Jan. 28, 1964 E. J. JUSTUS 3,119,324

CONTROLLED DEFLECTION ROLL

Filed Aug. 29, 1960 2 Sheets-Sheet 1

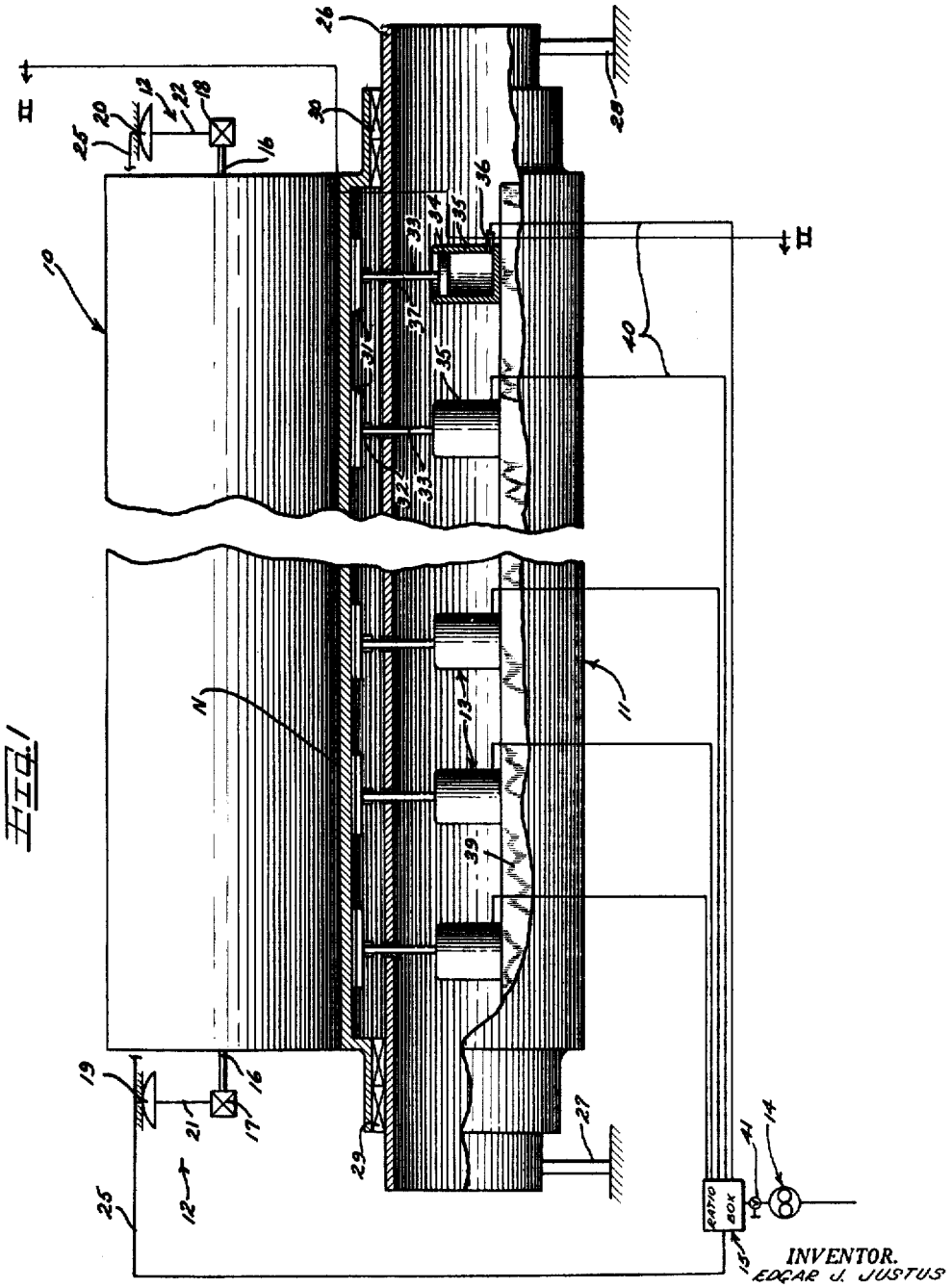


FIG. 1

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Fig. 3

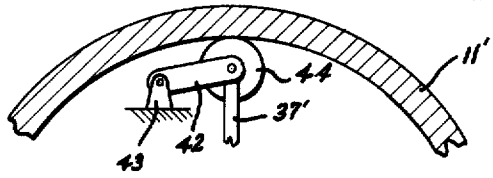
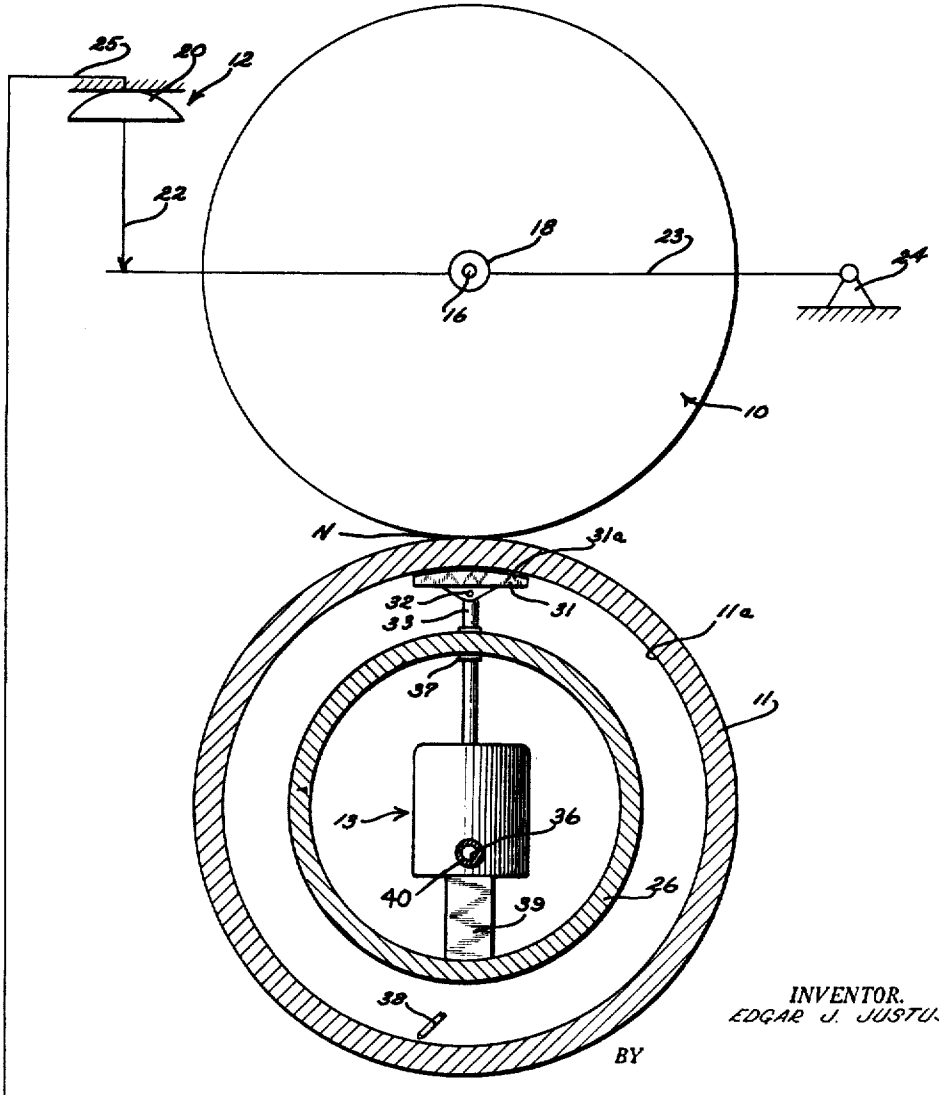


Fig. 2



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CONTROLLED DEFLECTION ROLL

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The present invention relates to improvements in supported rolls and mechanisms for controlling the deflection of the rolls.

In various uses of press rolls and in support or drive rolls deflection of the roll exists. Mechanisms employ rolls positioned to form a pressure nip for rolling materials between them which will cause a deflection of the rolls due to forces at the nip. Other mechanisms employ rolls subject to deflection forces such as those carrying a travelling belt or web. In paper making machinery, for example, drive rolls mounted to engage the loop of the forming wire in a Fourdrinier type paper making machine engage the surface of the wire and the weight of the roll coupled with an applied load arising from the resistance of the wire to being driven produce a force component which tends to deflect the drive roll in a direction downwardly and toward the oncoming forming wire. The deflection of the roll tends to cause the off-running portion of the forming wire to be compacted or squeezed materially increasing the wear on the wire. As well, in press roll couples and other roll arrangements wherein at least a pair of rolls are in nip defining relationship the algebraic summation of the weight, the nip forces, the bending movements produced by the journal loading, and torque (if any) tends to produce in each of such rolls a curvature of its centroidal axis, in accordance with well-known laws of flexure of materials. It is common to attempt to counter this effect by "crowning," i.e. by grinding the rolls slightly barrel shape in an amount and curvature calculated to offset the curvature under operating conditions. In certain environments this causes undesirable effects and the difference in the surface speed of the roll between the central and end portions of the roll is often disadvantageous to the product being rolled. Various stages in the course of paper manufacturing employ such roll structures. Efforts have heretofore been made to avoid the undesirable effects of deflection or eliminate the deflection such as by constructing the rolls with a crowned shape, as referred to above, or by externally supporting mid-portions of the roll.

A feature of the present invention is to provide a roll and a support therefor wherein the deflection of the roll can be controlled to eliminate deflection or to obtain a controlled amount of desirable deflection.

The mechanism contemplates providing either a single roll, or a pair of rolls in nip defining relationship. Where a pair of rolls are used, the mechanism includes a first roll having support bearings at its ends and a second tubular shaped roll with a plurality of support members engaging the inner surface opposite the pressure nip between the rolls. A first fluid pressure means is provided for supporting the bearings and a second fluid pressure means is provided for supporting the support members. A selectively controlled pressure source is connected to the pressure means through a ratio control so that a constant ratio is maintained between the pressure applied to the

bearings and to the support members. The support members in a preferred form for a single roll or for the second roll of a pair of rolls are pivotally carried arcuately shaped shoes which form a film of fluid between the shoe surfaces and the inner surface of the second roll from fluid carried within the roll.

Accordingly, an object of the present invention is to provide an improved roll assembly of the above nature in which the deflection of a single roll is controlled or in which deflection of opposed rolls is controlled in an improved manner to obtain a desirable pressure along the pressure nip.

A further object of the invention is to provide an improved roll assembly wherein the roll pressures may be selectively changed to obtain desirable variations in pressure conditions along the pressure nip or to obtain uniform pressure along the nip.

A further object of the invention is to provide a support for a pressure roll which does not have to engage the outer surface of the roll and which supports the inner surface of a tubular roll with a minimum frictional drag and is capable of a long wearing life.

A still further object of the invention is to provide an improved pressure roll assembly of simplified construction well suited to use in the paper industry.

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

FIGURE 1 is a schematic elevational view, with portions in section, of pressure rolls embodying the principles of the present invention;

FIGURE 2 is a vertical sectional view taken substantially along line II—II of FIGURE 1; and

FIGURE 3 is a fragmentary sectional view of a portion of the lower pressure roll illustrating a modified form of the invention.

As shown on the drawings:

FIGURES 1 and 2 show a first upper roll **10** forming a pressure nip with a second lower roll **11**. The lower roll is tubular in construction. The first roll **10** has a first fluid pressure means or support members **12** at the ends supporting it and holding it in pressure engagement with the second roll **11**. A second fluid pressure operated means or support members **13** within the tubular second roll urges the roll upwardly providing a support at the inner surface of the tubular roll holding it in pressure engagement with the first roll. A fluid pressure source **14** shown in the form of a pump supplies fluid such as air under pressure to operate the pressure means **12** and **13** and a fluid pressure ratio control box **15** is positioned between the pump **14** and the first and second pressure means **12** and **13** maintaining a predetermined ratio of the pressure of air delivered to the pressure means **12** and **13**.

In greater detail, the upper roll **10** has a supporting shaft **16** carried on bearings **17** and **18** at the ends of the roll. Fluid pressure members **19** and **20** shown in the form of fixedly supported chambers with flexible diaphragms apply a downward force to the bearings and the diaphragms are connected to the bearings by rods **21** and **22**. The various elements described are illustrated schematically and as will be appreciated by those skilled

in the art may take various other forms. The pressure members **19** and **20** for example may take the form of pistons slidably mounted in fixed cylinders. The rods **21** and **22** are connected to the ends of lever arms such as illustrated at **23** in FIGURE 2, with the other end of the lever arms mounted on a fixed pivot **24** and secured at a midpoint to the bearings **17** and **18**. Accordingly, the downward force applied to the upper roll will be dependent on the air pressure delivered to the pressure members **19** and **20** and air is delivered through a line **25** connected to the ratio box **15**.

As will be understood by those skilled in the art, the ratio box is a fluid pressure control mechanism or valve assembly which controls the outlet pressure in output lines maintaining the pressures at a predetermined ratio with the pressures varying as the input pressure but maintaining said ratio. These valves are commercially available and need not be described in detail.

The pressure to the ratio box may be selectively varied such as by a pressure control valve **41** connected to the supply for the ratio box. This may of course be incorporated into the valve of the ratio box.

The second or lower tubular roll **11** is carried on a beam member **26** conveniently in the form of a hollow tube. The beam member **26** is mounted at its ends on fixed end supports **27** and **28**. The support for the deflection control pressure applied to the lower roll **11** and for the weight of the roll assembly is provided by the fixed supports **27** and **28**.

The lower roll **11** is rotatably positioned by being rotatably mounted on the beam **26** on bearings **29** and **30** at its ends. The load carried by the bearings **29** and **30** will vary dependent upon the upwardly acting forces applied to the inside of the roll **11** by the support members **13** and the primary support for the roll **11** and the force at the nip N is provided by the support members **13**.

The support members **13** are positioned at axially spaced locations within the lower roll **11** and engage the inner surface of the lower roll at positions opposite the pressure nip N between the rolls **10** and **11**.

Each support member **13** includes a shoe **31** having an arcuate outer face **31***a* facing the inner surface **11***a*, FIGURE 2, of the roll **11**. Each shoe is pivotally mounted at **32** on a piston rod **33** supported in a bearing sleeve **37** in the tube shaped beam **26**.

The shoes **31** slide along on the inner surface **11***a* of the roll **11** and a supporting film or cushion of lubricant is formed between the outer surface **31***a* of the shoe and the inner surface **11***a* of the roll **11** from lubricant within the roll. Lubricant may be conveniently supplied to the interior of the roll through a supply tube **38**, FIGURE 2. The lubricant may be a suitable fluid such as oil which maintains the frictional drag between the shoes **31** and the roll **11** at a very low amount and also functions to dissipate heat.

These shoes **31** are urged upwardly to provide a backing support for the lower roll **11** by pistons **34**, FIGURE 1, connected to the lower ends of the piston rods **33** and slidably mounted in supported cylinders **35**, mounted on supports **39** within the tubular beam **26**. Air pressure is delivered to a lower end of the cylinders **35** through ports **36** connected to lines **40** to the ratio box **15**.

FIGURE 3 illustrates another form somewhat different in construction than the foregoing preferred form, wherein a lower roll **11'** is supported on a plurality of rollers **44** carried on pivotal arms **42** mounted on fixed pivots **43** within the roll **11'**. Each of the rollers **44** is forced upwardly on a piston rod **37'** connected to a piston within a cylinder similar to the construction shown in FIGURES 1 and 2.

In the aforedescribed arrangements the forces on each of the shoes **31** or rollers **44** are preferably equal inasmuch as this provides the most practical and versatile structure. It is contemplated however that the forces applied by different shoes can be different such as, for example, having the shoes at the center of the roll apply a larger force. This could be accomplished by pressure regulators in the lines **40** and delivering a higher pressure to certain of the cylinders. It also could be accomplished by providing the pistons **34** and cylinders **35** for different shoes of different sizes, or it could be accomplished by decreasing or increasing the spacing between certain support members.

The support members **13** may be employed to achieve various nip loading effects such as uniform loading across the nip or unequal loading. The effect of unequal loading across the nip is useful in paper making machinery wherein a paper web passing between the rolls may tend to crush at the outer edges and may have a less tendency to crush at the center of the nip. For this operation a nip load is used wherein a greater load is applied at the center of the rolls than at the edges and this is accomplished by bowing the lower roll **11** upwardly at the center to obtain a greater force at the center of the nip.

By way of an example of structure wherein a greater loading at the center of the nip can be accomplished, a roll assembly is used wherein the total area of the diaphragms of the fluid pressure means **19** and **20** for the top roll are equal to the total areas of the pistons **34** for the lower roll **11**. A ratio box is used wherein the fluid pressure delivered to the cylinders **35** is double that of the pressure delivered to the pressure members **19** and **20**. A pressure of 100 pounds per square inch in the line **25** and a pressure of 200 pounds per square inch in the lower lines **40** will cause the bottom roll to bow up thereby creating a greater pressure at the center of the nip than at the edges. If the pressures in both of the lines **25** and **40** are dropped, which can be accomplished by reducing the output pressures of the ratio box such as by reducing the delivery pressure through the control valve shown schematically at **41**, the bowing of the lower roll **11** will decrease thus decreasing the difference between the pressure at the center of the nip and the edges. At some lesser fluid pressure the pressure along the nip N will become uniform. Further reduction in pressure will result in a greater pressure at the edges of the rolls. However, the structure for a particular use will normally be designed for the nip pressure relationship that is to be used during normal running operation and the pressure in the nip is also dependent on factors as the weight of the roll and their strength or resistance to deflection. Thus it will be seen that various effects can be accomplished both by design and by pressure control.

It is also contemplated that the lower tubular roll **11** be used without an upper roll such as for applying a rolling pressure to a surface or for carrying a travelling belt or wire.

As to the ratio box referred to above, various commercial structures for automatically providing an output pressure as a function of a variable input pressure may be employed as will be fully recognized by those versed in the art. For example, a device available commercially known as a Kendall biasing regulator could be used with a separate regulator for each of the cylinders to obtain the fluid pressure desired for each cylinder with a change in supply pressure.

In paper making machinery, the lower roll may be used to carry a travelling wire as in the Fourdrinier section of the machine. The roll may also be used as a drive roll for the wire. The upper roll **10** is of course omitted and a drive mechanism is attached to the lower roll **11**. In carrying a Fourdrinier wire deflection of the roll due to the weight of the wire and due to driving forces on the roll will cause deflection of the roll to tend to cause the off-running portion of the forming wire to be compacted or squeezed laterally which substantially increases the wear on the wire. This deflection of the roll and the ultimate undesirable effects on the wire can be avoided by the roll of the instant invention wherein the support members

13 are placed at an appropriate location and apply a support force to prevent deflection.

By this it will be seen that I have provided an improved roll assembly which meets the objectives and advantages above set forth. The mechanism is susceptible of uses in many fields and provides a reliable structure capable of long operating life and wherein controlled deflection of the roll is accomplished without undesirable effects and without excessive frictional drag.

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

I claim as my invention:

1. In a roll assembly subject to deflection, an elongated tubular cylindrical roll shell adapted to receive lubricating fluid on the inner surface thereof, a rigid support within said roll shell, bearing means at each end of the roll shell positioning the ends of said roll shell relative to the support, a shoe inside of said roll shell having an arcuate stationary convex surface supportingly engaging only a portion of the inner circumference of the roll shell, said stationary convex surface being formed to build up a supporting film of fluid during relative rotation of the roll shell from the fluid within the roll shell, and means positioned between the shoe and support for applying a predetermined radial force to said shoe thereby urging said shoe radially outwardly against the inside of the roll shell for controlling deflection of the roll shell.

2. In a roll assembly subject to deflection, an elongated tubular cylindrical roll shell adapted to receive lubricating fluid on the inner surface thereof, a rigid support within said roll shell, bearing means at each end of the roll shell positioning the ends of said roll shell relative to the support, a plurality of shoes axially spaced inside of said roll shell each having an arcuate stationary convex surface supportingly engaging only a portion of the inner circumference of the roll shell, said stationary convex surface being formed to build up a supporting film of fluid during relative rotation of the roll shell from the fluid within the roll shell, and means positioned between each of the shoes and the support for applying predetermined radial forces to said shoes thereby urging said shoes radially outwardly against the inside of the roll shell for controlling deflection of the roll shell.

3. In a roll assembly subject to deflection, an elongated tubular cylindrical roll shell adapted to receive lubricating fluid on the inner surface thereof, a rigid support within said roll shell, bearing means at each end of the roll shell positioning the ends of said roll shell relative to the support, a plurality of shoes axially spaced inside of said roll shell each having an arcuate stationary convex surface supportingly engaging only a portion of the inner circumference of the roll shell, said stationary convex surface being formed to build up a supporting film of fluid during relative rotation of the roll shell from the fluid within the roll shell, means pivotally supporting each of said shoes about an axis parallel to the roll shell axis, and means positioned between each of said pivotal supporting means for the shoes and said support for applying predetermined radial forces to said shoes thereby urging said shoes radially outwardly against the inside of the roll shell for controlling deflection of the roll shell.

4. In a roll assembly subject to deflection, an elongated tubular cylindrical roll shell adapted to receive lubricating fluid on the inner surface thereof, a rigid support within said roll shell, bearing means at each end of the roll shell positioning the ends of said roll shell relative to the support, a shoe inside of said roll shell having an arcuate stationary convex surface supportingly engaging only a portion of the inner circumference of the roll shell, said stationary convex surface being formed to build up a supporting film of fluid during relative rotation of the roll shell from the fluid within the roll shell, and a fluid motor positioned between the shoe and support for applying a predetermined radial force to said shoe thereby urging said shoe radially outwardly against the inside of the roll shell for controlling the deflection of the roll shell.

5. In a roll assembly subject to deflection, an elongated tubular cylindrical roll shell adapted to receive lubricating fluid on the inner surface thereof, a rigid support within said roll shell, bearing means at each end of the roll shell positioning the ends of said roll shell relative to the support, a plurality of shoes axially spaced inside of said roll shell each having an arcuate stationary convex surface supportingly engaging only a portion of the inner circumference of the roll shell, said stationary convex surface being formed to build up a supporting film of fluid during relative rotation of the roll shell from the fluid within the roll shell, a force applying means positioned between each of the shoes and the support, and means for individually operating each of the force applying means so that independent forces may be applied to each of the shoes urging the shoes radially outwardly against the inside of the roll shell for controlling deflection of the roll shell.

6. A pressure rolling mechanism comprising a first rotatable roll, a second rotatable roll shell, a first variable pressure means providing a support for the first roll holding it in pressure engagement with said second roll shell forming a pressure nip therebetween, a plurality of support elements in engagement with the inner surface of said second roll shell opposite the pressure nip, second pressure means having individual members connected to said support elements providing a support for the second roll shell and controlling deflection thereof for obtaining a predetermined nip load, said members being individually controllable for applying pressures to obtain a predetermined nip load characteristic along the nip, nip loading means connected to said first and said second pressure means for changing the nip load, and ratio control means connected to said nip loading means and to said fluid pressure members controlling said individual members to retain said predetermined characteristic with change in nip load.

7. A pressure rolling mechanism in accordance with claim 6 wherein said ratio control means provides a uniform nip pressure along the length of the nip at different operating nip loads.

8. A pressure rolling mechanism comprising a first rotatable roll, a tubular second rotatable roll shell, a first variable fluid pressure means providing a support for the first roll holding it in pressure engagement with said second roll shell forming a pressure nip therebetween, a plurality of support elements in engagement with the inner surface of the second roll shell opposite the pressure nip, second variable fluid pressure means having individual members connected to said support elements providing a support for the second roll shell and controlling deflection thereof, said members being individually controllable for applying pressures to obtain a predetermined nip load characteristic along the nip, a fluid pressure supply means connected to said first and second pressure means for changing the pressure of the supply fluid and changing the nip load, and ratio control means connected to said fluid pressure members controlling said individual members to retain said predetermined characteristic with change in nip load.

9. A pressure rolling mechanism comprising a first rotatable roll, a tubular second rotatable roll shell, a support for the first roll holding it in pressure engagement with said second roll forming a pressure nip therebetween, a plurality of support elements in engagement with the inner surface of the second roll shell opposite the pressure nip, variable fluid pressure means having individual members connected to said support elements providing a

support for the second roll shell and controlling deflection thereof and nip pressure, said members being individually controllable for applying pressures to obtain a uniform nip load characteristic along the nip, nip loading means connected to said variable pressure means for changing the total nip load, and ratio control means connected to said nip loading means and said fluid pressure members controlling said individual members to retain said uniform characteristic along the nip with change of said nip loading means.

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