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METHOD AND APPARATUS FOR COATING PAPER

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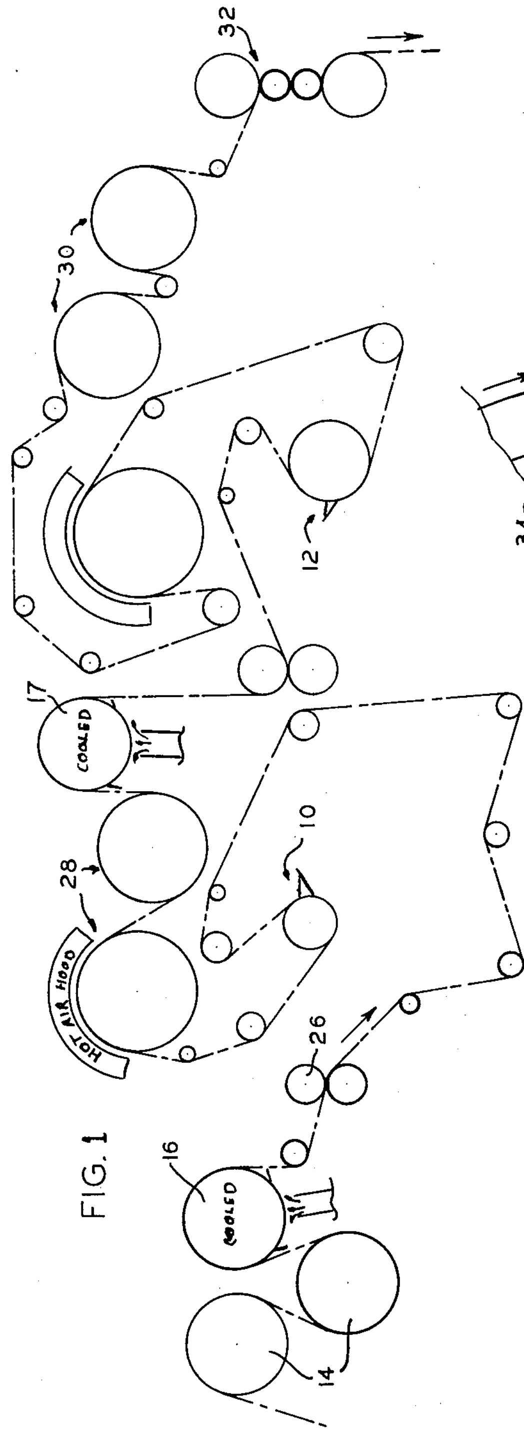


FIG. 1

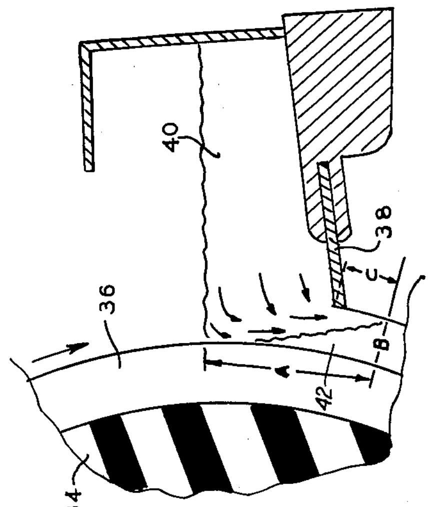


FIG. 2

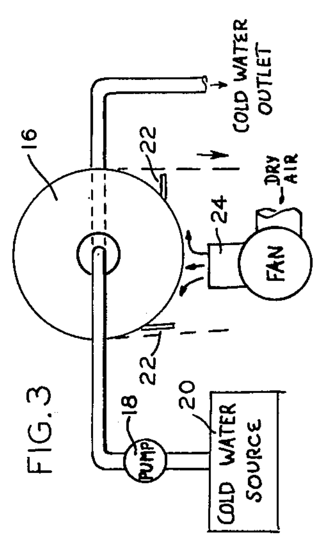


FIG. 3

INVENTOR.

*John Alfred Bicknell*

BY *Porter, Chittick and Russell*

*Attys.*

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# METHOD AND APPARATUS FOR COATING PAPER

John Alfred Bicknell, Westbrook, Maine, assignor to S. D. Warren Company, Westbrook, Maine, a corporation of Maine

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This invention relates to a method and apparatus for coating paper, and more particularly to coating paper at high speed as an integral step in the production of paper on a paper-making machine.

The principal object of this invention is to provide a method and apparatus for applying a coating to paper at high speeds and in series with a paper-making machine. Another object of this invention is the provision of a method and apparatus for eliminating streaks normally encountered in blade coating. A further object of this invention is the provision of a process and apparatus for applying coatings of relatively high solids to paper at high speeds and in series with a paper-making machine.

In the accomplishment of these and other objects of my invention in a preferred embodiment thereof, I employ a coating apparatus mounted in a break between drier sections of a paper-making machine. It consists essentially in a metal blade mounted to apply pressure across the paper web along a line of contact applied against a resilient backing roll. A coating material is introduced against the paper in back of the blade and forms a pool adjacent to the paper as it passes beneath the blade. In advance of this coating mechanism I employ a cooling roll which may be the last can of a drying series in the paper-making machine. This roll is internally cooled, and as the paper passes over it from the last drying stage of the paper machine, the cooling roll brings the temperature of the paper from 150° F. down to below 110° F., and preferably below 80° F. A cooling roll of this sort readily condenses moisture from the air surrounding it, and unless care is taken it sweats and leaves moisture marks on the paper. This propensity of the cooling rool is overcome in my invention by blowing hot dry air thereon and wiping the same with a felt or doctor.

It is a feature of my invention that coating materials of unusually high solids content may be employed. Highly satisfactory results have been obtained using coating materials having greater than 60% solids. When this has been tried previously as an integral part of the paper production process, coatings of such high solids cause drastic streaking under the blade and are objectionable for that reason. Another feature of my invention is that a comparatively free body stock can be used without impairing the performance of the coater or the high quality of the surface obtained. Ordinarily the relatively free paper stock required for higher speed paper-making takes up the water so fast from the coating materials that caking and streaking under the blade invariably occurs. This happens less when the process and apparatus of my invention are employed.

While I do not intend this invention to be limited to any precise theory, certain theoretical considerations may be of importance. In the first place, it is believed that the streaking which has traditionally plagued blade coating operations is due to a build-up of clay or other coating particles on the blade edge. This build-up furthermore appears to occur when the solids content of the coating material immediately adjacent to the blade edge exceeds a given maximum. Usually this occurs when a "filter cake" of coating material builds up on the paper in advance of the blade. Another consideration relates



to the pressure of the blade against the paper and the forces which hold it up. Apparently the smoothness of the coating and its uniformity result from using a resilient blade pressing against the coating materials and being held up from contact with the paper by the dynamic forces of the coating materials which have been drawn down and accelerated towards the blade edge by surface contact with the moving paper. Thus it is apparent that more coating material can be applied for a given blade pressure and paper throughput speed when more coating material is accelerated so as to hold the blade further from the paper base. A third consideration relates to the speed of throughput and its relation to the consistency of the coating materials. In order to flow smoothly and flatly under the blade at high speeds, the coating materials must be relatively thin in consistency and have good dynamic flow characteristics. At first glance, these three considerations appear to call for conflicting solutions. The most obvious way to keep the coating materials from building up a "filter cake" is to shorten their length of contact with the paper prior to reaching the blade edge. Doing this, however, reduces the acceleration of the coating materials by the paper and renders it difficult to apply any appreciable weight of coating. Likewise, thickening the consistency of such a coating will not solve the problem because, even though thickening the mixture will increase the weight of coating applied, the further result of thickening will be to cause a "filter cake" build-up.

It will now be seen that a major feature of my invention is that it provides a way for resolving these apparently conflicting requirements. By cooling the paper prior to applying the coating materials thereto a marked improvement in "hold-up" (resistance to water transfer from coating materials to paper) is observed. This means that for a given coating formulation, the length of coating-to-paper contact can be increased without a dangerous "filter cake" build-up. This in turn means that more coating material may be accelerated against the blade thereby holding it further away from the paper and permitting more coating material to pass thereunder. Likewise it also means that a lighter and more fluid coating material may be employed thereby permitting higher speed operation, and of particular significance, for the first time permitting successful blade coating as an integral part of the paper-making process.

Further objects and features of my invention will best be understood and appreciated from the following detailed description of a preferred embodiment thereof, selected for purposes of illustration and shown in the accompanying drawings, in which:

FIG. 1 is a diagrammatic view in cross section of the final drying drums of a paper-making machine incorporating the cooling roll and blade coating mechanisms of my invention;

FIG. 2 is an enlarged view in cross section illustrating the flow conditions of coating material underneath a blade with the horizontal dimension greatly increased in proportion for purposes of illustration; and

FIG. 3 is a diagrammatic view of the cooling roll and condensation drying air blast employed in the process and apparatus of my invention.

In carrying out my invention I employ a paper-making machine, the final stages of which are indicated generally in FIG. 1. In series with this machine I employ a first blade coater **10** for applying coating materials for one side of the paper issuing from a paper-making machine, and a second blade coater **12** for applying coating materials to the other side of the paper. In general the sequence is as follows. The paper indicated in dotted lines in FIG. 1 is formed on the paper-making machine and dried on drying rolls. A pair of drying rolls 14 of the paper-making machine appear at the left-hand side of FIG. 1. From these rolls 14 the paper, which may or may not at this stage include filling and sizing materials, passes to a cooling roll 16 which is maintained at a temperature below 110° F., and preferably below 80° F., by means of cold water pumped therethrough by pump 18 from a cold water source 20 (see FIG. 3). It will be understood that the roll 16 being substantially colder than the surrounding air causes condensation readily to form on the roll, and unless some provision were taken to counteract the water droplets thus formed would tend to spoil the paper. This disadvantage is overcome in the apparatus of my invention by employing felt doctors 22 and directing a blast of dry air at 24 against the roll 16. After leaving the roll 16, the paper may be passed through a calender stack 26 and thence around rolls to the blade coater 10. From the blade coater 10 the paper is passed through another series of drying rolls indicated at 28, and if it is then desired to coat the opposite side of the paper, the paper is then run over another cooling roll 17 (similar to roll 16) down to the second blade coater 12 and again through a set of drying rolls indicated at 30. Finally the paper is optionally passed through a calender stack indicated at 32.

The process of my invention has been carried out in accordance with the following specific examples.

EXAMPLE 1

A moderately beaten paper-making furnish of about equal parts of bleached pulp made from soft wood and bleached pulp made from hardwood, sized with rosin-size and alum, was formed into a web of paper weighing 28 pounds, dry weight, per ream of 500 sheets cut 25 x 38 inches. The paper was dried by passing over a series of drying cylinders in the paper machine. The web was then passed through a size-press where a starch solution was applied to one side of the web in amount equivalent to one pound dry weight per ream. The sized paper was again dried by passage over more drying cylinders. Then the dried paper was cooled at 80° F. by passing around a cylinder internally cooled by cold water. The cool paper was passed through a trailing-blade coating device which applied to the starch-sized side of the web a layer of coating amounting to seven pounds dry weight per ream. The coating applied was according to the following Formula I in which figures are given in parts dry weight.

*Formula I*

60 clay
40 calcium carbonate
5 soy protein (low viscosity) solvated by ammonia
11 styrene-butadiene copolymer (added as 48% solids latex #512R, Dow Chemical Co.)
¾ anti-foam agent
Water to make solids content, 58%

This coating has a viscosity of 400 centipoises.

The coated web was dried first on a heated cylinder while hot air was blown over the coated surface and then further dried by passage over further drying cylinders. The dried paper was then passed through a paper-machine calender and reeled up into a roll at the end of the paper machine. The speed of operation was 1000 feet per minute. The coated paper so produced was free from streaks, was uniform in appearance and had a matte or semi-dull surface.

Part of the paper was later calendered in a conventional supercalender and developed a gloss of 55 as measured on a Bausch and Lomb glossmeter.

EXAMPLE 2

A rosin-sized paper was made weighing 45 pounds per ream. This contained 14% of clay filler and had a 40:60 ratio of bleached soft wood to bleached hardwood chemical fibers. The web was passed from a section of drying cylinders into a squeeze-roll coating device where there was applied to one side of the web 9 pounds dry weight of a coating composition of 48% solids containing 40 pounds of oxidized starch adhesive to 100 parts of clay. The coated web was dried by passage over another series of heated drying cylinders. Then the paper was cooled to 80° F. by passage about an internally cooled cylinder.



The cooled web was passed through a trailing-blade coating device where there was applied to the prime-coated side of the web a 12 pound dry weight per ream layer of coating of composition the same as that of preceding Formula I except that it contained only sufficient water to make the solids content 65%, and had a viscosity of 7,000 centipoises.

The so-coated paper was dried, calendered, and reeled up at 1,000 feet per minute just as in the case of Example 1.

Additional specific coating formulas which have been used successfully are the following:

*Formula II*

85 clay
15 calcium carbonate
30 oxidized starch
1 dimethylol urea
¾ tallow
¾ anti-foam agent
Water to make solids, 60%
Viscosity, 4,500 centipoises
6 to 8 pounds dry weight put on at 700 feet per minute
Temperature, about 90° F.

*Formula III*

50 clay
50 calcium carbonate
8 soy protein (low viscosity) solvated by ammonia
2 casein solvated by ammonia
5 styrene-butadiene copolymer (as latex)
¾ anti-foam agent
Water to make solids, 62%
Viscosity, 2,000 centipoises
6 to 8 pounds dry weight put on at 700 feet per minute
Temperature, 90–95° F.

*Formula IV*

20 clay
80 calcium carbonate
4 soy protein solvated by ammonia
9 styrene-butadiene copolymer (as latex)
¾ anti-foam agent
Water to make solids, 60%
Viscosity, 1,000 centipoises
8 pounds put on at 700 feet per minute
Temperature, 90–95° F.

*Formula V*

100 clay
15 soy protein solvated by ammonia
4 styrene-butadiene copolymer (as latex)
1½ melamine-formaldehyde condensate
¾ defoamer
Water to make solids, 60%.
Viscosity, 5,300 centipoises
8 pounds put on at 700 feet per minute
Temperature, 90–95° F.

These latter four formulas were all used in prime-coated paper like that used in Example 2. The weight of the paper base can be varied widely, for instance, from 40 pounds to 100 pounds per ream. The paper can be prime-coated on one or both sides at the same time by a squeeze roll (impregnation) coater. Likewise the top or blade-coating can be applied to both sides, but in this case only one side can be blade coated at a time, and the first coated side must be dried (and the sheet again cooled) before the other side is blade-coated.

Although each of the above examples employed a sized base paper, this invention is applicable to uncoated, unsized paper although it is sometimes necessary to calender it prior to the blade-coater. A calender with water-cooled rolls may be used following the cooling cylinder, or, more awkwardly, a cooling cylinder may be installed after the calender and before the blade-coater.

In connection with the above specific examples, each one will show streakiness if run at paper machine speeds of 900 f.p.m. and at a paper temperature of 150–170° F.

All viscosity measurements given in the above examples were made on a Brookfield viscometer at 100 f.p.m. and 80° F. and then converted to centipoises.

When the product of my invention is supercalendered the gloss usually falls between 55 and 60 on a Bausch and Lomb glossmeter.

In accordance with this invention a light-weight coating may be applied employing a prime-coated base paper cooled at 95° F. and coated with 3 pounds (per ream) dry weight of the composition of following Formula VI.

*Formula VI*

60 clay
40 calcium carbonate (ground chalk)
30 starch adhesive (oxidized starch)
1 dimethylol urea
¾ tallow
¾ defoamer
Water to make 53% solids
Viscosity, 940 centipoises
3 pounds put on at 700 feet per minute
Temperature, 95° F.

In FIG. 2, I have shown a diagrammatic representation of a resilient backing roll **34**, with a base paper **36** thereon, a resilient blade **38**, and a pool of coating material **40**. The purpose of FIG. 2 is to facilitate an understanding of what happens during the coating process. The dimension lettered A represents the distance between initial contact between coating material and the point at which water absorption into the paper base (or other forms of coating water loss) brings the "filter cake" to the distance of the blade **38** from the paper **36**. The latter distance is represented by the letter B. Naturally, the distance B depends on the thickness of coating deposited. Usually it is only about .0004″. In order to avoid streakiness, the liquid coating material **40** must be accelerated by contact with the paper **36** to be projected against the blade **38** with sufficient velocity to hold up the resilient pressure of the blade **38**, and before the "filter cake" (indicated at **42**) has built up. This is done in my invention by cooling the paper which I find to be an extremely important step. With the cool paper the dimension A may be increased so that the coating **40** gains substantial velocity prior to reaching the blade **38**. The dimension C represents the distance through which the coating surface **40** remains in the fully liquid (and dynamically fluid) state after passing the blade **38**. Streakiness cannot be avoided unless this dimension extends clearly beyond the last point of contact between the blade **38** and the coating material.

In analysing coating compositions of the types described herein, I find that their ability to retain water increases sharply once their temperature is brought down below about 110° F. Thus, by tests made by depositing a measured quantity of coating on a paper base and determining the time it takes for water to penetrate the base, most coatings have very poor water retention at temperatures of 160° F. Coatings containing latex are in general less retentive than those containing only casein. In general, the water retention time doubles between 160° F. and 120° F. and again doubles between 120° F. and 100° F. From there down to 80° F. the retention time curve rises steeply and the retention time more than triples between 80° F. and 70° F. Naturally, the viscosity of the coating material also increases as the temperature drops, and since the temperature of the paper is substantially more important than the temperature of the coating material pool above the blade, my invention permits regulation of the amount of coating applied to the paper by regulating the temperature of the paper. I regard this as entirely novel and intend to claim the same herein broadly. In addition to and in combination with the foregoing, my invention permits the use of a heated coating material in the blade pool above room temperature while cooling the paper base below room temperature. This greatly expands the range of possible useful coating materials.

Since numerous minor variations of this preferred embodiment of my invention will now be apparent to those skilled in the art, it is not my intention to confine the invention to the precise form herein shown, but rather to limit it in terms of the appended claims.

Having thus disclosed and described a preferred embodiment of my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In the process for making coated paper wherein the paper body stock is formed on a paper machine, then dried by the application of heat thereto at a temperature of above about 150° F., and thereafter coated in a continuous sequence, the steps of: preparing liquid coating materials including a mineral filler, an aqueous adhesive and water; applying said materials to said body stock with said body stock proceeding at the same rate at which it is formed on said paper machine, retarding the rate of formation of a "filter cake" of said coating materials on said body stock by lowering the temperature of said body stock to below about 110° F. prior to the application of said coating materials thereto; and smoothing said coating materials on said body stock simultaneously with said application step by passing the same through a smoothing means while at least the surface of said materials is still in said liquid state.

2. A process for manufacturing paper comprising the steps of: forming a paper web, drying said web at a temperature above about 150° F., passing said web into a pressure nip formed between a backing roll and an essentially resilient pressure member pressing in the direction of said backing roll, accelerating a liquid coating material containing a mineral filler by applying said coating material to said web immediately prior to the entrance of said web into said nip, projecting said accelerated liquid coating material against said member with sufficient force to hold said member away from contact with said paper, and simultaneously retarding the formation of a "filter cake" of said coating material on the surface of said web by cooling said web prior to the application of said coating material thereto to a temperature of below about 110° F.

3. A process for coating paper comprising: preparing an aqueous coating material containing a mineral filler, cooling a paper base, thereafter passing said paper base through a blade coater wherein said material is applied to said paper base, and regulating the thickness of said coating material so applied by regulating the temperature of said paper base prior to the application of said material.

4. A process for coating paper comprising: preparing an aqueous coating material containing a mineral filler, reducing the viscosity of said material by heating the same above room temperature, cooling a paper base, thereafter passing said paper base through a blade coater wherein said material is applied to said paper base, and regulating the thickness of said coating material so applied by regulating the temperature of said paper base prior to the application of said material.

5. Apparatus for manufacturing paper comprising a paper-making machine including a series of heated drying rolls, means in a break between two of said drying rolls for cooling and controlling the temperature of a paper

web formed on said machine to a degree substantially below the temperature of said drying rolls, and means in close sequence following said cooling means for applying aqueous mineral filled coating material to said web.

6. The apparatus defined in claim 5 further characterized by means for preventing condensed moisture from forming adjacent to said cooling means and contacting said paper web.

7. In a papermaking machine apparatus comprising a series of heated drying rolls, a breaker stack, means between said series of heated drying rolls and said breaker



stack for cooling a paper web and means for applying a coating to the cooled web.

**References Cited** in the file of this patent

UNITED STATES PATENTS

2,237,068 Bradner ---------------- Apr. 1, 1941

OTHER REFERENCES

Calkin: "Modern Pulp v. Paper-Making," 3 ed., 1957, pages 312 and 313.