United States Patent [19]

Maag et al.

[11] **3,834,205**

[45] **Sept. 10, 1974**

[54] **SELECTIVELY INSULATED MILL ROLL**

[75] Inventors: **Gustav A. Maag**, Crestview Hills, Ky.; **John E. Callaham**, Marbrough, Mo.

[73] Assignee: **The Procter & Gamble Company**, Cincinnati, Ohio

[22] Filed: **Dec. 20, 1972**

[21] Appl. No.: **316,809**

[52] **U.S. Cl.** **72/201,** 72/342, 165/90, 65/356

[51] **Int. Cl.** **B21b 27/08**

[58] **Field of Search** 72/200, 201; 65/253–257, 356; 165/89, 90

[56] **References Cited**

UNITED STATES PATENTS

1,382,608	6/1921	Shuman	165/89 X
1,781,378	11/1930	Feeney	165/89
2,531,988	11/1950	Price	165/89
2,849,951	9/1958	Heinrich	165/89 X
2,912,556	11/1959	Hold	165/89 X
3,484,227	12/1969	Martin	65/253 X
3,738,423	6/1973	Fleissner	165/89

Primary Examiner—C. W. Lanham
Assistant Examiner—Donald M. Gurley
Attorney, Agent, or Firm—Thomas J. Slone; John V. Gorman; Richard C. Witte

[57] **ABSTRACT**

An improved mill roll having means for having flowable heat transfer medium circulated therethrough in close proximity to its working surface for effecting temperature control of the working surface in which roll selective insulation is provided to obviate overaffecting non-working portions of the mill roll. The improved mill roll may further comprise rods disposed within its medium-conducting passageways for the purpose of increasing the velocity of medium therethrough for any given rate of medium flow. Such rods may be configured to profile the velocity of medium through the passageways so that areas of the roll subjected to the highest head loads are contacted by the highest velocity medium and vice versa. The improvements reduce the distortion of mill rolls which would otherwise occur due to thermal gradients.

2 Claims, 4 Drawing Figures

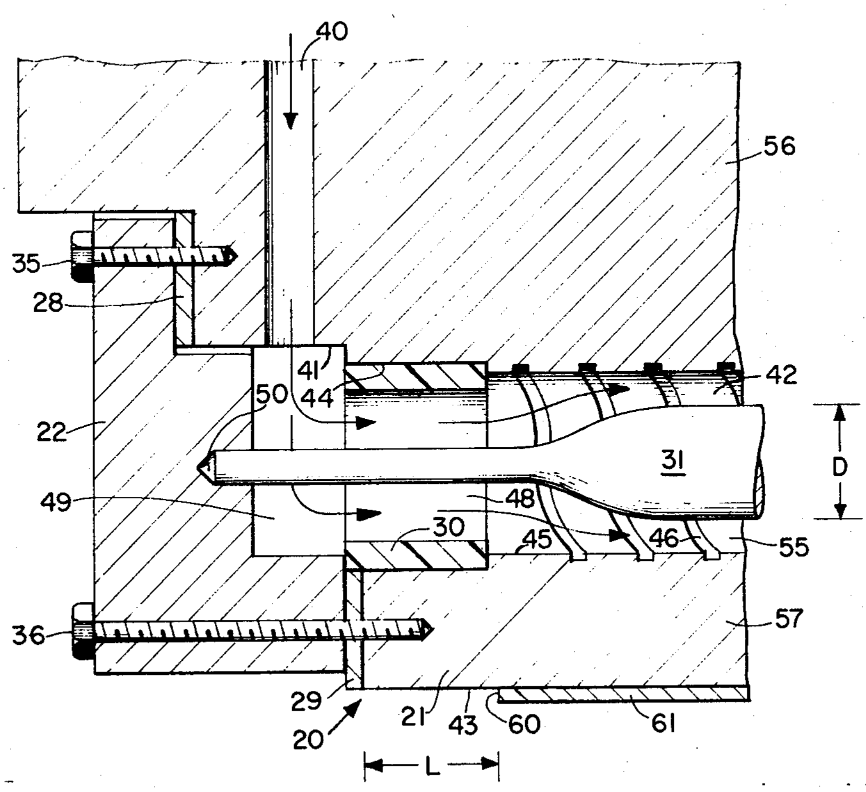


Fig. 1

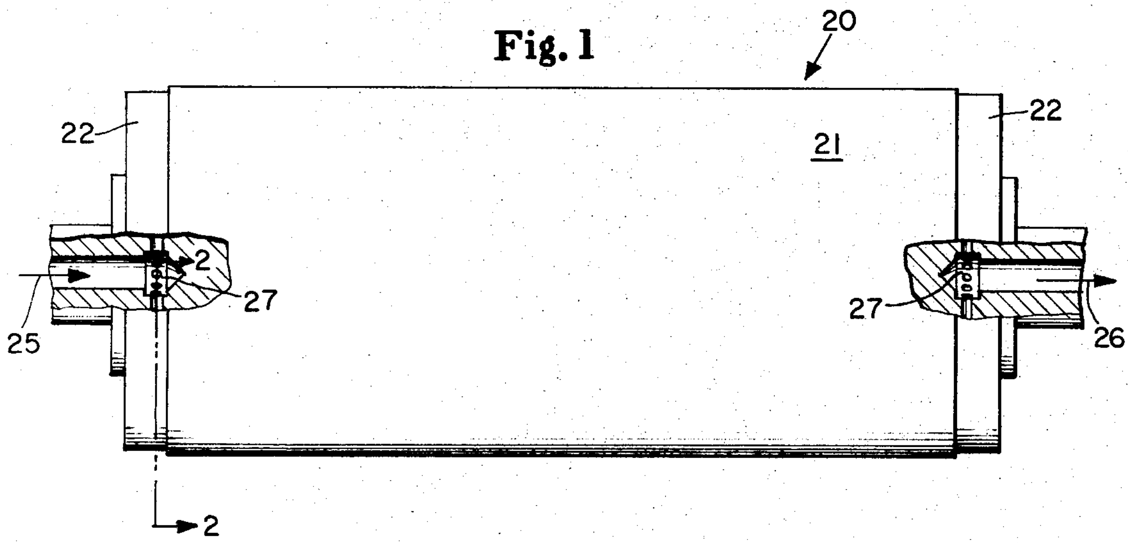

20
22
22
21
2
27
27
25
26
2

Fig. 3

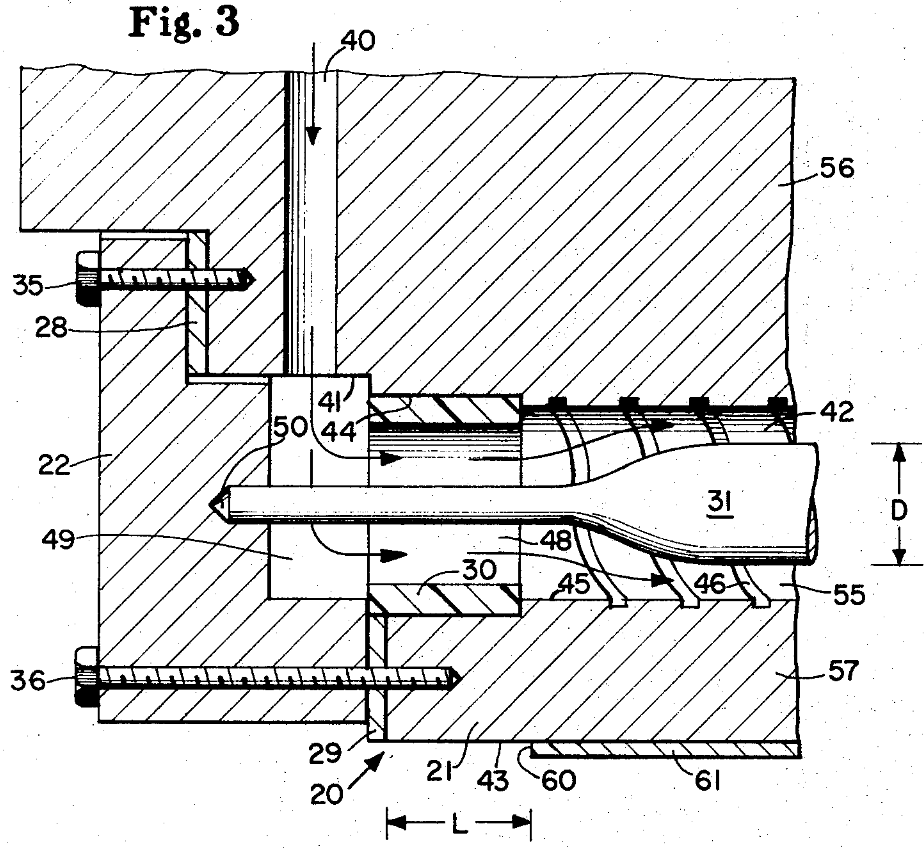

40
56
35
28
41
44
42
50
22
D
31
49
48
30
45
46
55
57
36
29
21
43
60
61
20
L

Fig. 2

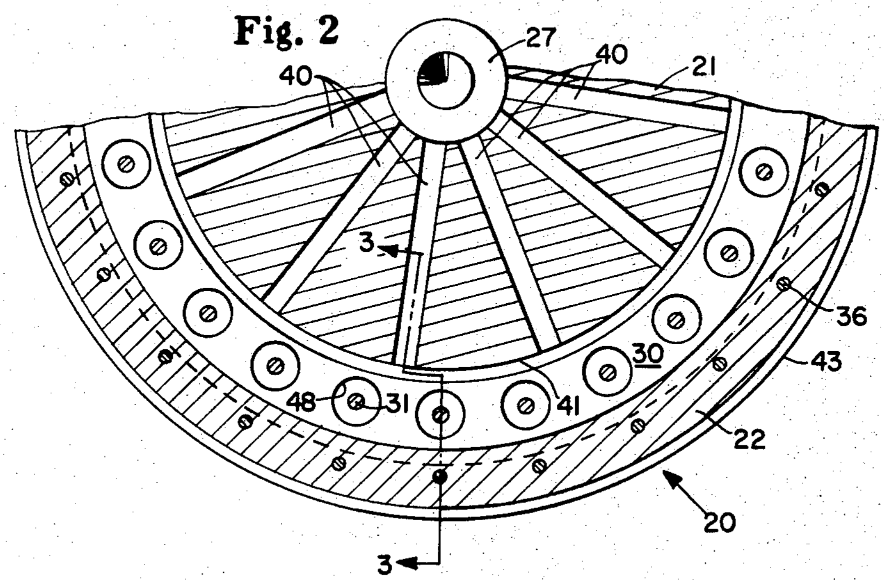
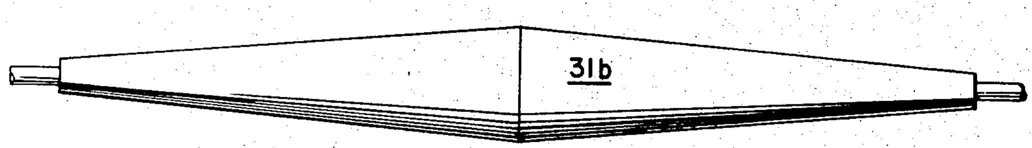


Fig. 4



SELECTIVELY INSULATED MILL ROLL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the commonly assigned and concurrently filed application of Gustav A. Maag and John E. Callaham entitled "IMPROVED MILL ROLL" filed Dec. 20, 1972, Ser. No. 316,807.

FIELD OF THE INVENTION

This invention relates generally to providing mill rolls which are internally cooled or heated by having flowable heat transfer media circulated through them. This invention specifically relates to means for decreasing temperature gradients in and thermally induced distortion of high mill rolls and means for improving the effectiveness of heat transfer media being circulated therethrough.

BACKGROUND OF THE INVENTION

Ideally, mill rolls used for rolling sheet or web type products such as paper, metals or dough have true, right circular cylindrical working surfaces so that nips formed between adjacent parallel mill rolls are of uniform height throughout the axial length of the working surfaces of the mill rolls. Unless the rolls are distorted, web type products issuing from such nips are of uniform thickness throughout their entire widths. Such uniform-height nips are ideal also for milling, grinding, or comminuting and the like because of the resulting uniformity of action on materials being milled by the mill rolls throughout the lengths of such nips.

Mill roll applications commonly require the working surface of each roll which contacts process stream materials to be maintained isothermally at a predetermined temperature or within a predetermined temperature range because of temperature limitations of the process stream materials. To effect such temperature control, some mill rolls must be heated and others cooled. For simplicity, the present invention is hereinafter described as applied to cooling mill rolls. However, it is not intended to thereby exclude heated mill rolls from the scope of the invention.

It is basic, of course, that to maintain a heated surface at a constant temperature, heat must be removed therefrom at the same rate heat is applied thereto or generated thereon. Areas of high heat load must have heat removed proportionally faster than areas of lower heat load to maintain all of the areas at a uniform temperature.

In internally cooled mill rolls, heat is removed primarily be establishing conductive heat flux from the friction heated working surface to a zone of lower temperature. Circulating coolant provides the zone of lower temperature through the transfer of heat to the coolant from the internal surfaces of the mill roll which the coolant contacts. Heat transfer to such a coolant is directly related to the velocity of the coolant.

In actual practice, mill rolls generally do not have isothermal working surfaces. Such mill rolls are distorted from their ideal cylindrical shape by thermally induced stresses.

Axial thermal gradients on mill rolls commonly result from overcooling unheated portions of them or from the asymmetrical generation of heat by the milling or rolling action along the length of a nip formed between adjacent rolls. For instance, it is not uncommon to confine milling to a centrally disposed working portion of the cylindrical surface of a mill roll, which portion extends axially intermediate non-working portions of the cylindrical surface of the mill roll. Internally cooling such a mill roll by passing coolant through axially extending passageways subjacent its entire cylindrical surface commonly results in overcooling the unheated end portions of the roll intermediate the non-working surfaces and the subjacent passageways. Such overcooling distorts mill rolls which distortion compromises the constant-clearance integrity of nips formed therebetween. That is, mill rolls which are machined to have right circular cylindrical working surfaces and which, when operated, have cool ends, tend to be somewhat barrel-shaped with the ends having smaller diameters than their middles. Thus, adjacent non-isothermal mill rolls having overcooled ends tend to form hour-glass shaped nips.

The prior art discloses a variety of approaches for controlling the temperature of the working surfaces of mill rolls and for reducing thermally induced distortions of mill rolls. Representative prior art U.S. Pat. Nos. include 530,094 issued Dec. 4, 1894 to Stewart A. Davis, 626,847 issued June 13, 1899 to William M. Theobald, 737,571 issued Sept. 1, 1903 to Charles W. Bray, 1,392,626 issued Oct. 4, 1921 to Walter Cox, and 2,793,006 issued May 21, 1957 to LeRoy Eaby. However, none of these approaches has solved the problems associated with thermally distorted mill rolls in the manner nor to the degree of the instant invention.

SUMMARY OF THE INVENTION

The nature and substance of the invention will be more readily appreciated after giving consideration to its major aims and purposes. The principal objects of the invention are recited in the ensuing paragraphs in order to provide a better appreciation of its important aspects prior to describing the details of a preferred embodiment in later portions of this description.

A major object of the invention is providing an improved, internally cooled mill roll assembly having selectively insulated non-working end portions so that heat flow within the non-working end portions is substantially obviated whereby over-cooling of the end portions is substantially precluded.

Another object of the invention is providing an improved, selectively insulated, internally cooled mill roll assembly wherein the efficiency of the circulating coolant, for any given rate of coolant flow, is improved by defining coolant passageways having high ratios of heat transfer surface areas to their cross sectional areas, as compared to tubular passageways having circular cross sections, whereby the coolant is forced to flow faster across the heat transfer surface areas.

Yet another object of the present invention is providing an improved, selectively insulated, internally cooled mill roll assembly wherein the relationship between coolant velocity and its heat transfer coefficient is applied, through providing coolant passageways of non-uniform cross sectional areas, to achieve higher heat flux in zones of higher heat load and vice versa so that an asymmetrically heated working surface can be maintained at a substantially isothermal condition.

These and other objects are achieved by providing an improved mill roll assembly having axially extending tubular passageways disposed subjacent the cylindrical surface of the mill roll, and which assembly further includes means for conducting coolant into the mill roll assembly, through the passageways, and for conducting the coolant from the mill roll. The improved mill roll assembly includes selectively insulating non-working end portions of the assembly disposed intermediate the outside of the mill roll assembly and the subjacent portions of the coolant passageways so that heat flow within the end portions is substantially obviated. The improved mill roll may further comprise means within the passageways for improving the heat transfer coefficient between the heat transfer medium and the mill roll assembly within the passageways. Such means for improving the heat transfer coefficient includes means for establishing greater velocity of the coolant across the heat transfer surface areas of the passageways for any given rate of coolant flow as compared to simple tubular passageways. Also, the improved mill roll assembly may include coolant passageways of non-uniform cross sectional areas so that zones of high heat load may be cooled by relatively high velocity coolant and vice versa whereby an asymmetrically heated working surface can be maintained at a substantially isothermal condition.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarded as forming the present invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a fragmentary, partially cut away longitudinal view of a mill roll assembly embodying the instant invention.

FIG. 2 is an enlarged scale, fragmentary cross-sectional view of the mill roll assembly of FIG. 1 taken along line 2—2 thereof.

FIG. 3 is a fragmentary, enlarged scale, cross-sectional view of the mill roll assembly of FIGS. 1 and 2 taken along line 3—3 of FIG. 2.

FIG. 4 is a fragmentary longitudinal view of an alternate embodiment cylindrical member which is suitable for transforming tubular coolant passageways into annular conduits of non-uniform cross sectional areas in accordance with the instant invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Mill roll **20**, FIG. **1**, is a preferred embodiment of the present invention which comprises cylinder **21** and two closure collars **22**.

Cylinder **21**, FIG. **1**, has integral hollow journals for the purpose of providing means for introducing coolant and removing coolant, as indicated by arrows **25, 26,** while being rotated. Each hollow journal communicates with an integral coolant manifold **27.** Referring now to FIGS. **2** and **3**, mill roll **20** further comprises gaskets **28, 29,** two bushings **30,** and rods or tubes **31.** As indicated in FIG. **3** which shows only one of substantially identical ends of mill roll **20**, the assembly is held together by two rings of circumferentially spaced bolts **35, 36** at each end.

Cylinder **21**, FIG. **1–3**, is substantially solid. Each end of cylinder **21** is provided with a plurality of radially extending holes **40** intermediate manifold **27** and shoulder **41.** Cylinder **21** also has a plurality of circumferentially spaced, parallel, axially extending, cylindrical passageways **42** provided subjacent its cylindrical surface **43** and parallel thereto. Each end of cylinder **21**, FIG. **3**, has an axially extending, toroidal-shape channel **44** formed in it to interconnect adjacent ends of all passageways **42** and to receive bushing **30.** The wall **45** of each passageway **42** has a spiral groove **46** (a quasi female thread) formed in it for a purpose to be described hereinafter.

Each bushing **30**, one of which is shown in FIG. **3**, is a toroid having a rectangular cross section. In the preferred embodiment of the present invention, bushings **30** are dimensioned to provide press fits in channels **44.** Each bushing **30** is provided with a plurality of axially extending holes **48** which are spaced for concentric registration with passageways **42** when bushing **30** is pressed into channel **44** as shown in FIG. **3.** Bushings **30** are fabricated from material having a relatively low coefficient of thermal conductivity so that when they are pressed into channels **44,** they insulate the end portions of cylinder **21** from circulating coolant.

Each closure collar **22**, only one of which is shown in FIG. **3**, is configured so that, when bolted to cylinder **21** as shown in FIG. **3**, it is thermally isolated from cylinder **21** by gaskets **28, 29.** Each closure collar **22** has a counterbore **49** to interconnect, when bolted to cylinder **21**, holes **40** with passageways **42** via holes **48** in bushing **30.** Further, each closure collar **22** is provided with a plurality of sockets **50** which are concentrically disposed with respect to passageways **42** and holes **48** when mill roll **20** is assembled. Sockets **50** are provided to support rods **31** as shown in FIG. **3.**

Rods **31** are cylindrical members, one of which is installed in each passageway **42** to transform the passageways **42** into annular conduits **55.**

When assembled as indicated in FIG. **3**, mill roll **20** comprises a solid core portion **56** which is essentially enveloped by a sheath of coolant in holes **40**, counterbores **49**, and conduits **55** when coolant is introduced through one journal and removed through the oppositely disposed journal. Thus, when coolant is passed through mill roll **20** at a velocity great enough to incur only a nominal temperature rise, core portion **46** is a virtually isothermal strongback for the portion of cylinder **21** disposed radially outwardly from the core, which portion is hereby designated the shell portion **57** of cylinder **21.** The virtually isothermal solid core resists deformation of the working surface **43** of cylinder **21** which would otherwise be induced by thermal gradients in the shell portion of the cylinder or by mechanical stresses. That is, the strongback resists straining of the shell portion **57** of cylinder **21** which would otherwise be precipitated by thermal or mechanical stresses.

Referring again to FIG. **3**, a groove **46** is provided in each passageway **42** for the purpose of stimulating and sustaining turbulent flow throughout the length of each passageway so that the heat transfer coefficient between flowing coolant and cylinder **21** is substantially constant. Although grooves **46** in the preferred embodiment of the present invention are spiral, spiral grooves are but one means of promoting turbulent flow.

Rods **31**, FIGS. **2, 3**, are provided to improve the heat transfer coefficient of circulating coolant. That is, for any given coolant flow rate, coolant must flow faster through conduits **55** than through passageways **42** without rods 31 disposed in them. The relative velocity increase precipitates a commensurate increase in the heat transfer coefficient. Another way of looking at this is that the heat transfer coefficient between coolant and walls **45** is directly related to the ratio of the heat transfer area of the wall **45** of a passageway **42** or conduit **55** to the cross sectional area of the coolant flowing therethrough.

Each rod **31**, FIG. **3**, has a uniform diameter D over virtually its entire length so that the velocity of coolant is substantially uniform throughout the length of each conduit **55**. In combination with grooves **46**, rods **31** are provided to stimulate and sustain turbulent flow at relatively high constant velocity through conduits **55**. Therefore, the heat transfer coefficient between the coolant and wall **45** of cylinder **21** is relatively high and uniform throughout the length of conduits **55**. Referring again to FIG. **3**, the edge **60** of web **61** is axially spaced distance L from the end of the cylindrical surface **43** of cylinder **21**. This reflects the common practice of using less than the full width of a mill roll as a working surface to effect milling and the like. Frictional heat is generated on the working surface of cylinder **21** subjacent web **61** but not on the non-working end portions of its cylindrical surface. Thus, if heat could flow axially through the end portion of cylinder **21** subjacent its non-working surfaces, axial temperature gradients would develop. However, because bushings **30** and gaskets **29** are composed of insulating material to substantially preclude such heat flow, such axial temperture gradients are substantially obviated. Gaskets **28**, also composed of insulating material, further obviate heat paths from the ends of cylinder **21** through closure collars **22**. Because heat flow through the ends of the shell portion **57** of cylinder **21** is substantially precluded, the ends will operate at nearly the same temperature as the rest of the shell portion **57** of cylinder **21**. By thus virtually eliminating axial thermal gradients, thermal distortion of mill roll **20** is practically eliminated.

Rod **31*b***, FIG. **4**, is yet another means for custom tailoring the heat transfer coefficient between circulating coolant and a mill roll. The cross sectional area of rod **31*b*** is varied to satisfy asymmetrical mill roll heat loads by virtue of the relationship between coolant velocity and the heat transfer coefficient. For instance, were rods 31b to replace rods **31** in mill roll **20, FIG. 3**, the coolant velocity would rise from the inlet end of conduit **55** to its middle and then fall from the middle to the outlet end of conduit **55.** Such a velocity profile would yield a maximum heat transfer coefficient at the middle of mill roll **20.** For mill rolls which are subjected to higher heat loads at their centers than their ends, rods **31*b*** provide means for removing the heat so that a substantially isothermal working surface can be maintained. Within the range that velocity changes can affect the heat transfer coefficient, the profile of rod **31*b*** can be tailored to accommodate the above described and other asymmetrical heat load profiles.

Although the preferred embodiment of the present invention has been described as including rods **31**, FIGS. **2, 3**, to effect improved cooling through increased or varied coolant velocity, substantially improved cooling uniformity and effectiveness are achieved through simply selectively insulating the unheated ends of cylinder **21** as described hereinbefore.

While particular embodiments of the present invention have been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention. It is intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. A mill roll assembly comprising a substantially solid cylinder, a pair of annular bushings, a pair of closure collars, a plurality of annular gaskets, and means for sealingly securing said collars and gaskets to said cylinder,

said cylinder comprising a core portion having a right circular cylindrical surface, and a shoulder of reduced diameter on each end of said cylinder, said cylinder also having an axially extending manifold disposed centrally in each end, a plurality of holes in each end which holes extend substantially radially intermediate each said manifold and the adjacent said shoulder, a longitudinally extending annular channel disposed in each end of said cylinder radially outwardly from said shoulders, and a plurality of parallel, circumferentially spaced passageways disposed subjacent said cylindrical surface and extending longitudinally of said cylinder intermediate said channels,

said cylindrical surface comprising a cylindrical working zone intermediate cylindrical nonworking end zones,

said cylinder further comprising an annular-shape end portion defined intermediate each said nonworking end zone and the radially outwardly disposed surface of the adjacent said channel,

said bushings being configured to be press fit into said channels and provided with a longitudinally extending hole in registration with each said passageway so that coolant cannot flow through said channels except through said holes in said bushings,

said collars and said gaskets being configured to define annular manifolds for sealingly interconnecting said radial holes with said passageays through said bushings when sealingly secured with said means to said cylinder adjacent said shoulders whereby coolant can be conducted through said assembly via said manifolds, said holes, and said passageways to virtually sheath the core portion of said cylinder disposed radially inwardly of said passageways and to remove heat from the cylinder which heat is generated on said working surface during milling, said collars and said gaskets being sealingly secured to said cylinder by said means with one of said gaskets disposed intermediate each said annular-shape end portion of said cylinder and the adjacent said collar to insulate said end portions from said collars, said bushings and said gaskets being further configured to also insulate said end portions from coolant being circulated through said assembly,

said gaskets being composed of material of sufficiently low thermal conductivity to virtually preclude longitudinal heat flow through said annular-shape end portions of said cylinder, and

said bushings being composed of material of sufficiently low thermal conductivity to substantially preclude radial heat flow from said annular-shape end portions of said cylinder,

whereby said annular-shape end portions of said cylinder are not overaffected by coolant being conducted through said assembly for the purpose of controlling the temperature of said working surface.

2. The mill roll assembly of claim **1** wherein the surfaces defining said passageways are provided with spiral grooves of sufficient size and pitch to stimulate and sustain turbulent flow of coolant throughout the length of each said passageway.

* * * * *