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(54) **HEATED CONTROLLED DEFLECTION ROLL**

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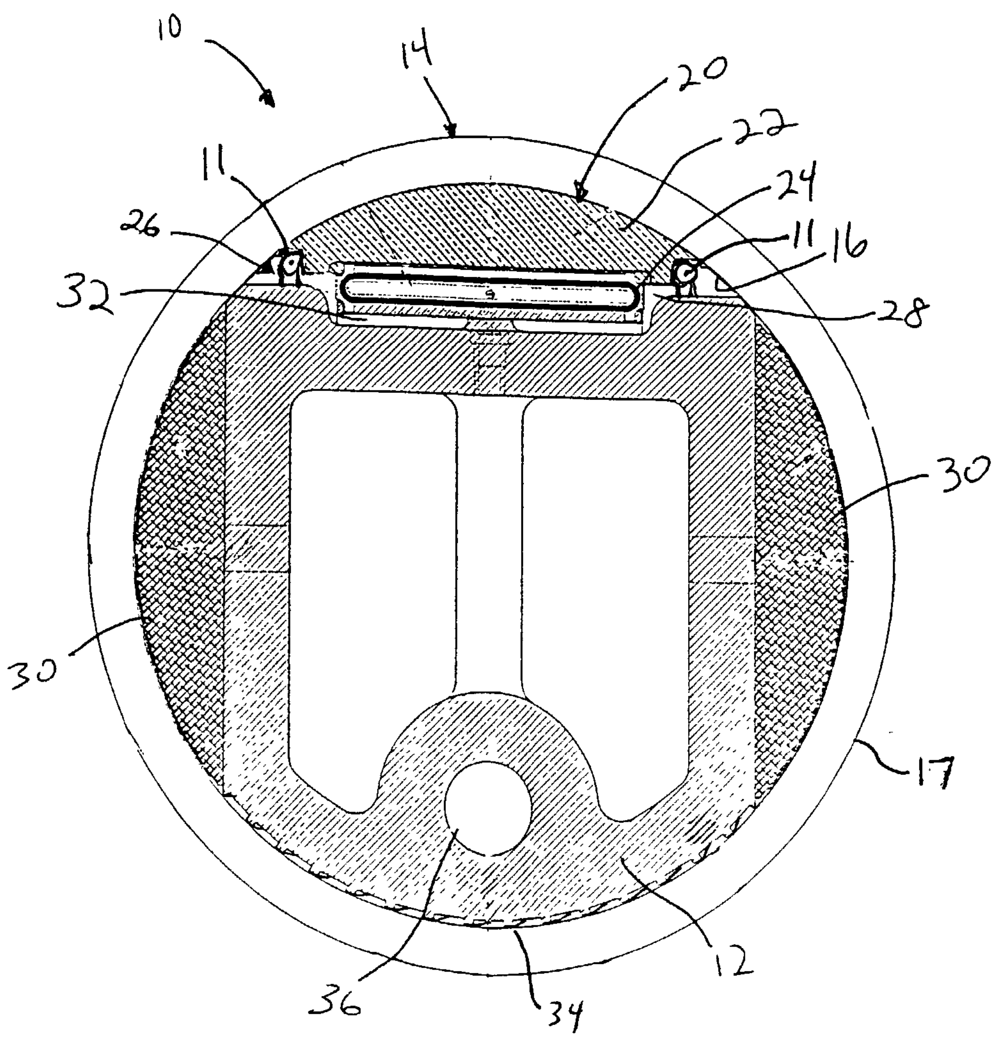
(57) **ABSTRACT**

A heated controlled deflection roll including a center support and a rotatable roll shell surrounding the center support. A shoe assembly connects the center support and the inside surface of the rotatable roll shell. The shoe assembly includes a shoe in contact with the inside surface of the rotatable roll shell and a bladder positioned between the shoe and the center support. The shoe assembly has a length substantially equal to a length of the inside surface of the rotatable roll shell. Free space within a chamber within the rotatable roll shell is filled with a heat transfer fluid and heater elements. The heater elements have angled fins for directing the flow of the heat transfer fluid in a helical pattern towards one end of the rotatable roll shell. The heat transfer fluid returns to the opposite end of the chamber through a passage through the center support.



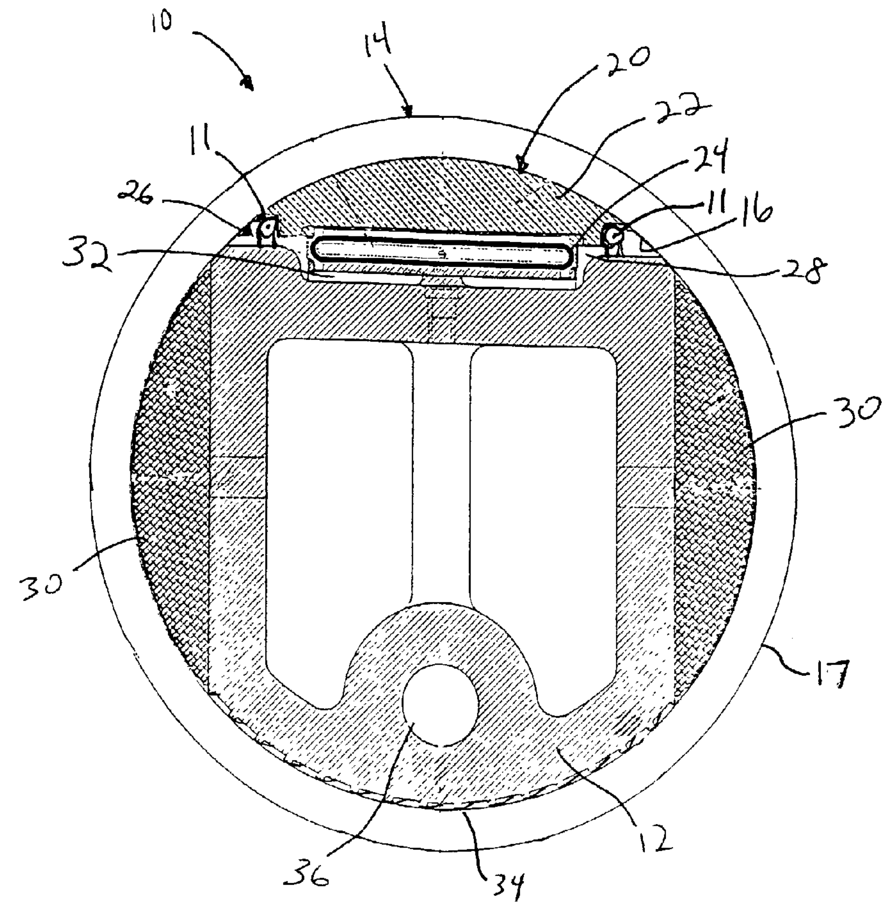

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FIG. 1

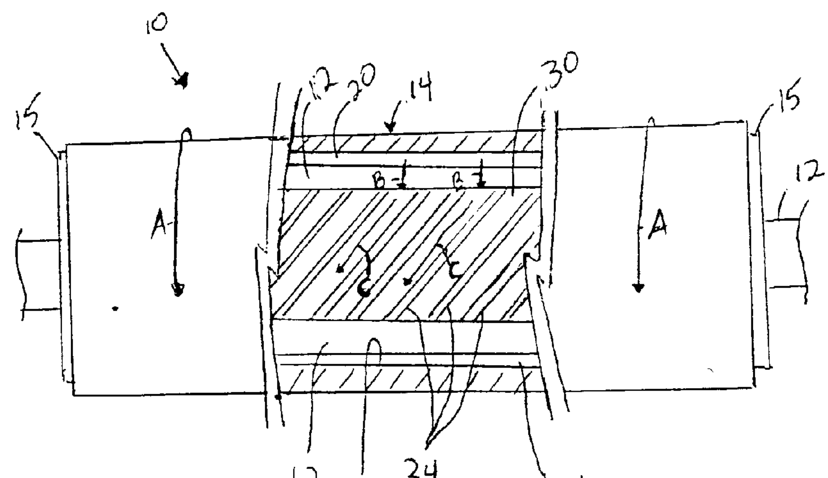
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FIG. 2

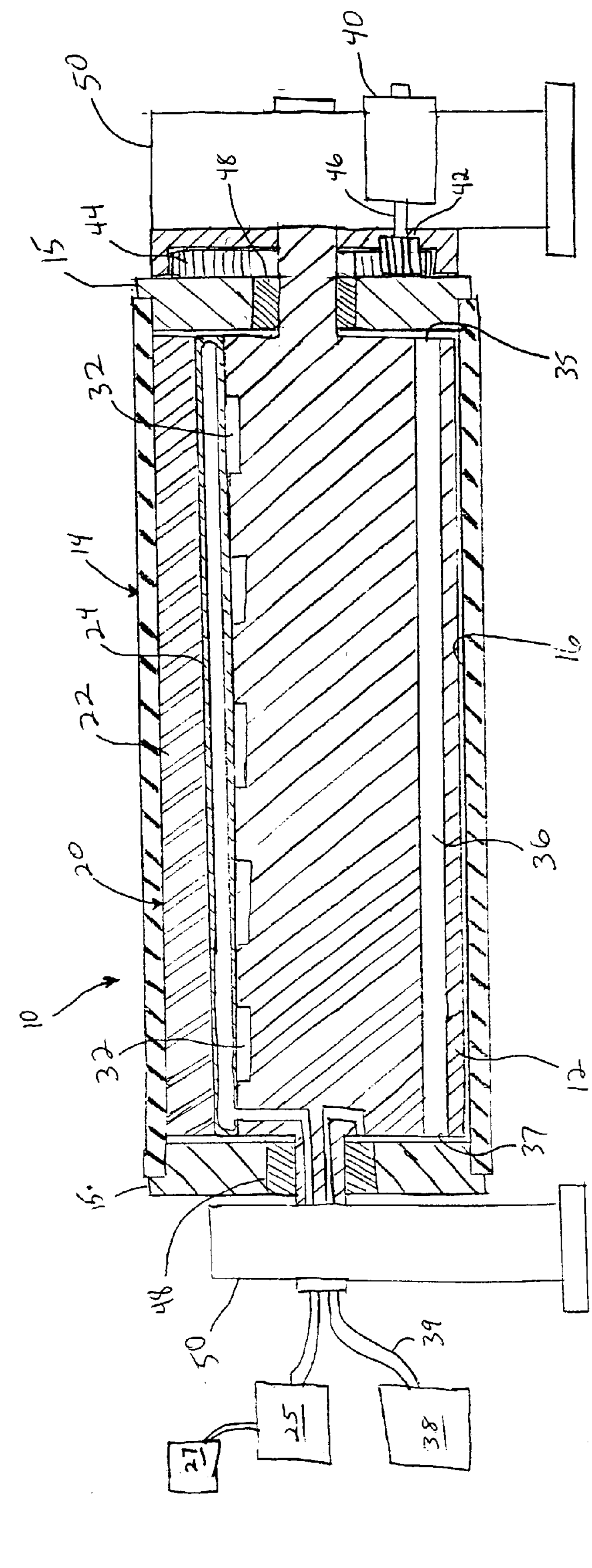
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FIG. 3

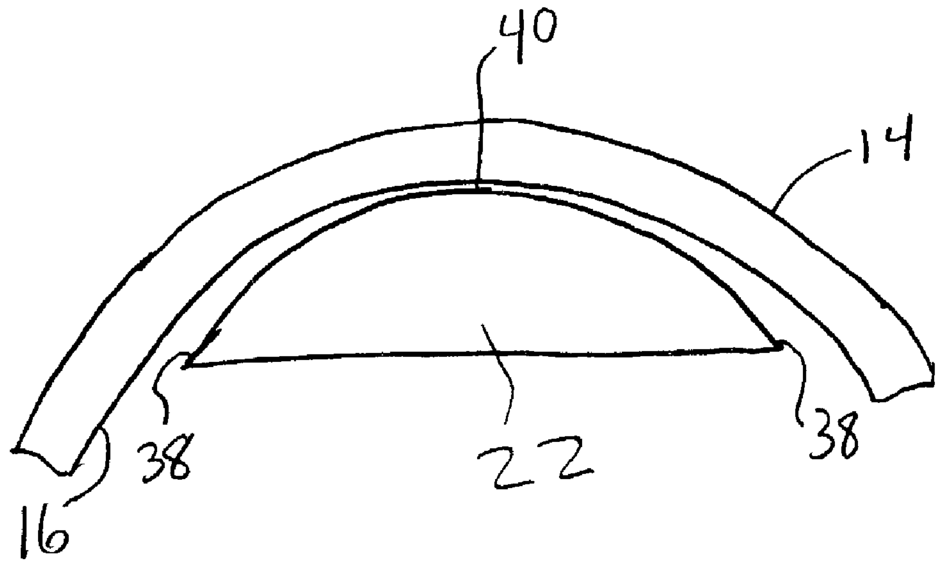

FIG. 4

HEATED CONTROLLED DEFLECTION ROLL

FIELD OF INVENTION

[0001] The present invention relates to a heated controlled deflection roll useful in pairs or in combination with other types of rolls for nip rolling fibrous materials such as nonwoven webs.

BACKGROUND OF THE INVENTION

[0002] Pairs of mated rolls forming a nip through which a traveling web passes are well known in the field of paper making, and more recently, in the textile and nonwovens industries to remove water from the web, calender, bind, or emboss the fibrous web. In such cases the nip pressures cause the rolls to deflect to an extent that some form of compensation for the roll deflection must be provided. Without compensation the resulting nip pressure will be extremely non-uniform across the width of the rolls.

[0003] One common way of compensating for roll deflection is to grind a "crown" on one of the mated rolls. Crowning is a common method of deflection compensation due to its relatively lower cost. A "crown" is defined as a slight and gradual increase in the diameter of the roll shell near the center of the roller as compared to either end. However, the shape of the roll crown is difficult to identify because the crown must precisely match the shape of the deflection curve if a uniform nip is to result. Even when the shape is identified by several iterations of grinding and observing the resulting nip pressure profile, the precision required in the grinding process is also difficult to consistently attain.

[0004] Another disadvantage of roll deflection compensation by crowning is that, once crowned, the roll is capable of providing a uniform nip pressure only at the particular value of nip pressure for which it was planned and calculated. A lower nip pressure will result in too much pressure at the center, and a higher nip pressure will result in a much higher pressure at the roll ends. Being limited to one pressure after grinding a roll to a particular amount of crown is a disadvantage for most of the processes using nip rolls.

[0005] Another method of compensating for roll deflection is roll bending. Roll bending is commonly used in the textile and plastics industries where highly uniform nip pressures are not required. A bending moment is placed on the roll ends by two sets of bearings and extended roll journals. However, the resulting shape of the rolls typically does not fit the deflection curves exactly.

[0006] Still another method used in the textile industry is to use rolls of sufficiently large diameter and then cover one or both rolls with an elastomeric material. The large roll diameters and flexible covers mitigate the inherent non-uniformity of the nip pressure. This method is generally limited to processes that allow the use of a flexible cover, where exact pressure uniformity is not required, and when a heated nip is not required.

[0007] Self-loading controlled deflection rolls use internal pistons or "shoes" to move the roll shell into the mated roll. The stationary pistons or shoes at the nip centerline press on the rotating roll shell and counterbalance the nip pressure, thereby forcing the control deflection roll shell into the mated roll shell as needed to compensate for deflection of the mated rolls. Controlled deflection rolls are generally more complex than previously discussed rolls and thus have a higher cost. A commonly used controlled deflection roll is commonly referred to as a "swim roll." This type of roll uses a pressure of about two or three bars in the upper half of an annulus formed by the rotating shell and the non-rotating center support. Axial seals at the 3:00 and 9:00 o'clock positions run the length of the roll shell/center support. Circumferential seals on each end are also employed. This design is generally commercially limited to a 505 millimeter (19.9 inch) maximum diameter, which limits its use for high speed bonding of melt spun fibers which typically require larger roll diameters to increase the bonding time within the nip. Another disadvantage of this design when used as a heated roll is the maintenance, safety, and housekeeping concerns associated with pumping hot oil at high pressures.

[0008] The pistons used in current controlled deflection rolls are typically loaded with hydraulic pressure supplied by pumps external to the roll. The oil is brought to cavities at the top of the pistons. The cavities are formed on one side by the rotating shell. The cavities are designed to balance the piston force, such that the pistons float on a hydrostatic cushion of oil. Some oil also flows out of the cavity lubricating the piston surface in contact with the rotating shell. Stationary crescent shaped "shoes" generally use internally generated hydrodynamic oil pressure to lubricate the shoe/shell interface and prevent metal to metal contact. Hydrodynamic oil pressure is created when one moving plate (the roll shell) and one stationary plate (the shoe) are at a slight angel to each other, creating a wedge as the oil is drawn into the diminishing clearance between the two plates by the moving plate. Pressures in excess of 1000 pounds per square inch can be generated by this method.

[0009] Current controlled deflection rolls are typically limited to smaller diameters as well as low operating temperatures. Additionally, controlled deflection rolls are typically expensive due to the complexity of the loading mechanisms. The cost of typical current controlled deflection rolls prohibits the use of the rolls in pairs, which is generally most desirable. Using controlled deflection rolls in pairs is ideal for nip uniformity since both roll shells can remain straight, with zero bending stress (and strain), and zero shear stress (and strain) and therefore neither roll has to conform to the other.

[0010] Current commercial heated controlled deflection rolls include external oil heaters and pumps, as well as the piping that is used to connect these external parts. The high pressure, high temperature pumps and filters are difficult to maintain and typically have some oil leakage. Roll changes are difficult because disconnecting the roll from the external piping causes some loss of oil. The loss of oil from pump seals, roll changes, and other maintenance operations are a housekeeping and safety concern.

[0011] There is a need for a less complex, less expensive, large diameter, heated, controlled deflection roll. There is particularly a need for low cost controlled deflection rolls that allow for cost efficient use in pairs. There is a need for a self-contained controlled deflection roll that does not require many or any external pumps or heaters, and therefore can more easily be added or removed from a machine frame.

SUMMARY OF THE INVENTION

[0012] A general object of the invention is to provide improved heated controlled deflection rolls. A more specific objective of the invention is to overcome one or more of the problems described above.

[0013] A general object of the invention can be attained, at least in part, through a fluid-filled controlled deflection roll including internal heating elements. The heated controlled deflection rolls of this invention utilize a hydrodynamic shoe assembly that extends substantially the full length of an inside surface of the roll shell.

[0014] In one embodiment of this invention, a controlled deflection roll includes a center support and a rotatable roll shell including an inside surface surrounding the center support. A shoe assembly is between the center support and the inside surface of the rotatable roll shell. The shoe assembly includes a shoe in contact with the inside surface of the rotatable roll shell and a bladder positioned between the shoe and the center support. The shoe assembly has a length substantially equal to a length of the inside surface of the rotatable roll shell, and includes a single shoe and a single bladder that both extend a length substantially equal to a length of the inside surface of the rotatable roll shell.

[0015] In another embodiment of this invention, the controlled deflection roll includes a center support, a shoe assembly in combination with the center support, and a rotatable roll shell, surrounding the center support and having an inside surface contacting the shoe assembly. An end element surrounds the center support on each end of the rotatable roll shell, and the rotatable roll shell and the end elements enclose a chamber. A heat transfer fluid is contained within the chamber. The heat transfer fluid is driven by the inside surface of the rotatable roll shell and flows within the chamber around the center support in a direction of rotation of the rotatable shell.

[0016] In yet another embodiment of this invention, a controlled deflection roll includes a center support, a rotatable roll shell including an inside surface surrounding the center support, and an end element surrounding the center support on each end of the roll shell. The rotatable roll shell and the end elements enclose a chamber. The center support extends through the chamber and out past each of the end elements. The chamber encloses at least one heater element and a heat transfer fluid. At least one of the center support and the at least one heater element includes at least one angled fin thereon for mixing and directing the flow of the heat transfer fluid within the chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other objects and features of this invention will be better understood from the following detailed description taken in conjunction with the drawings, wherein:

[0018] **FIG. 1** shows a cross section view of a controlled deflection roll according to an embodiment of this invention.

[0019] **FIG. 2** shows a partial sectional view of a controlled deflection roll according to an embodiment of this invention.

[0020] **FIG. 3** shows a partial sectional view of a controlled deflection roll and frame according to an embodiment of this invention.

[0021] **FIG. 4** shows a partial sectional view of a shoe and a rotatable roll shell of a controlled deflection roll according to an embodiment of this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0022] **FIG. 1** shows a cross-sectional view of a controlled deflection roll **10** of one embodiment of this invention. The controlled deflection roll **10** of this invention can be used in combination with a second roll to create a nip between the pair of rolls through which a fibrous web material, such as a nonwoven fabric, is run. The controlled deflection rolls of this invention can be used in combination with various types of rolls known in the art, such as plain cylindrical heated rolls or other types of controlled deflection rolls, and is desirably used in combination with a second, similar controlled deflection roll of this invention.

[0023] The controlled deflection roll **10** includes a center support **12** extending through the controlled deflection roll **10**. A rotatable roll shell **14** is positioned around the center support **12**, such that an inside surface **16** of the rotatable roll shell **14** surrounds the center support **12**. The inside surface **16** extends between two end elements **15**, one on each side of rotatable roll shell **14**. The center support **12** desirably extends beyond the opposite end elements **15** of the rotatable roll shell **14** for connecting the controlled deflection roll **10** to a machine frame, such as supports **50** as shown in **FIG. 3**. The center support **12** is stationary and fixed to the machine frame, and will support the controlled deflection roll **10** within the desired ranges of deflection. The center support **12** is desirably made of materials such as steel or cast iron.

[0024] The rotatable roll shell **14** can vary in diameter, and is suitably about 400 to 2000 millimeters, and desirably about 600 to 1000 millimeters. The rotatable roll shell **14** can be made of materials such as alloy steel or cast iron. The nip created by the rotatable roll shell and a second roll shell can be used for calendering, bonding, or embossing a fibrous material traveling through the nip. An external surface **17** of the rotatable roll shell **14** can be smooth, rough, or include a pattern for embossing fibrous webs.

[0025] **FIG. 1** shows a shoe assembly **20** including a shoe **22** in contact with the inside surface **16** of the rotatable roll shell **14** and a bladder **24** positioned between the shoe **22** and the center support **12**. The shoe assembly **20**, including both the shoe and the bladder, has a length substantially equal to a length of the nip load, which desirably runs about 8 to 20 inches less than the length of the inside surface **16** of the rotatable roll shell **14**. In one embodiment of this invention, the shoe assembly **20** has a length substantially equal to a length of the inside surface **16** of the rotatable roll shell **14**, and includes a single shoe **22** and a single bladder **24** that both extend a length substantially equal to a length of the inside surface **16** of the rotatable roll shell **14**. The shoe can be made from materials such as brass, bronze, cast iron, or steel, and is desirably made from brass or bronze in order to provide a wearing surface against the rotatable shell. As shown in **FIGS. 2 and 3**, the rotatable roll shell **14** of this invention has an end element **15** on each of opposite ends of the rotatable roll shell **14** enclosing a chamber **26** around a length of the center support **12**. The length of the shoe assembly **20** desirably runs approximately the length of the nip load between the two end elements **15**. The end elements **15** can include various designs and parts; however each of the end elements **15** typically includes at least one movable part, such as a roller bearing, that allows the rotatable roll shell **14** to rotate around the center support **12**, and seals which seal the enclosed chamber **26** for containing a heat transfer fluid. As the end elements **15** include moving parts allowing the rotatable roll shell **14** to rotate, it is desirable that the ends of the non-rotating shoe assembly **20** do not contact the end elements **15**. Therefore, the shoe assembly **20** and the end elements **15** are desirably separated by a minimal space.

[**0026**] The shoe assembly **20** is connected to the center support **12** via the bladder **24** and is guided and restrained by roller elements **11** on either side of the shoe **22** and fastened to the center support **12**. The shoe **22** contacts the inner surface of the rotatable roll shell **14** and is ground to a diameter slightly less than that of the inside surface **16**. The shoe assembly **20** exerts a load on the rotatable roll shell **14** in a direction towards a nip between the controlled deflection roll **10** and a mated second roll. The bladder **24** is made of an expandable elastomeric material such as VITON®, a fluroelastomer available from DuPont Dow Elastomers, LLC, or silicone, which allows the bladder **24** to expand when a pressure within the bladder is increased, and which allows the bladder **24**, and therefore controlled deflection roll **10**, to be used in high temperature applications. The bladder **24** exerts an increased load on the shoe **22** when the pressure within the bladder is increased. Oppositely, the load on the shoe **22** can be decreased by decreasing the pressure within the bladder **24**. The controlled deflection roll **10** of this invention can be used to provide nip loading up to about 3500 pounds per linear inch and desirably between about 200 to 1500 pounds per linear inch. The bladder **24** contains one of a gas or fluid such as oil. Desirably the bladder is pressurized with the same heat transfer fluid used to fill the chamber **26** between the rotatable shell **14** and the center support **12**. The pressure within the bladder **24** is controlled by a compressed air regulator **27** which feeds air directly to the bladder, or desirably, as shown in **FIG. 3**, to an "air over oil" device **25**, such as known in the art, external to the roll which contains the same heat transfer fluid used inside the chamber **26**, such that the air pressure above the heat transfer fluid maintains its pressure and allows the fluid to flow in or out of the bladder **24** as needed to maintain the desired pressure.

[**0027**] The bladder **24** exerts a load on shoe **22** which in turn exerts a load on the rotatable roll shell **14**. As shown in **FIG. 4**, the shoe **22** desirably includes a circular portion oriented towards the inside surface **16** of the rotatable roll shell **14**. The radius of a curvature of the shoe **22** must be manufactured to a radius slightly less than the diameter of the inside surface **16** of the rotatable roll shell **14**. In order to create a desired high hydrodynamic oil pressure, and thus a safe operating condition for the lubrication of the shoe, the difference in radii will result in a desirable average gap at the sides **38** of the shoe **22** which is 2.2 times the gap at the center **40** of the shoe **22**. However, the gap at the center **40** of the shoe **22** is a function of: 1) the load of the shoe; 2) the viscosity of the heat transfer fluid; and 3) the surface speed of the inside surface **16** of the rotatable roll shell **14**. Therefore, obtaining the desired gap ratio of 2.2 can be maintained only for one set of conditions.

[**0028**] As discussed above, the controlled deflection roll **10** includes an end element **15** at each end of the rotatable roll shell **14**. As shown in **FIGS. 2 and 3**, the end elements **15** surround the center support at each end of the rotatable roll shell **14** and include movable parts, such as roller bearings **48**. The roller bearings **48** allow the rotatable roll shell **14** to rotate around the center support **12**. The rotatable roll shell **14** and the end elements **15** enclose a chamber **26** surrounding a portion of the center support **12** between the end elements **15**. The chamber **26** includes an annulus that contains, and is desirably filled with, a heat transfer fluid **28**. "Annulus" refers to an interstitial free space within the chamber **26** around the components of the controlled deflection roll **10** within the chamber **26**. The size and dimensions of the annulus depends on the size and shape of the components of the controlled deflection roll **10** within the chamber **26**, such as the shoe assembly **20** and the center support **12**. The heat transfer fluid **28** freely flows within the annulus of the chamber **26**. Upon rotation of the rotatable roll shell **14**, the heat transfer fluid **28** will flow around the center support **12**, as well as around the other components in the chamber **26**, in a direction of rotation of the rotatable roll shell **14**. The heat transfer fluid **28** provides lubrication between the shoe **22** and the inside surface **16** and can be used to transfer heat to the rotatable roll shell **14** from one or more heater elements **30** within the chamber **26**. The heat transfer fluid **28** of this invention includes, without limitation, oils, synthetic oils or heat transfer fluids. Desirably, the bladder **24** contains the same material as the heat transfer fluid **28** so that if a small leak occurs in the bladder **24**, the leak will not displace the heat transfer fluid **28** with a different material such as air.

[**0029**] In one embodiment of this invention, the controlled deflection roll **10** includes a shoe assembly bypass **32** in combination with the shoe assembly **20**. The heat transfer fluid **28** flows in a direction of rotation of the rotatable roll shell **14** and lubricates the surface of shoe **22** exerting force on the inside surface **16** of the rotatable roll shell **14**. The amount of heat transfer fluid **28** that passes between the shoe **22** and the inside surface **16** is minimal compared to the total amount of heat transfer fluid **28** which is desirably flowing circumferentially, and thus the shoe assembly bypass **32** allows the flow of heat transfer fluid **28** to continue through the chamber **26** and around the center support **12**. Thus the shoe assembly bypass **32** prevents an obstruction of the flow of the heat transfer fluid **28** caused by the shoe **22** and the shoe assembly **20**. The shoe assembly bypass **32** is shown in **FIGS. 1 and 3** between the bladder **24** and the center support **12**. The shoe assembly bypass **32** allows the heat transfer fluid **28** to flow between the bladder **24** and the center support **12**. The shoe assembly bypass **32** can include channels between the connections connecting the bladder **24** and the center support **12** or be channels formed in the center support **12**. One skilled in the art will appreciate the various configurations possible for the shoe assembly bypass **32**, such as channels between the bladder **24** and the shoe **22**, preformed passageways through the bladder itself, and combinations of these embodiments.

[**0030**] The controlled deflection roll **10** includes at least one heater element **30** within the chamber and in contact with the heat transfer fluid **28**. **FIG. 1** shows two heater elements **30** located between the center support **12** and the rotatable roll shell **14**. As will be appreciated by one skilled in the art, the heater elements **30** can include various configurations. In one embodiment of this invention, the heater elements **30** desirably run the length of the center support **12** within chamber **26**. The heater elements **30** are suitably electric heater elements and made from a conductive material such as aluminum. The heater elements **30** are shown in **FIG. 1** as crescent shaped to fit between the center support **12** and rotatable roll shell **14**. The size and shape of the heater elements can vary depending on the size and shape of the center support **12** and/or the rotatable roll shell **14**.

[**0031**] The heat transfer fluid **28** passes over the heater elements **30** as it circumferentially flows through the chamber **26** around the center support **12**. The heat produced by the heater elements **30** heats the heat transfer fluid **28** and the heat transfer fluid **28** in turn heats the rotatable roll shell **14**. Suitably the heater elements **30** and the heat transfer fluid **28** heat an outer surface of the rotatable roll shell **14** to obtain a temperature of at least about 100° C., more desirably about 100° C. to 260° C. The controlled deflection roll **10** of this invention can include an external heat transfer fluid expansion tank **38** connected to the chamber **26** by a heat transfer fluid expansion line **39**. The expansion tank holds additional heat transfer fluid **28**. If the heat transfer fluid **28** expands upon heating, an amount of the heat transfer fluid **28** enters the expansion tank **38** through the expansion line **39** thereby maintaining a desired low pressure of the heat transfer fluid **28** within the chamber **26**. The expansion tank can be located above the controlled deflection roll or include an air cushion (not shown) to balance the pressure of the heat transfer fluid **28** in the expansion tank with the pressure in the chamber **26**. As shown in **FIG. 3**, the expansion line **39** can enter the center support **12** at one end and connect to chamber **26**. In one embodiment the heat expansion tank **38** is located within chamber **26**. In one embodiment of this invention,, the heat expansion tank **38** and the pump **25** for the bladder **24** are both within the chamber **26**, providing a self-contained controlled deflection roll **10**. The self-contained controlled deflection roll **10** allows for easy removal and roll changes.

[**0032**] As shown in **FIG. 3**, the rotatable roll shell **14** rotates around the center support **12** via a motor **40** and gears **42** and **44**. The motor **40** turns a shaft **46** including a first gear **42** that corresponds to a second gear **44** connected to one end element **15** of the controlled deflection roll **10**. **FIG. 3** shows the gears **42** and **44** as spur gears however other gear configurations can be used, such as two helical gears. The motor **40** rotates the rotatable roll shell **14** around roller bearings **48** that extend around the center support **12** at both end elements **15** of the rotatable roll shell **14**. The center support **12** does not rotate and is fixed to a support **50** at each end of center support **12**. The end elements **15** are desirably sealed to avoid leaking the heat transfer fluid **28**.

[**0033**] As the rotatable roll shell **14** rotates around the center support **12**, the rotatable roll shell **14** produces drag forces that cause the heat transfer fluid **28** to flow in the same circumferential direction. The resulting flow of the heat transfer fluid **28** has characteristics described by Couette flow dynamics. "Couette flow" refers to the movement of a fluid between two surfaces, wherein at least one surface is moving. The heat transfer fluid **28** in contact with the rotatable roll shell **14** moves in a direction of rotation of the rotatable roll shell **14**. The heat transfer fluid **28** in contact with the center support **12**, or other stationary surfaces within the chamber **26**, does not move with the same velocity, if at all, as the heat transfer fluid **28** toward the rotatable roll shell **14** due to the viscosity of the heat transfer fluid **28**. The result is a gradient of circumferential flow velocity of the heat transfer fluid **28** between the rotatable roll shell **14** and the center support **12**.

[**0034**] The dimensions of the annulus of chamber **26**, as well as the geometry of any mixing fins, can affect the amount of turbulence in the flow of the heat transfer fluid **28**. In addition, the dimensions of the annulus of chamber **26** can affect the motor power required to rotate the rotatable roll shell **14**, as the degree of turbulence of the heat transfer fluid will affect the required motor power. A smaller dimensioned annulus can cause a laminar flow of the heat transfer fluid **28**. Oppositely, a larger dimensioned annulus allows for a more turbulent flow. Laminar flow of the heat transfer fluid reduces the power necessary to rotate the rotatable roll shell **14** as compared to turbulent flow. Turbulent flow, however, has the advantage of more efficient heat transfer from the heating elements **30** to the heat transfer fluid **28**, as well as from the heat transfer fluid **28** to the rotatable roll shell **14**. Also, the motor power needed to shear the heat transfer fluid **28** typically results in an amount of heat energy in the heat transfer fluid **28**. Thus, the controlled deflection roll **10** can include various annulus configurations including smaller annulus dimension in areas of chamber **26** for reducing the required motor power and larger annulus dimensions in other areas of chamber **26** to promote efficient heat transfer. In one embodiment of this invention, a larger dimensioned annulus of chamber **26** is used in combination with a heater element **30** to promote efficient heat transfer through turbulent flow of the heat transfer fluid **28**. The dimensions of the annulus of chamber **26** can be controlled by varying the size of the components of the controlled deflection roll **10** within chamber **26**, such as the size and shape of the center support **12** and heater elements **30**.

[**0035**] Discontinuous surfaces, such as fins extending from a surface within the chamber **26** can also be used to create or enhance flow turbulence in the annulus. In one embodiment of this invention, the controlled deflection roll **10** includes at least one heater element **30** having fins which increase turbulent flow over the at least one heater element **30**. The fins of one embodiment of this invention have a height of about 0.63 centimeters, and are suitably about 0.3 to 1.5 centimeters.

[**0036**] **FIG. 2** shows the heater elements **30** including a plurality of angled fins **34**. The controlled deflection roll **10** in **FIG. 2** rotates in a direction shown by the arrows A. The rotation of the rotatable roll shell **14** causes the heat transfer fluid to flow in a similar rotational direction shown by arrows B. The angled fins **34** change in the direction of the flow as shown by the arrows C. The angled fins **34** cause turbulence in the flow of the heat transfer fluid **28** and direct the flow in a helical pattern in a direction towards one end of the chamber **26**. The helical flow resulting from angled fins **34** provides efficient heating over a length of the rotatable roll shell **14**. In on embodiment of this invention the angle of the angled fins **34** are about 0 to 80 degrees from a line parallel to the center support **12**, more suitably about 30 to 70 degrees, and desirably about 40 to 60 degrees. The center support **12** can also include fins for promoting turbulent flow. As shown in **FIG. 1**, the fins on the center support **12** are angled fins **34** having a same or different angle than the angled fins **34** on the heater elements **30**. The fins on the center support **12** can also be straight fins parallel or perpendicular to the rotational direction of the rotatable roll shell **14**.

[**0037**] The angled fins **34** direct the flow of the heat transfer fluid **28** in a helical pattern around the center support **12** from one end of the chamber **26** to an opposite end of the chamber **26**. The controlled deflection roll **10** shown in **FIG. 1** includes a heat transfer fluid passage **36**. As shown in **FIG. 3**, the heat transfer fluid passage **36** extends through a length of the center support **12** from at least one first opening **35** between the center support **12** and the end element **15** proximate to one end of the chamber **26** to at least one similar second opening **37** at the opposite end of the chamber **26**. The heat transfer fluid **28** can be directed axially to one end of the chamber **26** by the angled fins **34**. Reaching the end of the chamber **26** the heat transfer fluid enters the first opening **35** of the heat transfer fluid passage **36** and flows through the passage **36** towards the opposite end of the chamber **26** and reenters the chamber **26** at the second opening **37** of the heat transfer fluid passage **36**. The heat transfer fluid passage **36** allows for a continuous helical flow of heat transfer fluid **28** through chamber **26**.

[**0038**] While in the foregoing specification this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purpose of illustration, it will be apparent to those skilled in the art that the invention is susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the invention.

What is claimed is:

1. A controlled deflection roll, comprising:

a center support;

a rotatable roll shell including an inside surface surrounding the center support; and

a shoe assembly including a shoe in contact with the inside surface of the rotatable roll shell and a bladder positioned between the shoe and the center support, the shoe assembly having a length substantially equal to a length of the inside surface of the rotatable roll shell.

2. The controlled deflection roll of claim 1, wherein the bladder contains one of a gas and a fluid.

3. The controlled deflection roll of claim 2, wherein the bladder exerts a load on the shoe when a pressure within the bladder is increased.

4. The controlled deflection roll of claim 1, further comprising an end element surrounding the center support on each end of the roll shell, the rotatable roll shell and the end elements enclosing a chamber containing a heat transfer fluid.

5. The controlled deflection roll of claim 4, wherein the heat transfer fluid flows within the chamber around the center support in a direction of rotation of the rotatable shell.

6. The controlled deflection roll of claim 5, further comprising a shoe assembly bypass in combination with the shoe assembly.

7. The controlled deflection roll of claim 6, wherein the shoe assembly bypass allows the heat transfer fluid to flow between the bladder and the center support.

8. The controlled deflection roll of claim 4, further comprising at least one heater element within the chamber and in contact with the heat transfer fluid.

9. A controlled deflection roll, comprising:

a center support;

a shoe assembly in combination with the center support;

a rotatable roll shell including an inside surface contacting the shoe assembly, the rotatable roll shell surrounding the center support;

an end element surrounding the center support on each end of the roll shell, the rotatable roll shell and the end elements enclosing a chamber; and

a heat transfer fluid within the chamber, wherein the heat transfer fluid flows within the chamber around the center support in a direction of rotation of the rotatable shell.

10. The controlled deflection roll of claim 9, further comprising a heat transfer fluid expansion line connecting the chamber to a heat transfer fluid expansion tank external of the chamber.

11. The controlled deflection roll of claim 9, further comprising at least one heater element within the chamber and in contact with the heat transfer fluid.

12. The controlled deflection roll of claim 11, further comprising fins on at least one of the heater element and the center support.

13. The controlled deflection roll of claim 12, wherein the fins are configured to direct the flow of the heat transfer fluid in a helical pattern around the center support from one end of the chamber to an opposite end of the chamber.

14. The controlled deflection roll of claim 13, further comprising a heat transfer fluid passage extending through a length of the center support.

15. The controlled deflection roll of claim 9, wherein the shoe assembly has a length substantially equal to a length of the rotatable roll shell.

16. The controlled deflection roll of claim 15, further comprising a shoe assembly bypass in combination with the shoe assembly.

17. A controlled deflection roll, comprising:

a center support;

a rotatable roll shell including an inside surface surrounding the center support;

an end element surrounding the center support on each end of the roll shell, the rotatable roll shell and the end elements enclosing a chamber;

at least one heater element within the chamber;

a heat transfer fluid within the chamber; and

at least one angled fin on at least one of the center support and the at least one heater element for directing a flow of the heat transfer fluid within the chamber.

18. The controlled deflection roll of claim 17, further comprising a heat transfer fluid passage extending through a length of the center support.

19. The controlled deflection roll of claim 17, further comprising a shoe assembly between the center support and the roll shell.

20. The controlled deflection roll of claim 19, further comprising a shoe assembly bypass in combination with the shoe assembly.

21. The controlled deflection roll of claim 17, wherein the at least on angle fin is configured to cause turbulence in the heat transfer fluid flow as the heat transfer fluid flows over the surface of the heater element.

22. The controlled deflection roll of claim 17, wherein the heat transfer fluid fills an annulus of the chamber.

23. The controlled deflection roll of claim 17, wherein the heat transfer fluid is an oil.

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