

July 16, 1963

E. J. JUSTUS

3,097,590

ANTI-DEFLECTION ROLL

Filed April 12, 1961

2 Sheets-Sheet 1

Fig-1

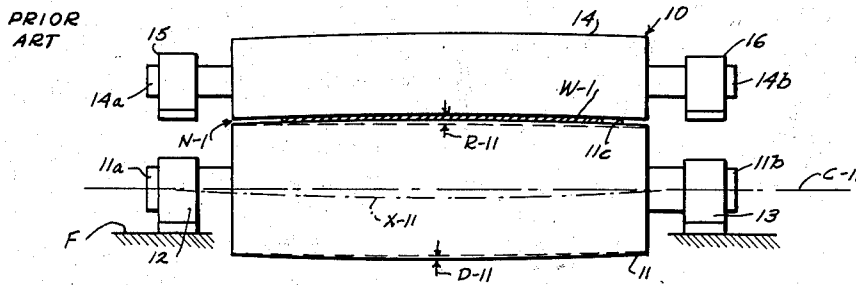


Fig. 2

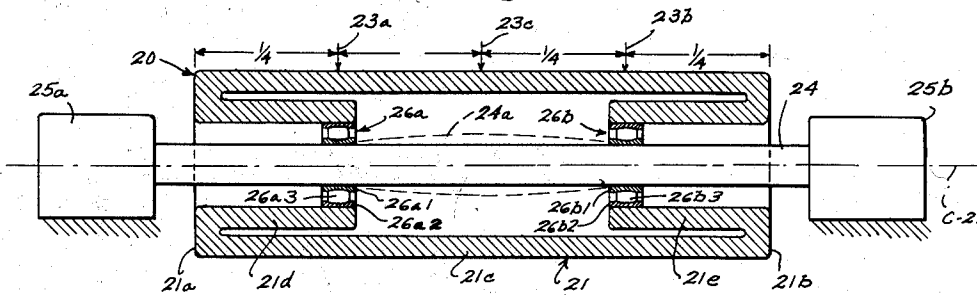
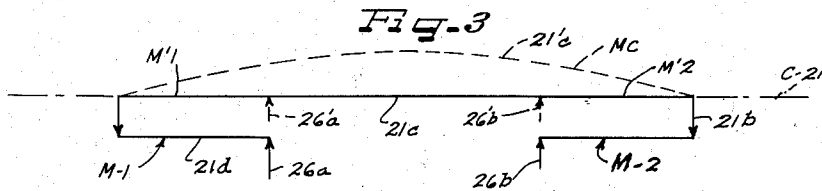
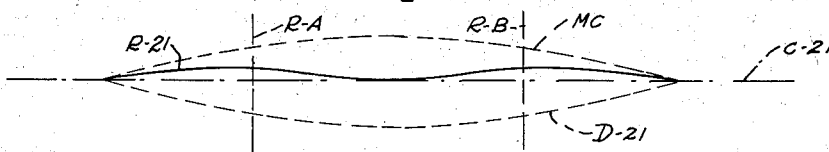


Fig-3


$$F_2 \text{ g. 4}$$


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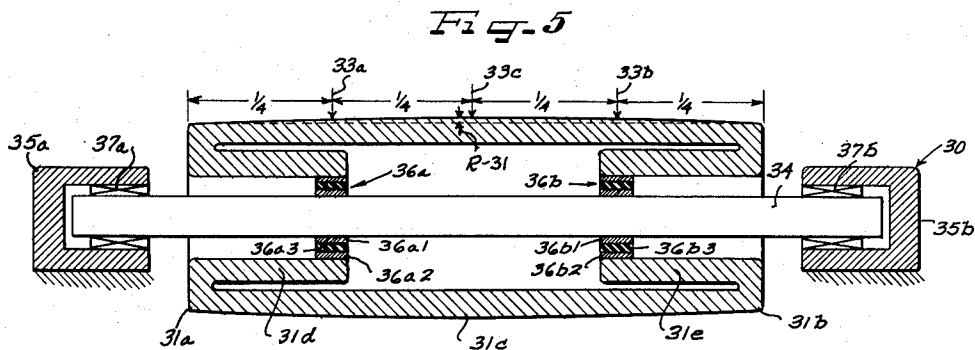
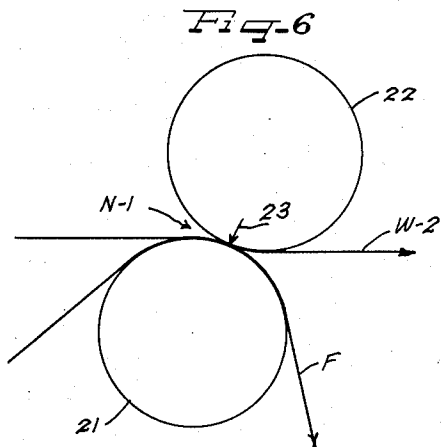
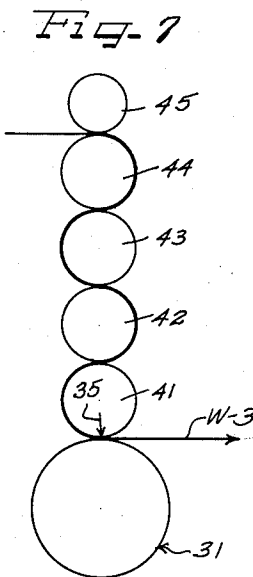
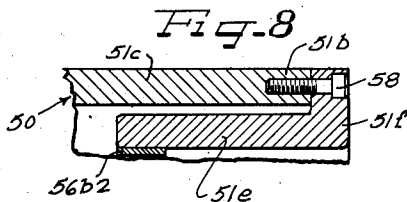
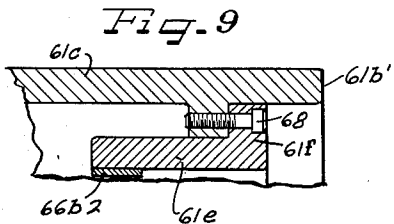
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2 Sheets-Sheet 2



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3,097,590

ANTI-DEFLECTION ROLL

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17 Claims. (Cl. 100—155)

This invention relates to apparatus for mounting a roll whose centroidal axis is subject to deflection, and more particularly, to an apparatus for mounting a roll that is subjected to a load tending to effect central deflection of the roll axis.

Although the instant invention may be useful in a number of arts, it is particularly useful in the paper making art and will be described primarily in connection therewith. In paper machines there are a number of different types of rolls of substantial size (i.e., substantial length-to-diameter ratio) which are subjected to loads tending to deflect such rolls centrally. For example, in press couples, calender stacks, etc., the web passes through a nip between a pair of rolls whereat the web is subjected to pressures. The pressures thus applied at such nip tend to load the rolls defining the nip and to deflect the axes of these rolls in a direction generally away from the nip. If one of the rolls defining a nip is backed up by other rolls or other means, its tendency to deflect away from the nip is reduced or may be completely overcome so that it is deflected in the direction of the nip. On the other hand, certain press rolls and, for example, the king roll or bottom roll in a calender stack may not be provided with back up means and the pressures or load thus applied to the nip for a calender stack king roll (as for example) tends to deflect the same centrally downwardly. Such deflection results in an undesirable application of forces across the nip and other undesirable operating features; and such deflection is often corrected in paper machines by "crowning" of the king roll. The crowning of the 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; but 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 operating conditions.

In arts relating to the paper machine art, such as the coating of paper or fabrics with plastic materials, pressure or calender rolls are also used. In addition, paint mixing systems or the like are also subject to the buildup of forces in the central portion of 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 pressure nips.

It will be appreciated that one may think of most of these various pressure rolls in terms of the outer annularly cross-sectioned functional component or "shell" thereof. The instant invention affords a simple but unique mounting arrangement for a roll shell subject to a load tending to cause deflection of its centroidal axis. One important aspect of the instant invention involves the use of force couples for applying internal counter-deflection moments to the shell in response to the application of the load to the shell in such a manner as to more or less automatically resist or minimize deflection of the roll when it is subjected to varying loads. This is accomplished through the use of allochiral mounting means secured to the ends of the shell, but extending inwardly from the ends of the shell to be supported at locations disposed inwardly of the shell ends from the points at which these mounting means are secured to the ends of the shell. These mounting means are allochiral in that they are "right hand"

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and "left hand" members mounted at opposite ends of the shell (or looking in the "machine direction" at opposite sides of the roll shell). These members are referred to herein as "allochiral" for the reason that they are opposed right and left hand assemblies although not necessarily entirely symmetrical in every detail.

The use of a pair of bearings to rotatably receive a stub shaft extending outwardly from the end of the roll for the purpose of applying a force couple thereto, wherein one of the bearings is fixed and the other movable, is shown in the prior art, for example, in Goulding U.S. Patent No. 2,611,150. The Goulding mounting arrangement calls for a pair of bearings for each of the stub shafts at opposite ends of the roll. In addition, the prior art in the form of Hornbostel U.S. Patents Nos. 2,648,122 and 2,651,103 shows the mounting of a roll shell on a through shaft using mounting elements that are positioned inwardly from the ends of the shell, but which afford a direct (radially aligned force) connection between the through shaft and the shell at the mounting element positions inwardly from the ends of the shell.

In the instant invention, however, the advantages of applying a counter-deflection moment to the shell are obtained without the necessity of using a pair of bearings at each end of the roll, and without the necessity of providing means for applying a force couple to each of such pairs of bearings. The application of a counter-deflection moment to the shell in the instant invention is effected by the use of a unique and simple arrangement of allochiral mounting (and "force couple applying") means preferably in the form of annular members which are secured to the ends of the shell but which extend inwardly rather than outwardly of the shell ends. These mounting members are carried at a location inwardly from their outer extremities and the ends of the shell by means of a through shaft or the mechanical equivalent thereof, which provides shaft means extending from mounting means for the shaft outside of opposite ends of the shell inwardly to afford support for such annular mounting members at the previously described location inwardly from the shell ends. The exterior mounting means for the through shaft component may mount the through shaft for rotation, and thus the entire roll assembly for rotation; or advantages may be obtained from the use of internal bearing means carried on the through shaft component and rotatably mounting the aforesaid annular mounting members at the previously described location inwardly from the shell ends.

In any event, substantially the entire weight of the shell and any load applied thereto is carried by the through shaft component at the previously described locations inwardly from the shell ends. And the internal mounting means or annular mounting members which are to effect the internal counter-deflection moments in the shell are mounted on and fully supported by the through shaft component at the aforesaid locations inwardly from the shell ends, but these annular members are not connected directly to the interior of the shell radially opposite to the positions at which they are mounted on the through shaft component. Instead, these annular mounting members extend outwardly from the locations at which they are carried by the through shaft component and they in turn are secured to the shell at the ends thereof (although not necessarily the exact extremities of the shell) in such a manner that the internal counter deflection moment is applied to the shell via these annular mounting members in response to the application of a load to the shell. This results in a greatly simplified, sturdy assembly which is essentially "self-correcting" with respect to its tendency to resist the normal deflection to which conventionally mounted rolls are subjected under load.

It is, therefore, an important object of the instant inven-

tion to provide an improved anti-deflection roll and/or anti-deflection assembly for the mounting of a roll shell subject to a load.

It is another object of the instant invention to provide an improved roll assembly wherein force couples are applied to effect internal counter-deflection moments via simple, sturdy and effective members positioned internally of the shell ends.

Yet another object of the instant invention is to provide a rotatable roll shell whose axis is subject to deflection in response to a load applied to said shell, through shaft means received by said shell, and allochiral mounting means rigidly secured to the ends of said shell and supporting the weight of said shell on said shaft inwardly from the ends of said shell, thereby applying internal counter-deflection moments to said shell in response to the application of the load to said shell.

Other and further objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:

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

FIGURE 2 is a diagrammatic illustration similar to FIGURE 1, but showing the roll shell in sectional elevation for an assembly embodying the invention;

FIGURE 3 is an essentially diagrammatic view showing the alignment of internal counter-deflection moments of the type effected in the operation of the assembly of FIGURE 2;

FIGURE 4 is an essentially diagrammatic illustration of deflection curves involved in a consideration of the instant invention;

FIGURE 5 is a view comparable to that of FIGURE 2 showing another embodiment of the instant invention;

FIGURE 6 is an essentially diagrammatic side elevational view showing a press couple arrangement wherein a roll assembly of the instant invention is used;

FIGURE 7 is an essentially diagrammatic side elevational view showing a calender stack wherein a roll assembly of the instant invention is used;

FIGURE 8 is a fragmentary detail view of an end assembly or end mounting of another embodiment of the instant invention, comparable generally to the end mounting shown for the shell in the upper right hand corner of FIGURES 2 and 5; and

FIGURE 9 is a view corresponding to that of FIGURE 8 showing still a different modification of the invention. As shown on the drawings:

In FIGURE 1, a bottom portion of a calender stack, indicated generally by the reference numeral 10, is shown 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 11a or shaft element which is 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 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 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 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 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, it will be seen that the assembly of the instant invention is adapted to mount a roll shell 21 whose centroidal axis in the unloaded condition of the roll (indicated at C-21 in FIGURES 2, 3 and 4) is subject to deflection. As will be appreciated, the extent of deflection and crown has been greatly exaggerated in FIGURE 1 and will also be exaggerated in the description of FIGURES 2, 3 and 4 for the purpose of simplifying the nature of the disclosure. As indicated diagrammatically in FIGURES 2, 3 and 4, the axis C-21 is a center line for the shell 21 which would be a substantially straight, horizontal line in the views shown, if the shell 21 were not subjected to any loading forces including the load of its own weight. The roll 21 is, however, subjected to a load across its entire width, including the load of its weight and the load of an upper press roll 22 (FIGURE 6) forming a press nip N-1 therewith. As indicated in FIGURE 6, a felt F is trained around the roll shell 21 and carries a paper web W-2 through the nip N-1 at which a substantial load indicated by the arrow 23 is applied against the shell 21. For the instant purposes the load indicated diagrammatically by the arrow 23 in FIGURE 6 will be understood to be applied uniformly across the entire width (or length) of the shell 21 and is represented in FIGURE 2 by the arrows 23a and 23b at the quarter points and 23c at the midpoint. As indicated diagrammatically in FIGURE 4, in the case of a conventionally mounted roll shell this load 23 would result in a conventional deflection curve D-21 in the shell axis.

The shell 21 is, however, mounted in accordance with the instant invention on a through shaft 24 which in this embodiment is received by the shell 21 extending completely therethrough to be held against rotation and fully supported by fixed mounting blocks 25a and 25b indicated diagrammatically. It will be appreciated that the assembly of the instant invention indicated generally by the reference numeral 20 in FIGURE 2 does not require a through shaft 24 which extends continuously throughout the interior of the shell 21, but only through shaft elements or means which extend inwardly from the respective mounting blocks 25a and 25b a sufficient distance to carry out the function of mounting the other elements which will be described. As a practical matter,

however, there are a number of distinct advantages in applying a through shaft 24 extending continuously throughout the length of the shell 21 in the manner here shown. There is an additional advantage in the use of a fixed through shaft 24 (held against rotation) and mounting the shell 21 for rotation via bearings 26a and 26b, for the reason that the non-rotating through shaft 24 may safely endure substantially greater stresses than should ordinarily be used with a rotating shaft.

The through shaft means 24 carries allochiral bearing elements 26a and 26b positioned inwardly from the corresponding shell ends 21a and 21b. The bearing assemblies 26a and 26b are shown diagrammatically since they may be of conventional structure, but it will be understood that spherical roller bearing assemblies are preferred for use in the invention, since these bearing assemblies are known to be resistant to a radially applied load, but capable of limited yielding to a pivotal or momental movement of the type desired herein. For this purpose the bearing assembly 26 is indicated diagrammatically as comprising inner and outer races 26a1, 26a2 and a central spherical roller element 26a3 and the other bearing assembly 26b is indicated in like manner. In this respect, it will be appreciated that the axis of the shaft 24 will tend to tilt or slope downwardly from the support 25b, for example, toward the middle of the shaft 24 (as indicated along the line D-21 in FIGURE 4); and the axis of the annular mounting means or inner shell 21e at the right hand side of FIGURE 2 will tend to tilt or slope downwardly in the opposite direction (or outwardly toward the support 25b) by virtue of the moment M-2 applied thereto (FIGURE 3), so the bearing 26b thus resists the radial load applied thereto but accommodates relative axial misalignment or tilting between the mounting means 21e and the shaft 24, hereinbefore referred to as "pivotal" or momental movement.

The shell 21 comprises a generally annularly cross-sectioned functioning body portion 21c plus generally coaxially spaced, rigidly secured or integral, allochiral turned-in end portions 21d and 21e respectively, intermediate the shell 21 and the shaft 24. The shell 21 is here formed integrally with the turned-in portions (which may be referred to as "sleeves" or "inner shells") 21d and 21e, for example, by conventional casting techniques for metal which, of course, results in the formation of these annularly cross-sectioned "turned-in" (i.e. cantilevered) members 21d and 21e encircling or surrounding the through shaft 24 interiorly of the shell 21, but rigidly secured to the ends 21a and 21b only, respectively, of the shell 21 so as to be radially spaced from the shell axially inwardly from the ends 21a and 21b. These cantilevered members 21d and 21e extend appreciably axially inwardly from the shell ends 21a and 21b, respectively, to the bearing assemblies 26a, 26b (being directly connected to such mounting elements as the outer races 26a2 and 26b2 in conventional manner), so as to be radially spaced from the shaft 24 axially outwardly from the inner ends of the members 21d and 21e mounted on the shaft 24 via the bearing assemblies 26a and 26b.

It will thus be seen that the weight of the shell proper 21c and the load 23 applied thereto is carried first in its entirety at the outer rigid (integral) connection between the shell body 21c and the internal annular members 21d and 21e forming the (sole) rigid connection with the shell ends 21a and 21b, respectively. Next, it will be seen that the entire load 23, plus the weight of the shell proper 21c and the weight of the internal annular members 21d and 21e is carried solely, appreciably axially inwardly from the ends 21a and 21b of the shell 21 by the allochiral bearing assemblies 26a and 26b (or more specifically the mounting elements formed by the outer races 26a2 and 26b2 which engage the annular members 21d and 21e, respectively, at approximately the quarter point locations disposed inwardly of the shell ends 21a

and 21b) or from the "points" in the immediate vicinity of the shell ends 21a and 21b whereat the aforementioned rigid integral connection is effected. (It will thus be appreciated that in the embodiment of FIGURE 2 the shell 21 is supported interiorly or from within solely on the shaft 24, via the internal annular members 21d and 21e.) This arrangement results in generally allochiral moments M-1 and M-2 indicated diagrammatically in FIGURE 3.

As indicated in FIGURE 3 the left hand moment M-1 is developed initially in the annular member 21d by virtue of the downward force component at the end connection 21a (between the shell body 21c and the annular member 21d) and the upward load resisting force component at the center line of the bearing assembly 26a. Although there is no direct radially aligned connection between the bearing assembly 26a and the interior of the shell 21c, the moment or force couple M-1 necessarily results in the formation of a corresponding moment M'-1 in the main shell body 21c, which may be indicated diagrammatically in FIGURE 3 by the force couple arrows 26a and 26'a. The corresponding force arrangement for the opposite moment M-2 is also indicated in FIGURE 3. It will be appreciated that the resulting end moments M'-1 and M'-2 acting on the body of the shell 21c tend to bow the shell 21c upwardly in the center to a position indicated at 21'c in FIGURE 3 on the exaggerated deflection curve MC resulting from such end moments, which curve is also shown in the diagram of FIGURE 4 in contrast with the conventional deflection curve D-21. It will also be appreciated that the greater the overall load 23 that is applied to the working surface of the shell body 21c, the greater the end moments M-1 and M-2, and thus the greater the tendency for the end moments to bow or deflect the shell body 21c upwardly. This is thus the theoretical explanation for the self-correcting character of the instant roll assembly in response to variations in the load applied to the shell. In other words, if the load increases the so-called normal deflection curve D-21 (referring to FIGURE 4) would deflect downwardly to a greater extent, but the end moments would also increase and this would result in the "automatic correction" effect of this assembly whereby the end moment deflection curve MC is moved upwardly, in the diagrammatic showing of FIGURE 4. In each case, the two curves D-21 and MC substantially cancel each other out and the axis of the shell, indicated in a solid line R-21 in FIGURE 4, assumes a substantially straight line configuration conforming generally with the true center line C-21, with very slight peaks RA and RB at the quarter point. These so-called "peaks" RA and RB are actually so small as to be negligible in most uses, even though they represent the maximum final deflection from the true center line C-21. It has been found that the self-correcting counter deflection effect is obtained in the most advantageous manner if the rigid connection between the shell body 21c and the inner annular members 21d and 21e is made substantially at the extremities of the shell body 21c and the entire load is transmitted from the annular members 21d and 21e to the through shaft 24 at approximately the quarter points (i.e. 23a and 23b) of the shell body 21c.

For example, in studying a preferred embodiment of the instant invention, the following critical factors are involved:

Metal shell-outside diameter (D)=38"

Face width, i.e. shell length (l)=280"

Wall or shell thickness (h)=5"

Nip load (N)=400 p.p.i.

Young's modulus of elasticity (E)=24×10⁶ p.s.i. (ductile iron)

Moment of inertia of shell (I)

Moment introduced at the ends during loading (M₀)

The shell deflection due to 400 p.p.i. nip load is computed from the following formula:

$$y = \frac{5Nl^4}{384EI} \left[\left[1 + 2 \left(\frac{D}{l} \right)^2 \right] - 8 \left[\frac{3}{5} + \left(\frac{D}{l} \right)^2 \right] \left(\frac{x}{l} \right)^2 + \frac{16}{5} \left(\frac{x}{l} \right)^4 \right] + \frac{1}{2} \frac{M_0 l^2}{EI} \left[\left(\frac{x}{l} \right)^2 - \frac{1}{4} \right]$$

wherein y indicates deflection normal to the axis and x indicates corresponding displacement parallel to the axis. The first part of the above equation represents the deflection of a simply supported shell, and the second part the counter-deflection due to the end moments developed during loading. By equalizing these two parts at the center of the shell the necessary moment M_0 may be calculated and consequently the distance of the bearing centers from the shell ends found. In the particular calculation for the ductile iron shell, and neglecting its weight for this calculation, the proper location of the bearing centers is found to be 64 inches from the ends (which is approximately at the quarter point of 70 inches), and the maximum total deflection is found to be less than 0.001 inch at approximately the quarter points of the shell (i.e. as represented diagrammatically at RA and RB in the deflection curve R-21 of FIGURE 4).

Since the moments developed during loading vary linearly with the nip load in the present assembly, the ideal locations of the bearings 26a and 26b remain constant with respect to the shell for all loadings. Thus if the nip load is doubled to 800 p.p.i. on the foregoing roll, the maximum beam deflection would double and would be less than 0.002 inch at the quarter points. If the shell body 21c is crowned, according to conventional prior art procedures, it will be appreciated that the maximum beam deflection may be reduced to an even greater extent. And for this purpose a slight crown R-31 is formed on the shell 31 shown in FIGURE 5 which will be described hereinafter.

In the aforementioned roll the diameter of the through shaft is 12 inches and the maximum stress developed in this shaft with a 400 p.p.i. nip load is 16,500 p.s.i., which would result in the maximum deflection at the center of about 1.25 inches. It will be appreciated that this deflection could be reduced by increasing the rigidity of the central portion of the shaft 24, for example, by increasing the diameter thereof as indicated in the dotted line at 24a, but the stress level actually computed is not excessive, particularly since the shaft 24 is not rotating. The extent of the deflection per se in the shaft 24 is not particularly significant with respect to deflection in the shell body 21c, for the reason that the position of the bearings 26a and 26b relative to each other remain substantially the same in spite of variations in the deflection of the overall shaft 24.

Referring now to FIGURE 5, it will be seen that the overall assembly indicated generally by the reference numeral 30 comprises a shell 31 having generally the same structure as the overall shell 21, except for the slight crown at the center indicated at R-31, and the corresponding parts of the shell 31 which are the same or substantially the same as elements of the shell 21 are indicated with the same reference numeral in the 30 series. In similar fashion the overall load is indicated diagrammatically at the quarter points 33a and 33b and at the midpoint 33c, a through shaft 34 is also shown mounted at its opposite ends in suitable mounting means 35a and 35b which in this case, however, are housings for bearings 37a and 37b respectively which rotatably mount the through shaft 34 for corotation with the shell 31 and remainder of the assembly 30. The entire load 33a, b, c on the shell 31 is again carried by the through shaft 34, which in turn is carried by the bearings 37a, 37b in this arrangement. The interior annular members 31d and 31e are again rigidly secured to (and integral with) the ends 31a and 31b of the shell proper 31c and extend

inwardly therefrom to mounting means 36a and 36b again positioned at approximately the quarter points for the shell 31c. In this case, however, the mounting means 36a form a sandwich structure defined by an inner metallic sleeve 36a1 engaging the through shaft 34 and an outer metallic sleeve 36a2 engaging and secured to the inner portion of the annular member 31d, with a solid elastomer element 36a3 sandwiched therebetween. The solid elastomer element 36a3 is formed of suitable natural or synthetic rubber which may be mounted between the metallic sleeves 36a1 and 36a2 and vulcanized in order to complete the formation of the sandwich structure 36a. A corresponding sandwich structure 36b is formed in like manner and designated by the corresponding reference numerals. The type of sandwich structures 36a, 36b employed here is similar to that described in detail in Hornbostel U.S. Patent No. 2,651,103, and it is capable of operation in a comparable manner to the extent that the sandwich structures 36a, 36b carry the radially aligned load, but yield to a limited extent at least to movement resulting from the application of the end moments in the manner already described herein (i.e., resulting in limited misalignment between the axes of the shaft means and the mounting means).

As indicated in FIGURE 7, the shell 31 may be used as a king roll in a calender stack provided with superimposed rolls 41, 42, 43, 44 and 45 receiving a web W-3 in conventional manner. The load indicated diagrammatically by the arrow 35 is transmitted to the sandwich structures 36a, 36b shown in FIGURE 5 so as to obtain a force arrangement already described in detail in connection with FIGURES 3 and 4 herein.

FIGURES 8 and 9 show modifications of the rigid connection between the shell and the internal mounting means. In the embodiment indicated generally by the reference numeral 50 in FIGURE 8, the shell body 51c is formed separately from the internally cantilevered, annularly cross-sectioned mounting member 51e (with the elements 51c and 51e functioning generally in a manner corresponding to the manner in which the elements 31c and 31e function in the embodiment 30). A mounting element 56b2 is also indicated in the view of FIGURE 8 to correspond with the metal sleeve 36b2 of FIGURE 5 and function in the same manner. In the embodiment 50, however, the annular member 51e is provided with an outer flange 51f which fits against the absolute extremity 51b of the shell body and is secured thereto, for example, by bolts indicated at 58 in order to effect the rigid connection therebetween which is employed in order to effect the desired end moments in the manner already described.

In FIGURE 9, corresponding elements are indicated in the 60 series of reference numerals, but it will be seen that the interior cantilevered member 61e in this case is provided with a flange 61f which is secured generally to the end 61b of the shell body 61c but not to the absolute extremity indicated at 61b'. In this embodiment the flange 61f is secured to the shell 61c by conventional bolt assembly 68 a short distance inwardly from the absolute extremity 61b' of the shell 61c and this may afford some advantages in connection with the mounting of other equipment at the absolute extremity 61b', although the length of the moment arm in the annular member 61e is, of course, reduced and the bending moment is correspondingly less effective. An essential feature of the invention is, however, indicated by the fact that the mounting means 66b2 which will be directly supported by the through shaft (not shown) are still positioned inwardly from the point of rigid connection 61f between the shell 61c and the annular member 61e.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention. As used herein, the terms "cantilevered" and "cantileverly" refer to a supporting arrangement for a member mounted on a given base element wherein one portion

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means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means and bearing means at the ends of the shaft means for corotatably supporting the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end and secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell being supported from within solely on said shaft means via said mounting means.

9. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, through shaft means extending continuously through and radially spaced from said shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, bearing means rotatably supporting said mounting means on said shaft means appreciably axially inwardly of each of the shell ends for rotatably mounting the shell, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means via said bearing means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end and secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell being supported from within solely on said shaft means via said mounting means, and said bearing means carrying the full weight of said shell, said mounting means, said shaft means and a load applied to said shell.

10. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, and means interposed between said shaft means and said mounting means accommodating limited axial misalignment while carrying the radial load of the mounting means on the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

11. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted

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on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, and allochiral bearing means interposed between said shaft means and said mounting means accommodating limited axial misalignment while carrying the radial load of the mounting means on the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end and secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

12. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, and allochiral solid elastomer mounting elements interposed between said shaft means and said mounting means accommodating limited axial misalignment while carrying the radial load of the mounting means on the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

13. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end approximately one quarter of the shell length axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

14. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, means applying a load to said shell tending to effect such deflection, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell

of such member is secured to and supported by such base element and another portion of such member extends away from such one portion and is not otherwise secured to or supported by such base element, i.e., as in the mounting of a conventional cantilever beam.

I claim as my invention:

1. 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, tubular inner support shells of substantial length extending inwardly from each of the ends of the roll shell and rotatable with the roll shell, said support shells being radially inwardly spaced from the roll shell and radially outwardly spaced from the shaft means, the outer ends of the support shells being rigidly connected to the outer ends of the roll shell, and 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, 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.

2. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end and appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

3. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end and appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell being supported from within solely on said shaft means via said mounting means.

4. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, shaft means in the shell and in radially spaced relation thereto, means on the shaft means for rotatably mounting the shell, and annular allochiral coaxially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end and appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end

secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell having a substantial length-to-diameter ratio, said shell being supported from within solely on said shaft means via said mounting means.

5. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, through shaft means extending continuously through and radially spaced from said shell, bearing means on the shaft means for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end and appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly for its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

6. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, through shaft means extending continuously through and radially spaced from said shell, bearing means at the ends of the shaft means for co-rotatably supporting the shell and the shaft means, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end at substantially 20 to 30% of the shell length axially inwardly from the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell being supported from within solely on said shaft means via said mounting means.

7. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, through shaft means extending continuously through and radially spaced from said shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, bearing means rotatably supporting said mounting means on said shaft means appreciably axially inwardly of each of the shell ends for rotatably mounting the shell, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means via said bearing means solely at its inner end and appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell, said shell being supported from within solely on said shaft means via said mounting means.

8. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, through shaft means extending continuously through and radially spaced from said shell, allochiral co-axially spaced mounting means surrounding the shaft

axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

15. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, a press roll in nip-defining relationship with said shell and applying a load to said shell tending to effect such deflection, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

16. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, at least one superimposed calender roll applying a load to said shell tending to effect such deflection, shaft means in the shell and in radially spaced relation thereto for rotatably mounting the shell, and allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means solely at its inner end appreciably axially inwardly of the shell ends, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection

moments to said shell in response to the application of a load to said shell.

17. In combination, a roll shell whose centroidal axis is subject to deflection in response to a load applied to said shell, said shell having a substantial length-to-diameter ratio, through shaft means extending continuously through and radially spaced from said shell, allochiral co-axially spaced mounting means surrounding the shaft means and extending appreciably axially inwardly of each of the shell ends intermediate the shell and the shaft means, bearing means at the ends of the shaft means for corotatably supporting the shell and the shaft means, and means interposed between said shaft means and said mounting means accomodating limited axial misalignment while carrying the radial load of the mounting means on the shaft means, each such mounting means being secured rigidly to the shell solely at its outer end and mounted on the shaft means via such interposed means solely at its inner end substantially 20 to 30% of the shell length axially inwardly of the shell end, each said mounting means being radially spaced from the shaft means axially outwardly from its inner end mounted on the shaft means and being radially spaced from the shell axially inwardly from its outer end secured to the shell, thereby applying internal counter-deflection moments to said shell in response to the application of a load to said shell.

References Cited in the file of this patent

UNITED STATES PATENTS

1,410,546	Batley	Mar. 28, 1922
1,518,836	Casel	Dec. 9, 1924
2,611,150	Goulding	Sept. 23, 1952
2,612,395	Russell	Sept. 30, 1952
2,648,122	Hornbostel	Aug. 11, 1953
2,651,103	Hornbostel	Sept. 8, 1953
2,676,387	McArn	Apr. 27, 1954

FOREIGN PATENTS

801,814	Great Britain	Sept. 24, 1958
543,540	Italy	May 1, 1958