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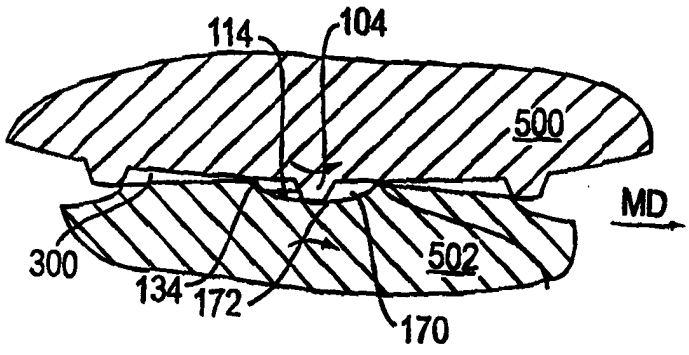
(54) Title: METHOD AND APPARATUS FOR EMBOSSING CONTINUOUS PAPER WEB

(57) Abstract

Method and apparatus are disclosed for embossing paper webs (200) using opposing embossing and imprinting rolls (500, 502). In the preferred embodiment, the embossing roll (500) and the imprinting roll (502) have differing diametrical dimensions, thereby producing differing velocities through the nip, causing the embossing projections (104), of the embossing roll (500) to sweep through modified imprint cells (120) of the imprint roll (502), thereby affecting an automatic sweeping of accumulated debris (170) from the imprinting cell (120) as the embossing operation takes place.



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# METHOD AND APPARATUS FOR EMBOSSING CONTINUOUS PAPER WEB

## BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for embossing a pattern upon a continuous web of paper, as the web passes between a pair of opposed metal embossing rolls.

1) Field Of The Invention:

This invention relates to method and apparatus for embossing a pattern upon a continuous web of paper, typically used for paper napkins, toilet tissue, and the like, by passing the web between a pair of matched pattern embossing rolls. Typically, in such apparatus and methods, as the web passes through the nip, between the rolls, debris is forced out of the paper, and tends to stick to the embossing roll surfaces, shortening roll life.

By the invention, as disclosed herein, an improvement in such apparatus and method is taught, whereby the resulting debris residue is inherently cleaned from the apparatus simultaneously, as the web of paper is embossed.

2) Description Of The Prior Art:

Embossing rolls are cylindrical rolls, mounted tangentially parallel and spaced apart to form a nip, therebetween, at the line of roll tangency.

Prior art rolls, are typically of the same diameter, and are rotated inward towards the nip at the same rotational speed. At a point in the nip, equidistant from the center of each roll, embossing projections, extending outward from the embossing roll, and concave imprinting cells, within the opposing imprint roll, move at the same linear speed. The embossing roll, with its embossing projections radially extending from the outer surface, is rotated in timed relationship, with the opposing imprint roll, whereby the embossing projections mesh with the embossing imprint cells, on the opposing imprint roll.

The paper web, as it passes through the nip, is tamped into the imprint cells, by the embossing projections. Tamping the web into the cells, by the tightly fitting projections, embosses a pattern into the web. Embossing paper webs, using a pair of mated steel rolls, is a production technique used to manufacture toilet tissue, paper hankies, paper napkins, paper towels, and like products.

The paper webs, now being received by converters, for embossing, are generally made from recycled paper and inherently contain adherent debris. The debris in the paper generally comprises a mixture of cellulose, latex, and tar. The cellulose, latex, and tar is adherent and sticky.

The presence of such adherent debris, in the recycled paper webs, shortens roll life because of an inherent debris build-up, which occurs within the imprint cells during the embossing operation.

Machine operational speeds are becoming faster, and paper web widths have increased beyond those addressed by prior art. New problems have begun to occur with the increasing speed of paper web embossing machines employing mated steel embossing rolls and using recycled paper webs with their adherent debris content.

When an imprint embossing cell fills with debris, there is no longer clearance between the male embossing projection, and the imprint cell. Thus the web is no longer tamped into the imprint cell, as desired, but is pounded between the male embossing projection and the debris build-up within the imprint cell. The pounding of the embossing projections against the hard debris accumulated within the cell, peens the embossing projections. The peened embossing projections, act to widen the cells as the peened embossing projections pound against the cell walls. A typical symptom of debris build-up, is tearing of the web during the embossing operation; another symptom of debris build up, is poor definition of the pattern embossed into the paper. When the web tears, or the pattern is no longer sharp, the mated rolls must be replaced.

One common, prior art, method used to extend roll life is to merely increase the clearance between the embossing projection and the imprint cell. Thus the embossing projection, and the matching cell is typically etched to create more clearance whereby the cell

may hold a greater amount of debris before replacement of the rolls becomes necessary.

Periodically scrubbing the imprint cells to remove the adherent debris, has also been tried in the prior art. However, the debris becomes as hard as glass as a result of the hammering of the embossing projection into the imprint cell and has proven difficult to remove.

Brush rolls, mounted tangent to the imprint rolls, and bearing against the imprint cells, have also been tried in the prior art to continuously clean the imprint cells during the embossing operation.

3) Related References:

A prior art patent search has been conducted which resulted in the discovery of the following related references:

a) Methods for embossing paper, to form napkins, paper towels, and toilet tissue is taught in Walton, U.S. Pat. No. 2,729,267, Walton discloses an embossing device wherein a decorative embossed pattern is formed about the periphery of a paper product, such as a napkin, thereby leaving a smooth center area.

b) An embossing machine consisting of an embossing roll and a matching imprint roll is disclosed in Palmer Et Al. U.S. Pat. No. 3,323,983. Palmer addresses the problem of adherent debris build up by providing the imprint roll with open ended circumferential grooves, into which the embossable paper is pressed by male projections on the embossing roll. The open ended grooves permit accumulated debris therein to fall from of the grooves as the imprint roll, upon which the grooves are carried, rotates, during the embossing operation. Alternatively, Palmer teaches the use of a system of brushes, attached to the embossing roll, to clean the grooves of the imprint roll as the rolls rotatingly separate.

c) Nystrand, U.S. Pat. No. 3,867,872, teaches use of a wheel and anvil, to bond and emboss paper products.

d) Schulz, U.S. Pat. No. 4,927,588, discloses embossing a pattern into a multi-ply, continuous paper web, by using a pair of opposed embossing rolls. After embossing a multi-ply web, the plies are separated from one another and longitudinally displaced, relative to one another, and recombined into a multi-ply sheet with the embossments out of register with one

another. The device as taught in Schulz incorporates a steel embossing roll, and a rubber roll as the platen.

e) Houk, U.S. Pat. No. 5,158,523, teaches use of a steel embossing roll, as in Schulz, U.S. Pat. No. 4,927,588, rollingly engaging a matching imprint roll having a resilient, impressionable surface and forming a nip therebetween. Projections, in the form of truncated pyramids, on the perimeter of the embossing roll extend outwardly therefrom and imprintingly engage the impressionable surface of the imprint roll. A web passing through the nip, between the embossing roll and the imprint roll, is embossed as the pattern of truncated rectangular pyramids is forced into the impressionable surface of the imprint roll.

In an alternate embodiment, Houk teaches a steel, non-impressionable, imprint roll having a plurality of pyramidal cavities machined into the roll surface wherein he truncated rectangular pyramids, on the embossing roll, tamp the web into the pyramidal cavities at the nip.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method and apparatus by which the adherent web debris is continuously removed from the imprint cells during an embossing operation.

It is an object of this invention, to use the wiping and stretching properties of embossable paper, to sweep the adherent debris, found in recycled paper, out of the imprint cell, as the web is being embossed.

It is an object of the invention to change the shape of the imprint cell, so that adherent debris is swept out of the imprint cell, by lengthening the imprint cell, in the machine direction.

It is an object of the invention to emboss a pattern by forming the web, between the side walls and the bottom of a modified imprint cell, and the embossing projections.

It is an object of the invention to increase productivity of a web embossing machine, by lessening the down time currently required for cleaning and/or replacing rolls.

It is an object of the invention to change the embossing technology, to emboss, while

sweeping a projection through the imprint cell, rather than by tamping the paper to be embossed, into the imprint cell, by the projection.

It is an object of the invention to rotate the embossing roll and the imprint roll, such that there is a surface speed differential between the imprint cell, and embossing projection, meshing at the nip.

It is an object of the invention, to rotate both the embossing roll and the imprint roll, while meshing, at a different linear speed, as measured at one point on the embossing projection at mesh, and measured at a second point on the imprint cell, at mesh.

It is an object of the invention, to sweep debris out of the imprint cell, by making one embossing roll of a smaller diameter than its opposed embossing roll.

It is an object of the invention, to rotate opposed embossing rolls of different diameters, towards the nip, creating a differential speed at the nip between the imprint cell, and the male embossing projection.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of an embossing device suitable for embodying the present invention having two parent rolls, a web, a matched pair of embossing rolls, and a finished roll.

FIG. 2 is a partial perspective of an embossing device for embodying the present invention.

FIG. 3 is a partial perspective of a male embossing roll and a matching female imprint roll, one mounted above the other.

FIG. 4 is a partial sectional view, in elevation, showing a typical prior art male and female embossing roll combination, one mounted one above the other.

FIG. 5 is a partial sectional view, similar to Fig. 4, illustrating the accumulation of debris experienced in prior art apparatus of the type illustrated in Fig. 4.

FIG. 6 is a partial sectional view, similar to Figs. 4 and 5, generally illustrating a modified imprint cell in accord with the present invention.

FIG. 7 is an elevational view looking into the nip of a pair of embossing rolls suitable

for embodying the present invention.

FIG. 8 a, b and c are schematics showing the movement of debris out of the modified imprint cell through one embossing cycle, with a small diameter male embossing roll.

FIG. 9 a, b, and c are schematics, similar to Fig. 9, showing the movement of debris out of the modified imprint cell through one embossing cycle, with a large diameter male embossing roll.

FIG. 10 is a distortion diagram from which the dimensions and configuration of the modified imprint cell, in accord with the present invention, are determined.

## DETAILED DESCRIPTION OF THE INVENTION

It is to be noted that in describing the present invention herein the embossable paper web, as illustrated in Figs. 1 through 4, is not shown all figures, in order to simplify the illustrations and the disclosure. Even though the embossable paper web is not illustrated in the said figures, one skilled in the art of manufacturing such products will readily understand the principles and operation of the herein disclosed and claimed invention.

FIG. 1 presents a schematic of a machine 100 for embossing a pattern into a continuous paper web 200. Web 200 is typically formed of two continuous sheets of embossable paper 150 and 152 supplied upon parent feed rolls 400 and 402. Continuous sheets 150 and 152 are fed, in an overlapping relationship, into nip 300 between rotating male embossing roll 500 and female imprint roll 502. Rolls 500 and 502 are mounted parallel to and one above the other, in meshing relationship and are rotated inward towards nip 300 in the machine direction MD thereby carrying the resulting composite web 200 through nip 300 and onto finished roll 600.

Referring additionally to Figs. 2 and 3, embossing roll 500 is provided with a pattern of radially extending male embossing projections 104 in matched relation to a pattern of radially inward extending female imprint cells 120 upon imprint roll 502. As the embossable paper sheets 150 and 152 are drawn into and through nip 300, the interaction of embossing projections 104 and imprint cells 120 emboss a decorative pattern 202 upon the composite web 200. Embossed pattern 202 may serve one of two functions or both. First the embossed

pattern 202 may function to "knit" the two separate sheets 150 and 152 together and/or may also serve to provide a decorative pattern within the finished composite web 200.

Referring now to Fig. 4 an expanded cross sectional view is illustrated of a typical Prior Art embossing roll 500 and imprinting roll 502, in meshing engagement, at nip 300 and rotating such as to advance web 200 in the machine direction MD. Male projection 104 generally comprises end walls 106 and 108 and bottom surface 110. Imprint cell 120 generally comprises a matching U-shaped, concave, indentation having side surfaces 122 and 124, and bottom surface 126. Surface 128 and surface 130 form the top of cell 120.

Typically as sheets 150 and 152, forming web 200, are fed into nip 300 between rolls 500 and 502 and pass therethrough, movement of projection 104 into and out of cell 120, causes web 200 to be tamped into cell 120 thereby embossing decorative pattern 202, into the composite 200. Referring additionally to FIG. 5, the typical Prior Art build-up of debris 700 that is released from web 200 during tamping and collecting within cell 120 over a period of time is illustrated. The amount of debris collected within cell 120 continues to increase with time and, by the tamping action of the embossing roll projections 104 is continuously compacted at the bottom of cell 120. As the accumulation of debris increases and continues to be compacted the working depth of cell 120 continuously decreases and projections 104 begin to impact an ever growing, hard, compact surface created by the compacted debris which eventually results in damage to projections 104 unless the machine is stopped and the compacted debris removed from cells 120.

Fig. 6 presents a view similar to Fig. 4 wherein an improved imprint cell 170 embodying the present invention is generally illustrated. Prior Art cell end walls 122 and 124, and bottom surface 126 have been reconfigured to form a smooth, continuous, concave, generally elliptical surface 172 extending from cell top surface 128 to opposite top surface 130. The lateral configuration of the cell 170, in the machine's cross direction CD, is unchanged and continues to comprise generally radially extending, planar, side walls having a CD dimension so as to accommodate the CD dimension of projection 104.

In operation, projection 104 not only penetrates cell 170, thereby embossing web 200 as it passes between rolls 500 and 502, but also, in accord with the present invention, sweeps

across elliptical surface 172 from cell top surface 128 to opposite top surface 130 thereby causing projection 104, and the embossed portion of web 200, to push any accumulated debris out of the cell ahead of projection 104. Thus there must be relative movement between projection 104 and elliptical surface 172 as they pass, in meshed relation, through nip 300. Therefore, if rolls 500 and 502, have equal diameters they must rotate at different rotational speeds to produce the required sweeping movement of embossing projection 104 through imprint cell 170. Alternatively, and most preferred, rolls 500 and 502 may by of different diameters as illustrated in Fig. 7, and may also rotate at the same or different rotational speed.

The difference in linear speed, between the male embossing roll and its opposed female embossing roll as they pass through nip 300, creates the desired sweeping action, at the line of embossing, i.e. the line of tangency between the two rolls. The sweeping motion, between projection 104 and cell 170, cleans out debris from the imprint cell. The meshing action of projection 104 with cell 170 also simultaneously embosses the web, on the side wall of imprint cell 170, and the bottom surface 172 of the imprint cell, rather than tamping the web between the walls of the imprint cell 120, and the male projection 104, as in the Prior Art. The Prior Art tamping causes the build up and hardening of debris within the imprint cell, which the sweeping motion of the present invention prevents. Herein the sweeping action of embossing projection 104 through imprint cell 170 is referred to as "sweep". Sweep is thus defined as the difference in velocity between a point on the tip of the male embossing projection 104, and a point in the female imprint cell 170, measured at the nip.

FIG. 7 shows an embossing roll 500 and an imprint roll 502 having differing diameters as measured across points 510 and 512, and points 522 and 524 respectively, whereby embossing roll 500 has a large diameter 530 and imprint roll 502 has a smaller diameter 532.

Referring now to Fig. 8. Figs. 8a, 8b, and 8c illustrate an embodiment of the present invention wherein the male embossing roll 500 is smaller in diameter than the female imprint roll 502. In such an embodiment the larger imprint roll 502 is moving faster than the smaller embossing roll 500. In Fig 8a, embossing projection 104 is shown as it first enters cell 170 at

the cell's leading edge 132. Debris 114 is shown as having collected in the bottom of cell 170. Since imprint roll 502 is moving faster than embossing roll 500, cell 170 effectively "sweeps past" projection 104 as the meshing embossing projection 104 and imprint cell 170 advance along the machine direction MD and through nip 300 thereby causing embossing projection 104 to not only emboss the paper web (not shown) therebetween but to also sweep through cell 170. As embossing projection 104 sweeps through cell 170, from right to left, as viewed in Fig. 8b, the collected debris 114, within cell 170, is swept or pushed along the floor 172 of cell 170 ahead of projection 104. As projection 104 exits cell 170, at the cells trailing edge 134, the accumulated debris 114 has also exited cell 170 ahead of projection 104 as illustrated in Fig. 8c. Thus accumulated debris left behind from the previous embossing operation within cell 170 is swept clear of the cell by the following embossing operation as it progresses within the cell.

Now referring to Fig. 9. Figs. 9a, 9b, and 9c similarly illustrate an embodiment of the present invention wherein the male embossing roll 500 is larger than the female imprint roll 502. In such an embodiment the larger embossing roll 500 is moving faster than the smaller imprint roll 502. Once again, following the relative progression of embossing projection 104 and imprint cell 170 through the figures, embossing projection 104 is shown entering cell 170 as projection 104 begins to mesh with cell 170 as illustrated in Fig. 9a. Because of the relatively faster speed of the embossing roll 500, projection 104 is caused to sweep through cell 170, from left to right as viewed in Fig. 9, as the meshing projection 104 and cell 170 pass through nip 300. Thus debris 114, accumulated from the previous embossing operation within cell 170, is swept ahead of embossing projection 104 as projection 104 advances through cell 170, as illustrated in Fig. 9b. As projection 104 continues its sweep through cell 170, accumulated debris 114 is ejected from cell 170 ahead of projection 104 as projection 104 exits cell 170, to the right, as illustrated in Fig. 9c.

Fig. 10 presents a distortion diagram for a pair of embossing rolls, in accord with the present invention, wherein the male embossing roll has a smaller diameter $DIA_S$ and the female imprint roll has a large diameter $DIA_L$. Distortion is herein defined as the difference in length, in the machine direction, between the extended elliptical imprint cell 170, of the

present invention, and the typical prior art imprint cell 120 as illustrated in Figs. 5 and 6. The distortion diagram, Fig. 10, is provided to visualize the configuration and relationship of the embossing roll 500, the imprint roll 502, embossing projections 104 and imprint cells 170 as configured in accord with the present invention as when rolls of different size are used.

The circumferential, straight line length of the imprint cell 170 in the machine direction MD, from its leading edge 132 to its trailing edge 134, is defined as the chord length $c_S$; $c_S$ is also the chord length of the two circles that represent the embossing roll 500 and the imprint roll 502, is seen in Fig. 10. The arc length $l_S$ of the imprint cell's bottom surface 172, as measured on an arc through the extended cell, may be calculated by the formulation given below.

The pattern depth PD of imprint cell 170, which also represents the height of the male projection 104, without any clearance allowance, is also calculated by the formulation given below.

In designing an imprint cell 170 the chord length $c_S$ is calculated to determine if there will be overlap between imprint cells.

The arc segment height $h_S$, measured between the chord $c_S$ and the depth of the pattern, on one circle, is added to arc segment height $h_L$ from the second circle to obtain the maximum height of the male embossing projection 104, without any clearance allowance.

The side wall angle of the imprint cell 170, is typically between 0 to 30 degrees.

The calculations to determine the chord $c_S$, the maximum projection height PD, and the arc length $l_S$ of the imprint cell 170, are made to determine whether the imprint cells 170 will run together. It is desired to have a space 138 between the imprint cells 170.

In Fig. 10 the following definitions and formulations apply when the male embossing roll 500 diameter is smaller than the diameter of the female imprint roll 502:

$DIA_L$ = Diameter of Large Roll 500

$DIA_S$ = Diameter of Small Roll 502

$DIA_M$ = Diameter of Male Protrusion 104

$h_L$ = Arc Segment Height of Large Roll

$h_S$ = Arc Segment Height of Small Roll

PD = Pattern Depth

$r_L$ = Radius of Large Roll

$l_L$ = Arc Length of Large Roll

$l_S$ = Arc Length of Small Roll

$\alpha$ = Sidewall Angle

$h_s = [(DIA_L \div DIA_L) \times PD] \div [1 + (DIA_L \div DIA_S)]$

$h_L = [(DIA_S \div DIA_L) \times PD] \div [1 + (DIA_S \div DIA_L)]$

$\ell_L = [(r_L \times \theta) \times [2 \times [\cos^{-1}[(r_L - h_L) \div r_L]]]] \div 180$

$\ell_S = [(r_S \times \theta) \times [2 \times [\cos^{-1}[(r_S - h_S) \div r_S]]]] \div 180$

However, when the male embossing roll 500 is larger than the female imprint roll the following parameters change accordingly:

$$d_S = [[[.5 \times \ell_L \times (DIA_S \div DIA_L)] - (\tan\alpha \times PD)] - (.5 \times \ell_S)] \times 2$$

and the cell length becomes:

$$c_S = d_S + DIA_M$$

When embossing roll 500 is smaller than imprint roll 502:

$$d_L = [[[.5 \times l_S \times (DIA_L \div DIA_S)] - (\tan\alpha \times PD)] - (.5 \times l_L)] \times 2$$

and the imprint cell length becomes:

$$c_L = d_L + DIA_M$$

As stated above sweep means the difference in peripheral speed of a point on the embossing projection 104 , and a point on the imprint cell 170.

The distortion diagram, as illustrated in Fig. 10, and the above formulations are used to determine the length of the imprint cell in the machine direction MD.

The difference between the diameter of the male embossing roll 500 and the female imprint roll 502, is determined by the amount of sweep needed to remove debris from the imprint cells 170 within imprint roll 502. The difference in the diameter between the embossing roll 502 and the imprint roll 502 is limited by the stretch in the paper web being embossed.

The embossable paper web must be chosen to have an adequate stretch so that the web will impress when the rolls are operated at different linear speeds, without tearing the

web. Further the embossable paper must produce an attractive impression, formed at the bearing surface between the sides of the projection 104, and the sides of the cells 170.

Embossable paper is typically sold in different weights and different stretch percentages. A typical embossable paper may be between six percent stretchable to rupture, to twenty percent stretchable to rupture. The apparatus typically used to emboss embossible paper generally works with a defined stretch percentage.

Papers of varied stretch were used in testing the present invention. Embossing, employing the present invention, was successfully performed with a forty percent difference in diameter between the large roll and the small roll. It is believed that the maximum difference in diameter would be a ratio of one to two and that the range of one-to-ten percent is preferred to effectively clear debris from the imprint roll cells during embossing.

A test should be performed, with each source of paper, to determine the amount of speed differential (sweep) that a particular paper will accept without tearing and providing a sharp, clearly differentiated, embossing pattern.

The amount of sweep (speed differential) necessary to sweep debris from an imprint cell, is largely based on the amount of stretch in the paper web. The amount of stretch, of a particular paper web, can be defined and obtained from physical testing of the web, to assure that the web stretch is within the desired operating parameters of a given embossing machine.

As a given web is embossed, the web will stretch at the point of embossing, and relax after the embossing; the sweep (speed differential) is determined by the amount of debris in the web fed to the nip, the amount of sweep necessary to clean out a cell, and by the debris formed by the pattern chosen.

The best method determined, is that the difference between the diameter of the embossing roll, and the imprint roll, is between two percent and 40 percent, with both rolls moving at the same radial speed, to mesh the male projections and the elongated imprint cells at the nip.

The following chart presents diameter differences between rolls necessary to create a particular sweep.

| % Sweep | $Dia_S$ | $Dia_L$ | Cell length |
|---|---|---|---|
| 20% | 4.036 | 4.865 | 0.1046 |
| 25% | 4.036 | 5.045 | 0.1222 |
| 30% | 4.036 | 5.247 | 0.1422 |
| 35% | 4.036 | 5.449 | 0.1624 |
| 40% | 4.036 | 5.650 | 0.1828 |
| 45% | 4.036 | 5.852 | 0.2035 |
| 50% | 4.036 | 6.054 | 0.2244 |

By way of an example the following parameters have been calculated for an embossing machine, in accord with the present invention, having large diameter imprint roll and a smaller diameter embossing roll:

Given the following parameters:

Small Roll Diameter = 4.036" (imprint roll)

Large Roll Diameter = 5.650" (embossing roll)

Pattern Depth = .016"

Male Protrusion Diameter = .0360"

Sidewall angle = 15°

Sweep = 40%

The following calculated parameters in accord with the above formulations are:

$h_S = [(5.650 \div 4.036)(.016)] \div [1 + (5.650 \div 4.036)]$

$= 0.009333058"$

$h_L = [[(4.036 \div 5.650)(.016)]] \div 1 + (4.036 \div 5.650)$

$= 0.006666942"$

$l_L = (2.825)(\pi)[2[\cos\text{-}1\ (2.825 - .006666942 \div 2.825)]] \div 180$

$= .388242441$

$l_S = (2.018)(\pi)[2[\cos\text{-}1\ (2.018 - .009333058 \div 2.018)]] \div 180$

$= .388315818"$

When the male embossing roll is smaller:

$d_L = [[[(.5)(.388315818)(5.650 \div 4.036)] - [\text{TAN } 15^\circ\ (.016)]] - [(.5)(.388242441)]](2)$

$= 0.1468$

$c_L = 0.1468 + 0.0360$

$= 0.1828$

Alternate methods of meshing embossing rolls, take the form of a pair of rolls, timed to mesh at a nip, with the male embossing element, moved through the female cell, at a differential surface speed at mesh, to create the cleaning sweep described, rather than the tamping action in prior art machines.

In accordance with the provisions of the patent statutes, the principle and best mode of my invention has been illustrated and described in what is considered to represent its preferred embodiment. However, it should be understood that the invention can be practiced otherwise than as specifically illustrated and described herein without departing from its spirit or scope. Accordingly, the invention is intended to embrace any and all alternatives, modifications and variations as may fall within the spirit and scope of the appended claims.

## CLAIMS

I claim:

1. An apparatus for continuously embossing paper, containing adherent debris, at a nip formed between opposed embossing rolls, while sweeping said debris from the embossing surface, comprising:

a. a cylindrical steel male embossing roll;

b. a plurality of projections formed on the cylindrical steel male embossing roll, extending outwardly therefrom;

c. a cylindrical steel imprint roll;

d. concave imprint cells, formed into the peripheral surface of said imprint roll, said imprint cells having an elongated shape in the machine direction;

e. said imprint roll mounted parallel to, and tangent to, said embossing roll;

f. a nip, formed at the line of tangency between said embossing roll and said imprint roll;

g. means for rotating said embossing roll towards said nip;

h. means for rotating said imprint roll towards said nip;

i. the diameter of one of said rolls, being larger than the diameter of said other roll, so that a point on said projection, at said nip, is moving at a different linear speed than a point directly opposite the projection, on said concave imprint cell, whereby a sweeping motion takes place between said projection and said concave imprint cell;

j. a source of embossable paper;

k. means to feed said embossable paper into said nip;

l. means to remove embossed paper from said nip.

2. Apparatus for embossing paper comprising:

a. an embossing roll having a metal surface;

b. a plurality of projections formed on said metal surface of said embossing roll extending outwardly therefrom;

c. an imprint roll, having a metal surface, said imprint roll mounted parallel to, and

tangent to, said embossing roll, thereby forming a nip at the line of tangency of said rolls,

d. a plurality of concave cells formed on said imprint roll surface, said cells in matched register with said projections, whereby said projections extend into and are received by, said cells formed in the surface of said imprint as said rolls rotate inward toward said nip;

e. means for rotating said embossing roll and said imprint roll towards said nip;

f. the diameter of one of said rolls, selected to provide a sweeping action, within said cell thereby sweeping contaminant out of said cells, at said nip, as the rolls are rotated;

g. a source of embossable paper;

h. means for feeding said embossable paper, to said nip;

i. means for removing the resulting embossed paper from said nip.

3. The apparatus as claimed in claim 1 wherein said cell is substantially longer, in the machine direction, that said projection.

4. The apparatus as claimed in claim 1 wherein said cell floor comprises a smooth concave, curved surface from said cell's leading edge to said cells trailing edge.

5. The apparatus as claimed in claim 4 wherein said curved surface is elliptical.

6. The apparatus as claimed in claim 1 wherein tangential velocity of said projection is greater than the tangential velocity of said cell whereby said projection sweeps through said cell as said projection intermeshes with said cell.

7. The apparatus as claimed in claim 1 wherein the tangential velocity of said projection is less than the tangential velocity of said cell whereby said cell sweeps past said projection as said projection intermeshes with said cell.

8. In a continuous paper web embossing machine having an embossing roll and an opposing imprint roll wherein said embossing roll includes a multiplicity of embossing projections extending from the cylindrical surface thereof and wherein said imprint roll includes a plurality of concave imprint cells about the cylindrical surface thereof in matched relation to said embossing projections the improvement wherein said concave imprint cells have a circumferential length, in the machine direction, greater than said cell's axial width in the cross machine direction.

9. The improvement as claimed in claim 8 wherein said rolls rotate at same rotational speeds.

10. The improvement as claimed in claim 9 wherein said embossing roll surface speed is greater than said imprint roll surface speed.

11. The improvement as claimed in claim 9 wherein said embossing roll surface speed is less than said imprint roll surface speed.

12. The improvement as claimed in claim 8 wherein said embossing roll and said imprint roll have different diameters.

13. The improvement as claimed in claim 12 wherein the diameter of said embossing roll is less than the diameter of said imprint roll.

14. The improvement as claimed in claim 12 wherein the ratio of diameters of said rolls is less than 1 to 1.5.

15. The improvement as claimed in claim 12 wherein difference in roll diameters is five percent.

16. The improvement as claimed in claim 8 wherein the bottom surface of said imprint cells comprises a smooth curved surface from said cell's leading edge to said cell's trailing edge.

17. The improvement as claimed in claim 16 wherein said smooth curved cell surface approximates an elliptical curve.

18. The improvement as claimed in claim 16 wherein said bottom surface comprises a circular arc.

19. A method of embossing a continuous sheet of embossible paper between a pair of embossing rolls comprising the steps of:

a. providing a first embossing roll having a cylindrical surface, said surface having a plurality of embossing projections extending outwardly therefrom;

b. providing a second imprinting roll having a cylindrical surface, said surface having a multiplicity of concave cells extending inwardly from said surface wherein said cells are substantially longer, in the machine direction, than said embossing projections;

c. aligning the central axis of said rolls, one above the other, in a parallel relationship such that said rolls form a nip therebetween;

d. rotating said embossing roll inward toward said nip at a first surface speed;

e. rotating said imprint roll at a second surface speed, wherein the rotational speed of said imprint roll is different than the surface speed of said embossing roll, thereby causing relative motion between said projections and said cells, whereby said projections sweep through said concave cells as they intermesh with said cells;

f. passing a continuous sheet of embossible paper through said nip.

20. A method of embossing a continuous sheet of embossible paper between a pair of embossing rolls comprising the steps of:

a. providing a first embossing roll having a cylindrical surface, said surface having a plurality of embossing projections extending outwardly therefrom;

b. providing a second imprinting roll having a cylindrical surface wherein the radius of said cylindrical surface is greater than the radius of said embossing roll's cylindrical surface, and said imprinting cylindrical surface includes a multiplicity of concave cells extending inwardly from said surface wherein said cells are substantially longer, in the machine direction, than said embossing projections and said cells are in matched registry with said embossing projections;

c. aligning the central axis of said rolls, one above the other, in a parallel relationship such that said rolls form a nip therebetween;

d. rotating said embossing roll inward toward said nip at a first surface speed;

e. rotating said imprint roll inward toward said nip at a second predetermined surface speed thereby causing relative motion between said projections and said cells whereby said projections sweep through said concave cells as they intermesh with said cells;

f. passing a continuous sheet of embossable paper through said nip.

FIG. 1

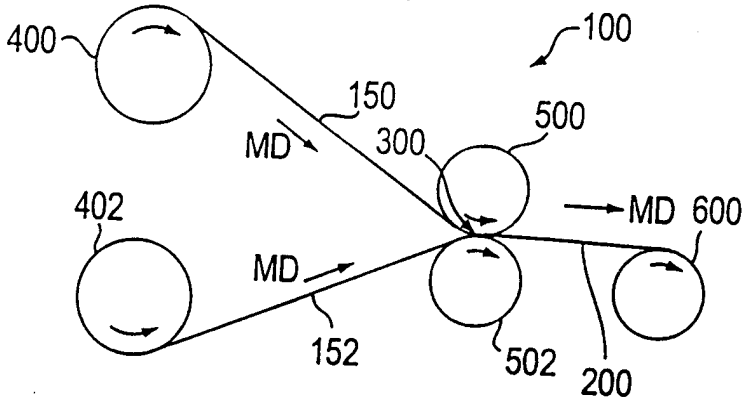



FIG. 2

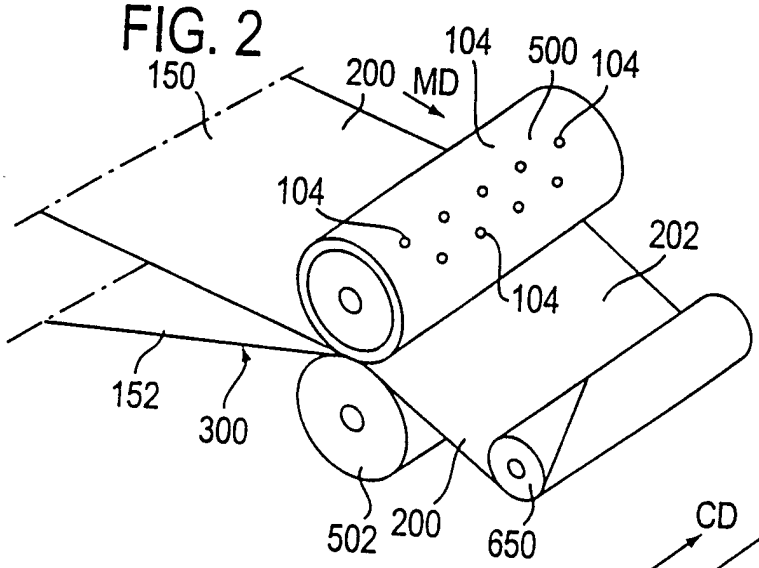



FIG. 3

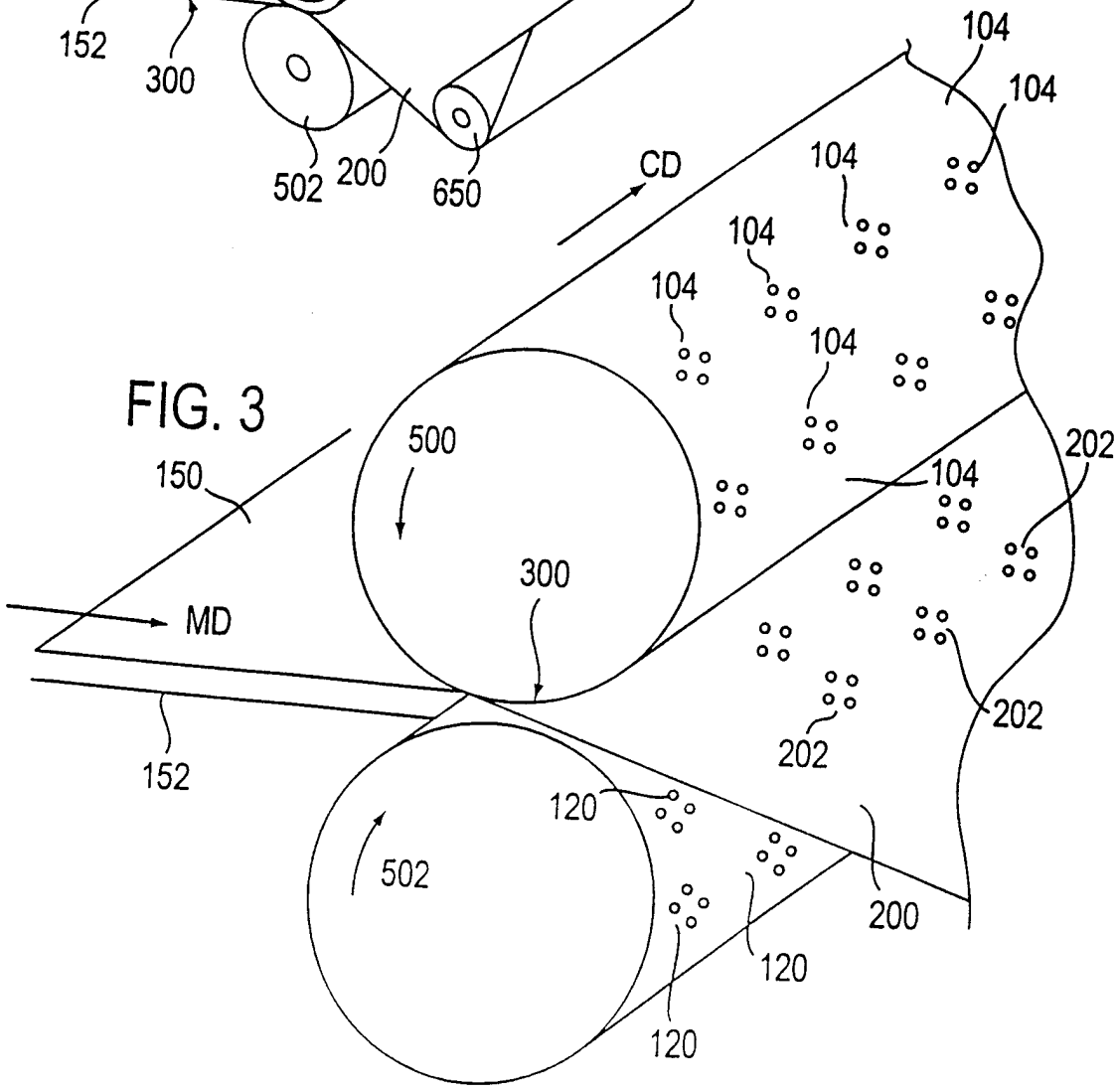


FIG. 5

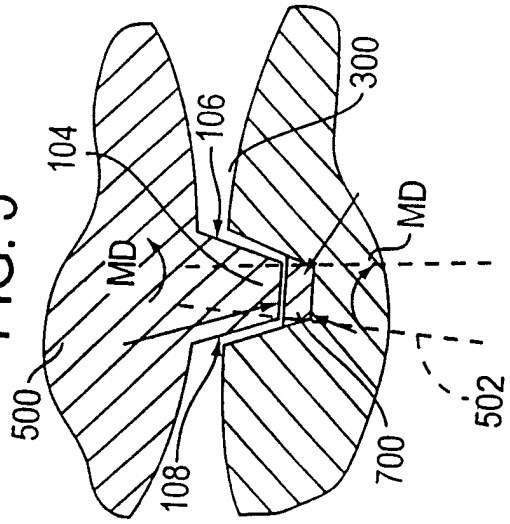



FIG. 4

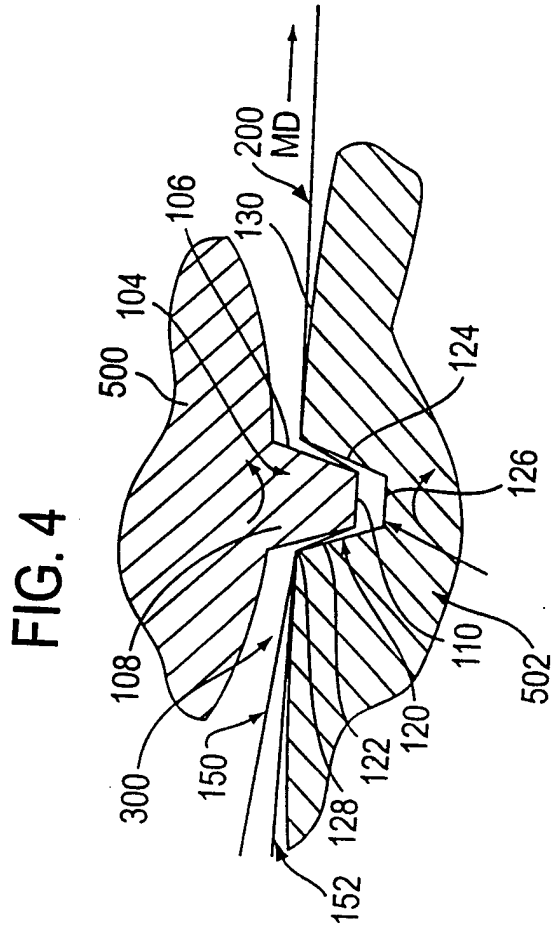
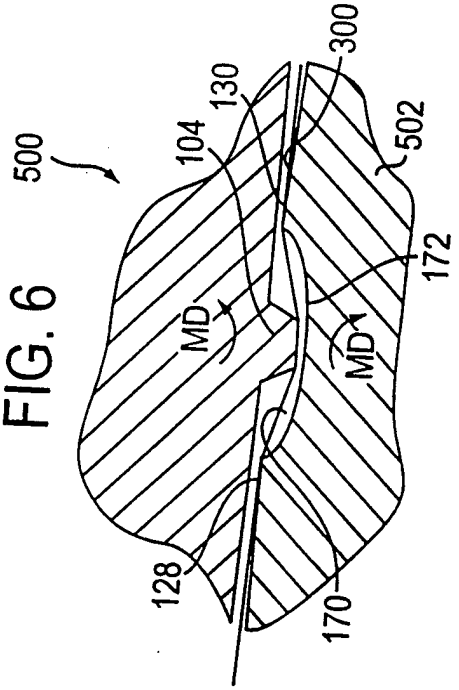



FIG. 6



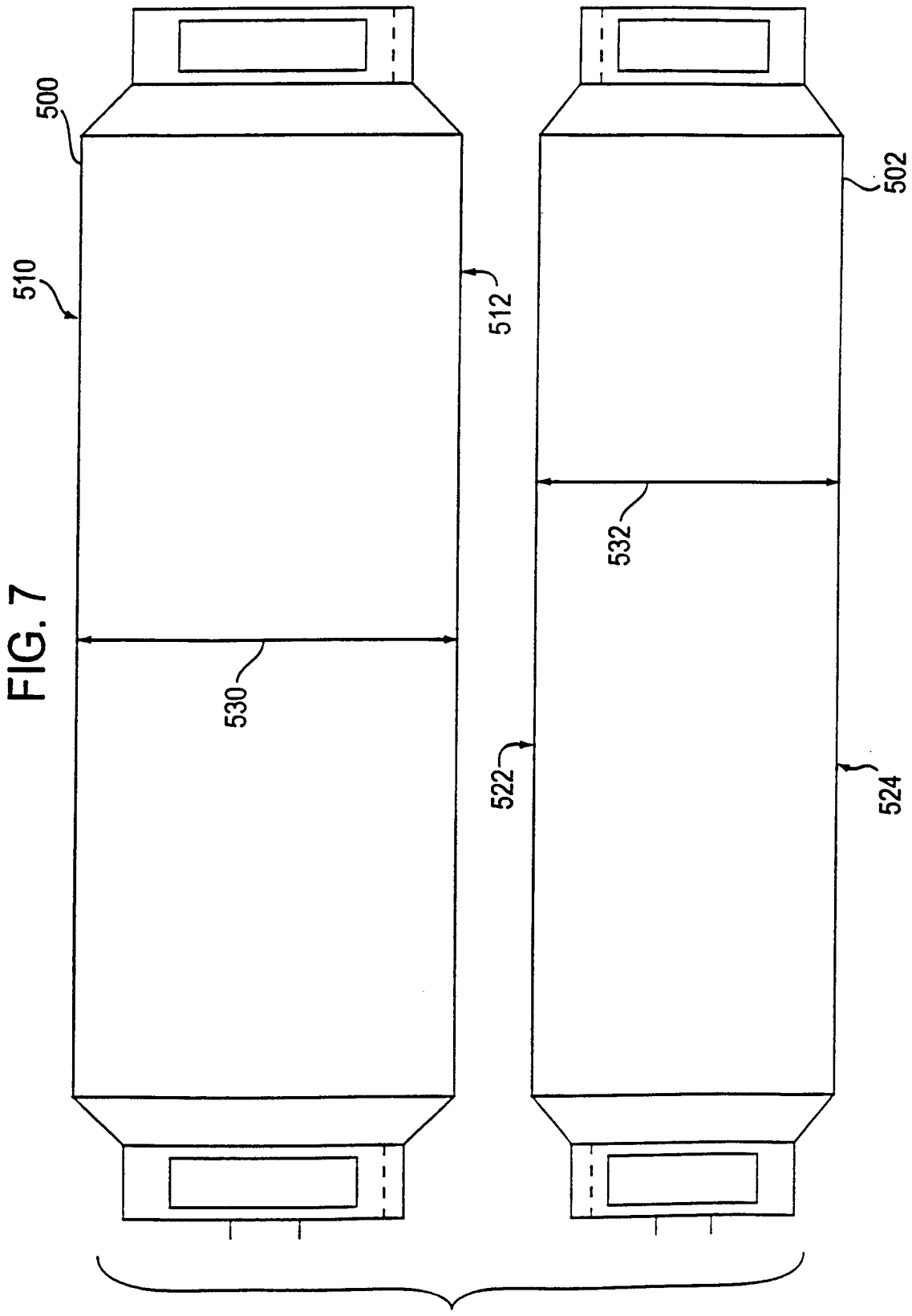



FIG. 7

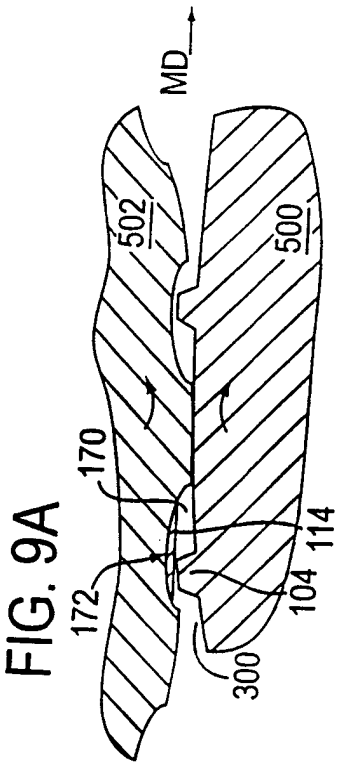



FIG. 9A

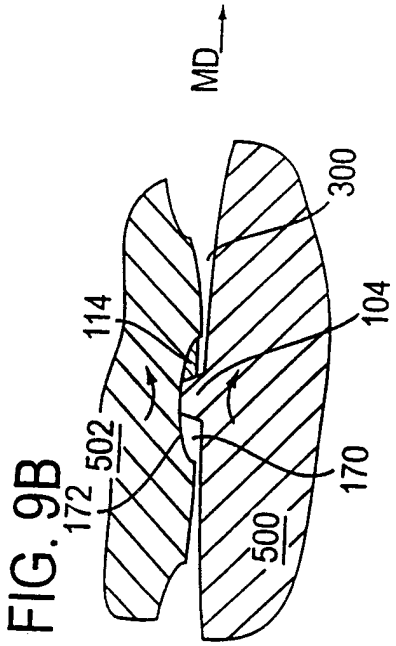



FIG. 9B

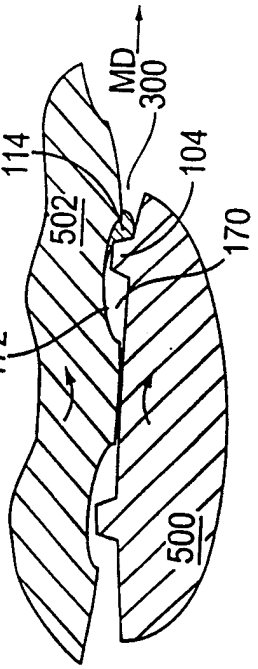



FIG. 9C

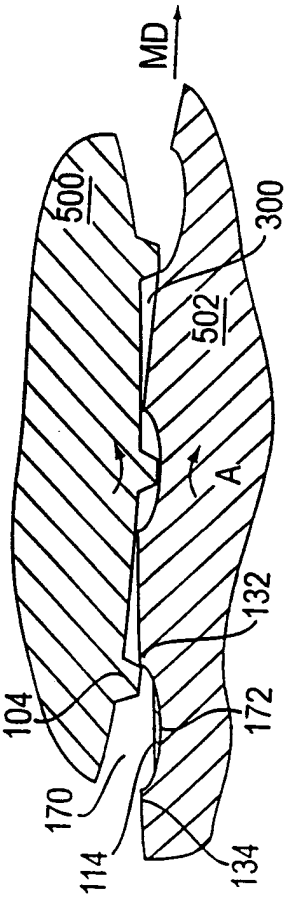



FIG. 8A

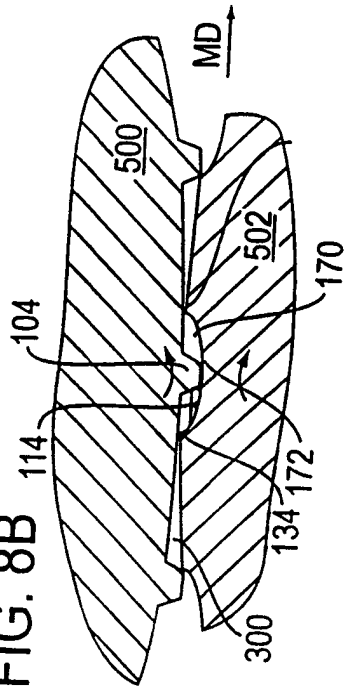



FIG. 8B

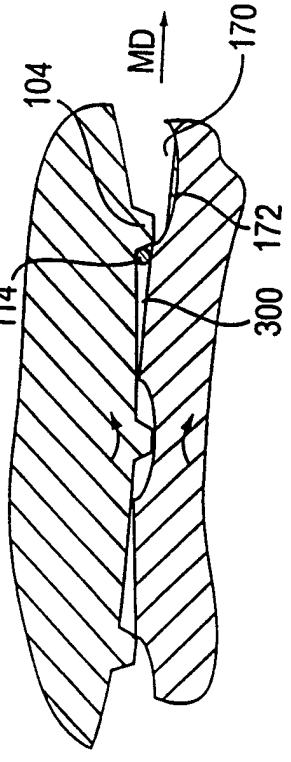
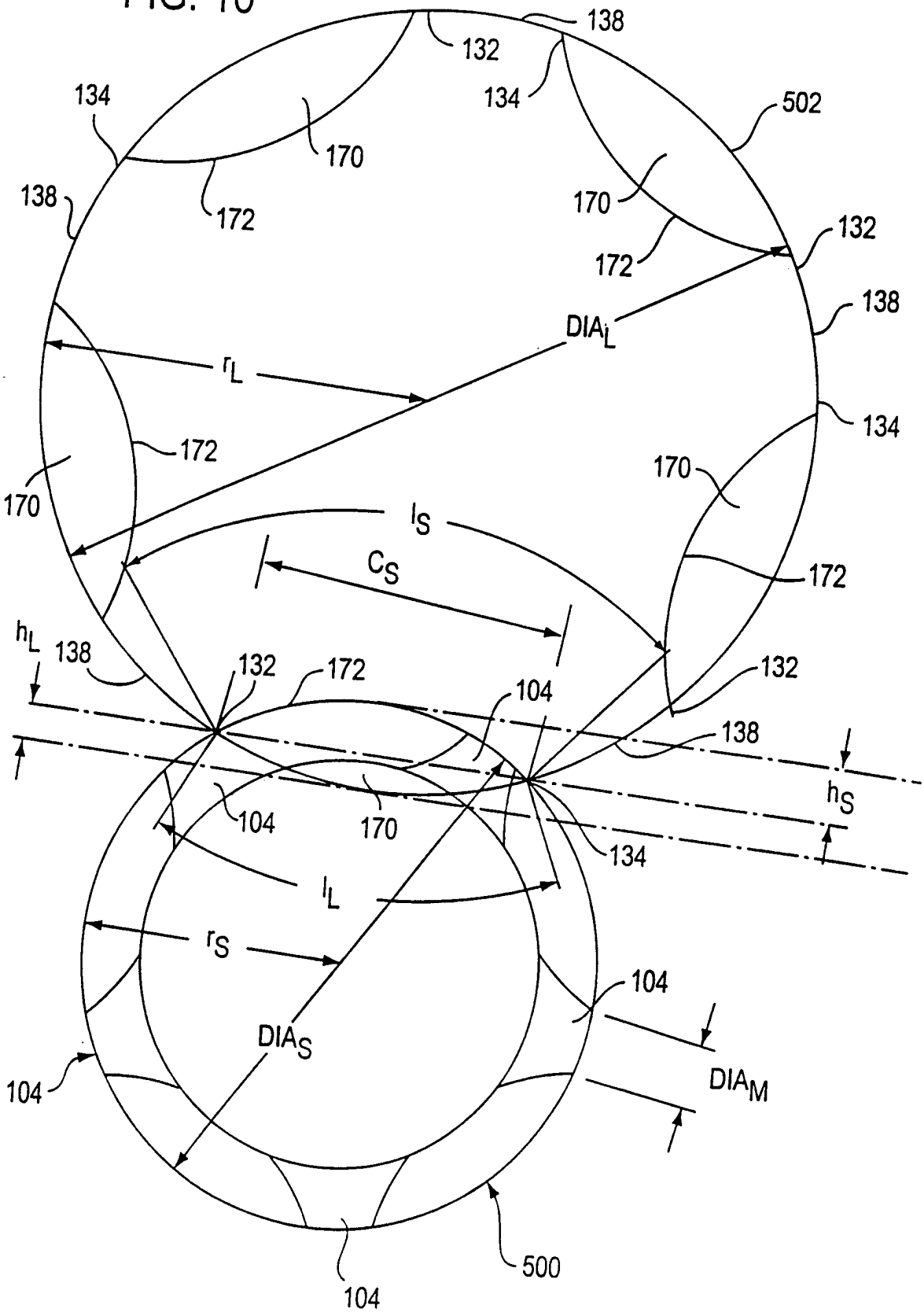



FIG. 8C

FIG. 10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DIA$_M$
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104

# INTERNATIONAL SEARCH REPORT

international application No.
PCT/US98/07403

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :B31B 1/88
US CL :493/58

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 2,729,267 A (WALTON) 03 JANUARY 1956, SEE ENTIRE DOCUMENT. | 1 |
| A | US 3,323,983 A (PALMER) 06 JUNE 1967, SEE COLUMN 4, LINES 50-75. | 1-20 |
| A | US 3,608,047 A (WIGGINS) 21 SEPTEMBER 1971, SEE ENTIRE DOCUMENT. | 1 |
| A | US 3,650,882 A (THOMAS) 21 MARCH 1972, SEE ENTIRE DOCUMENT. | 1 |
| A | US 3,867,872 A (NYSTRAND) 25 FEBRUARY 1975, SEE ENTIRE DOCUMENT. | 1 |
| A | US 4,280,978 A (DANNHEIM) 28 JULY 1981, SEE ENTIRE DOCUMENT. | 1 |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "E" | earlier document published on or after the international filing date | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" | document member of the same patent family |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

| | |
|---|---|
| Date of the actual completion of the international search<br>22 JULY 1998 | Date of mailing of the international search report<br>18 AUG 1998 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703) 305-3230 | Authorized officer<br>For CHRISTOPHER W. DAY<br>Telephone No. (703) 308-1359 |

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Form PCT/ISA/210 (second sheet)(July 1992)★

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/07403

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 4,614,632 A (KEZUKA) 30 SEPTEMBER 1986, SEE ENTIRE DOCUMENT. | 1 |
| A | US 4,888,145 A (ALLNER) 19 DECEMBER 1989, SEE ENTIRE DOCUMENT. | 1 |
| A | US 4,927,588 A (SCHULZ) 22 MAY 1990, SEE ENTIRE DOCUMENT. | 1 |
| A | US 5,158,523 A (HOUK ET AL) 27 OCTOBER 1992, SEE ENTIRE DOCUMENT. | 1-20 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/07403

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

493/58-60,82,83,342,355,373,395,396,402,403;
264/258,282,284;
101/3.1,5,6,22,23