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L. HORNBOSTEL

3,161,125

ADJUSTABLE CROWN ROLL

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Fig-1

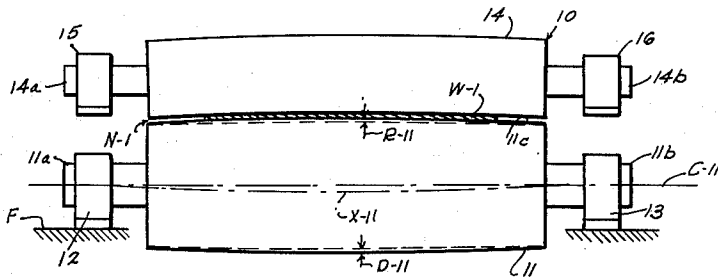


Fig-2

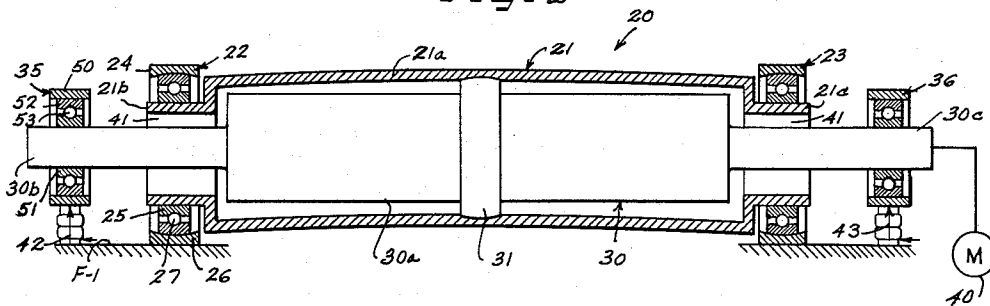
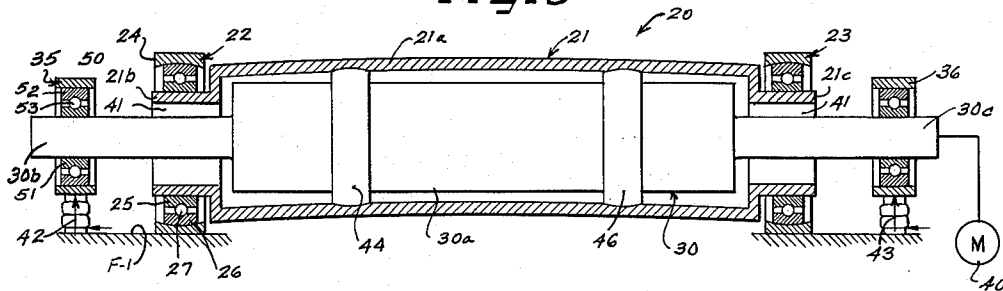


Fig-3



INVENTOR.

Lloyd Hornbostel

BY

Hill, Sherman, Mann, Cross & Simpson

ATTORNEYS

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ADJUSTABLE CROWN ROLL

Lloyd Hornbostel, Beloit, Wis., assignor to Beloit Iron Works, Beloit, Wis., a corporation of Wisconsin
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The present invention relates broadly to roll structures, and is more particularly concerned with a new and improved roll constructed to counteract the tendency of the roll axis to deflect in response to a load applied to the roll.

The instant invention is of utility in various arts, however, it is particularly useful in the paper making art and will accordingly be described particularly in connection therewith. In paper machines there are numerous types of rolls of substantial size which are subjected to loads tending to deflect the rolls centrally. Illustratively, wire return rolls in a Fourdrinier paper machine are subject to a load tending to effect central deflection thereof by reason of the weight of the rolls themselves, the weight of the Fourdrinier wire carried by the rolls, the tension on the Fourdrinier wire, and in the case of a driven roll, the force component resulting from the reaction or resistance of the wire itself to the driving force. Such forces tend to deflect the roll downwardly in the middle, and this results in an undesirable guidance of the traveling wire, which condition has been found advantageous to avoid by counteracting the tendency for downward deflection of the return roll by one means or another.

In addition, in press couples, calender stacks and the like the web passes through a nip between a pair of superimposed rolls whereat the nip is subjected to pressures. The pressures applied at the nip tend to load the lower roll and deflect the same centrally downwardly. This deflection results in an undesirable application of forces across the nip, and other undesirable operating features. It has accordingly been the practice to correct such deflection in paper machines by "crowning" the lower roll. However, the crowning of a roll requires accurate and expensive finishing of the roll surface so as to obtain a slightly greater roll diameter in the central portion of the roll. As well, such crowning is carried out on the basis of a predetermined set of force conditions, and may not be satisfactory for operation under a different set of force conditions. Accordingly, crowning of rolls often does not afford satisfactory operation for many different types of conditions.

In other arts related to paper machines, exemplified by the coating of paper or fabrics with plastic materials, pressure or calender rolls are also used. In addition, paint mixing roll systems or the like are subjected to a build up of forces in the central portion of the pressure nips, which tend to cause central deflection of the rolls and result in non-uniform and/or other undesirable conditions across the width of such press nips.

The instant invention affords a simple and unique roll structure for a roll subject to a load tending to cause deflection of its axis. In the present roll structure the crowning of the roll may be varied without rebuilding the roll or refinishing the surface thereof. Instead, the crowning of the roll is effected by mounting a roll shell in fixed bearings at the opposite ends thereof, by supporting the shell inwardly of the opposite ends thereof upon shaft means, and by applying an upwardly directed force to bearing means receiving opposite ends of the shaft means. Since opposite ends of the shell are restrained against vertical movement by the fixed bearing means and since between opposite ends of the shell said shell is supported by the shaft means, forces applied to opposite ends of the shaft means are transmitted through the support arrangement for the shaft to deflect the same generally

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centrally thereof. Of course, the shell and shaft are coaxially spaced so that when a lifting force is applied to opposite ends of the shaft means, the shell and shaft do not initially contact and the shell deflects generally centrally of its restrained opposite ends.

It is accordingly an important aim of the present invention to provide an improved roll structure.

Another object of the instant invention is to provide an improved structure for a roll whose axis is subject to deflection in response to a load applied to the roll, by supporting a roll shell in coaxially spaced relation upon shaft means mounted in movable bearing means adjacent the opposite ends thereof and by journaling opposite ends of the shell in fixed bearing means, a lifting force then being applied to the bearing means for the shaft means to deflect the shell generally centrally thereof.

A further object of this invention is to provide a novel combination comprising a roll shell having normally a central deflection, fixed bearings rotatably mounting the roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, support means contacting the shaft means and the roll shell inwardly of the opposite ends thereof and normally maintaining the shaft means and shell in coaxially spaced relation, and means for applying forces to the shaft portions and through the support means thereby relieving the normal deflection.

Other objects and advantages of the invention will become apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals designate like parts throughout the same:

FIGURE 1 is a diagrammatic illustration showing two lower rolls of a stack of rolls, illustrating in somewhat exaggerated form the manner in which such rolls may be deflected during the specific correlation among the essential control factors in a calender stack of the prior art;

FIGURE 2 is an elevational view of one form of roll assembly constructed in accordance with this invention, parts thereof being shown in section and other parts diagrammatically; and

FIGURE 3 is a view along the lines of FIGURE 2, but showing another arrangement of support means between the shaft and roll shell.

Referring first to FIGURE 1, there is shown a bottom portion of a calender stack, indicated generally by the reference numeral 10, and comprising a king roll 11 at the bottom mounted on suitable bearings 12 and 13 which are in turn firmly secured to a fixed mounting such as a floor F. Immediately above the king roll 11 is a calender roll 14 which in turn is mounted for rotation in bearings 15 and 16. Actually, the roll 11 is provided with a left hand stub shaft or shaft element 11a rotatably received by the left hand bearing 12, and a right hand stub shaft 11b which is rotatably received by the right hand bearing 13. The roll 14 is also provided with a left hand stub shaft 14a which is rotatably received by the left hand bearing 15, and a right hand stub shaft 14b rotatably received by the right hand bearing 16.

As will be noted, the centroidal axis X-11 for the roll 11 is deflected downwardly below a horizontal or center line C-11 at the middle of the roll 11 (which straight line C-11 is the unloaded roll's normal centroidal axis) and this is caused by the load applied to the roll 11 by the weight of the roll 14 (and any other rolls thereabove). This weight is transmitted through the sheet of paper (shown in exaggerated thickness at W-1) passing through the nip between the rolls 11 and 14. In the calender 10, however, the central portion of the top surface of the roll 11 is still crowned so as to extend a distance R-11

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above the outer extremities of the roll 11, and the bottom surface of the roll 11 is downwardly bowed still a greater distance D-11. The amount of operating crown R-11 depends upon the amount of original crown formed on the roll 11 and the total weight of the calender stack of rolls 14, etc. mounted thereabove. As will be appreciated, if it is desired to operate a calender with substantially no operating crown (R-11) in the king roll 11, the initial crown of the king roll 11 and the total weight of the calender rolls 14, etc. are correlated so as to obtain substantially no operating crown. If, however, it then becomes desirable to make a change in the operation of the prior art calender by using less calender rolls in the stack, then a greater operating crown R-11 will be obtained. This may possibly result in an undesirable pressure distribution at the portion of the web W-1 passing through the nip N-1. The same is true with respect to variations in load which may be applied to any other crowned roll in a paper machine or other device.

In many of such prior art devices, the crown initially formed on the roll being subjected to the load is just sufficient to permit the roll to deflect in response to this predetermined load to such an extent that the roll presents a substantially flat (usually horizontal) nip defining surface. It will be appreciated that any variation from such predetermined load will, however, necessarily result in a deviation from the desired flat or level contour of the operating surface or nip defining line of the roll (herein designated 11c).

Referring now to FIGURE 2, there is shown and generally designated therein by the numeral 20 a roll assembly effective to overcome the problems herein discussed. The roll assembly 20 comprises a roll shell or roll member 21 having a relatively large diameter main body portion 21a and reduced diameter end portions 21b and 21c journaled in bearing means 22 and 23, fixed as shown to a floor or the like F-1 and constructed essentially identically. The description of one bearing means will accordingly suffice for the other, and it may be seen that the bearing means 22 comprises a housing 24 mounting therewithin inner and outer races 25 and 26 receiving therebetween ball means 27.

Forming a part of the roll assembly 20 and providing the means for bowing the roll shell 21 or for relieving any central deflection therein caused by its own weight or other factors is shaft means 30 having a main body portion 30a and reduced diameter end portions 30b and 30c extending outwardly from opposite ends of the shell end portions 21b and 21c. Of course, the shaft means 30 could be of uniform diameter throughout, but in any event the roll shell 21 is maintained in coaxially spaced relation with respect to the shaft means 30 by support means 31 which may take the form of an annular collar, as shown, secured to the shaft body portion 30a. It may be found that for certain applications the support means 31 may be provided by self-aligning bearing means affixed in any desired manner to the shaft, but regardless of the particular construction of the support means 31, such means as appears in FIGURE 2 is located centrally of opposite ends of both the roll shell 21 and shaft means 30. The support means 31 not only normally maintains the shell and shaft in the coaxially spaced relation illustrated, but functions additionally as force transmitting means to relieve deflection in the manner to be hereinafter described.

The end portions 30b and 30c of the shaft means 30 are journaled in separate and independent non-fixed or movable bearing means 35 and 36, which as illustrated are of the conventional type, whereas the bearing means 22 and 23 for the roll shell 21 are desirably self-aligning, as illustrated. The bearing means 35 and 36 each comprises a housing 50 mounting therewithin inner and outer races 51 and 52 receiving therebetween ball means 53. Naturally, the latter two bearing means need not be constructed in the precise manner shown, however, such

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bearing means are positioned along the shaft end portions 30b and 30c essentially in the locations indicated.

The shaft means 30, depending upon the particular application in which it is employed, may be positively driven by motive means diagrammatically shown and indicated by the numeral 40, and in such arrangement the roll shell 21 is thus driven through a rigid connection with the driven shaft means 30 (via the force transmitting means 31 which is drivingly connected to the shell 21 due to friction pressure engagement therewith or by being welded thereto—the shell may be shrink fit over the member 31 so that the member 31 presses into the inner surface of the shell 21, with the outer surface of the shell 21 being ground to a cylindrical shape). On the other hand, if employed in a press couple or in another environment wherein the roll shell 21 is in nip-defining relationship with another roll, the driving force may be supplied by said other roll. Likewise, the roll shell 21 and connecting shaft means 30 may be driven by a traveling band moving thereover.

It has been noted hereinabove that the shaft means 30 may be of uniform diameter throughout the length thereof and need not be provided with a relatively greater diameter body portion 30a. However, it is critical that the inner diameter of the shell end portions 21b and 21c and the outer diameter of the shaft end portions 30b and 30c surrounded by the shell end portions be so sized as to provide an adequate annular gap or space 41 therebetween. The reason therefor is believed now apparent and will be quite clear as the description continues.

In order to bow the shell member 21 or to relieve any central deflection therein caused by its own weight or other factors there is applied to the shaft end portions 30b and 30c generally upwardly directed forces in the nature of lift. Such forces may take numerous forms, and for this reason the force applying means are indicated diagrammatically by arrows, to which the numerals 42 and 43 have been applied. Desirably, the lifting forces are applied to the non-fixed bearing means 35 and 36, and the means for applying such forces can be fluid actuators of either the pneumatic or hydraulic type. It is known that such fluid actuators provide a continuous resilient force, and they are thus separate and independent means for selectively positively displacing the bearings 22, 23 and continuously resiliently urging such bearings 22, 23 upwardly.

Upon the application of lifting forces to the shaft end portions 30b and 30c through the bearing means 35 and 36, such forces are transmitted through the shaft body portion 30a and support means 31 to the body portion 21a of the roll shell 21. Since the end portions 21b and 21c of the roll shell 21 are restrained against vertical movement by the fixed bearing means 22 and 23, the applied forces to the shaft end portions have the effect of lifting and thereby deflecting the shell body portion 21a generally centrally and for a distance outwardly to the restrained opposite ends thereof. Generally stated, the maximum bowing or crowning achieved depends not only upon the magnitude of the forces applied and the strength of the materials, but upon the extent of the annular gaps 41 between the shell end portions 21b and 21c and the portions of the shaft ends 30b and 30c surrounded thereby. In other words, it is conceivable that the roll shell could be deflected, bowed or crowned until there is contact between the shell and shaft end portions in the region of the annular spaces or gaps 41. In any event, by applying lifting forces with such fluid actuators indicated diagrammatically at 42 and 43 to the shaft means 30 in the roll assembly illustrated and described, the load applied to the shell is continuously counteracted and normal deflection of the roll shell 21 is effectively relieved. It is also apparent from the drawing and the foregoing description that in the application of such lifting forces at 42 and 43 the inherent resistance to deflection in the shell 21 yields to the inherent resistance to deflection of the shaft 30, so that

a deflection change occurs substantially in the shell 21 otherwise normally deflected in response to the load applied thereto. The shell 21 is shown bent in FIGURES 2 and 3 while the shaft means 30 is straight. This is for reasons of illustration, although the shell normally will bend more inasmuch as it has less total stiffness but it will of course be understood that some bending occurs in the shaft means 30 and particularly at the ends 30b and 30c which are of lighter weight than the center 30a.

It may be found under particular circumstances that the normal deflection in the roll shell 21 is not uniform outwardly of the vertical centerline thereof, and accordingly, the application of deflection relieving forces through the centrally located support means 31 may not produce the results desired. For this purpose, and as appears in FIGURE 3, there is provided at equally spaced locations from the vertical centerline of the shaft means 30 a pair of auxiliary support means 44 and 46. The latter means may take the form of annular collar members in contact with both the outer diameter of the shaft body portion 30a and the inner diameter of the shell body portion 21a. As appears, the support means 44 and 46 may be constructed identically to the support member 31 of FIGURE 2, and would therefore desirably be secured to the shaft portion 30a. In this manner, forces applied at 42 and 43 to the bearing means 35 and 36, and transmitted through the central support means 31 to the roll shell body portion 21a, are uniformly distributed through the auxiliary support means 44 and 46 to assure that the deflection curve is properly matched and better flexure control attained.

It will of course be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. Apparatus comprising, a roll shell having normally a straight line centroidal axis that develops normally, a central deflection in response to a load applied to the shell, fixed bearings rotatably mounting the ends of said roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, support means between said shaft means and said roll shell inwardly of the opposite ends thereof and normally maintaining said shaft means and said shell in coaxially spaced relation, and movable fluid actuated resilient means for applying a lifting force to each of said shaft portions in opposition to the restraint on said roll shell provided by said fixed bearings continuously counteracting said load to relieve the normal deflection in said shell, said roll shell having a given inherent resistance to deflection and said shaft means having a substantially greater inherent resistance to deflection, and said given inherent resistance to deflection of the shell yielding substantially to said greater inherent resistance of the shaft means.

2. Apparatus comprising, a roll shell having a given inherent resistance to deflection and having in unloaded condition a straight-line centroidal axis that develops normally a central deflection in response to a load applied to the shell, fixed bearings rotatably mounting the ends of said roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, said shaft means having an inherent resistance to deflection greater than said given resistance, force transmitting means surrounding said shaft means inwardly of the opposite ends thereof and bearing against the inner surface of said roll shell inwardly of the ends thereof, and movable fluid actuated means acting against the shaft portions outside the roll shell for selectively raising said shaft means and continuously counteracting said load to deflect said roll shell generally centrally thereof through said force transmitting means and in opposition to restraint on the shell ends provided by said fixed bearings, whereby said given inherent resistance to deflection of

the shell yields substantially to the greater inherent resistance of said shaft means.

3. Apparatus comprising a roll shell having a given inherent resistance to deflection and having in unloaded condition a straight-line centroidal axis that develops normally a central deflection in response to a load applied to the shell, load means acting against said roll shell normally tending to effect such deflection, fixed bearings rotatably mounting the ends of said roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, said shaft means having an inherent resistance to deflection greater than said given resistance, force transmitting means surrounding said shaft means inwardly of the opposite ends thereof and in rigid assembly with the inner surface of said roll shell inwardly of the ends thereof, drive means for rotating the shaft means and the roll shell thereby, and movable fluid actuated means acting against the shaft portions outside the roll shell for selectively raising said shaft means and continuously counteracting said load to correct for the deflection in the roll shell which said load means tends to effect generally centrally thereof through said force transmitting means and in opposition to restraint on the shell ends provided by said fixed bearings, whereby said given inherent resistance to deflection of the shell yields substantially to the greater inherent resistance of said shaft means.

4. Apparatus comprising, a roll shell having a given inherent resistance to deflection and developing normally a central deflection in response to a load applied thereto, fixed bearings rotatably mounting the ends of said roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, said shaft means having greater inherent resistance to deflection than said roll shell, force transmitting means surrounding said shaft means at spaced locations therealong and bearing against the inner surface of said roll shell inwardly of the opposite ends thereof and movable means for raising said shaft means to deflect said roll shell generally centrally thereof through said force transmitting means and in opposition to the restraint on the shell ends provided by said fixed bearings, said movable means being fluid pressure actuators acting against the shaft portions outwardly of the shell ends whereby the inherent resistance to deflection of the roll shell yields to the greater inherent resistance to deflection of the shaft.

5. Apparatus comprising, a roll shell having a given inherent resistance to deflection and normally a central deflection in response to a load applied to the shell, fixed bearings rotatably mounting said roll shell, shaft means for the roll shell having shaft portions extending outwardly from the opposite ends thereof, said shaft means having an inherent resistance to deflection greater than said given resistance to deflection of the roll shell, second bearing means rotatably mounting the extended shaft portions, self-aligning bearing support means between said shaft means and said roll shell inwardly of the opposite ends thereof and normally maintaining said shaft means and said shell in coaxially spaced relation, and movable fluid actuators acting against said second bearing means for selectively raising said shaft means and continuously counteracting said load to deflect said roll shell generally centrally thereof through said self-aligning bearing support means and in opposition to restraint on the shell ends provided by said fixed bearings, whereby said given inherent resistance to deflection of the shell yields substantially to the greater inherent resistance of said shaft means.

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