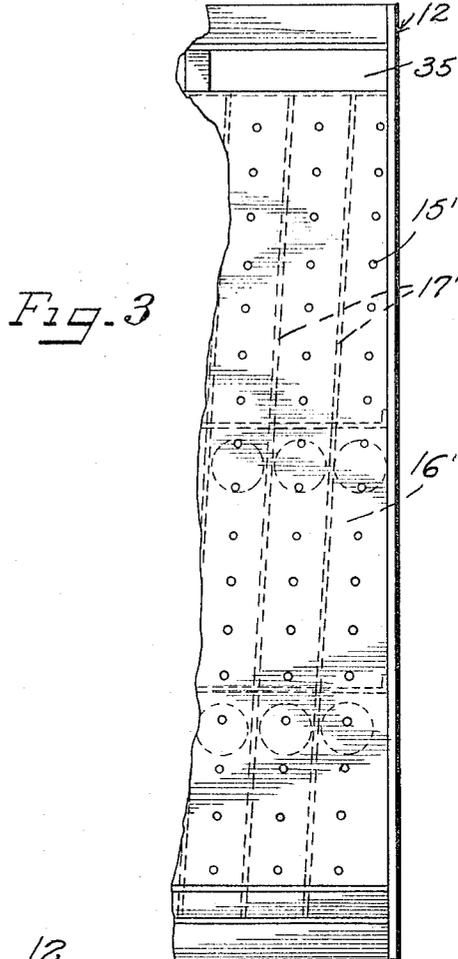


Fig. 3

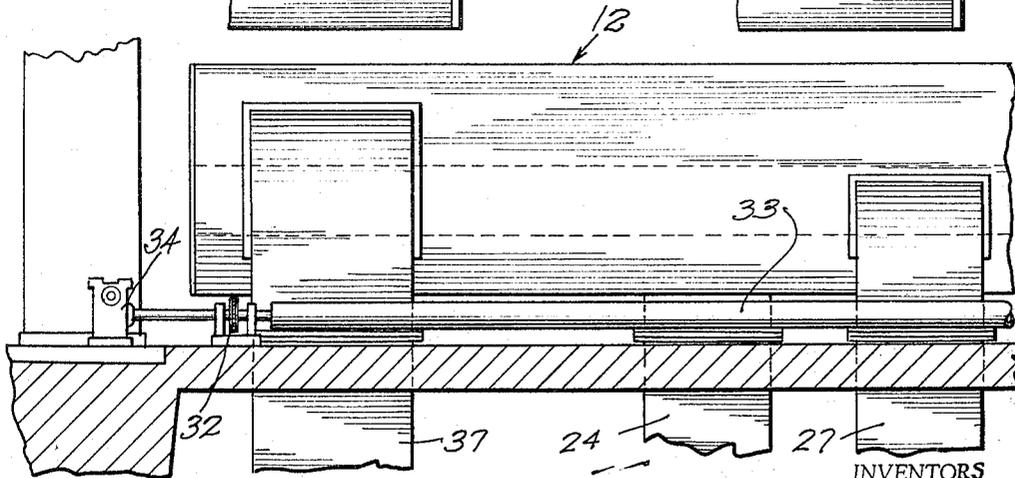


Fig. 4

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METHOD AND MEANS FOR CORRECTING THE CROWN OF A ROLL

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The present invention relates to a mechanism for controllably changing the crown of a roll during operation such as a roll in a calender stack in a paper machine.

While the control of the shape of an elongated cylindrical roll and the changing of the shape of such a roll may be used in various industrial environments, the features of the invention are particularly useful in controlling and correcting the crown of a bottom calender roll in a paper processing machine and for ease of description the invention will be described for this use. In a paper machine calender stack the paper web is threaded in a serpentine path through the nips formed by a vertical stack of calender rolls. The weight of the stack plus forces applied to the rolls to control nip pressures will cause bowing of the rolls and in order to obtain uniform nip pressure it is common practice to crown the rolls a predetermined amount, particularly the lowermost or king roll of the stack. The operating conditions of a calender stack may be changed such as by adding one or more rolls to the stack which of course will change the weight of the stack and will change the crown required for the king roll to obtain uniform nip pressure. This would normally require either accepting poor calendaring results or regrinding or replacing the king roll to obtain a king roll of a crown different than the original king roll.

It is a feature of the present invention to provide a mechanism wherein the overall crown of an existing roll can be controllably changed without regrinding the roll.

It is accordingly an object of the present invention to provide a mechanism wherein the shape or crown of a roll can be changed in its operating location without removal of the roll and without adversely affecting its operating function.

A further object of the invention is to provide an improved arrangement for controllably affecting the temperature of a roll along its axial length and obtaining a temperature gradient along the length which will give it a desired crown.

A further object of the invention is the provision of a method and apparatus for obtaining a tapered temperature in an operating roll wherein the temperature gradient from the center to the ends of the roll either increases or decreases in a uniform controlled gradient for the overall roll.

A still further object of the invention is to provide a mechanism for controlling the operating temperature of a roll during operation by an apparatus which applies a blanket of air to the roll surface at a predetermined temperature to obtain a gradient along the roll length and wherein the mechanism is movable to a non-operating position away from the roll or to an operating position closely adjacent the roll.

Another object of the invention is to provide a mechanism which applied a blanket of controlled temperature air along the length of a roll which will not adversely affect a travelling paper web carried on a portion of the surface of the roll.

A further object of the invention is to provide a method and mechanism for both mechanically and thermally controlling the deflection of a roll for obtaining controlled roll conformation or controlled nip pressure.

Other objects, advantages and features will become more apparent with the teaching of the principles of the present invention in connection with the disclosure of the preferred embodiments thereof in the specification, claims and drawings, in which:

FIGURE 1 is an end elevational view with parts in section for controlling the overall crown of a roll along its length, embodying the principles of the present invention;

FIGURE 2 is a vertical sectional view taken substantially along line II—II of FIGURE 1 showing the perforated wall of the hood of the mechanism in fragmentary elevational view;

FIGURE 3 is a fragmentary elevational view similar to FIGURE 2 showing another structural arrangement;

FIGURE 4 is a fragmentary vertical sectional view in reduced size taken substantially along line IV—IV of FIGURE 1; and

FIGURE 5 is a vertical sectional view taken through a roll in an assembly embodying a modified form of the invention.

On the drawings:

FIGURE 1 shows a calender stack with a king roll 10 and additional rolls thereabove such as 11 forming a nip N through which a paper web is carried in a calendaring operation. The king roll 10 has a crown, not shown, and the profile or size of the crown is controlled by an air hood 12.

The air hood 12 incorporates an enclosing wall 12a and an arcuate concave perforate wall 14 with air flow openings 15 therein. The air flow openings are arranged in a pattern to direct a uniform flow of air onto the surface of the king roll 10 to affect its temperature and the effective crown of the roll 10 which arrives at the nip N will be determined by the roll temperature along its length. As will be recognized since expansion of the metal of the roll 10 is a function of its temperature, if the roll gradually increases in temperature toward its center it will have an effective crown at the center. Similarly, if the temperature of the roll gradually increases from the center to the ends, the crown will be decreased. In order to usefully control the crown, the temperature gradient along the roll must be uniform and the amount of air directed against the roll should be controlled inasmuch as the heat transmitted to the roll 10 will be a function of the temperature of the air directed against its surface and the rate of air flow. The air is directed over the roll surface in a blanket over a uniform arc with the air temperature controlled along the roll so that the temperature gradient of the roll will be controlled.

Behind the perforate wall 14 is a plenum chamber 16 defined by a rear wall 16a. The plenum chamber is divided into a series of axially spaced chambers by axially spaced baffles 17, FIGURE 2. Hot and cold air is mixed in each of the compartments to obtain the desired temperature and each successive compartment operates at either a slightly warmer or slightly cooler temperature than its adjacent compartment and so on progressively from the center of the roll to the outer end of the roll.

Air from each of the compartments is delivered through the perforations or air delivery openings 15 and these openings are arranged in vertical rows which extend generally at an angle to the movement of the surface of the roll. The openings 15 are in effect staggered so that no two openings direct air at the same axial location on the roll and the air is uniformly distributed along the length of the roll. By arranging the openings 15 in rows and slanting the rows as illustrated in FIGURE 2, a uniform distribution of air is achieved. The rows are slanted so that each of the openings is spaced axially a uniform distance from the one below it, and the uppermost opening

of one row, for example 15a of one row is spaced axially from the lowermost opening 15b of the next row the same distance as the axial spacing between openings in any of the rows.

Cold air is received in the compartments through a passage 18 controlled by a flow control valve 19. Warm air is received by the compartments through a passage 20 controlled by a warm air valve 21. The cold and warm air valves are manually adjusted by individual adjustments 22 and 23 respectively. Air is supplied to the cold air valve through a cold air conduit 24 which may be room air or as illustrated, air drawn from a basement, and a filter 25 is positioned in the cold air conduit 24 to prevent drawing dust or other foreign materials which might be deposited on the king roll 10. Warm or hot air is supplied through a conduit 27 to the valve 21 with the air being warmed by suitable heating means such as a steam coil.

Each of the conduits have separable connections 26 and 28 so that the entire hood 12 may be drawn away from the king roll 10, to the dotted line position of FIGURE 1 and the connections 26 and 28 have ground faces and are formed at an angle so that when the hood is moved horizontally away from the king roll 10 to its rest position (the dotted line position) the connectors 26 and 28 separate. When the hood is moved horizontally to its operating position (the solid line position of FIGURE 1), the connectors automatically reconnect. The same type of connection is provided for an air removal conduit 37.

For supporting the hood 12 to be moved back to its rest position, supporting wheels 29 and 30 are provided rolling on supports on a supporting floor surface 13. The hood 12 may be moved by suitable means and is shown as being moved by a cable or chain 31 which passes over sheaves or sprockets 32. A chain and sprocket arrangement is preferred with a chain provided at each axial end of the hood so that equal forces can be applied to the hood ends to insure that the spacing between the perforate wall 14 and the king roll 10 will be uniform along its axial length. For driving the rear sprockets 32 they are mounted on a cross shaft 33 which is of increased diameter and tubular in form, as shown in FIGURE 4, to prevent any twisting along its length and to further insure that the chains at each end will remain at the same position for mounting the ends of the air hood at the same position with respect to the roll 10. The shaft 33 is driven by a motor through a gear reduction 34.

The temperature-controlled air is removed from the surface of the roll 10 through an air removal opening 34 which leads into a compartment 36 in the hood connecting to the air removal conduit 37. The conduit 37 is provided with a suitable suction fan. By the removal of the air through the opening 35 it insures a uniform and continued circulation of air along the surface of the roll 10, and also prevents the air from being carried upwardly along the roll surface to possibly cause flutter of the web.

In the arrangement in FIGURE 2 the individual compartments 16 in the plenum chambers are vertical with vertical baffles 17 therebetween. The arrangement may be modified as shown in FIGURE 3 by positioning baffles 17' at an angle and having the perforations 15' extending down the center of the compartments 16'.

In operation, the amount of crown of the king roll 10 (at uniform temperature along its length) is measured or known, and the desired crown is determined. From these figures it is easy to calculate the temperature differential along the length of the roll 10 which must be maintained to give additional crowning (by increasing the temperature toward the center of the roll) or to reduce the crowning (by decreasing the temperature gradually toward the center of the roll or in other words by increasing the temperature toward the ends of the rolls). When the temperature gradient or differential along the roll is deter-

mined, the hot and cold air valves 19 and 21 are set by the adjustments 22 and 23. This setting is accomplished by indications on the valves or by a trial run and by temperature indicators which will indicate the temperature in each of the compartments. Various types of valves may be employed, and as shown a simple valve is provided which has alternate radial slots and solid portions with a damper behind the valve having solid portions for partially covering the slots.

When the roll 10 rotates a constant uniform flow of air will be directed against its surface so that it will have a controlled temperature along its length to obtain a predetermined crown, as controlled by temperature.

It has been found that in a preferred operation the openings or perforations 15 should be in the range of 1-2% of the area of the wall 14. With this area, air should be supplied to each of the compartments so that the air issues from the openings 15 at a relatively high velocity, on the order of 8,500 feet per minute. The air will be carried upwardly with the rotating roll 10 and will be removed through the opening 35.

Thus it will be seen that I have provided a new and improved apparatus and method for crowning a roll and for controlling or changing a crown during operation without requiring the reworking of the roll. The mechanism provided achieves the objectives and advantages above set forth and provides a relatively inexpensive and reliable device which eliminates the expense and need for reworking a crowned roll when load conditions change. This arrangement also permits using a roll with an improper roll crown and correcting the crown to the desired operating profile.

FIGURE 5 illustrates an arrangement wherein a roll assembly 40 is provided with both a mechanical means and a thermal means for controlling the nip load between the lower roll 40 and an upper roll 41 forming a nip N therebetween.

The lower roll 40 has a roll shell 42 with hollow tubular inner support shells 46 and 47 of substantial length extending inwardly from each of the ends of the roll shell and attached thereto at the ends such as by being integral therewith. The support shells 46 and 47 are radially inwardly spaced from the roll shell and radially outwardly spaced from a through shaft means 43. The through shaft means is supported on mounts 44 and 45 at its ends.

For rotatably supporting the roll shell 42, self-aligning bearings 48 and 49 are provided between the inner ends of the inner support shells 46 and 47 and the through shaft 43.

The tubular inner support shells 46 and 47 with the through shaft 43 provide a mechanical means for applying a counter-deflection force to the roll shell 42, applying internal counter-deflection moments to the ends of the shell in response to the application of the nip load on the shell. The through shaft means 43 does not rotate and is therefore capable of carrying relatively heavy loads and supports the allochiral bearings 48 and 49 supporting the allochiral mounts or inner support shells 46 and 47, which are in effect "turned-in," i.e., cantilevered, members. As a nip load is applied to the shell 42, creating a bending force on the roll shell 42 tending to cause it to bow inwardly at its center, counter bending moments are applied by the allochiral supports 46 and 47 which have a self-correcting effect. The length of the allochiral supports 46 and 47 are chosen so that a self-correcting effect is achieved to tend to provide a desirable nip load which is usually a uniform nip load along the length of the rolls. The determination of the characteristics of the structure may be accomplished in accordance with U.S. Patent 3,097,590, issued April 12, 1961, to E. J. Justus. The mechanical application of force to the roll shell 42 is preferred in accordance with the arrangement above described, but it is to be understood that

other mechanical roll deflection arrangements may be employed.

In the arrangement above described, slight peaks in nip load will occur between each of the ends and the center of the roll due to the resultant counter deflection forces applied by the support shells 46 and 47. These peaks can be eliminated by controlled contouring of the roll shell 42 by thermal control applied by the mechanism 50 which is the same as the mechanism described in detail in connection with FIGURE 1 (which is behind the roll shell 42 in FIGURE 5 and not shown in detail). In other words, by thermal control of the diameter of the roll shell 42, the tendency of the mechanical mechanism for applying counter deflection moments to apply slight nonuniform loads can be controlled so as to obtain a completely uniform nip load or to obtain a nip load of any desired predetermined characteristic. Accordingly, the present invention contemplates combining mechanical and thermal means for obtaining a predetermined nip load characteristic for a roll.

The drawings and specification present a detailed disclosure of the preferred embodiments of the invention, and it is to be understood that the invention is not limited to the specific forms disclosed, but covers all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by the invention.

We claim as our invention:

1. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - a hood facing the roll for confining air against the surface of the roll,
 - a plenum chamber in the hood having a perforate wall in close-running relation to the roll,
 - a series of baffles spaced along said hood in the direction of the axis of rotation of the roll and dividing the plenum chamber into a series of side by side compartments for substantially the length of the roll, hot and cold air inlets into each of said compartments, and flow control means for each of the inlets to controllably regulate the flow of hot and cold air into each compartment so that the temperature in the compartment can be controlled.
2. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - a hood facing the roll for confining air against the surface of the roll,
 - a plenum chamber in the hood having a perforate wall in close-running relation to the roll,
 - a series of baffles spaced along said hood in the direction of the axis of rotation of the roll and dividing the plenum chamber into a series of side by side compartments extending for substantially the length of the roll, hot and cold air inlets into each of said compartments extending for substantially the length of the roll, flow control means for each of the inlets to controllably regulate the flow of hot and cold air into each compartment so that the temperature in the compartment can be controlled,
 - and air withdrawal opening means in said hood extending axially therealong following said perforate wall for withdrawing air from the roll surface supplied through said perforate wall.
3. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - air discharge means positioned for directing a flow of air radially of the surface of the roll and circumferentially thereabout,

a plurality of air supply chambers at locations extending axially along the exterior surface of the roll and connected to said discharge means, and means for controlling the temperatures in each of said chambers so that a controlled temperature gradient can be obtained along the length of the roll.

4. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - a hood facing the roll for confining air against the surface of the roll,
 - a plenum chamber in the hood having a perforate wall in close-running relation to the roll, the perforations being spaced circumferentially to cover a substantial arcuate area of the roll and being spaced substantially uniformly in an axial direction,
 - a series of axially spaced baffles dividing the plenum chamber into a number of compartments, hot and cold air inlets into each of said compartments, and flow control means for each of the inlets to controllably regulate the flow of hot and cold air into each compartment so that the temperature in the compartment can be controlled.
5. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - a hood facing the roll for confining air against the surface of the roll,
 - a plenum chamber in the hood having a perforate wall in close-running relation to the roll,
 - a series of axially spaced baffles dividing the plenum chamber into a number of compartment, the perforations arranged in circumferentially extending rows for each compartment with the rows extending at an angle with respect to the travel of the roll surface so that successive streams of air emitted from said perforations will engage the roll at different axial locations, hot and cold air inlets into each of said compartments, and flow control means for each of the inlets to controllably regulate the flow of hot and cold air into each compartment so that the temperature in the compartment can be controlled.
6. An apparatus for imparting diameter variations along the length of a rotatable roll subject to deflection comprising in combination,
 - a hood facing the roll for confining air against the surface of the roll,
 - a plenum chamber in the hood having a perforate wall in close-running relation to the roll,
 - a series of axially spaced baffles dividing the plenum chamber into a number of compartments, hot and cold air inlets into each of said compartment, flow control means for each of the inlets to controllably regulate the flow of hot and cold air into each compartment so that the temperature in the compartment can be controlled,
 - an air removal chamber in said hood having a chamber air inlet opening adjacent the roll following said perforate wall for removing air emitted from the perforations, and means for moving the hood radially from a rest position spaced from the roll to an operating position adjacent the roll.
7. The method of crowning a roll which comprises, mixing hot and cold air in chambers in controlled quantities for obtaining a plurality of chambers of air of different temperatures, and directing air from the chambers along the length of the roll in a pattern so that an increasing or decreasing temperature of air is applied from the roll center to the roll ends for changing the crown of the roll.

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8. The method of crowning a roll which comprises, directing a blanket of air over the outer periphery of the roll along the axial length of the roll, controlling the temperature of said air along the length of the roll so that a gradual gradient occurs from the center outwardly to the ends of the roll, and removing the air from the roll surface at a location after the location at which it is applied with respect to the movement of the roll surface. 5

9. In combination, a rotatable roll shell whose axis is subject to deflection in response to a given load applied to said shell, through shaft means extending axially through said shell, 10

tubular inner support shells of substantial length extending inwardly from each of the ends of the roll shell and rotatable with the roll shell, 15

said support shells being radially inwardly spaced from the roll shell and radially outwardly spaced from the shaft means, 20

the outer ends of the support shells being rigidly connected to the outer ends of the roll shell, 25

a support means for each of the support shells supporting the inner ends thereof on the shaft means an appreciable distance from the outer ends so that the inner support shells are free to bend along their length, 30

said tubular support shells being of a substantial length for applying a predetermined deflection moment to the ends of said roll shell with said given load, 35

air discharge means positioned for directing a flow of air to control the temperature of the roll along its length,

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and means for controllably varying the axial temperature gradient of air along the roll for controlling the temperature of the roll surface so that the overall deflection of the roll is a function of its thermal deflection caused by the heated air and its mechanical deflection caused by said tubular inner support shells.

10. In combination, a rotatable roll, mechanical means applying a bending moment to the roll for controlling the deflection of the axis of the roll, thermal means exterior of the roll controlling the temperature of the roll along its length by the impingement of air on the periphery of the roll for the length thereof, and means controlling said thermal means and varying the temperature of the roll along its length by the impingement of air on the periphery of the roll and applying an increasing or decreasing temperature of air from the roll center to the roll ends and thereby being operative relative to said mechanical means for obtaining a desired overall roll surface contour along the roll length.

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