March 26, 1963 E. J. JUSTUS 3,082,683

ROLL STRUCTURE

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Fig. 1

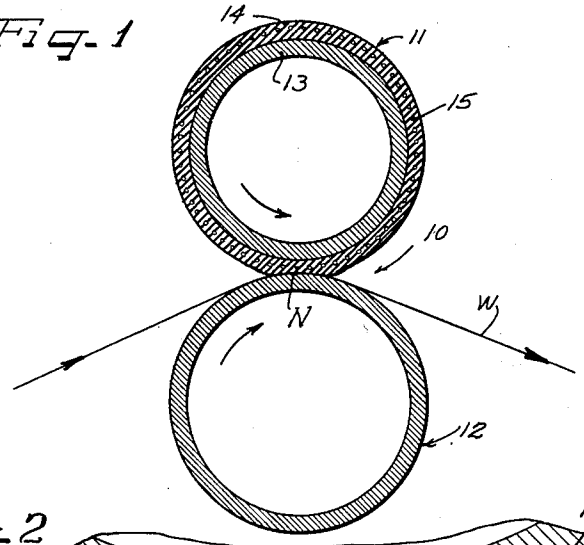


Fig. 2

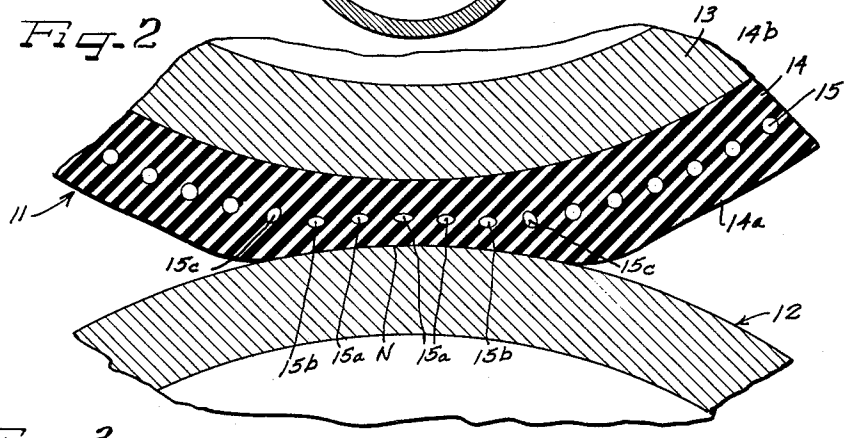
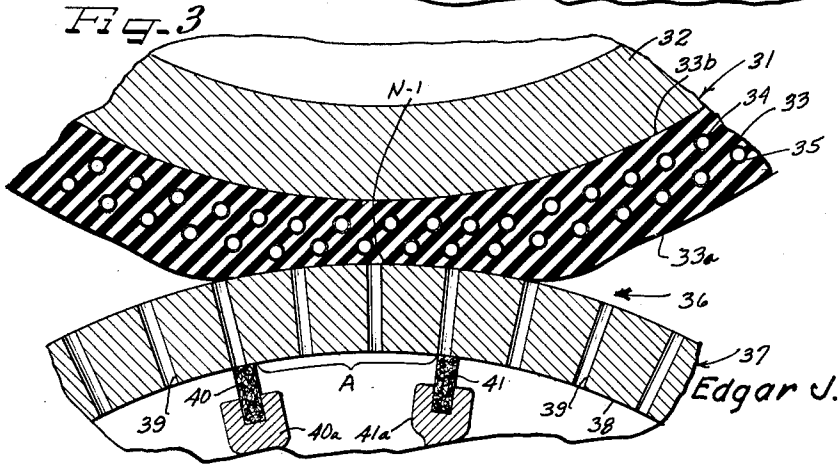


Fig. 3



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Fig-4

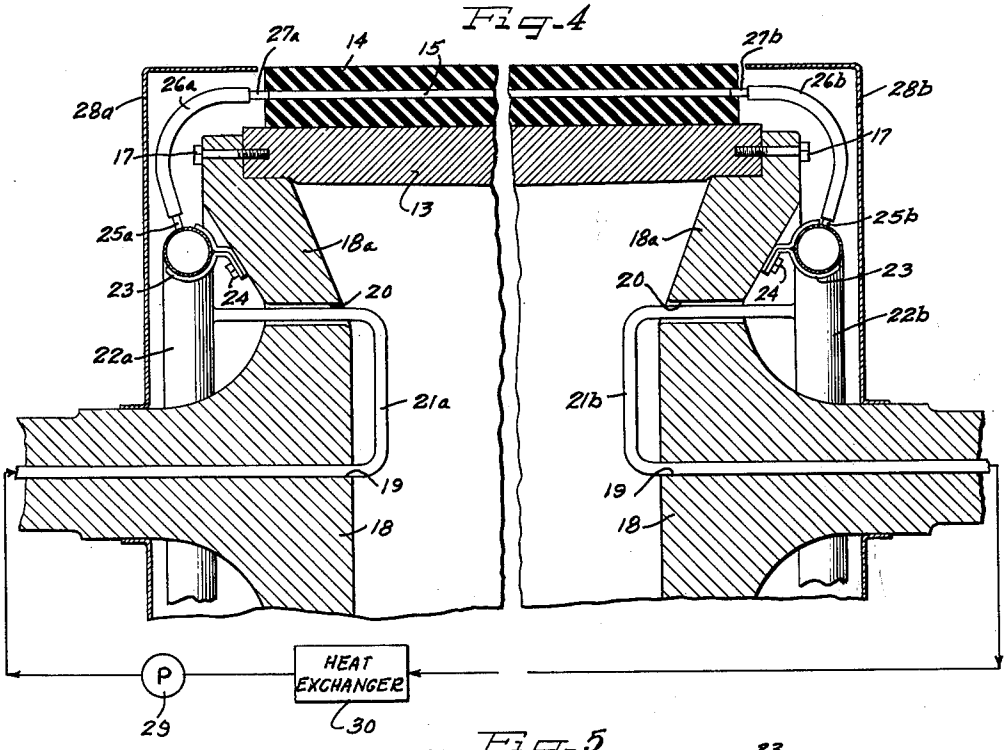
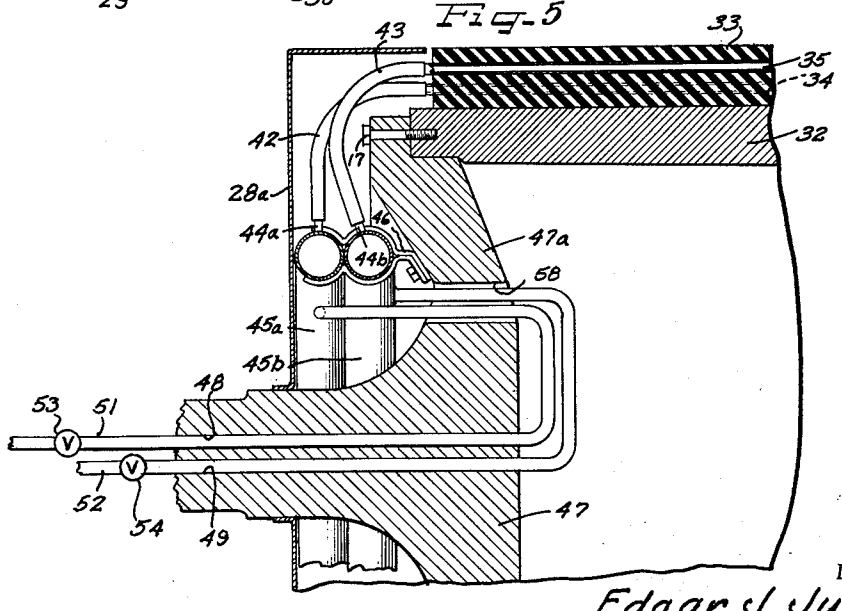


Fig-5



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ROLL STRUCTURE

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The present invention relates broadly to roll structures, and is more particularly concerned with a new and improved roll especially well adapted for use with web materials and having an elastomeric covering thereon provided with coolant passages for the circulation of a heat exchange medium to facilitate heat dissipation during flexure of the elastomeric covering.

It has of course long been known to employ rubber covered rolls in the treatment of web materials exemplified by paper, textiles and the like. In the paper making art, rolls with rubber coverings or jackets are utilized in a press couple whereat there is performed water removal functions and/or improvements in the surface character of the web. Where such treatment is effected in the presence of quantities of water or other cooling materials, and when the rotational speed of the rolls is relatively low, the conventional rubber covering gives generally satisfactory life when applied carefully in accordance with modern techniques.

Recently, however, a number of processes have been developed which require the treatment of web materials with rolls operated at speeds and under other conditions which do not permit sufficiently fast dissipation of the considerable heat generated by flexure of the elastomeric cover or jacket. Illustratively, it has recently been proposed to compact paper in order to improve its strength and physical properties, and for these purposes there is employed rubber covers of substantial radial thicknesses which are severely distorted as the cover passes through the nip of a roll couple. The great amount of cover distortion required for effective exploitation of these processes increases markedly the amount of heat developed within the rubber due to the flexing action. Additionally, and of considerable importance, rubber is a relatively poor conductor of heat, the removal of which is rendered even more difficult by the substantial radial thickness of the covers employed in the compaction and other recently developed techniques. It has accordingly been found that since the heat generated does not have an effective escape path, there is a degradation of the rubber properties and in many circumstances the bond between the cover and supporting shell or core is greatly weakened. As a result, premature failure of the rolls occurs, and if such failures take place suddenly, much equipment damage and possible personnel injury can result.

In an endeavor to provide a solution to the named problems, the prior art long ago provided various circuitry arrangements to direct coolant interiorly of the rolls and cylinders. However, such expedients have not been particularly effective to dissipate heat from the rubber cover during its flexure, and because of the substantial distortion of the rubber cover as it passes through the nip of a roll couple, it has not been practical to employ such circuits within the rubber covering or layer itself.

It is accordingly an important aim of the present invention to provide a new and improved roll structure featuring an elastomeric cover constructed to effectively remove the heat of flexure during operation.

Another object of this invention lies in the provision of a roll comprised of a supporting shell or core and an elastomeric covering secured thereto, the covering having a plurality of axial passages formed therethrough to provide a plurality of coolant circulation paths for

dissipation of the heat developed during deformation of the covering.

A further object of this invention is to provide an elastomeric covering for bonding to the outer diameter of a shell or cylinder, the covering being passaged axially at a plurality of circumferentially spaced locations whereby a heat exchange medium may be circulated through the passages to remove heat generated during flexure of the covering.

Still another object of this invention lies in the provision of a roll structure of the character described, incorporating therein a fluid manifold in communication with the coolant passages and a source of coolant fluid to provide a continuous circulation of coolant from one end to the opposite end of the passages for heat dissipation purposes.

Other objects and advantages of the invention will become more 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 sectional view of a roll couple incorporating a rubber covered roll constructed in accordance with the principles of this invention;

FIGURE 2 is a fragmentary detail sectional view of the roll couple of FIGURE 1 showing one form of passaged elastomeric covering in a more or less exaggerated flexed condition at the roll couple nip;

FIGURE 3 is a fragmentary detail sectional view of another form of roll couple embodying a lower suction roll and a top rubber covered roll provided with a modified arrangement of coolant passages;

FIGURE 4 is a longitudinal vertical sectional view, with parts broken away and with parts taken in elevation, to illustrate a coolant distribution system which may be employed in association with the form of rubber covered roll shown in FIGURES 1 and 2; and

FIGURE 5 is a view similar to FIGURE 4 and showing a coolant distribution system which may be utilized to feed an arrangement of coolant passages taking the form shown in FIGURE 3.

Referring now to the drawings, there is shown in FIGURE 1 a roll couple generally designated by the numeral **10** and comprised of a pair of rolls **11** and **12** defining therebetween a nip N receiving a web W of paper, textiles and the like. The roll couple **10** may be employed at various locations in the course of paper manufacture and subsequent treatments, and as the instant description will bring out in detail, the roll couple **10** could be part of a press section prior to advancement of the web W to a drying section, or could be located downstream of a drying section for use in the compaction of a paper web in order to improve its strength and physical properties, or the couple **10** could be embodied in a paper coating arrangement to act upon a coated web carrying a dried glossy surface thereon. The present invention is directed particularly to a rubber covered roll having coolant passages therein, and with this in mind it will be readily apparent that the environments for such a roll are numerous and that the drawings only illustrate exemplary locations for the novel roll structure.

The lower roll **12** of FIGURE 1 is illustratively indicated as a metal cylinder, although if the covered roll **11** was employed in a press section, it may be desired that the lower roll **12** carry thereon a relatively hard rubber covering. Or, as will be described in connection with FIGURE 3, the lower roll **12** may be a suction roll. In any event, a covered roll **11** whether in a top or bottom position with respect to a relatively non-yieldable roll, or whether used in association with a plain or suction roll, comprises an inner cylindrical shell **13** to which is

bonded or otherwise attached an elastomeric covering **14** provided with a plurality of axially extending and circumferentially spaced coolant passages **15**. Either or both of the rolls **11** and **12** would connect with suitable driving means (not shown), and a conventional approach would be to positively drive the roll **12** from which the roll **11** would obtain its driving force. Of course, helper drives could connect with the top roll **11**.

Present day paper making machines require first that the roll couple operate at substantial speeds, and when employed for such applications as paper compaction, the roll couples further exert relatively high nip loads, which could be of the order of 400 pounds per linear inch of the width of the paper web W. In particular paper making or treating environments, on the other hand, there may be present both high speeds and high nip loads, and whether either or both of these conditions exist, it is apparent that the rubber or elastomeric covering is subjected to substantial flexure or deformation, which gives rise to the generation of substantial amounts of thermal energy.

It was not until relatively recently that elastomeric coverings having a radial thickness of the order or about three inches came into relatively active use, and as was noted hereinabove, when there existed either relatively low machine speeds or sufficient quantities of water or other cooling materials at the nip, heating of the rubber cover or jacket did not pose a particular problem. However, in order to effectively perform paper compaction or other treatments on the web surfaces or on coatings carried by one or both of the web surfaces, it was necessary to increase the radial thickness, and in company with high nip loads, there arose the noted heat dissipation problem. As a result, the rubber properties were degraded, and the bond between the covering and supporting shell or core was weakened, causing premature failure of the rolls and the possibilities of equipment damage and personnel injuries, if such failures occurred suddenly.

A highly effective structural arrangement for dissipating the heat of rubber flexure was briefly noted in connection with FIGURES 1 and 2, and it may be seen therefrom that the passages **15** are uniformly circumferentially spaced and extend generally parallel with the axis of the cylindrical supporting shell **13** to which the exposed rubber covering or jacket **14** is bonded or otherwise attached. The passages **15** can be formed in the covering **14** in various ways, as by locating removable core rods within the vulcanizable rubbery polymer during its molding. The passages **15** are desirably positioned relatively closer to the cover working or exterior surface **14***a* than to inner surface **14***b* since the flexure of the rubber is relatively greater in the outer radial thickness of the cover **14**, and consequently a greater amount of heat is generated in this portion. However, the passages **15** should be a sufficient distance radially inwardly of the surface **14***a* in order not to limit substantially the wall thickness available for regrinding to maintain the working surface **14***a* in the desired condition.

The passages **15** present in cross-section a generally circular configuration, and each passage is sized to a diameter calculated to provide sufficient coolant flow for maximum heat removal effectiveness at minimum pumping power requirements while also avoiding large temperature differentials in the coolant entering and leaving the passages **15**. On the other hand, the passage diameters should be limited so that there is proper rubber flow action at the nip N, and this would be particularly true if the coolant passages were provided by metal tubes in either a single row or a plurality of rows as in FIGURE 3. The diameter of each passage **15** also should be sufficient to prevent closure or blocking as the rubber is compacted or flexed at the nip in the manner of FIGURE 2. As is shown therein in more or less exaggerated condition, the passages **15** along the area of maximum nip pressures are distorted or flattened as at **15***a*, while at opposite sides of the area of maximum nip pressures the passages **15** are compacted to a lesser degree, as indicated at **15***b*. On the other hand, reduced nip pressures at the oncoming and off-running sides of the nip N compress the passages **15** to an even lesser degree, as indicated at **15***c*, while prior to and after application of nip pressures the passages **15** present their normal generally circular configuration in cross-section. As stated, the relative flattening of the passages **15** is indicated as somewhat exaggerated in FIGURE 2, and variations in the passage diameters, rubber hardness and nip loadings will cause differences in the appearance of the passages during movement through the nip N. In any event, the conditions are controlled so that the passages **15** carry therethrough sufficient coolant to dissipate the heat of flexure at the nip N. More particularly, in the embodiments of both FIGURES 2 and 3, the elastomeric coverings **13** and **32** have a high bulk modulus or relatively low volumetric compressibility so that the passages **15** and tubes **34** and **35** therein remain open during flexure of the coverings to permit free flow of coolant therethrough.

An illustrative coolant circulation system is shown in FIGURE 4, and this system can be employed as well with a roll structure wherein the rubber cover is provided with coolant passages in the form of metal tubes in substitution for the bare openings shown. As appears in FIGURE 4, the cylindrical shell **13** supporting the cover **14** is secured at opposite ends by bolt means or the like **17** to radial flange portions **18***a* on journal members **18**. Each journal member **18** is axially bored at **19** and **20** to receive a generally U-shaped coolant pipe **21***a* and **21***b*, the pipe **21***a* providing the supply connection and the pipe **21***b* the discharge connection.

The coolant supply pipe **21***a* connects at one end to an annular supply manifold **22***a*, while the discharge pipe **21***b* is connected to an annular discharge manifold **22***b*. The manifolds **22***a* and **22***b* mount clamping means **23** to attach the manifolds to the journal radial flanges **18***a*, as by screw means **24**. The manifolds **22***a* and **22***b* can be seen to mount a plurality of relatively slender tubes **25***a* and **25***b*, equivalent in number to the number of passages **15** in the rubber cover **14**, and each tube **25***a* and **25***b* receives a flexible connector member **26***a* and **26***b* supporting at their opposite ends a relatively slender tube portion **27***a* and **27***b* partially received in opposite ends of the coolant passages **15**. Flexibility in the connector tubes **26***a* and **26***b* is particularly desirable when the coolant passages **15** are provided by relatively slender metal tubes since there is a change in the radial position of such tubes as they pass through the nip N, and further, since the actual tangential velocity of such tubes changes during their passage through the nip.

The structure described is encased at opposite ends by cover members **28***a* and **28***b* as a safety measure, as well as to improve the appearance and to prevent damage to the manifolds and connecting structure. As is apparent, the journal members **18** would be provided with suitable bearing means, and the coolant supply and discharge tubes **21***a* and **21***b* connect with conventional rotary joints (not shown). As is indicated somewhat diagrammatically in FIGURE 4, coolant is supplied to the pipe or connection **21***a* under action of pump means **29** drawing coolant through heat exchange means **30** connected to the discharge tube **21***b* from the discharge manifold **22***b*. Thereby, a continuous circulation system is provided wherein a coolant such as water carrying heat absorbed from the cover **14** by reason of its flexure is passed from the discharge manifold **22***b* through the tube connection **21***b* and passed through the heat exchange means **30** to effect a temperature reduction therein, prior to return to the supply manifold **22***a* and through the coolant passages **15** in the cover **14**.

It has been noted above that the coolant passages or channels **15** may receive therein metal tubes, and of course, such tubes could be formed to plastics or other materials. An additional modification of the instant in-

vention is shown in FIGURES 3 and 5 in the form of a pair of radially spaced rows of metal tubes providing the coolant passages. Such an arrangement, in association with a suitable control valve system, has as one advantage the attainment of a high order of uniform temperatures throughout the radial thickness of the covering by alternating the coolant flow through the pair of radially spaced rows of coolant tubes.

A rubber covered roll is indicated generally in FIGURE 3 by the numeral **31** and comprises an inner cylindrical shell **32** to which is bonded a rubber covering **33** receiving therewithin a pair of radially spaced rows of tubes **34** and **35**, the tubes **34** in one row and the tubes **35** in another row extending parallel to the axis of the cylindrical shell **32** and being uniformly circumferentially spaced with respect to one another. The tubes **34** and **35** may be seen to be arranged in radially spaced and staggered relation, and the two rows of tubes are desirably uniformly radially spaced with respect to working surface **33***a* and inner surface **33***b* of the elastomeric covering or jacket **33**. As was indicated in connection with FIGURE 2, it is desirable to utilize tubes of a sufficiently large diameter so as to minimize the pumping power required to circulate the fluid and to provide a fluid flow capacity for heat removal without large temperature differences; however, the tube diameters must be limited in order to obtain minimum interference with the rubber flow action in the nip. Additionally, as between the tubes **34** in one row or between the tubes **35** in another row, the circumferential spacing is preferably as close as possible in order to contribute to smooth operation within the nip, although it is further necessary that the tubes be spaced a sufficient distance from one another circumferentially in order to maintain the integrity of the rubber cover and to avoid a plane of weakness which might contribute to premature separation of the cover **33** from the supporting cylindrical shell **32**.

In the arrangement of FIGURE 2 utilizing passages **15**, or in a structure wherein a single row of metal tubes provided the coolant passages, or in the arrangement of FIGURE 3, the attainment of uniform heat removal functions dictates that the passages or tubes in either a single or a plurality of rows be at a uniform radius. The same would of course apply if a pair of rows of passages were provided in substitution for the tubes **34** and **35**, and it is believed to be further apparent that in any arrangement of passages or tubes there can be departures from the axially parallel tube or passage direction. As for example, the tubes or passages could be disclosed in a herringbone pattern arrangement, or a small helix angle could be anticipated to produce good results.

The rubber covered roll **31** in FIGURE 3 provides a roll couple **36** with a lower suction roll **37**, although of course the roll **31** may be employed in association with a lower plain roll **12** as in FIGURE 1, and a pair of rubber covered rolls **31** could be utilized in nip defining relationship. In the arrangement of FIGURE 3, however, the lower suction roll **37** is comprised of a cylindrical shell **38** having a plurality of radially extending and circumferentially spaced openings **39** therethrough. As is conventional, interiorly of the suction roll **37** a pair of sealing strips **40** and **41** carried in suitable mounting means **40***a* and **41***a* define therebetween a suction area A.

The roll couple **36** comprised of a rubber covered roll **31** and suction roll **37** produces highly advantageous results in press applications wherein it is desired to perform water removal functions upon an advancing paper web and/or press felt. However, under particular conditions the quantities of water at a suction press nip may be insufficient to perform a cooling action upon the rubber cover, and as well, a portion of the water is removed by the suction gland of the suction press roll. It can accordingly be appreciated that when the rubber cover is of a substantial radial thickness and relatively high nip loads and relatively high speeds of roll rotation are employed, substantial amounts of heat energy are generated at the nip, producing the likelihood of degradation of the rubber, with the noted eventual breaking of the rubber bond to the supporting inner shell. However, by continuously circulating a coolant fluid axially through the rubber cover, whether by bare passages **15** or tube passages **34** or **35**, the heat produced by rubber flexure is dissipated and markedly increased roll life obtained.

The top rubber covered roll **31** and bottom suction roll **37** in FIGURE 3 define therebetween a nip N–**1**, and it is to be observed from the more or less exaggerated presentation in FIGURE 3 that while the tubes **34** and **35** shift slightly radially under maximum nip pressures, there remains a generally uniform radial and circumferential spacing of the tubes **34** and **35** for effective heat removal. Of course, by provision of the illustrated staggered tube arrangement, a substantially greater amount of cover deformation could take place at the nip N–**1** without there being any interference between the tubes nor an impairment of the rubber flow action in the nip.

The double row of tubes **34** and **35** in FIGURE 3 has the noted advantage of permitting an alternate circulation of coolant through either row of tubes to prevent any possibility of substantial temperature differentials throughout the radial thickness of the cover **33**. As well, it may upon occasion be desired to employ both banks of tubes **34** and **35**, and whether the tubes be alternately or continuously utilized as heat exchange paths, an advantageous arrangement of dual manifolds and valving is provided by the structure of FIGURE 5. As appears therein, the rows or banks of tubes **34** and **35** connect, respectively, with flexible tube means **42** and **43** received upon connecting portions **44***a* and **44***b* on manifolds **45***a* and **45***b* mounted by bracket means **46** connected to radial flange portion **47***a* on journal member **47**. As is appreciated, a journal member is provided at the opposite end of the roll structure, and a dual manifold arrangement is provided thereat.

The journal member **47** is axially passaged at **48** and **49**, and as well at **50**, to receive a pair of generally U-shaped pipe connections **51** and **52** terminating at their ends in the manifolds **45***a* and **45***b*, respectively. The tubular connecting means **51** and **52** mount therein valve means **53** and **54**, and the connections **51** and **52** connect with similar discharge connections at the opposite end of the roll structure of FIGURE 5. As well, pump means and heat exchange means would be employed in the arrangement of FIGURE 5. However, by provision of the dual manifolds and valve means **53** and **54** in the lines **51** and **52**, either row of coolant passages **34** or **35** can alternately or in unison have coolant circulated therethrough, to assure the avoidance of excessively non-uniform temperatures throughout the radial thickness of the elastomeric covering **33**.

It has been noted hereinabove that certain particular variations can be practiced in the arrangements of passages and roll combinations, and it can be appreciated therefrom that other modifications can be accomplished without departing from the novel concepts of this invention.

I claim as my invention:

1. A roll assembly for treatment of paper, textiles and other web materials comprising an inner supporting shell, an outer elastomeric covering attached to said shell and provided with a plurality of axially extending and circumferentially spaced passages, journal means connected to said shell at the opposite ends thereof, an annular manifold mounted by each of said journal means and connected to opposite ends of each of the passages, tubular means extending through each of the journal means and

connected to each of the manifolds, and pump means connected to said tubular means and pumping coolant through the tubular means, manifolds and passages in the covering to dissipate heat generated during flexure of said covering.

2. A roll assembly for treatment of paper, textiles and other web materials comprising an inner supporting shell, an outer elastomeric covering attached to said shell, a plurality of radially spaced rows of axially extending and circumferentially spaced tubes embedded in said covering and providing coolant passages therethrough, journal means connected to said shell at the opposite ends thereof, a pair of annular manifolds mounted by each of said journal means, means connecting one manifold at each end of said shell to opposite ends of one row of said passages, means connecting another manifold at each end of said shell to opposite ends of another row of said passages, tubular means extending through each of the journal means and connected to each of the manifolds, and valve means in each of said tubular means controlling coolant flow through either row of the passages to reduce any temperature differences across radial thickness of said covering.

3. A roll structure for treatment of paper, textiles and other web materials, comprising a cylindrical inner rigid supporting shell, and a web contacting outer elastomeric covering attached to said shell and provided with a plurality of axially extending and circumferentially spaced passages for the flow of coolant therethrough to dissipate heat generated during flexure of said covering, said elastomeric covering being of substantial radial thickness, said passages being embedded in and completely surrounded by said elastomeric covering, and tubes in said passages and defining the walls thereof for conducting the aforesaid flow of coolant.

4. A roll structure for treatment of paper, textiles and other web materials, comprising a generally cylindrical inner rigid supporting shell, and a web contacting outer elastomeric covering attached to said shell and provided with a plurality of groups of axially extending and circumferentially spaced passages for the flow of coolant therethrough to dissipate heat generated during flexure of said covering, said elastomeric covering being of substantial radial thickness, said passages being embedded in and completely surrounded by said elastomeric covering, and said groups of passages being positioned in said elastomeric covering at different radial distances from the centroidal axis of said shell.

5. A roll assembly for the treatment of paper, textiles and other web materials comprising an inner supporting shell, an outer elastomeric covering attached to said shell and provided with a plurality of axially extending and circumferentially spaced passages, journal means connected to said shell at the opposite ends thereof, manifold means mounted by said journal means and connected to the passages, tubular means extending through the journal means and connected to the manifold means, and pump means connected to said tubular means and pumping coolant through the tubular means, manifold means and passages in the covering to dissipate heat generated during flexure of said covering, said elastomeric covering being of substantial radial thickness, said passages being embedded in and completely surrounded by said elastomeric covering.

6. A roll couple for treatment of paper, textiles and other web materials, comprising a pair of rolls in nip defining relationship, one of said rolls including an inner supporting shell, an outer elastomeric covering attached to said shell and provided with a plurality of axially extending and circumferentially spaced passages, journal means connected to said shell at the opposite ends thereof, manifold means mounted by said journal means and connected to the passages, tubular means extending through the journal means and connected to the manifold means, and pump means connected to said tubular means and pumping coolant through the tubular means, manifold means and passages in the covering to dissipate heat generally through flexure of the covering, said elastomeric covering being of substantial radial thickness, and said passages being embedded in and completely surrounded by said elastomeric covering.

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