Aug. 22, 1967 M. M. BRUNDIGE ETAL 3,336,862

CALENDER ROLL

Filed May 26, 1964 2 Sheets-Sheet 1

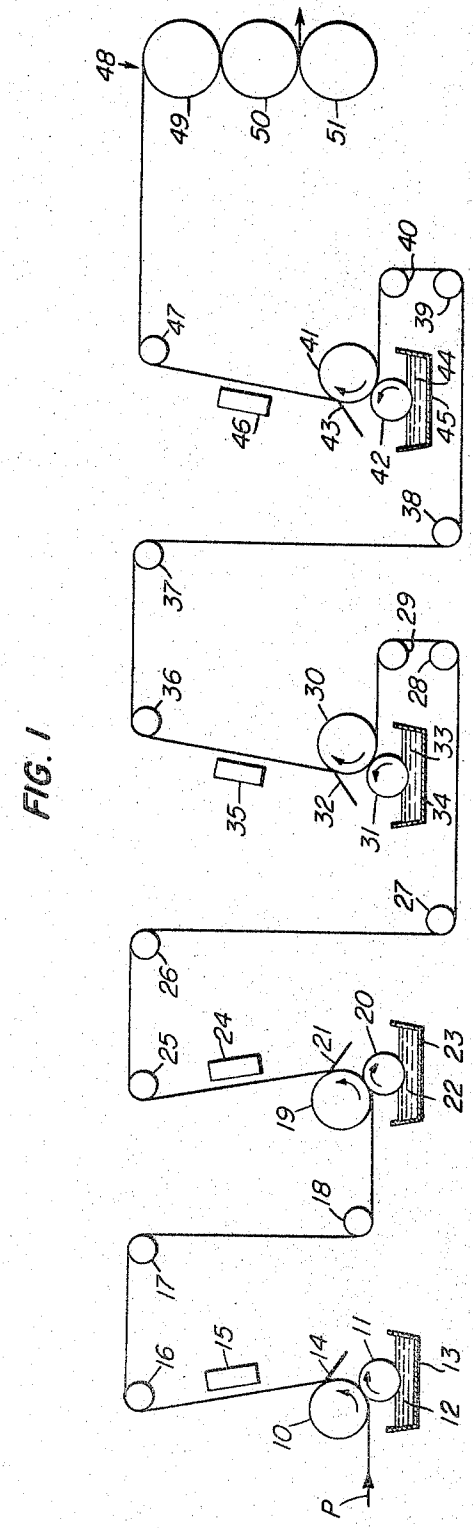

FIG. 1

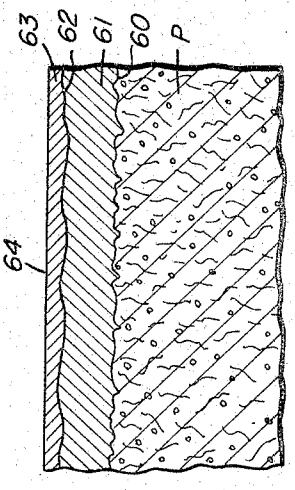

FIG. 3

FIG. 2

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CALENDER ROLL

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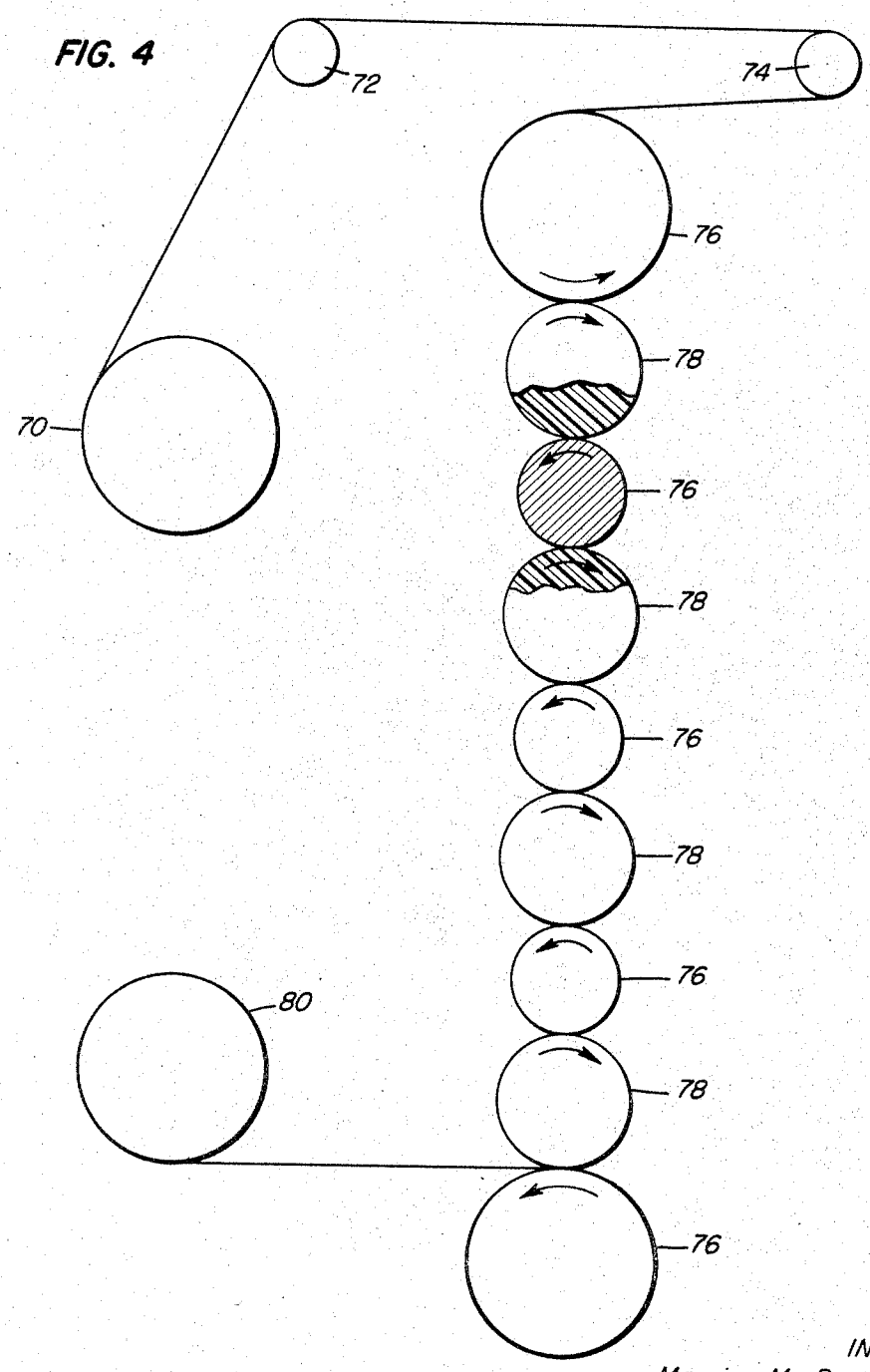
FIG. 4



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CALENDER ROLL

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14 Claims. (Cl. 100—162)

This invention relates to improved calender rolls, and more particularly, it relates to improved resilient or soft rolls which may be used in an on-the-machine calender stack as well as in an off-machine supercalender stack for treating paper, paperboard, and the like.

The present application is a continuation-in-part of the copending application Ser. No. 80,646, filed Jan. 4, 1961, for Process and Apparatus for Manufacturing and Finishing Coated Paper, and Resultant Product.

In the manufacture of high grade printing papers, the web of paper is coated before it is finished by the finishing action of a machine calender and/or off-machine supercalender. In general, most methods employed in coating operations on paper and paperboard may be classed as either roll coating or doctor coating. In the former operation, a layer of coating material is deposited upon a traveling web of paper by being transferred from a coating applicator roll in contact with the web. It is very difficult to produce a smoothly coated web in this fashion due to the formation of a pattern on the surface caused by film splitting at the exit nip, such pattern often being referred to as a nip pattern or roll pattern, which is seemingly an inherent characteristic of roll coating.

It has long been known in the art that coating may be applied to paper through the action of some type of doctoring or trowelling device serving to meter and smooth the coating onto a traveling web of paper. Such devices usually take the form of doctor rods or doctor blades, but, regardless of the form, their function is generally the same, to meter and smooth coatings on the traveling web.

In certain instances, it is desirable to double coat a traveling web of paper, that is, to apply a second layer of a coating material over a first layer of the same or different coating composition. The objective of such an operation may be the utilization of a relatively inexpensive base coating, employing a premium coating only in the top coat. Another object may be the manufacture of coated paper possessing high coat weights for the purpose of enhancing brightness, opacity, printability, and smoothness.

It has been found that a web of coated paper with an extremely smooth surface can be produced through the use of two doctor blades in the application of two layers of coating material on each side of a traveling web of paper.

A first layer of coating is smoothed onto the web and excess coating is wiped off the web by a doctor blade. A second layer of coating is applied to the surface of the first coating layer, and a second doctor blade serves to wipe excess coating from the web and to smooth the surface of the second coating layer. The first coating layer tends to fill in the low areas of the basestock by being trowelled into those areas by the doctor blade and produces a relatively smooth surface, over which the second layer of coating is applied and again smoothed by the action of a doctor blade to produce a surface of uniformity and smoothness heretofore unknown in the art of double coating.

It has been found that the final smoothness of the coated sheet greatly depends upon the smoothness of the first coating layer. Application of this layer of coating by

roll coating produces a surface of non-uniform smoothness due to the roll pattern formed. A second layer of coating applied by doctor blade merely tends to fill in the low areas of the roll pattern, but the ultimate printing smoothness is inferior to a web of paper double coated by two doctor blade coaters. The final printing quality of paper that is coated by a roll coater followed by a blade coater is also inferior to paper that is double coated by two blade coaters according to the present invention.

As is well known in the art, paper may be finished by passing it through a calender or a supercalender. A calender is a stack of hard metal rolls, usually chilled iron, which rest one on the other in a vertical bank. A calender is normally located at the end of a paper machine. Paper is passed between all or part of the rotating calender rolls to increase the smoothness and gloss of the paper. A supercalender is a type of calender, constructed on the same general principles as a calender, except that the metal rolls are alternated with soft rolls, usually compressed paper or cotton rolls. In the art, a supercalender is not an integral part of the paper machine.

Paper coated by the process of double doctor blade coating could be finished in the conventional manner of supercalendering the coated web in an off-machine process. Paper is passed through the nips formed by the supercalender rolls, and the web is pressed against the metal rolls by the resilient rolls. Pressures at the bottom nip are usually in the range of 1200 to 1600 pounds per pinear inch of nip. Paper finished in this manner has a very glossy surface, with good printing smoothness and substantial freedom of mottle. The word mottle as used in this specification and claims is intended to cover the non-uniformity of gloss that coated papers frequently exhibit when finished in particular finishing operations, as will be disclosed hereinafter. Because of the excellent quality of coated paper finished by the action of a supercalender, this finishing method is used extensively in the art of manufacturing high grade coated papers.

Coated paper has also been finished on the paper machine by the action of on-the-machine calender stacks. In a machine calender stack, the metal rolls are loaded to pressures very substantially less than the pressure loadings to which supercalender rolls are subjected. Paper is passed through the machine calender stack in a continuous web, while the web is still on the paper machine. With coated papers, a high degree of surface smoothness can be obtained due to the flattening action of the calender rolls, but the coated paper will also possess objectionable non-uniformity of gloss. The metal rolls are too hard to yield and conform to the surface of the web being calendered, and high spots in the web are densified and polished more than low spots immediately adjacent thereto. The polishing of these high spots creates a differential in the gloss between the high areas and low areas of the web, and thus contributes to a non-uniform surface gloss defined as mottle. Mottle is objectionable in high grade printing papers because it detracts greatly from the overall uniform appearance of the paper upon subsequent printing. Non-uniform densification of paper affects the ink absorptivity of the paper, which also contributes to a non-uniform surface gloss after printing.

It has been greatly desired to produce paper having the qualities of good printing smoothness and freedom of mottle in one continuous operation, such as by the finishing of a coated web of paper while it is still on the paper machine. Because the final finishing operation heretofore could not be accomplished by chilled iron rolls in a machine calender stack due to the mottle developed on the surface of the coated web, a resilient roll has long been sought which could be placed in a machine

calender stack and withstand the operating conditions to which a roll in a machine calender stack is subjected, and at the same time the roll would yield to conform to the surface of the paper web and polish it in a uniform manner. While cotton rolls have the ability to uniformly finish coated paper, as is seen by their action in a supercalender stack, they are not damage resistant enough to withstand the battering that rolls in a machine calender undergo during web threading operations or other situations such as wrap-ups of paper around the calender rolls and web breaks. During a web break, the tail of the web passing through the stack becomes creased and folded over, and concentrates the load on the stack in a few areas while leaving immediately adjacent areas with substantially no load. This high pressure is sufficient to permanently deform a cotton or paper filled roll. The deformations caused in the surfaces of these rolls prevent uniform finishing of a coated paper web.

Finishing paper in a single on-the-machine operation eliminates the added step of supercalendering. Paper coming off a paper machine must be transported to the supercalender for further finishing, and there usually is an added step of rewinding the paper before it is supercelendered. The time involved in handling the paper in separate operations, as well as the capital investment and maintenance costs, makes a continuous manufacturing and finishing operation on-the-machine very desirable.

It has been found that the qualities of good printing smoothness and freedom of mottle can be afforded a coated web of paper by coating the web by double doctor blade coating and by finishing the coated web by the action of certain resilient rolls at calender pressures up to 600 pound per linear inch, all while the web is on a paper machine, thus eliminating the separate off-machine supercalendering operation while maintaining the benefits of such an operation. The resilient rolls employed in this fashion in a machine calender stack may also be used in a supercalender in place of cotton rolls to finish paper.

We have found that resilient elastic composition rolls, having a hardness within certain specified ranges and possessing the ability to resist the normal battering encountered by rolls in a machine calender stack, can be used in a machine calender or supercalender stack to finish paper. The term "elastic composition roll" used throughout the specification and claims may be defined as a roll comprising a metal inner mandrel and an outer cover of an elastic composition or plastic material. The first requisite of such a roll for use as a calender roll is that it be hard enough to develop gloss and smoothness on a coated web of paper when used in a calender stack. It has been found that such rolls can be provided, having the necessary hardnesses, possessing sufficient elasticities, even greater than cotton rolls, which are able to conform to the paper being calendered on-the-machine, and which can develop uniform gloss and good printing smoothness with freedom of mottle. These rolls also possess considerably more ability than cotton or paper rolls to recover from the deformations caused by the battering to which rolls in a machine calender are subjected. Finally, these rolls have the ability to maintain suitable hardness up to temperatures which exceed those conditions normally encountered on a machine calender or supercalender stack.

The invention will be best understood by reference to the following detailed description and drawing forming part of this specification in which:

FIGURE 1 is a diagrammatic representation of the process and apparatus employed in the present invention;

FIGURE 2 is an elevational view of an elastic composition roll forming part of the invention;

FIGURE 3 is an enlarged and exaggerated illustration of the cross section of a sheet of paper which has been double coated according to the present invention;

FIGURE 4 is a diagrammatic end view of a supercalendering machine.

Referring to FIGURE 1 of the drawing, a traveling web of paper P is passed through the first blade coater comprising a backing roll **10** and an applicator roll **11**, both rolls rotating in the direction of web travel. Applicator roll **11** rotatively carries coating **12** from the coating pan **13**, and applies coating to the web P on the side of web P referred to as the wire side. Doctor blade **14** (shown in a trailing position in relation to web travel and referred to as a trailing blade) serves to act upon the coated web to smooth the coating and to limit the amount of coating which passes the doctor blade **14** to a predetermined thickness. Coating is trowelled into the low areas of the basestock (web P) and the resultant coated web has a relatively smooth surface. The web P is then conducted into drier section **15** (generally drier drums heated by steam) to set the coating on the web. The web P, substantially dried, is then passed over guide rolls **16** and **17**, under guide roll **18** and through a second blade coater comprising a backing roll **19**, an applicator roll **20**, and a doctor blade **21**. Applicator roll **20** rotatively carries coating **22** from the coating pan **23**, and applies a second layer of coating, over the first coating layer, to the precoated web P. Doctor blade **21** (also shown in a trailing position) acts upon the coating to meter a predetermined amount of coating onto the precoated web P and to smooth the surface of the coating. The double coated web on one side is then passed into drier section **24**, where the coated web is substantially dried, and then passed around guide rolls **25, 26, 27, 28** and **29**, and through a third blade coater comprising a backing roll **30**, an applicator roll **31**, and a doctor blade **32**.

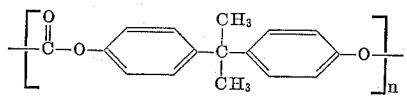
The coating operation for the last two coaters is similar to that of the first two coaters, except that the web P is coaed on the side opposite to that previously coated by the first two coaters. This side of the web P, as illustrated in FIGURE 1, is referred to as the felt side of the web. At the third coater, applicator roll **31** rotatively carries coating **33** from the coating pan **34**, and applies a first coating layer to the felt side of web P. Doctor blade **32** smooths the coating on web P and wipes excess coating from web P, which is then conducted into drier section **35** to set the first coating layer on the felt side. Web P, which is substantially dried, is then passed around guide rolls **36, 37, 38, 39** and **40**, and through a fourth blade coater comprising a backing roll **41**, an applicator roll **42**, and a doctor blade **43**. Applicator roll **42** rotatively carries coating **44** from coating pan **45**, and applies a second layer of coating, over the first coating layer, on the felt side of web P. Doctor blade **43** meters and smooths the second coating layer onto the precoated felt side of web P in a similar fashion to blades **14, 21,** and **32**, as previously shown. At this point the web P has been double coated on each side. Web P continues in travel into drier section **46**, where the coated web is substantially dried, passes over guide roll **47**, and into the machine calender stack **48**.

The coated web P is finished by the action of calender rolls **49, 50** and **51** forming the stack **48**. Rolls **49** and **51** are hard surfaced metal rolls, such as chilled iron. Roll **50** is a soft roll, i.e. a resilient, elastic composition roll, and serves to press web P against the metal rolls **49** and **51** as web P passes through the nips defined by the three calender rolls **49, 50** and **51**. It is to be understood that calender stack **48** is purely illustrative, and may comprise more or less than the number of calender rolls shown, said rolls being alternating metal and elastic composition rolls, or any combination thereof, as long as two metal rolls are not in contact with each other.

Elastic composition calender roll **50**, as shown in FIGURE 2, is comprised of a metal mandrel **52** having an integrally connected core **53**, and an outer cover **54** of a plastic or elastic composition, which cover **54** has been

placed on the mandrel 52 by a conventional shrink fitting process. It has been found that elastic compositions may be employed as the outer cover for a calender roll as long as the roll has a hardness of at least 53 Shore D durometer under operating conditions. The roll must have the ability to substantially maintain its hardness at temperatures up to 200° F., and we prefer that the hardness decreases no more than about 10 durometer units when the temperature rises from room temperature to 200° F., the reason being that as the hardness decreases, the gloss producing ability of the roll also decreases. The roll must also possess suitable resistance to damage. By the term "suitable damage-resistance," it is understood to means such resistance that the elastic composition cover will be able to resist and/or recover from the tendency to become permanently indented and marked when several thicknesses of paper pass through the nip between the elastic composition roll and a metal roll, which may occur during threading operations and web breaks, as previously described. The resistance and recovery must be at least to the extent that indentations occurring in the plastic cover are not injurious to the surface of the coated web or detrimental to a uniform finishing operation. The elastic composition rolls set forth in this specification and claims have the properties outlined above.

The elastic composition covers which we have found to be successful as outer covers for the soft rolls of this invention are covers of any one of the following polymers: polyamide polymers sold under the trade-name "nylon" and defined as nylon 6, polycaprolactam; nylon 6/6, polyhexamethylene adipamide; and nylon 11, poly-ω-aminoundecanoic acid, all of which are well known polymers and are readily defined in the literature, as for example in Modern Plastics, Encyclopedia Issue for 1961, pp. 90–94; and a polycarbonate polymer sold under the trade-name "Lexan" which may be defined as a polyaryl carbonate manufactured by the General Electric Company and prepared by reacting phosgene with bisphenol A to give aromatic carbonates of the following general structure:



We prefer the use of plastic covers of 1¼ inches in thickness, but covers of greater or lesser thicknesses may also be employed.

While we have found that an elastic composition roll should possess a hardness value of at least 53 Shore D durometer in order to produce a significant increase in gloss, the preferred range of hardness values lies above 80 Shore D durometer for the most beneficial finishing results. Elastic composition rolls with hardnesses up to 94 Shore D durometer have been employed satisfactorily. Rolls possessing even greater hardnesses may be used as long as they do not crush the web in the manner of conventional chilled iron calender rolls, polishing the high areas of the web more than the low areas and producing a mottled surface of non-uniform gloss.

Example 1

The following table set forth data showing the effect of the hardness of a resilient roll on gloss development. The paper used for these tests was paper of 32 pound basis weight (ream of 500 sheets, 25 x 38 inches) double coated on the wire side by two trailing blade coaters, applying a first layer of 4 pounds per ream of a coating composition (53% solids content) comprising mineral pigment and containing 17% starch on clay, and a second layer of 2 pounds per ream of a coating composition (43% solids content) comprising mineral pigment and containing 17% butadiene-styrene latex on clay to produce a coated paper of 38 pounds basis weight. The coated paper was finished by passing it through one nip, formed by one chilled iron roll and one of each of the composition rolls below, loaded at a pressure of about 400 pounds per linear inch of nip. The coated side of the web against the chilled iron roll during the finishing operation, and the gloss data is for that side.

Roll	Hardness	Gloss
Rubber	53	21
Do	73	28
Do	80	29
Nylon 6/6	83	30

The gloss of the coated web before finishing was about 16, and it can be seen that the softest roll had very little finishing effect on the coated web. The gloss measurements throughout this specification are in accordance with TAPPI Standard T–480m–51.

As previously stated, the elastic composition rolls forming part of this invention may also be used in an off-machine supercalender stack to replace cotton rolls. For example, a nylon roll of 83 Shore D durometer hardness was used under conditions normally encountered in a supercalender finish coated paper. Part of the same web of paper was finished by the action of a conventional cotton roll in a supercalender. In both instances, the nip formed by each of the above resilient rolls and a chilled iron roll was loaded to a pressure of 1200 pounds per linear inch of nip, a pressure loading common in off-machine supercalendering operations. The table below gives the data for the finishing action in each case on paper coated similarly to Example 1. The coated paper was passed through two nips and also four nips of the above description, and the data is representative of the coated side of the web which was against the chilled iron roll during the finishing operation.

Nip	No. of Nips	Gloss	Caliper, in.	Pressure, lbs./linear in.
Coated paper	0	16	.0028	0
Nylon-chilled iron	2	41	.0023	1,200
Cotton-chilled iron	2	46	.0023	1,200
Nylon-chilled iron	4	48	.0023	1,200
Cotton-chilled iron	4	51	.0023	1,200

It can be seen that the nylon roll produces gloss essentially equivalent to that produced by a cotton roll under supercalendering conditions.

Off-machine supercalenders are well known in the art and include conventional features, as shown in FIGURE 4, such as a vertical stack of rolls **76** and **78** and a frame means (not shown), said stack of rolls comprised of a series of alternate hard rolls **76** and soft rolls **78** mounted for rotation and held in vertical alignment and touching relationship to each other by said frame means; means (feed roll **70**) for feeding paper to be supercalendered into said stack of rolls and means (roll **80**) for withdrawing paper after it has passed through said stack of rolls; and drive means (not shown) for driving at least the lowermost roll of said stack of rolls.

It is apparent that the supercalender shown in FIGURE 4 is a schematic of an off-machine supercalender and the details for maintaining the rolls in alignment as by means of a suitable frame having bearings for the various roll journals, as well as the unwind and rewind mechanisms and their supporting frames, are not shown. These details have been omitted for purposes of clarity since they are well known in the art and do not form a part of this invention.

Example 2

As showing the nature of the complete process and resultant product of the present invention, employing double trailing blade coating and elastic composition roll on-the-machine finishing, the following illustration sets forth the preferred method of producing a unique light-

weight publication paper having the properties of a smooth printing surface with freedom of mottle and a bulk uncommon to such a lightweight sheet.

A web of paper of 32 pounds basis weight is double coated on each side by two trailing blade coaters, applying to each side a base coat of 4 pounds per ream and a top coat of 2 pounds per ream of the same coating formulations disclosed in Example 1. The paper is dried to about 6% moisture content through the application of heat.

The dried, coated web is then passed through two nips formed by a chilled iron roll, nylon roll, chilled iron roll combination. The web may be conventionally machine calendered before such finishing treatment, but it is essential that such precalendering be of a very light nature in order to avoid the production of a mottled surface.

As an exaggerated illustration of the web after double coating on one side, reference is made to FIGURE 3. The basestock P, which has a relatively rough surface **60** with respect to the smoothness necessary for high quality letterpress printing, has a coating **61** smoothed over its surface **60**, and the coating **61** is trowelled into the low areas of basestock P, and forms a relatively smooth top surface **62**. A second layer of coating **63** is smoothed over the first layer **61** and the result is a double coated web on one side with an extremely smooth top surface **64**.

In the final finishing on-the-machine with the nylon roll mentioned above, the bottom nip between the nylon roll and the chilled iron roll is loaded to a pressure of about 400 pounds per linear inch of nip. This finishing action provides for a very uniform finish on the coated surface of the web.

The paper produced by the above method has the following properties:

Gloss	29
Bulk	1.10
Printing smoothness	Excellent
Mottle	Excellent
Brightness	75.7
Opacity	88

The relatively low gloss of the final product is attributed to the fact that severe calendering of the web has been avoided. For printing papers, a gloss below 35 is often preferred because of the ease with which the paper can be viewed by a reader after printing of the paper has occurred.

The amount of mottle exhibited by the above paper was negligible, and a mottle rating of excellent was assigned to that paper. Throughout the specification, ratings of poor, good, and excellent have been arbitrarily assigned to papers exhibiting amounts of mottle from extreme galvanized surfaces to surfaces which are free of mottle.

Brightness, opacity, and bulk measurements shown throughout the specification are in accordance with TAPPI Standards T–452m–58, T–425m–44, and T–220m–46, respectively.

Part of the same paper set forth in Example 2 was finished by two nips of three chilled iron rolls loaded at 400 pounds per linear inch at the bottom nip and compared to the finished paper of Example 2.

Gloss	35
Bulk	1.01
Printing smoothness	Excellent
Mottle	Poor
Brightness	75.4
Opacity	88

Although the chilled iron rolls produce more gloss than in the above preferred method, they provide a mottled surface because of their inability to conform to the web and polish it evenly.

Part of the same paper from Example 2 was also finished by passing the coated web through two nips formed by a cotton roll and two chilled iron rolls in an off-machine supercalender stack. The following data is illustrative for this type of operation with a bottom nip loading of 1200 pounds per linear inch.

Gloss	45
Bulk	1.01
Printing smoothness	Excellent
Mottle	Excellent
Brightness	74.8
Opacity	86

It can be seen that although the gloss is higher in this finishing operation than in the above preferred operation, the printing smoothness and freedom of mottle in both instances are substantially equivalent. Bulk of the paper finished by the preferred method is higher because the calendering is a less severe calendering operation than is supercalendering. Brightness and opacity are also higher with the preferred finishing method for the same reason. Thus, we have discovered how to produce in one continuous operation a coated paper with the printing quality of a supercalendered sheet, maintaining higher bulk, brightness, and opacity. Such paper finds great utility in the field of publication paper, such as that used in textbooks and magazines. The increased bulk lends to the high degree of opacity obtained, and helps prevent show-through when the paper is printed on both sides.

The term printing smoothness as used in the above examples and in the claims may be defined as that smoothness quality exhibited by paper which enables the surface of the paper to make contact with ink on a printing plate when the paper is printed. The test for printing smoothness is carried out under the following standardized conditions. A sheet of paper is printed on a Vandercook No. 4 proof press, using an ink film thickness of 1.71 mg. per sq. in. and a pressure of 143 pounds per linear inch. The ink employed is designated as IPI No. 2 tack graded ink, and the areas printed are 5 inches x 7 inches. The sample in question is evaluated visually by a group of experts using comparison standards and judging the paper on the completeness of coverage of ink on the paper after printing. Paper exhibiting high coverage is rated as having a high degree of printing smoothness. The evaluation intentionally ignores factors other than smoothness, such as the gloss of ink or the blackness of the ink, because these properties are influenced by factors other than the smoothness of the paper.

The comparison standards used for evaluation purposes are graded samples previously printed under the above conditions and exhibit varying degrees of printing smoothness. The ink coverage on these samples ranges from a relatively poor coverage assigned an arbitrary value of 60 to a value of 95 for commercial paper finished against a highly polished surface and possessing a mirror image finish, and exhibiting the best ink coverage known in the art. The gradations between 60 and 95 are arbitrarily assigned 5 unit differences, that is, 60, 65, 70, 75, 80, 85, 90 and 95, and are gradual differences in ink coverage over the entire scale, but are sufficiently different between each 5 unit interval that one skilled in the art of evaluating ink coverage can make an obvious distinction between them. Printed paper with values of 90 and 95 is considered as having excellent printing smoothness, values of 80 and 85 are considered good, values of 65 to 75 are considered fair, and values of 60 and below are considered extremely poor for suitable publication paper.

Example 3

To show the benefits to the final quality of paper provided by double trailing blade coating, as compared to roll coating followed by trailing blade, the following example is set forth. Paper of 32 pounds basis weight was coated on both sides in each instance with 4 pounds per ream of a mineral coating containing 17% starch on

clay. The top coat on both sides of the web in each operation was 2 pounds per ream of a mineral coating containing 20% acrylic latix and 80% standard machine coating clay. The coated paper was dried to about 3% moisture content and finished by the preferred method as set forth in Example 2.

In the following chart, DTB denotes the double trailing blade operation and RC+TB denotes that the base coat was applied by a roll coater and the top coat was applied by a trailing blade coater. The Bekk smoothness values shown are in accordance with TAPPI Standard T-479sm-48.

WIRE SIDE

Coating Operation	Calender Pressure	Gloss	Bekk Smoothness	Printing Smoothness
DTB	0	17	100	
RC+TB	0	12	90	
DTB	200	23	150	Excellent.
RC+TB	200	19	170	Fair.
DTB	400	31	245	Excellent.
RC+TB	400	24	225	Fair.

FELT SIDE

DTB	0	18	145	
RC+TB	0	11	140	
DTB	200	26	185	Excellent.
RC+TB	200	19	170	Fair.
DTB	400	31	235	Excellent.
RC+TB	400	21	195	Fair.

It can be seen from the above tables that the gloss and in general Bekk smoothness of the paper coated by the preferred method were higher even without calendering, and these properties remained higher when the paprs were subsequently calendered. But more significantly, it is to be noted that the printing smoothness of the paper coated by double trailing blade ranked very high, even after light calendering, and was superior to the paper which was roll coated, followed by trailing blade coating. The property of excellent printing smoothness, at the relatively low calender pressures, is very important to the manufacture on the paper machine of a high grade printing paper. The subsequent calendering of the paper by the use of elastic composition rolls in a machine calender, providing a surface which is free of mottle, becomes an important supplement to the overall operations of manufacturing such paper on the paper machine. Best results are obtained, however, when the coated web before calendering is as smooth as possible, as by the use of double blade coating.

We have also found that best results are obtained when a resin rich top coat, such as 17% latex on clay, is employed. Paper of 32 pounds basis weight was coated by trailing blade with 4 pounds of a coating composition comprising mineral pigment and containing 17% starch on clay. A two pound per ream top coat containing 17% latex on clay was applied over the base coat by trailing blade to part of the paper, and a two pound per ream top coat of 17% starch on clay was applied over the base coat by trailing blade to the rest of the paper. The paper was finished by passing it through the nip formed by a nylon roll of 83 Shore D durometer and a chilled iron roll.

Top Coat	Calendar Pressure, lbs./lin. in.	Gloss	Bekk Smoothness	Mottle
17% starch on clay	200	29	150	Poor.
Do	400	34	185	Do.
17% latex on clay	200	36	165	Good.
Do	400	38	200	Do.

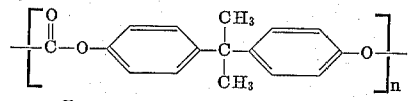
It can be seen that final gloss is increased by employing latex in the top coat, but, also important to the manufacture of a high grade printing paper, is the substantial lack of a mottled surface exhibited by the latex top coat. Even with nylon roll finishing, a mottled surface was evidenced when a starch-clay top coat was employed. Although a butadiene-styrene latex has been set forth in Example 1, other latices may be used. We have found that a top coat containing at least about 13% latex on clay should be used for suitable surface strength.

While we have disclosed the application of two coats to one side of the web followed by two coats to the other side of the web to produce double coated paper on each side, we have found that comparable paper can be produced by first precoating each side of the web followed by top coats on each side of the web without respect to the order in which the top coats are applied.

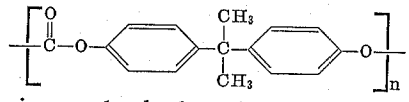
The coating and finishing processes disclosed herein may be employed in the manufacture of paper coated only on one side, and it is to be understood that the coating and finishing processes may be used on web material other than paper, such as paperboard, and the like.

We claim:

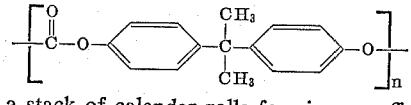
1. Apparatus for supercalendering paper comprised of a vertical stack of rolls and a frame means, said stack of rolls comprised of a series of alternate hard and soft rolls mounted for rotation and held in vertical alignment and touching relationship to each other by said frame means; means for feeding paper to be supercalendered into said stack of rolls and means for withdrawing paper after it has passed through said stack of rolls; drive means for driving at least the lowermost roll of said stack of rolls; characterized in that at least a substantial outer portion of said soft rolls is comprised of a polyaryl carbonate having the structural formula:



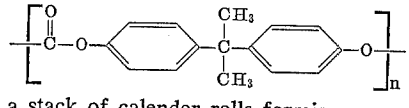
2. In an off-machine supercalender which includes a stack of alternating hard rolls and soft rolls, the combination with said hard rolls of soft rolls characterized in that a substantial outer portion of said soft rolls is comprised of a polyaryl carbonate having the structural formula:



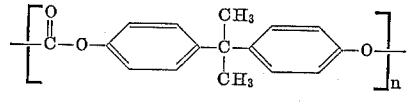
3. An improved calender roll comprised of an inner metallic load sustaining core and an outer cover encompassing said load sustaining core, said cover being a polyaryl carbonate having the structural formula:



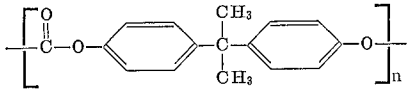
4. In a stack of calender rolls forming an off-machine supercalender, the combination of a plurality of hard rolls alternated with a plurality of soft rolls, each of said soft rolls comprising an inner metallic load sustaining core and an outer cover encompassing said load sustaining core, said cover being a polyaryl carbonate having the structural formula:



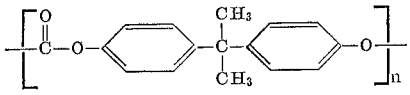
5. In a stack of calender rolls forming an on-the-machine calender, the combination of at least one soft roll alternated with a plurality of hard rolls, said soft roll comprising an inner metallic load sustaining core and an outer cover encompassing said load sustaining core, said cover being a polyaryl carbonate having the structural formula:



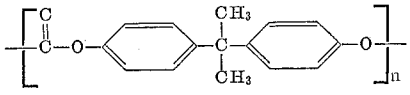
6. Apparatus for supercalendering paper comprised of a vertical stack of rolls, said stack of rolls comprised of a series of alternate hard and soft rolls mounted for rotation and held in vertical alignment and touching relationship to each other; characterized in that at least a substantial outer portion of said soft rolls is comprised of a polyaryl carbonate having the structural formula:



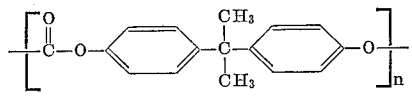
7. Apparatus for supercalendering paper comprised of a vertical stack of rolls, said stack of rolls comprised of a series of alternate hard and soft rolls; characterized in that at least a substantial outer portion of said soft rolls is comprised of a polyaryl carbonate having the structural formula:



8. In a calender for finishing a web of paper while said web is on a paper machine, wherein said calender normally includes a stack of metal rolls, the improvement characterized in that at least one soft roll is alternated with a plurality of metal rolls, said soft roll comprising an inner metallic load sustaining core and an outer cover encompassing said load sustaining core, said cover being a polyaryl carbonate having the structural formula:



9. In a stack of calender rolls forming apparatus for calendering and glossing paper, the combination of at least one resilient roll alternated with a plurality of metal rolls, said resilient roll comprising an inner metallic load sustaining core and an outer solid cover of a non-fibrous synthetic polymeric composition selected from the group consisting of polycaprolactam, polyhexamethylene adipamide poly-ω-aminoundecanoic acid, and a polyaryl carbonate having the structural formula:



said synthetic polymeric composition cover being shrink fitted on said core and having an inner surface which contacts said core at substantially all points of the outer surface of said core, said resilient roll having a Shore D hardness of at least about 53 at room temperature.

10. The combination of claim 9 in which the resilient roll has a Shore D hardness in the range of 80 to 94 at room temperature.

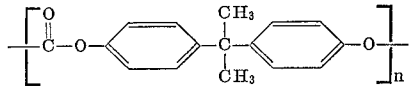
11. In a stack of calender rolls forming apparatus for calendering and glossing paper, the combination of at least one resilient roll alternated with a plurality of metal

rolls, said resilient roll comprising an inner metallic load sustaining core and an outer solid cover of polycaprolactam, said cover being shrink fitted on said core and having an inner surface in intimate contact with said core at substantially all points of the outer surface of said core, said resilient roll having a Shore D hardness of at least about 80 at room temperature.

12. In a stack of calender rolls forming apparatus for calendering and glossing paper, the combination of at least one resilient roll alternated with a plurality of metal rolls, said resilient roll comprising an inner metallic load sustaining core and an outer solid cover of polyhexamethylene adipamide, said cover being shrink fitted on said core and having an inner surface in intimate contact with said core at substantially all points of the outer surface of said core, said resilient roll having a Shore D hardness of at least about 80 at room temperature.

13. In a stack of calender rolls forming apparatus for calendering and glossing paper, the combination of at least one resilient roll alternated with a plurality of metal rolls, said resilient roll comprising an inner metallic load sustaining core and an outer solid cover of poly-ω-aminoundecanoic acid, said cover being shrink fitted on said core and having an inner surface in intimate contact with said core at substantially all points of the outer surface of said core, said resilient roll having a Shore D hardness of at least about 80 at room temperature.

14. In a stack of calender rolls forming apparatus for calendering and glossing paper, the combination of at least one resilient roll alternated with a plurality of metal rolls, said resilient roll comprising an inner metallic load sustaining core and an outer solid cover of a polyaryl carbonate having the structural formula:



said cover being shrink fitted on said core and having an inner surface in intimate contact with said core at substantially all points of the outer surface of said core, said resilient roll having a Shore D hardness of at least about 80 at room temperature.

References Cited

UNITED STATES PATENTS

2,763,893	9/1956	Hall	29—132
2,908,964	10/1959	Appenzeller	29—116
2,959,119	11/1960	Gould et al.	100—155 X
2,987,802	6/1961	Quinn	29—132 X
3,043,211	7/1962	Appenzeller	29—116
3,091,173	5/1963	Koch	100—162

OTHER REFERENCES

Modern Plastics, Encyclopedia Issue for 1960, September 1959, pp. 123–127.

LOUIS O. MAASSEL, *Primary Examiner.*

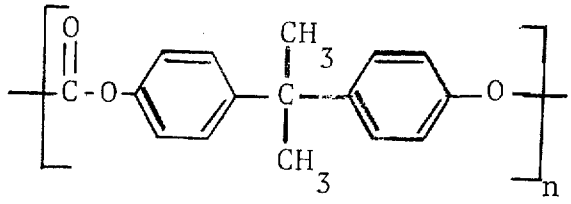
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,336,862 August 22, 1967

Maurice M. Brundige et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 30, for "pinear" read -- linear --; column 3, line 24, for "celendered" read -- calendered --; line 33, for "pound" read -- pounds --; column 4, line 37, for "coaed" read -- coated --; column 5, line 14, for "means" read -- mean --; line 62, for "set" read -- sets --; line 64, for "pound" read -- pounds --; column 6, line 23, after "supercalender" insert -- to --; column 9, line 3, for "latix" read -- latex --; line 34, for "paprs" read -- papers --; line 65, for "Calendar" read -- Calender --; column 11, lines 30 to 34, the formula should appear as shown below instead of as in the patent:



Signed and sealed this 30th day of July 1968.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents