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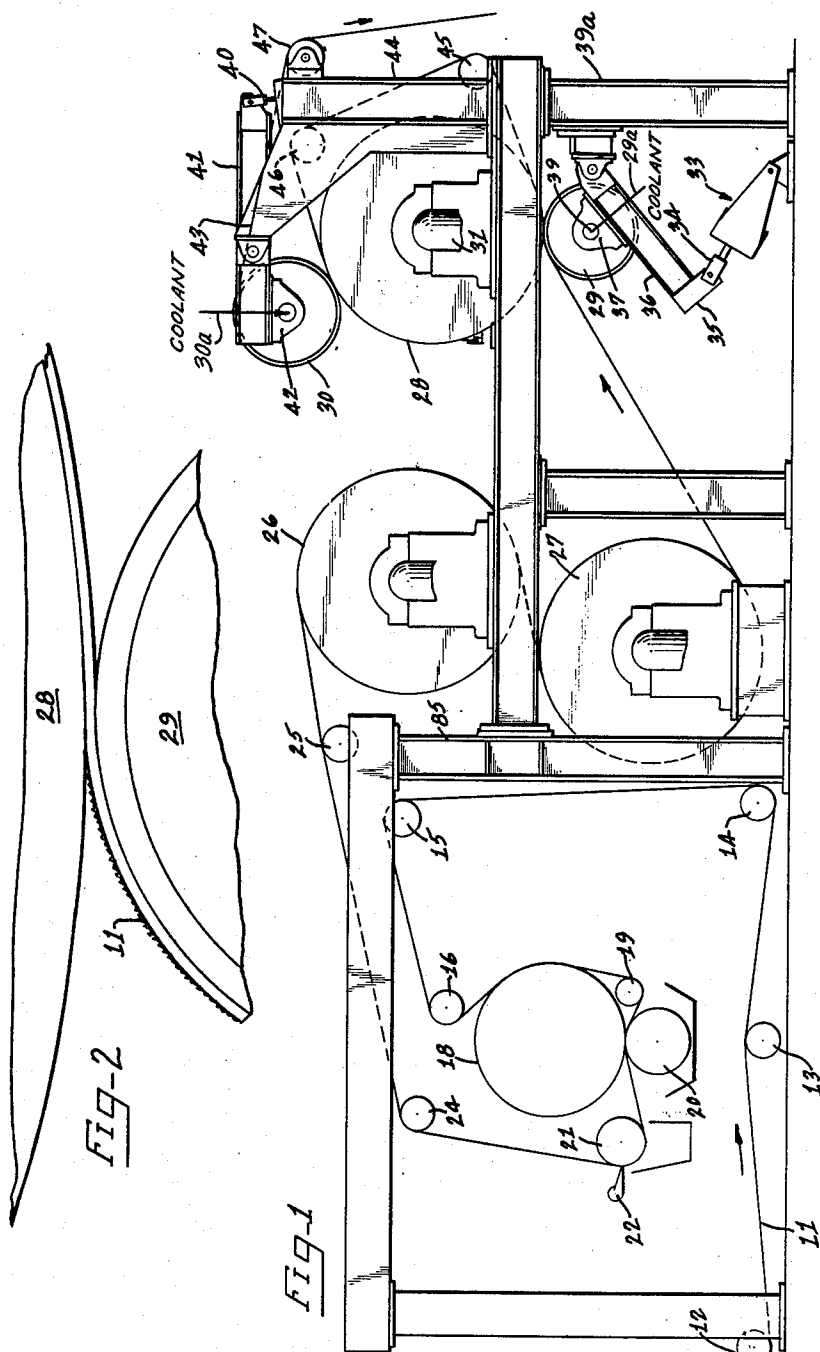
R. P. MAHONEY ETAL

3,124,480

HOT PRESSURE FINISHING APPARATUS FOR WEB MATERIALS

Filed April 4, 1960

2 Sheets-Sheet 1



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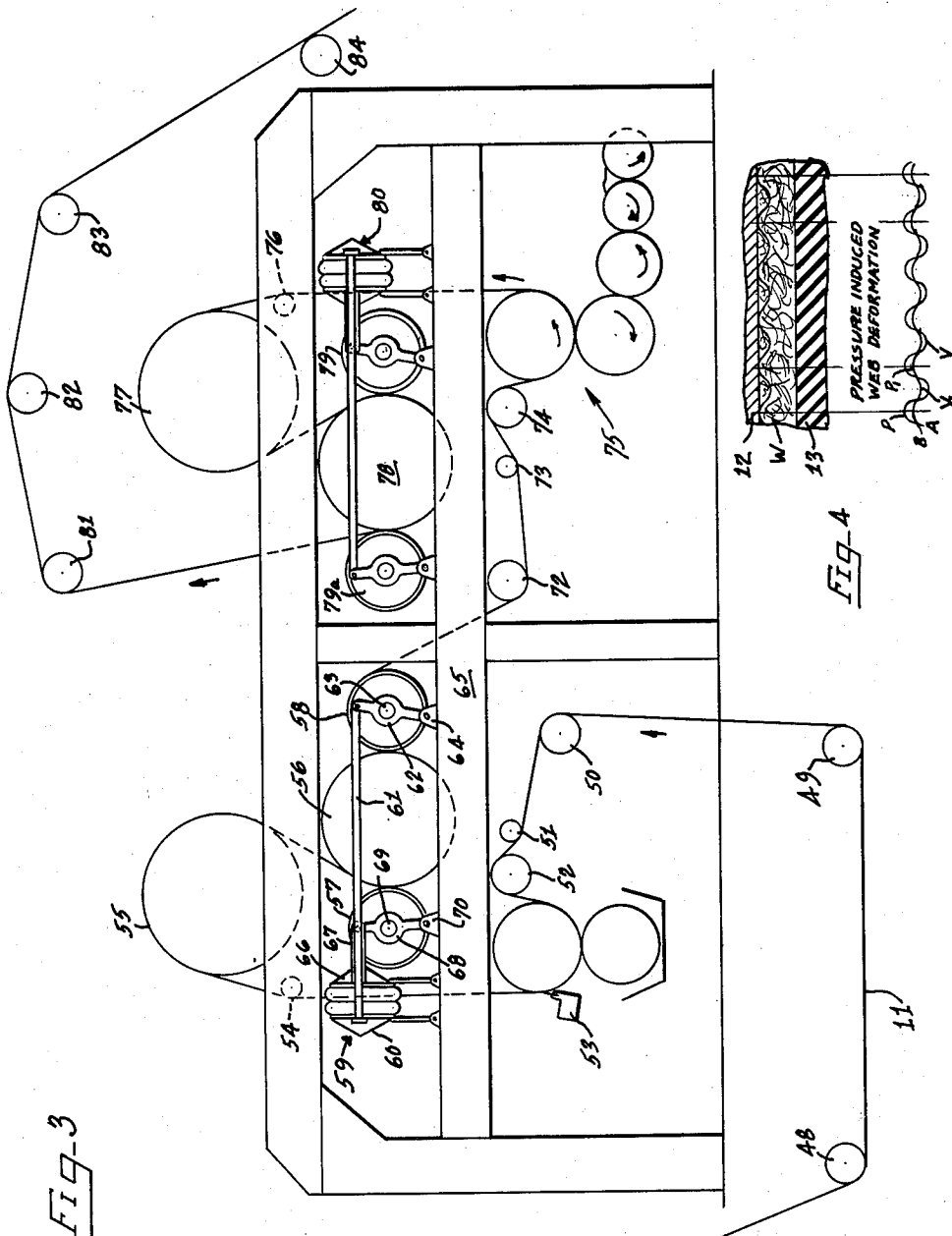


FIG-3

FIG-4

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HOT PRESSURE FINISHING APPARATUS FOR WEB MATERIALS

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The present invention relates broadly to the production of paper and related web materials and is more particularly concerned with improved methods and means for glossing paper and related web materials.

It is an object of the present invention to provide means for glossing coated or uncoated paper and related web materials.

This and other objects, advantages and features of the present invention will become apparent upon a careful consideration of the following detailed description, when considered in conjunction with the accompanying drawing illustrating preferred embodiments of the concepts of our invention, wherein like reference characters and numerals refer to like or corresponding parts throughout the several views.

On the drawings:

FIGURE 1 is a partially diagrammatic view in side elevation of apparatus for glossing one side of dried, coated paper constructed in accordance with the concepts of our invention.

FIGURE 2 is a fragmentary view in side elevation illustrating the narrow width nip concept of the present invention shown on an enlarged scale.

FIGURE 3 is a partially diagrammatic view in side elevation illustrating apparatus for coating and glossing both sides of a coated paper web in accordance with our invention.

FIGURE 4 is an enlarged fragmentary view in cross section illustrating the influence of pressure and the hardness of the backing roll on web deformation in the nip.

As shown on the drawing:

Briefly stated, the present invention involves glossing of either continuous or discontinuous paper or related web materials by contacting the surface with a polished finishing surface under temperature conditions sufficient to cause or induce a temporary condition of plasticity in the surface thereof and under pressure conditions sufficient to smooth, blend and polish the surface to thereby obtain a high degree of finish or gloss without crushing of the paper.

As appears in FIGURE 1, apparatus constructed in accordance with the principles of the present invention may be employed for glossing one side of paper or related web materials.

Uncoated paper or, if desired, previously coated paper 11 may be conveyed over a plurality of guide rolls 12, 13, 14 and 15 to a feed roll 16 and thence in contact with a furnishing platen or backing roll 18 for the application of the particular coating employed. Pick up roll 19 is utilized in the well known manner and the web fed through the nip defined by the furnishing roll 18 and the coating applicator roll 20. The web, freshly coated on one side, is then led around roll 21, and, in this arrangement, the coating machine is of the air knife type having an air knife 22. It will be appreciated that the particular type of coating machine used will depend primarily upon the end product desired.

From the coating machine the coated web is next led over guide rolls 24 and 25 for contact with a pair of conventional dryer rolls 26 and 27 for drying of both sides of the coated web. The web is dried to a commercial or marketable moisture content (usually between 5

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and 10% bone dry) and the coating is, therefore, completely plasticized or set when it leaves the dryer 27.

The web with its coating thus pre-dried and plasticized or set is now ready to be brought in contact with the highly polished finishing roll 28 for the glossing treatment.

In the arrangement shown in FIGURE 1, the glossing apparatus may take the form of a driven roll 28 having a highly polished finishing surface and a pair of hard surfaced but resilient backing rolls 29 and 30. Backing rolls 29 and 30 may be driven by contact with the web 11 and finishing roll 28 or drive means (not shown) may be provided.

The finishing rolls 28 may be constructed to provide the surface temperature required to plasticize the coating and coating surface of the paper web in the nip. For this purpose, a suitable source of heat medium may be introduced into the chamber defined by the roll through a conduit 31. The metal finishing roll 28 having a highly polished surface defines a narrow nip with the resiliently surfaced pressure backing roll 29 of high surface hardness. The surface of the finishing roll 28 may be plated, as with chrome or nickel, and the resilient rolls 29 and 30 may comprise a metal core having a rubber cover of the desired hardness.

For particular applications and in order to obtain a smooth level surface having excellent ink receptivity and printability, while avoiding the high specular gloss comparable to that obtained by cast coating methods achieved with the chrome plated or highly polished finishing surfaces, a smooth finished roll may be substituted for the highly polished roll 28. We have also found that the web may be immediately removed from the finishing nip without the necessity for permitting extended contact between the web and finishing roll and without damaging the gloss or other desirable characteristics of the web and coating.

In order to minimize the operating pressure loading of the respective rolls, it is desirable that the resilient rolls 29 and 30 be quite hard, i.e. less than 30 P. and J. ($\frac{1}{8}$ " ball). Employment of a hard surfaced roll permits concentration of total uniform pressure loading on a relatively narrow nip, in the direction of travel of the web, and, excellent results have been obtained when the nip is of a cross-sectional width, less than 1" and preferably about $\frac{1}{2}$ ". The development of high unit pressures in a narrow nip is desirable only below the crushing point of the web fibers. The hard and narrow nip assures uniform loading across the entire width of the sheet. It will be appreciated of course, that continued use of the nip will tend to cause the resilient or hard rubber surfaced rolls 29 and 30 to soften slightly due to the temperature conditions existing at the nip and due to the effects of working engagement with the web during operation. In order to maintain the backing rolls at the desired high hardness level and thereby the nip width within the desired limits, means may be employed, if desired, to cool the resilient rolls. For this purpose, a cooling agent may be maintained in the interior of each of the backing rolls. As will be fully appreciated by those versed in the art this may be done in various ways and is shown schematically in FIGURE 1 by coolant supply lines 29a and 30a leading to the rolls 29 and 30.

The temperatures maintained at the nip in conjunction with the other nip conditions, must be sufficient to induce momentarily or temporarily a condition of plasticity in the particular dried and set coating employed to permit the pressure applied by the backing roll to smooth, blend and gloss the thus plastic coating while in the nip. Generally the temperature at the nip is maintained above the boiling point of water or other vehicle of the coating and

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no known upper temperature limits exist other than the decomposition temperatures of the particular coatings and other materials involved. Thus any dried and set coating composition which may be rendered plastic to the extent set forth in the above described manner may be employed in the present invention. Experience has indicated that the transversely and uniformly distributed high intensity unit pressure at the nip is preferably within the range from about 250 pounds per square inch to about 2400 pounds per square inch, depending primarily upon the particular coating and paper web involved.

Thus, in the nip, the pressure and the high surface temperature of the finishing roll induce a condition of temporary plasticity in the previously pre-dried, plasticized or set coating, particularly in the surface thereof, and impart a gloss finish to the plastic surface of the coating, while at the same time the resilience of the hard surfaced backing roll permits sufficient yielding in the nip to minor web thickness inequalities whereby the bulk and opacity of the web is not materially reduced.

The above degree of resiliency avoids the disadvantages inherent in conventional calendering apparatuses and methods in which spot density of the web is increased thereby producing hard glossy spots which will not accept printing impressions. The unit pressures employed are significantly less than those employed in paper calendering machines and the speeds obtainable are much higher than those normally available for cast coating applications.

Satisfactory gloss results are obtained at any practical operating speeds and therefore glossing operating speeds are limited only by the operational speeds of the paper machine itself or the web supply means and of the rolls. It will be appreciated that glossing temperatures are generally in direct relation to operating speeds. For example, satisfactory glossing of coated board in the above manner which was supplied at the rate of 500 feet per minute was obtained with finishing roll and nip temperatures of approximately 300° F. and nip pressures of 400 lbs. per linear inch. Similarly, satisfactory glossing results were obtained with a coated lightweight paper running at 2000 ft. per minute through a pressure nip of approximately 1/2 inch width maintained at a temperature of 345° F. and pressures of 400 lbs. per linear inch.

The glossed, coated web may be immediately removed from the nip and fed to a winding reel, or may remain in contact with the finishing roll for purposes of positioning the coated web in the proper manner preparatory to a second glossing treatment. It will be appreciated that the coating is only momentarily or temporarily plastic while in the nip and that, upon leaving the nip, almost instantaneously returns to its previous set or plasticized condition without any deleterious effects on the coating or web but with a gloss finish.

To vary the pressure applied at the nip for glossing of particular coating surfaces, means therefor may take the form of a hydraulically or pneumatically operated piston assembly 33 having its piston rod 34 connected to a cross arm 35 of a pair of support members 36 which carry brackets 37 for mounting the shaft 38 of the backing roll 29. The support members 36 may be pivotally mounted to the support stanchion 39a. Pneumatic or hydraulic operating pressures of the piston arrangement need only be increased or decreased in order to produce a corresponding pressure on the finishing roll and web.

A similar piston arrangement may be employed for controlling application of glossing pressure by the resilient roll 30 which includes a piston housing (not shown), a piston rod 40 mounted on a cross arm of a pair of support members 41 mounting the bearing brackets 42 for roll 30. Support arms 41 may be fulcrumed to a clevis 43 which is mounted on the frame stanchion 44. Thus by employment of a pair of support members 41 transverse uniform pressure is applied at the nip.

Thus in operation the web having a set and dried coat-

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ing thereon is introduced into the hard, narrow width nip defined by rolls 28 and 29 and the heat required at the nip plasticizes the coating or at least the surface of the coating temporarily while in the nip to a sufficient extent to permit the pressure exerted at the nip to smooth, blend and polish the coating surface. Upon leaving the nip the coating immediately sets and consequently may be removed to a winding reel. If desired, the coated web may be left in contact with the finishing roll 28 for proper introduction thereof into the second glossing nip defined by rolls 28 and 30. Alternately, the glossed coated web may be immediately removed from the nip and led around a pair of fly rolls 45 and 46, as appears in FIGURE 1, for subsequent introduction to the nip defined by rolls 28 and 30. Employment of fly rolls 45 and 46 is made possible since the coating is only temporarily plastic in the nip and upon removal therefrom immediately sets without interruption or damage to either the coating or web. If desired, the now glossed and dry coated web may then undergo a second polishing treatment in the nip defined by pressure backing roll 30 and finishing roll 28. It will be appreciated that the pressure roll 30 is identical in construction and operation to roll 29. After leaving the latter nip, the web may be then fed over a guide roll 47 to be wound on a reeler (not shown) awaiting subsequently disposition.

As appears in FIGURE 2 wherein the dried and set or hardened and immobile coating layer of the web is shown: in exaggerated form, the coated web, in its set or hardened and unglossed state, enter the narrow width and hard nip defined by rolls 28 and 29 with the hardened or set and dry coating brought in contact with the finishing surface of roll 28 where, while in the nip, the coating is momentarily or temporarily rendered plastic and is blended, smoothed and polished in the nip. It will be appreciated that the desired glossing results are accomplished where only one polishing nip is employed and that such apparatus may be utilized for on or off the paper making machine applications.

As appears in FIGURE 3, an alternative arrangement may be provided for on or off the machine coating and glossing of both sides of a paper web. In this arrangement, the web 11 is fed over a plurality of guide rolls 48, 49, 50 and 51 to a feed roll 52 for coating of one side of the web with the desired coating which may be applied by a trailing blade coating machine 53. The web is next carried over a fly roll 54 to a conventional dryer 55 where the contact of the non-coated surface of the web with the dryer dries the coating layer to an atmospheric moisture content. As a result of contact with the heated surface of the dryer roll the web coating is plasticized or set when it is subsequently introduced into the narrow width and hard glossing nip defined by the heated finishing roll 56 and backing roll 57. It will be appreciated that rolls 56 and 57 are identical in construction and operation to rolls 28 and 29, respectively, of FIGURE 1. The web is introduced into the nip with the coated surface in contact with the finished surface of roll 56.

For glossing heavier web, such as board, it is preferable to bring the coated surface of the web into contact with the finishing roll slightly in advance of the nip, as shown, in order to pre-heat the coating web for plasticizing of the coating in the nip.

The coated surface of the web in contact with the finishing surface of roll 56 is temporarily or momentarily rendered plastic and glossed in the nip. Upon leaving the nip the coated surface of the web immediately sets and, if desired, may be permitted to remain in contact with the finishing roll to be introduced into a second glossing nip defined by finishing roll 56 and a second resilient backing roll 58 which is identical in construction and operation to backing roll 57.

Means are provided for varying the pressure applied by rolls 57 and 58 and may take the form of a hydraulically or pneumatically operated bellows arrangement 59.

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The end cover 60 of the bellows arrangement may be connected to a movable link 61 which is pivotally connected at one end to an arm 62 fulcrummed to the bearing of the shaft 63 of roll 58. Arm 62 is connected at the other end to a bracket 64 mounted on the frame stanchion 65. Similarly, the end plate 66 of the bellows arrangement may be connected to a movable link 67 which is pivotally connected to a member 68 fulcrummed to the bearing of the shaft 69 of backing roll 57. Arm 68 is pivotally connected to a bracket 70 mounted on machine frame member 65. Similar, arm link and bracket assemblies, not shown, connect the bellows arrangement 59 to the opposite sides rolls 57 and 58 to obtain equal distribution of pressure transversely across the hard narrow width nip. Thus, as pressure in the bellows is increased, the bellows expand and rolls 57 and 58 will exert greater pressure against the finishing roll 56. Conversely, when pressure is decreased in the bellows, the bellows contract and less pressure is exerted by backing rolls 57 and 58 on finishing roll 56. It will be appreciated, however, that any conventional means may be employed to vary pressure application by either one or a pair of backing rolls depending upon the glossing arrangement adopted.

Therefore, depending upon the particular rheology of the various coating materials employed, simple and effective means may be provided to vary the pressure necessary to blend, smooth and polish the coating surface in the nip. Roller 58 is similar in construction and operation to roller 57, and heated to a temperature sufficient to render the particular coating surface plastic in the nip is roll 56.

After leaving the hard narrow width nip defined by rolls 56 and 58, the web coating immediately returns to its set or plasticized condition and may then be fed around the plurality of guide rolls 72 and 73 to a feed roll 74 for introduction thereof to a coating machine 75 for coating of the uncoated side of the web. After having been coated on the latter side, the web is then fed over a fly roll 76 to a conventional dryer 77 which may be similar in construction and operation to dryer 26. The web is fed to the dryer with the initially coated surface in contact with the dryer. When the web leaves the dryer 77 it is dried to atmospheric moisture content and the coating is completely plasticized or set and immobile.

Upon leaving the dryer, the now dried and plasticized or set unglossed coating of the paper is introduced into a hard, narrow width nip defined by a highly polished finishing roll 78 and a resilient backing roll having a surface of high hardness for glossing of this side of the paper web. An additional glossing treatment of the second side of the coated paper web may be accomplished, if desired, in a similar nip defined by finishing roll 78 and a backing roll 79a. Finishing roll 78 may be similar in construction and operation to finishing roll 56, and, similarly, backing rolls 79 and 79a may be similar in construction and operation to backing rolls 57 and 58 respectively. Means 80 similar in construction and operation to means 59 may be employed to vary the pressure applied by backing rolls 79 and 79a.

Thus when the web leaves the latter nip both sides of the coating are glossed, dried to atmospheric moisture content and plasticized or set. Glossing of the second side of the coated web occurs without disruption of the initially coated and glossed surface or web.

The web with the glossed coating on both sides thereof may then traverse a plurality of guide rolls 81, 82, 83 and 84 and be taken off the machine on a reeler (not shown) for subsequent disposition.

Experience has indicated that paper and board which had been printed by employment of any of the several common printing methods could be provided with a gloss finish, after printing, by subjecting the printed paper or board to a glossing process which employed apparatus

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constructed in accordance with the principles of our invention without otherwise affecting the quality of the printing or other characteristics of the paper or board. It is to be understood, of course, that for the above application the temperature and pressure at the nip will depend to an extent upon the properties of the paper and print undergoing treatment.

As an additional exemplification of our invention, a commercial grade clay-casein paper coating composition applied dried and finished on paper making apparatus as illustrated in FIG. 1, and within the temperature and pressure limits set forth above results in a coating finish comparable to commercial cast-surfaced coated paper now considered acceptable in the trade. Satisfactory finishing results have been obtained for various coated paper and related web materials with the finishing surfaces heated to a temperature within the range of from about 220° F. to about 400° F., while we prefer to employ temperatures within the range of from about 280° F. to 360° F.

Thus by employment of our invention we provide means for glossing dried and plasticized or set coated paper and related coated web materials having a variety of applications.

In general, the heat and pressure in the hard, narrow nip should be controlled to conform the surface being finished to the surface of the finishing roll without crushing the web and under conditions which accommodate removal of the web without disturbing the conformed web surface. Usually, tolerable moisture contents are lessened with increases in either nip temperature or nip pressure and enlarged with increases in basic web weight.

FIGURE 4 presents a graphical illustration of the combined influence on paper web material deformation of the pressure applied at the nip and the resilient yielding characteristics of the hard backing roll. Under microscopic examination, the web "W" is of varying cross-sectional thickness, as shown exaggerated in FIGURE 4, consisting of surface peaks of higher density and valleys of lower density. The valleys, of course, contain fibers and fibrils; however, the density of the web at the valleys is less than the density of the web at the peaks.

Conventional calendering operations, wherein high pressures are applied to the web, have an effect on web density and thickness which differs from the effect of the nip conditions of the present invention which permits lower pressures to be applied to the web in the hard narrow nip.

The curve "A" in FIGURE 4 illustrates the characteristic deformation of the web caused by the high pressures applied when conventional calendering apparatus is employed. The calendering pressures cause the greatest deformation of the web "W" at the peaks "P" and the least deformation of the web at the valleys "V." The web "W" is shown in FIGURE 4 as having peaks and valleys of equal and sequential height and depth for purposes of clarity only; however, it will be appreciated that the peaks and valleys are, in fact, of irregular heights and depths. The deformation of the web caused by the high pressures applied in calendering operations at the peaks result in the hard glossy spots aforementioned which refuse to accept ink or print.

However, by employment of our invention, the other conditions at the narrow nip, defined by the finishing roll 12 and the hard resiliently yieldable backing roll 13, cooperate to permit employment of lower pressures than those used in conventional calendering treatments and result in lesser web deformation. In addition, the lesser web deformation results in a more uniformly finished web surface.

As shown in curve "B," the resilient backing roll 13 yields at the peaks "P₁" to an extent causing less web peak deformation and also less web valley deformation than that caused by the conventional calendering treatments in the valleys "V₁" thus resulting in an overall

smoother leveling of the web surface being finished. It will be appreciated, therefore, that the provision of a resiliently yieldable backing roll cooperating with the other nip conditions of the present invention permit uniform deformation and leveling of the web coated surface to a degree unattainable by employment of conventional calendering treatments.

It is also apparent that the magnitude of the deformation of the backing roll is large only with regard to the thickness of the web being finished. Likewise the magnitude of deformation of the backing roll is small in the transverse direction to insure maintenance of the hard, narrow nip ($<1''$), at high unit pressure.

As used herein, the term "dried" is to be understood to mean coating dried sufficiently within the ranges herein specified so as not to adhere to the non-resilient finishing surface while in the nip.

As used herein, the term "polished" refers to the treatment of the non-resilient finishing surface to render the surface smooth, and the surface may be mirror finished or polished to a matte or like surface.

As used herein, the term "plasticized" is to be understood to mean that the web coating is hardened, immobile and rigid and the coated web is in a condition to be transported as an article of commerce without the necessity of additional immobilizing treatments.

Although various minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such embodiments as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In an apparatus, for improving the surface characteristics of a paper web, the combination comprising,
 - a first large diameter roll having a smooth precisely finished non-resilient surface,
 - a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,
 - said second roll being smaller than said first roll and forming a narrow nip therebetween,
 - a heating means for heating the surface of the first roll to plasticize the surface of the web in the nip,
 - means forcing the rolls together forming a transversely uniformly distributed high intensity unit pressure in said nip,
 - and guide means separating the web from the surface of the first roll substantially immediately following the nip.
2. In an apparatus for improving the surface characteristics of a paper web, the combination comprising,
 - a first large diameter roll having a smooth precisely finished non-resilient surface,
 - a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,
 - said second roll being smaller than said first roll and forming a narrow nip therebetween,
 - heating means for heating the surface of the first roll to plasticize the surface of the web in the nip,
 - means for cooling said second roll for maintaining the cover of said second roll at the desired high hardness,
 - and means forcing the rolls together forming a transversely uniformly distributed high intensity unit of pressure in said nip.
3. In an apparatus for improving the surface characteristics of a paper web, the combination comprising,
 - a first large diameter roll having a smooth precisely finished non-resilient surface,
 - a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween, heating means heating the surface of the first roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the paper web to plasticize the surface of the web in the nip,

and means forcing the rolls together forming a transversely uniformly distributed high intensity unit pressure in said nip of between 250 pounds per square inch to 2400 pounds per square inch.

4. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and a relatively thin outer resilient cover having a high hardness of less than 30 P. and J. ($\frac{1}{8}''$ ball) being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means for heating the surface of the first roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the web to plasticize the surface of the web in the nip,

and means forcing the rolls together forming a transversely uniformly distributed high intensity unit of pressure in said nip of between 250 pounds per square inch to 2400 pounds per square inch.

5. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow first nip therebetween,

heating means for heating the surface of the first roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the web to plasticize the surface of the web in the nip,

means forcing the rolls together forming a transversely uniformly distributed high intensity unit of pressure in said nip,

a third roll formed of a metal core and a relatively thin outer resilient cover having a high hardness,

said third roll being smaller than said first roll and forming a narrow second nip therebetween located with respect to the first roll substantially diametrically opposite the first nip,

and means forcing the third and first rolls together forming a transversely uniformly distributed high intensity unit pressure in said second nip with the web passing sequentially through said first and second nip,

the pressures in said nips being between 250 pounds per square inch to 2400 pounds per square inch.

6. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means heating the surface of the first roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the paper web to plasticize the surface of the web in the nip,

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a third large diameter roll having a smooth precisely finished non-resilient surface,

a fourth roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said third roll,

said fourth roll being smaller than said third roll and forming a narrow nip therebetween,

heating means heating the surface of said third roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the paper web to plasticize the surface of the web in the nip,

and means forcing said first and second rolls together and means forcing said third and fourth rolls together forming a transversely uniformly distributed high intensity unit pressure in each of said nips of between 250 pounds per square inch to 2400 pounds per square inch.

7. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means for heating the surface of the first roll to plasticize the surface of the web in the nip,

a third large diameter roll having a smooth precisely finished non-resilient surface,

a fourth roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said third roll,

said fourth roll being smaller than said third roll and forming a narrow nip therebetween,

heating means for heating the surface of the third roll to plasticize the surface of the web in the nip,

means forcing said first and second rolls together and means forcing said third and fourth rolls together forming transversely uniformly distributed high intensity unit pressures in said nips,

guide means separating the web from the surface of the first roll substantially immediately following the nip between said first and second rolls,

and second guide means separating the web from the surface of the third roll substantially immediately following the nip between the third and fourth rolls.

8. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a coating mechanism applying liquid coating to the surface of the web,

means drying the coating until it is set,

a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means heating the surface of the first roll to a temperature of between a lower limit of 220° F. and an upper limit up to the decomposition point of the paper web to plasticize the surface of the web in the nip,

and means forcing the rolls together forming a transversely uniformly distributed high intensity unit pressure in said nip of between 250 pounds per square inch to 2400 pounds per square inch.

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said web moving from the drying means into the nip between the rolls with a coated side engaging the surface of the first roll in the nip.

9. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a coating mechanism applying liquid coating to a surface of the web,

means drying the coating until it is set,

a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means for heating the surface of the first roll to plasticize the surface of the web in the nip,

means forcing the rolls together forming a transversely uniformly distributed high intensity unit pressure in said nip,

and guide means separating the web from the surface of the first roll substantially immediately following the nip,

said web moving from the drying means into the nip between the rolls with a coated side engaging the surface of the first roll in the nip.

10. In an apparatus for improving the surface characteristics of a paper web, the combination comprising, a coating mechanism applying liquid coating to a surface of the web,

means drying the coating until it is set,

a first large diameter roll having a smooth precisely finished non-resilient surface,

a second roll formed of a metal core and an outer resilient cover having a high hardness being in nip-defining relationship with said first roll,

said second roll being smaller than said first roll and forming a narrow nip therebetween,

heating means for heating the surface of the first roll to plasticize the surface of the web in the nip,

means for cooling said second roll for maintaining the cover of said second roll at the desired high hardness,

and means forcing the rolls together forming a transversely uniformly distributed high intensity unit of pressure in said nip,

said web moving from the drying means into the nip between the rolls with a coated side engaging the surface of the first roll in the nip.

References Cited in the file of this patent

UNITED STATES PATENTS

2,096,973	Munch	Oct. 26, 1937
2,313,497	Adrian	Mar. 9, 1943
2,419,207	Fisher	Apr. 22, 1947
2,647,842	Griesheimer et al.	Aug. 4, 1953

FOREIGN PATENTS

527,207	Canada	July 3, 1956
560,317	Canada	July 15, 1958

OTHER REFERENCES

"Manufacture of Pulp and Paper" (3rd ed.), vol. V, McGraw-Hill (1939), New York (pages 16-26 of section 3, and pages 54-55 of section 4 relied on).

"Pulp & Paper Manufacture," vol. 3 (1953); McGraw-Hill, New York (pages 275 and 675-679 relied on).