Nov. 29, 1966 J. A. RUSH ETAL 3,288,632

PRODUCTION OF COATED PAPER

Filed Aug. 23, 1962 2 Sheets-Sheet 1

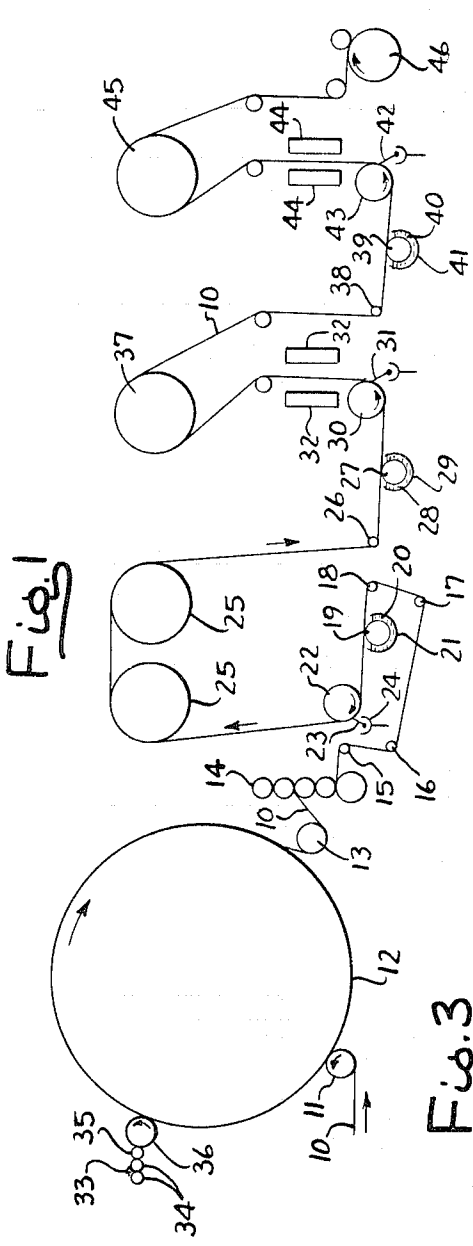

Fig. 1

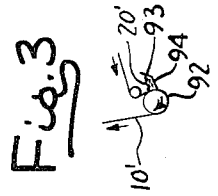

Fig. 3

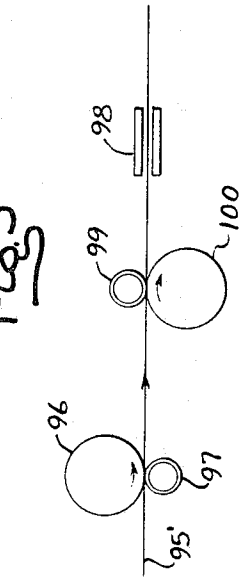

Fig. 5

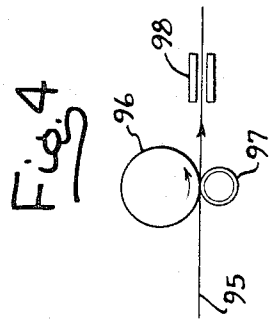

Fig. 4

INVENTORS
JAMES A. RUSH
BY SHERWOOD G. HOLT
Gary, Desmond & Parker
ATTYS

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Fig. 2

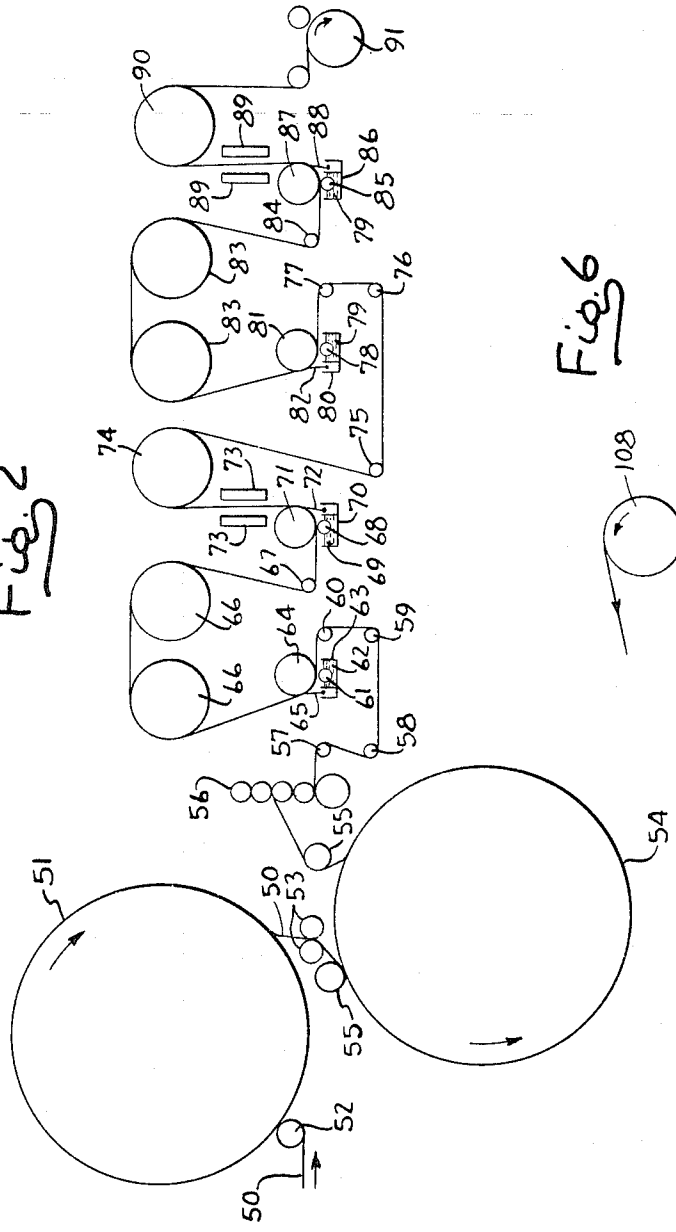
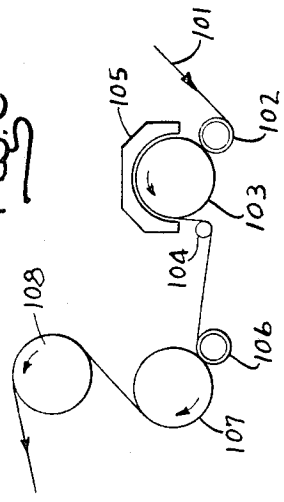


Fig. 6



INVENTORS
JAMES A. RUSH
SHERWOOD G. HOLT

BY Gary, Desmond & Parker
ATTYS.

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3,288,632

PRODUCTION OF COATED PAPER

James A. Rush, Stevens Point, and Sherwood G. Holt, Wisconsin Rapids, Wis., assignors to Consolidated Papers, Inc., Wisconsin Rapids, Wis., a corporation of Wisconsin

Filed Aug. 23, 1962, Ser. No. 218,928
4 Claims. (Cl. 117—68)

This invention relates to the production of coated paper of improved properties by a novel method. More particularly it is among the objects of the present invention to provide coated paper of improved printability suitable for use as either label and printed-one-side (P1S) packaging paper or printed-two-sides (P2S) book paper.

The improved printability of the present invention is accomplished by providing a coated paper with high gloss and better smoothness, controllable ink holdout and opacity, and better toughness than conventional supercalendered paper of equal opacity. Hence, the process of the present invention permits the use of lower weights of coating, lower weights of base stock and higher speed printing.

In general the process of the present invention and its foregoing object and other objects and advantages which will appear hereinafter, are accomplished by subjecting the uncoated paper web to at least two separate successive applications of aqueous coating composition followed by smoothing and leveling on the same side as by "blade" coating means.

In the preferred practice of the present invention, uncoated paper subjected to coating via this process is characterized by having its surface "ironed," that is, smoothed by means of a heated roll while moist, in order to level or lay down projecting fibers on one or both surfaces of the web. In this manner the surface of the paper web can be pre-smoothed so that 95% of its surface topographic discontinuities (peaks and valleys) are not greater than about 15–20 microns in height or depth. Such surface pretreatment can be accomplished by one or more means.

For example, one means of accomplishing the smoothing of the uncoated paper web and leveling of the fibers is by means of a "Yankee" dryer which is generally in the form of a polished steam-heated drum of about 12 feet in diameter. In Yankee drying a newly formed self-sustaining web of about 70% moisture content as it comes from the Fourdrinier wire, or after it has been partially dried to a moisture content of approximately 30 to 50% on conventional paper drying means, is pressed into contact with the polished Yankee dryer and dried thereon to a moisture content of about 4–8% and removed therefrom in what is known as a "machine glazed" condition, which is highly polished and the fibers flattened down, an example of such Yankee dryer being shown in Thiel & Richmond Patent 2,216,143 or Adrian Patent 2,313,497.

In a non-fully equivalent alternative, this effect may be accomplished and the opposed faces of the web smoothed and the fibers leveled by subjecting a newly formed paper web to drying by means of two Yankee dryers. Thus, for example, a newly formed web having a 65 to 75% moisture content is first dried on one side by means of a Yankee dryer drum to a moisture content of about 20–35%, and then dried on the other side to a moisture content of 4–8% in contact with a second Yankee dryer as, for example, set forth in the co-pending Hornbostel and Holt application Serial No. 794,594, filed February 20, 1959, now U.S. 3,079,700. In the process of the aforesaid pending application, while the surface of the web leaving the second drying drum becomes machine glazed, with a high gloss, the paper after leaving the first Yankee dryer loses some of its high polish but still remains ironed to a sufficient extent to smooth and level the fibers.

Alternatively, presmoothing can be accomplished by subjecting the freshly formed but not fully dried sheet to the action of a "gloss calender" or a "hot press."

One of the results of the process of the present invention and the coating compositions employed is that the final product requires little if any supercalendering. The present invention provides paper that with little or no supercalendering can be used for, for example, rotogravure printing of finenessses up to a 150 line screen and at speeds such as 1,000 feet per minute and with shallow etchings, and withal to provide faithful reproductions with a minimum of ink required. Indeed, one reason for the improved printability of the coated sheet of the present invention is the fact that the coated sheet still has "cushion" which is ordinarily lost during supercalendering.

It has previously been proposed to blade coat machine glazed paper with a single coating as in Rush Patent 2,746,878. However, the resulting coated surface is of a pitted nature and does not have the fine ink holdout and printability of the present process.

Thus far, attempts to avoid these pits through modifications to the previously disclosed Rush process (both equipment and formulation changes) have not been successful consistently. Pits have been successfully covered by the present invention through the use of a second blade or the like coater utilizing a coating having a greater proportion of adhesive to pigment than that of the first base or prime coat, and further having a major amount by weight of the binder solids in the form of an aqueous synthetic polymeric dispersion. This top coat formulation is further characterized by its free-flowing nature which helps in the filling of crevices, pits, and the like in the prime coat during the application of the top coat.

The process of the present invention is suitable for use in the fabrication of three distinctly different types of paper; label or wrapping paper, varying in basis weight from 25 to 45 pounds per ream, to be printed on but one side; lightweight publication or book papers (30–38 pounds per ream) to be printed on both sides; and heavy weight enameled or book papers (50–100 pounds per ream) to be printed on both sides. Each of these types of sheets has definite quality requirements which can be admirably met through the use of the process of our invention.

For example, in the manufacture of label or P1S wrapping paper it is necessary to produce a paper of both extreme smoothness and high ink holdout so as to allow labels and wrappers fabricated from it to be printed at high speeds (1000 feet per minute or more) and with the shallow etchings resulting from the use of the fine screens presently used in making rotagravure printing plates. Our invention is eminently suited for such purposes due to the extreme smoothness and controllable ink holdout achieved through use of synthetic polymer dispersions in formulating the top coating composition used in our invention.

Lightweight publication or book papers, on the other hand, demand a maximum of opacity at a satisfactory printability and again the process of our invention is eminently suited to answer the requirements of this type of paper because: proper use of our invention will enable one to produce a sheet of high smoothness, high ink holdout, and adequate gloss with little or no supercalendering. As a result the loss in opacity inherent in the supercalendering process is either avoided or minimized with the result being a finished sheet of appreciably greater opacity than conventional papers of equal printability.

Heavy weight enameled or book papers, however, often

suffer from variations in the manner in which adjacent areas absorb ink. This unequal absorption of ink is referred to as VIA, variable ink absorbency. The degree of the VIA is significantly affected by the extent of the supercalendering operation that is necessary to develop the required gloss and smoothness. The more severe the supercalendering (the greater the pressure, the more steam required to plasticize the coating, the greater the number of nips required) the more pronounced will be the undesirable VIA. The process of our present invention permits us to obtain good smoothness, good gloss and to reduce VIA by minimizing supercalendering. Furthermore, the degree of ink holdout can be varied at will from high to low by the incorporation of various synthetic aqueous polymeric dispersions in the top or sealer coat.

Hence, in each case it is the extreme smoothness and controllable ink holdout achievable through the use of our invention which has been used to solve the specific manufacturing problems but in each case these advantages were used to slightly different ends. In other words, in the case of label papers our process solved the paper quality problems directly by allowing smoothness and ink holdout to be increased whereas in the case of the light and heavy weight enameled papers the manufacturing problems of low opacity and variable ink absorbency were solved completely or partially indirectly through our inventious ability to give a sheet of good printability and controllable ink holdout while resorting to only a minimum of supercalendering.

It is known to provide paper as it comes off the conventional paper dryers with successive coating, as for example in the Dickerman et al. Patent 2,949,382 wherein the paper is first coated by means of an imprint roll type coater, and then with a relatively low adhesive content coating formulation by means of a trailing-blade coater in an attempt to level the marks left by the imprint roll coater. That process does not provide paper of the fine printability, smoothness and other properties obtainable by the present invention, however.

Blade coating as employed in the present invention refers to coating means wherein a blade is employed to level off the wet deposit of coating composition and where the blade is disposed (extending in either an adward or downward direction) either closely adjacent to or adjustably spaced from the coating applicator.

For example, one type of blade coater comprises a trough terminating in a flexible metal blade maintained against the paper web as it passes around a resilient roll and through a pool of coating composition in the trough, as shown for example in the aforesaid Dickerman et al. patent.

Another type comprises the application of coating composition to a passing web by means of a roll to which the coating is indirectly or directly applied and transferred therefrom to the paper web, following which at a spaced point excess wet coating is removed and doctored by means of a flexible blade such as in the aforesaid Rush patent.

FIG. 1 diagrammatically illustrates one arrangement of apparatus for carrying out the process of the present invention.

FIG. 2 diagrammatically illustrates another arrangement of apparatus for carrying out another embodiment of the process of the present invention.

FIG. 3 diagrammatically illustrates an apparatus component which may be employed in the arrangement of apparatus of either FIGS. 1 or 2.

FIG. 4 diagrammatically illustrates a modified arrangement of apparatus known as a gloss calender for smoothing one side of the newly formed paper web prior to coating, and

FIG. 5 is a diagrammatic arrangement of apparatus similar to that of FIG. 4 for smoothing the opposed faces of the paper web.

FIG. 6 diagrammatically illustrates another modified arrrangement of apparatus known as a hot press for smoothing the opposed faces of the newly formed paper web prior to coating.

According to the drawing, FIG. 1 diagrammatically illustrates an arrangement of apparatus for drying a newly formed wet paper web on a Yankee dryer and the dual coating thereof on the wire side of the paper by blade coater means with further illustration of means for optionally coating the back or felt side of the web which in this case has not been machine glazed. Thus, referring more specifically to FIG. 1, reference numeral **10** indicates a newly formed wet web after leaaving the Fourdrinier, either in the normal condition of about 65–75% moisture content or in a condition of partial dryness such as 30 to 50% moisture by reason of having passed over a plurality of conventional drum dryers (not shown).

The wet web is then transferred by means of a pressure roll **11** to the large polished surface, steam-heated Yankee drum dryer **12** and carried thereon about a major portion of its peripheral surface until it is stripped therefrom over the roll **13** at which time the moisture content has been reduced to about 4–8%. This stripping is conveniently accomplished by means of the rolls of the calender stack **14** which are usually driven via the bottom roll in the stack.

Although in the illustration the web **10** passes through three nips of the calender stack **14**, this stack may be replaced by a single pair of pinch rolls, not shown, for the purpose of stripping the paper from the drying drum **12**.

The surface of the wet web **10** which is brought into intimate contact with the highly finished and heated surface of the Yankee dryer drum **12** takes on a glazed or ironed appearance, generally designated as "machine glazed," characterized by the fibers on the glazed surface having become smoothed or laid down or hot pressed to such an extent that surface discontinuities in the sheet are reduced to not more than 5% greater than about 15 to about 20 microns in height or depth. One advantage of a surface of this nature is that lesser amounts of coating composition suffice to cover the surface of the web. This reduction in coat weight makes possible the fabrication of considerably lighter weight sheets while being able to retain the good printability of heavier weight papers.

The paper web **10** having a single machine glazed surface may be wound up and subsequently subjected to the coating method of the present process, but ideally coating is accomplished on-the-machine, that is, papermaking and coating are carried out in a continuous process at papermaking speeds. Thus, as further illustrated in FIG. 1 the web **10** after passing through the calender stack **14** is subjected to coating on the felt or unglazed side by the spaced blade coater means shown. The purpose in doing this is to give the web better opacity and density. This filling up of the web from the back side also enhances the printability of the web and reduces its requirement for coating on the machine glazed side. Furthermore, coating of the protruding fibers on the back or felt side also aids in minimizing the requirement of wax when the coated web is to be waxed for use in food wrapping.

Thus, as shown, after leaving the calender stack **14** the web **10** is trained around a plurality of rolls **15**, **16**, **17**, and **18** whereat the felt side of the web **10** is moved over and into contact with the surface of applicator roll **19** rotating in a body of coating composition **20** in the fountain **21**.

This applicator roll **19** is preferably driven by means of a variable speed motor not illustrated, and at approximately 70% of the paper speed. After the back side (felt side) of the web is coated, it passes around the resilient, i.e., rubber-covered, back-up roll **22**, and excess coating is removed from the web by means of a flexible doctor blade **23** whereat excess coating is collected in the trough **24** and returned to the system, preferably after screening

to remove fibers and other coarse particles. In addition, means, not shown, are provided for adjusting the angle and pressure of the doctor blade **23** with respect to the back-up roll or for further cleaning the blade when necessary. The web **10** with its felt side now coated by means of the described blade coating means comprising applicator roll **19** and blade **23**, is then dried by bringing its wire side into contact with and over drying drums **25**, **25** and reversing its direction of travel at the same time.

Although the felt side of the web has been described here as being coated by blade coater means at a point after machine glazing, this back side formulation may alternately be applied by means of an imprint roll coater arrangement while the paper web is still being dried on the Yankee dryer drum **12** as also shown in FIG. 1 where a supply of coating composition **33** is maintained between the oppositely rotating gate rolls **34**, **34** and distributed therefrom by the roll **35** to the roll **36**, which may be resilient surfaced. Thereafter it (the coating) is transferred in the form of a pre-formed film directly into the back or felt side of the web **10** as it passes around Yankee drying drum **12** and is dried thereon by the removal of the aqueous vehicle in the coating composition along with the rest of the moisture in the web **10**.

The coating composition **33** may be the conventional type employed for imprint roll coaters comprising mineral pigment and binder in an aqueous vehicle with a solids content of approximately 40–60%.

The next step in the process of our invention is to apply a base coating to the machine glazed, wire side of the web **10**. Thus the paper after passing over the roll **26** is brought into contact with the applicator roll **27** which picks up coating composition **28** from fountain **29** and applies it to the wire side of web **10**. This coating composition **28** may be the same or different from the composition **20**. After the machine glazed surface of the web is coated, the web **10** passes around resilient back-up roll **30** whereat the composition **28** is doctored by means of flexible blade **31**, the applicator roll **27** and doctor blade **31** providing a blade coater similar to the arrangement of applicator roll **19** and doctor blade **23** previously described.

The web **10** now coated on each of its opposed surfaces passes between the spaced dryers **32**, **32** which may comprise banks of infrared lamps or air jets and the wet coating on the web's wire side is coalesced to a semi-solid state.

After leaving the drying drum **37**, which follows immediately behind the blade coater station where base coating is applied to the machine glazed side of the sheet, the web is drawn around the roll **38** and its machine glazed side is again brought into contact with an applicator roll **39** which picks up top coating composition **40** from the fountain **41** and deposits it onto the prime coated surface of the web. Coating composition **40**, as previously indicated, is characterized by its free-flowing character and high content (30 to 100% based on pigment) of an aqueous emulsion of synthetic polymeric material. The excess of coating composition **40** applied by roll **39** is doctored off by means of flexible blade **42** acting against the web **10** as it passes around the resilient surfaced back-up roll **43**. This final or top coating on the machine glazed surface is then dried as for example by passing the web **10** between dryers **44**, **44** and around the drying drum **45** before winding it up on the reel **46** in final dried form with the polymeric particles and coating pigment particles coalesced in the top coat.

The aforesaid sheet has one surface of a highly printable character because of its machine glazed and dual, blade coated surface. Paper of this nature is eminently suitable for the production of labels which are printed on but one face or "wrapping" papers to be printed on only one side, the word "wrapping" in this instance being understood to include sheets which are applied as by wrapping or by adhesion to paper board containers or used separately without such support for food wrapping.

FIG. 2 as previously indicated shows an arrangement of apparatus for applying dual coatings to each of the opposed faces of a paper web which is used for book paper, i.e., coated paper intended for use in applications where both of its sides are to be printed, and which has prior to application of such coatings been ironed, that is, had its surfaces smoothed and the fibers thereof laid in substantial parallelism to the web surface by drying the newly formed wet web as it leaves the Fourdrinier wire by training it around two large Yankee dryers via the procedure previously described in the aforesaid Hornbostel and Holt co-pending application. Thus, in this case the paper web **50** is delivered from the Fourdrinier wire without pre-drying at a moisture content of about 65–75% and brought into contact with the heated polished surface of the Yankee dryer **51** by means of the roll **52** and dried thereon to a moisture content of about 20–35%. In this condition the web **50** is then stripped from the dryer **51** by means of the draw rolls **53**, **53** and then pressed into contact with the second Yankee dryer drum **54** by means of the roll **55**. The opposed surface of the new partially dried web is caused to be machine glazed by having been dried in contact with the polished surface of Yankee dryer drum **54**. The resultant web is then stripped from the drum **54** around the roll **55** by being caused to pass through one or more nips of the calender stack **56** similar to the calender stack **14** previously described.

The paper web as a result of having passed around the Yankee drying drums **51** and **54** which serve to smooth and level or machine glaze the opposed surfaces of the web can now be effectively coated in the manner described for use on the machine glazed surface of web **10**. Thus, web **50** after leaving the calender stack **56** and being trained around a plurality of rolls such as **57**, **58**, **59** and **60** is caused to be brought against applicator roll **61**, contacting prime coating composition **62** in fountain **63**, so as to apply coating compositions **62** to web **50** as it passes around back-up roll **64**. As the coated web **50** passes around roll **64**, excess coating is doctored off by means of an inverted flexible blade **65**. Thus, a blade coater arrangement comprising applicator roll **61** and trailing or following blade **65** similar to the arrangements shown in FIG. 1 with respect to applicator roll doctor blades **19**, **23**; **27**, **31**; and **39**, **42** is achieved.

The web **50** having a prime coating on one surface is then drawn around a pair of drying drums **66**, **66** and brought around roll **67** so as to bring the opposed face of the web into contact with applicator roll **68** revolving in a coating composition **69** which may be the same as that of coating composition **62** since both are used as prime or base coatings. Shortly after application of the coating composition **69** and while the web is still in contact with roll **71**, the excess coating is doctored off and smoothed by means of the flexible blade **72** providing another blade coating arrangement similar to those previously described. The web **50** now having a prime coating on its opposed faces, is passed between opposed drying means **73**, **73** which may be drying means similar to dryers **32**, **32** and **44**, **44** previously described.

The web then passes around drying drum **74** where its direction of travel is reversed so as to allow it to be passed around a plurality of rolls such as **75**, **76**, and **77** to allow the first side coated to be provided with a second or top coating by being brought against applicator roll **78** which picks up top coating formulation **79** from fountain **80**, as the web passes around resilient back-up roll **81** where excess coating is doctored off by means of the flexible doctor blade **82**. The web **50** then passes around the pair of drying drums **83**, **83** and roll **84** and is brought into contact with applicator roll **85** which applies a layer of top coating composition **110** which may be the same as top coating formulation **79**. Shortly thereafter, the web contacts resilient back-up roll **87** where excess top coating **110** is doctored off by blade **88** and

the residual remaining on the sheet is partially dried by passing web **50** between the banks of dryers **89, 89** and round drying drum **90** for final drying of the smooth top coating before finally being wound up on the reel **91**.

FIG. 3 illustrates a modified but well known blade coater which may be employed in lieu of one or more or all of the blade coaters previously described. Thus FIG. 3 illustrates a web **10'** which may be the same as webs **10** or **50** previously described, as it is passed around a resilient roll **92** and drawn through a pool of coating composition **20'** which may be the same as the prime or top coatings employed in previous arrangements or even the same as the coating composition applied to the back side of the web in FIG. 1. A pool of this coating composition **20'** is maintained in contact with the paper web **10'** as it passes around roll **92** by means of a trough defined by the backing member of blade holder **93** and the flexible doctor blade **94** which smooths and levels the coating composition **20'** as the web **10'** leaves the pool.

For the purpose of the present invention it is possible to use means other than the single Yankee dryer **12** or pair of Yankee dryers **51** and **54** to iron the paper web so as to smooth its surface and level the fibers thereon into substantial parallelism with the web surface. For example, the paper web may be subjected to the action of a one-side gloss calendar illustrated in FIG. 4.

This device, the gloss calendar, consists of a chrome plated, large diameter, steam heated backing roll **96** opposing a rubber or plastic covered nip roll **97**. Its successful operation depends upon the passage of a relatively dry web **95** (5–25% moisture) through the nip formed by its two rolls while these rolls are pressed together at a pressure of 100–400 pounds per linear inch. This results in an ironing or smoothing of the surface of the web which is quite useful to the process of our invention. If necessary, the web can be passed between dryers **98** before coating.

Furthermore, the gloss calendar may be used to polish or pre-smooth both sides of the web as illustrated in FIG. 5 where the web **95'** is drawn through the two gloss calenders **96, 97** and **99, 100** to smooth its opposed faces, whereupon it may be dried by means **98** if necessary.

As previously mentioned a device similar to the gloss calender but usually referred to as a "hot press" may be used to treat a web in a relatively moist state (35–50% moisture). The action of the hot press is somewhat analogous to a conventional Yankee dryer upon which little drying is accomplished but in either case the net effect is to give the web a polished surface eminently suited for use in our process. Generally speaking one or more hot presses are located midway in the first dryer section of a paper machine so that a relatively wet sheet can be pre-smoothed as illustrated in FIG. 6. Here, web **101** (25–50% moisture) wraps around resilient roll **102** which presses it against polished, steam heated dryer **103** where moisture is removed by wrapping dryer **103** and subjecting the sheet **101** to the action of high velocity dryer **105**. Subsequently, web **101** is trained around roll **104** and directed to the nip of resilient press roll **106** and polished dryer **107** where its other face is smoothed and additional moisture is removed before sending it on to conventional can dryer **108**.

One of the great advantages of our process is that although supercalendering is conventionally employed as a final step in the process of making coated printing paper, the use of the process of our present invention eliminates or substantially reduces the requirement for supercalendering in the manufacture of such papers. This allows a substantial improvement in the economy of the process since in our invention it appears likely that in many instances an off-machine operation (supercalendering) can be eliminated thereby allowing a coated printing paper to be converted from raw materials into a finished salable product in but one manufacturing operation. Since paper manufactured by such a process is bound to be less expensive than paper produced by conventional means the economy of our invention is obvious.

Thus far, we have only mentioned the use of blade coaters to apply the smooth prime and top coats required by this invention. This should not be inferred to preclude the use of other coaters using doctors such as rods or small rolls on the ends of the blades or smoothing rolls which make lubricated contact with the web after application of coating in order to smooth the coating applied to the web.

The coating compositions employed in each instance basically comprise a mineral pigment such as paper coating clay, precipitated calcium carbonate, titanium dioxide and the like or mixtures thereof. Materials such as titanium dioxide will be particularly useful where enhanced opacity is desired. In addition, clay deflocculating agents or mineral dispersing agents such as tetrasodium pyrophosphate, sodium hexametaphosphate and the like are employed in combination with the above pigments.

Additionally, binders are employed such as enzyme converted or oxidized starches, dextrines, casein and other proteinaceous materials such as zein derived from corn and soybean alpha protein or mixtures thereof. Other binders used alone or in combination with the above are water soluble resinous materials such as carboxymethyl cellulose and polyvinyl alcohol. Particularly desirable are aqueous dispersions of thermoplastic polymeric materials, sometimes referred to by the generic name latexes, consisting of aqueous dispersions of synthetic homo- and copolymers which are generally designated herein as polymers.

The solids content of the coating compositions employed may be from about 20 to 65% solids by weight, but preferably in the range of from about 40–60% by weight. The binder solids may comprise from about 10 to 100% by weight of the mineral pigment depending upon the use or place of application. Thus, for example, when applying a coating to the back side of the web which is machine glazed on a single surface as in FIG. 1, and where the coating composition is to be applied by means of an imprint type roll coater, the coating composition **33** may be of a somewhat thixotropic nature and comprised of essentially 100 parts of coating clay and 10 to 30 parts of a starch, such as enzyme converted starch, together with a small amount of ammonium stearate and tetrasodium pyrophosphate with water to produce a solids content of approximately 50%. On the other hand, when this back or felt side is to be coated by means of a blade coater such as is shown in FIGS. 1 and 3, the formulation used may contain 10 to 25% of a latex by weight of the pigment as binder.

The use of aqueous dispersions of thermoplastic, synthetic polymeric materials as the binder component is desirable when blade type coaters are used because they allow coating compositions of good flowability free from large amounts of either thixotropy or dilatency to be formulated. When starch or protein binders are used, however, achievement of good flow properties at desirable solids is often quite difficult.

For the prime coating compositions on the polished or machine glazed surface of the webs employed in the present invention, it is preferred that the coating compositions contain some polymeric binder and we have found it desirable to use from about 10 to 25% of such thermoplastic polymeric substances based on the weight of the mineral pigment employed.

An example of such a coating is one composed of 34 parts titanium dioxide, 20 parts calcium carbonate, 46 parts coating clay together with 14 parts of an acrylic resin latex, 2 parts of zein and a small amount of pigment dispersing agents and ammonia preservative for the acrylic binder. In addition, water is usually added to achieve a final solids content of about 60 to 64%.

Another and much more economical coating composition for the machine glazed prime coat may be made from 100 parts of coating clay, 16 parts of enzyme converted starch and sufficient water to bring the final solids content of the formulation to about 52%.

Still another base or prime coating formulation that can be applied to the glazed or smooth surface of the web is as follows:

	Pounds
Coating clay	575
TiO_2 (titanox RA–50)	400
Precipitated calcium carbonate (Purecal O)	225
Carbowax solution at 50% solids (solid water-soluble high molecular weight polyethylene glycol lubricating agent)	48
15% solids protein solution (soybean alpha protein)	160
26–28° Baumé ammonia diluted 50–50 with water	40
Vinyl acetate- acrylic copolymer resin—46% solids aqueous dispersion (National Resin 25–1103)	352
Quadrofos (sodium tetraphosphate)	1
Calgon (sodium hexamitaphosphate)	2.5

The foregoing composition has a dry solids content of 1415 pounds and is mixed with added water to give a solids content of 61%. The vinyl acetate-acrylic copolymer solids content was 13.5% while the protein content was 2% by weight on the mineral pigments.

The foregoing base coating composition is best applied by blade type coasters in amounts of from 3 to about 8 pounds per ream (500 25" x 38" sheets) in that below 3 pounds the raw stock coverage achieved is apt to be inadequate whereas above about 6 pounds per ream streaking and other operational problems increase rapidly in severity. (The base sheet basis weight may not be much less than 20 pounds per ream but there seems to be no reasonable upper limit.)

The top sealer coating composition in the preferred practice of the present invention contains little if any starch or protein as a binder. Instead, it is preferred to use aqueous dispersions of synthetic thermoplastic polymeric materials previously described. The reason being that the large hydrophobic polymeric particles tend to remain on the top of the prime coated surface and coating formulations made with such materials as the principal binder have good free-flowing properties that aid in filling up any cracks or crevices in the base coat. In addition, the preferred practice of the present invention dictates that the content of thermoplastic polymeric binder in the top coat should fall somewhere between about 30 to about 100% based on the weight of pigment in the formulation and that the solids content of the composition should not fall below 20 to above about 65% solids while showing a Brookfield viscosity (20 r.p.m.) of 15 to 50 centipoises at a solids content of 40% at 25° C.

This top coating is employed to wipe out discontinuities in the coated surface of papers and give a sheet having not only better but also more uniform quality. In the process of our invention the amounts of top coating applied vary from a minimum of about ½ pound per ream to a maximum of 3 pounds per ream with an average of 1 to 1½ pounds per ream giving highly satisfactory results. Below ½ pound per ream coverage and filling in of discontinuities in the base coat is not achieved. Above 3 pounds per ream cost becomes a factor and because no appreciable improvement in quality is achieved 3 pounds per ream has been arbitrarily taken as an upper limit despite the fact that it is quite feasible to apply more than 3 pounds per ream.

The viscosities of these top coating compositions are also desirably low and in part dependent on the total solids content. For example, in applying a coating of 1 pound per ream the coating composition should be about 40% solids with a Brookfield viscosity (20 r.p.m.) of 25 cps. at 25° C. For applying a 3 pounds per ream top coat the coating composition suitably has a solids content of about 60% yielding a Brookfield viscosity (20 r.p.m.) of about 3,000 cps. at 25° C.

A suitable top coating formulation can be as follows:

	Pounds
Titanium dioxide	240
Coating clay	560
Dispersing agent	5
Commercial aqua. ammonia diluted with 12# of water	12
Rhoplex B–60–A (46% solids acrylic copolymer resin aqueous dispersion or emulsion of the type described in U.S. Patent 2,795,564)	1305

This composition being composed of 1400 parts by weight of dry solids was mixed with added water to a solids content of 41%. The proportion of polymeric binder to mineral pigments was 75%.

Another example of a vapor sealer top coat composition is one composed of 100 parts coating clay and 50 parts polyvinylidene chloride-vinyl chloride copolymer mixed with added water to provide a 30% solids coating composition.

Other aqueous dispersions of synthetic thermoplastic polymeric binders may be composed of copolymers of styrene and butadiene, butadiene and acrylonitrile, polybutadiene, polyethylene, polyvinylbutyral, polychloroprene, acrylonitrile-polyvinyl acetate, vinylidene chloride-acrylonitrile, and the like thermoplastic dispersions of rubber and resin particles which coalesce upon drying and remain on the top of the sheet by reason of their large particle size and hydrophobic nature. Included among these are the acrylate resins which are thermoplastic polymers or copolymers of acrylic acid, methacrylic acid, esters of these acids, or acrylonitrile. Coating formulations using any of the above polymeric binders have the ability to fill up and smooth out minute cracks and crevices in a prime coated paper web when applied via blade and equivalent coating means; the result being a sheet characterized by gloss, better ink holdout and increased smoothness such that Sheffield smoothness readings of 10 to 15 (0 reading being perfect) can be achieved consistently.

Another rating of the smoothness and enhanced printability of the sheet of the present invention is an empirical one base on a 25-power magnification and optical observance of the number and severity of the pits in the coated sheet. Using a rating of 90 to 100 we have been able to achieve ratings of 96 consistently, utilizing conventional equipment similar to that described in the Rush Patent 2,746,878. With the process of our present invention ratings of 98 to 99 have been achieved consistently thereby allowing this type of paper to be printed at high speeds with the shallow etchings necessitated by a screen fineness of 150 lines per inch. This performance can be achieved through the application of a 3 pounds per ream base coat and a 1 pound per ream top coat.

A typical example of a sheet now being commercially manufactured uses a paper, machine glazed on but one surface, and coated in accordance with the method described in FIG. 1 of the drawings. The base stock has a weight of 28 pounds per ream with 2–2½ pounds per ream of coating composition applied to the back or felt side by either roll or blade coating means, and a total of 4¼–4½ pounds per ream of coating applied by the dual blade process heretofore described on the machine glazed wire side.

Although we have shown and described preferred embodiments of our invention, it will be understood by those skilled in the art that changes may be made in the details thereof without departing from its scope as comprehended by the following claims.

We claim:

1. The method of making paper of enhanced smoothness and printability which comprises applying onto each of opposed pre-smoothened surfaces of a forwardly moving dry web of paper two separate layers of aqueous coat-

ing composition of from about 20 to about 65% solids content comprising mineral pigment and adhesive and separately heat drying each coating after it has been applied and leveled, the adhesive in the first coating being from about 10 to about 30% by weight of the pigment and the adhesive in the last coating being greater in amount by weight of the pigment than that of the preceding coating and being from 30% to 100% by weight of the pigment and comprised principally of a thermoplastic synthetic aqueous polymeric dispersion.

2. The method of making paper of enhanced smoothness and printability which can be used for fine rotogravure printing with little or no supercalendering which comprises applying onto each of the surfaces of a double machine glazed forwardly moving dry web of paper two separate layers of aqueous coating composition of from about 20 to about 65% solids content comprising mineral pigment and adhesive and separately heat drying each coating after it has been applied and leveled, the adhesive in the first coating being from about 10 to about 30% by weight of the pigment and the adhesive in the last coating being greater in amount by weight of the pigment than that of the preceding coating and being from 30% to 100% by weight of the pigment and comprised principally of a thermoplastic synthetic aqueous polymeric dispersion.

3. The method of making paper of enhanced smoothness and printability which comprises applying onto a double machine glazed surface of a forwardly moving dry web of paper two separate layers of aqueous coating composition comprising of from about 40 to about 60% solids content mineral pigment and adhesive and separately wiping and leveling each layer of coating before applying a successive coating, the adhesive in the last coating being greater in amount by the weight of the pigment than that of the preceding coating, the binder of each coating being comprised principally of a thermoplastic synthetic aqueous

polymeric dispersion, the amount of polymeric material in the first coating being from about 10% to 25% by weight of the pigment, and that of the second coating being from about 30% to 100% by weight of the pigment.

4. The method of making paper of enhanced smoothness and printability which comprises applying onto the opposed surfaces of a forwardly moving dry web of paper whereof said surfaces are ironed and about 95% of its surface topographic discontinuities are not greater than about 15 to 20 microns in height and depth, a plurailty of separate layers of aqueous coating composition of from about 20 to about 65% solids content comprising mineral pigment and adhesive to each of said surfaces and separately wiping and leveling each layer of coating before applying a successive coating, the adhesive in the first coating being from about 10 to about 30% by weight of the pigment and the adhesive in the last coating being greater in amount by weight of the pigment than that of the preceding coating and being from 30% to 100% by weight of the pigment and comprised principally of a thermoplastic synthetic aqueous polymeric dispersion.

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MURRAY KATZ, *Primary Examiner.*

R. HUSACK, *Assistant Examiner.*