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(54) METHOD AND APPARATUS FOR APPLYING A FILM OF COATING MATERIAL ONTO A WEB

(71) We, POLYCHROME CORPORATION, a corporation organised and existing under the laws of the State of New York, United States of America, of 137 Alexander Street, Yonkers, State of New York 10702, United States of America, (assignee of SIMON LONG CHU; PETER SHU and ROBERT SHAROWSKY), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to roller-type apparatus employed for applying a coating on one surface of a moving web without contaminating the anterior side thereof.

In conventional roller or dip coating methods of applying a thin film or coating to a continuously moving web of metal or other substantially non-porous materials, because the support or backing roller is essentially the same width as the web, the coating material applied to the front of the web often contaminates the anterior surface of the web. That is, since coating material is applied at the web edges, some of this material migrates by capillary action or seepage to the interior surface of the web. When there is a backing roller of the same width as the web, the cylindrical surface of the backing roller becomes contaminated and in turn contaminates the anterior surface of the web which engages the backing roller. Because of this, prior art backing rollers require constant cleaning and maintenance over very short intervals. Further, when coating the back of the web, contaminants from the front side redissolve causing the back coating solution to become contaminated and the back coating is often specked with front coating material. While coating the face of the web across its entire width, edge seepage from the face to the anterior surface will contaminate any coating present on the anterior surface of the web.

Accordingly, a primary object of the present invention is to provide a novel method and apparatus for applying a controlled liquid film to the face of a moving web of substantially non-porous material by utilizing a backing roller that is narrower than the web.

Another object is to provide apparatus of this type so constructed that stress on the web being coated is below that which will cause permanent or detrimental deformation of the web.

Still another object is to provide apparatus for this type in which the undercut portions of the backing roll are not normally engaged by deflected edges of the web.

According to one aspect of the present invention, a method for applying a film of coating material on to a substantially non-porous web having predetermined dimensional characteristics comprises the steps of moving said web lengthwise under a predetermined operating tension with one surface of the web engaged with and supported over the major part of its width by a central portion of a backing roll which has reduced diameter end portions each co-operating with said central portion to define a radial step having a radial height not exceeding 5% of the diameter of the central roll portion, applying a coating material in liquid form to the other surface of the web in the vicinity of the backing roll by providing a meniscus supported solely by surface tension, and inter-relating said operating tension and the radial height of said steps to maintain the lateral edges of the web isolated from said backing roller while said operating tension retains its predetermined value, said roller reduced diameter end portions acting to limit deflection of the web about said steps consequent upon transient increases in web tension.

According to another aspect of the invention, apparatus for applying a film of coating material on to a substantially non-porous web having predetermined dimensional characteristics comprises a backing roll including a central portion and a portion of reduced diameter at each end of the central portion, said central roll portion co-operating with each of said reduced diameter portions to define a step having a radial height not exceeding 5% of the diameter of said central portion, means for moving said web lengthwise under a predetermined tension with one

surface of the web engaged with and supported over the major portion of its width by said central roll portion, and means in the vicinity of the backing roll for applying coating material in liquid form to the other surface of the web by providing a meniscus supported solely by surface tension, said step isolating the lateral edges of said web from the remainder of said backing roller while said web moves under said predetermined tension and the reduced diameter end portions of the roller acting to limit deflection of said lateral edges in the event of transient increase in web tension.

By providing a backing or support roller that is undercut at the ends thereof so that the central portion of the roll is narrower than the web to an extent which assures that coating material will not migrate from the edges of the web along its anterior surface, the invention prevents the anterior surface of the web from becoming contaminated with coating material being applied to the face of the web.

The central portion of the backing roller is wide enough so that the web is not stressed to a point where permanent or detrimental deformation thereof takes place. The undercut is deep enough so that deflection of the web along the edges thereof will not bring the edges into engagement with the undercut portions of the backing roller while the web is subjected solely to the predetermined operating tension but only when it experiences transient increases in tension.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a side elevation in schematic form of web coating apparatus constructed in accordance with the teaching of the present invention; and

Fig. 2 is a cross-section taken through line 2–2 of Fig. 1 looking in direction of arrows 2–2.

Referring to the drawing coating apparatus 10 includes backing roller 12 mounted for rotation in fixed bearings 13 and 14. Roller 12 includes central portion 15 which extends for a major portion of the width of roll 12, and undercut portions 16, 17 at opposite ends of central portion 15. Driving power is supplied to roll 12 through gear 99.

The anterior surface 22 of the web 25 is engaged by the roller 12 and brought into sufficiently close proximity to the coating material pool 18 in the reservoir 19 so that a coating meniscus 21 is formed and wets the face or front 31 of web 22. Solution 18 may be a photosensitive liquid, such as diazo resin. The amount of coating solution 18 applied to face 31 of the web 25 is controlled by the level of the solution 18 and the size of the reservoir 19. The solution 18 is thus applied across the entire width of the face 32 of the web 25.

Moving web 25 drawn from supply roll 26 passes above idlers 27, 28 in engagement therewith. In the region between idlers 27, 28 web 25 is partially wrapped around central portion 15 of backing roller 12 so that coating material 18 is transferred from the reservoir 19 to front surface 31 of web 25. In a manner well known to the art, a tension force acting on web 25 in a direction parallel to its direction of motion is controlled by brake means 29 which acts on the shaft of supply roll 26.

As best seen in Fig. 2, web 25 is substantially wider than central portion 15 of backing roller 12. Thus, the web edges are unsupported so that the stress on web 25 causes the edges thereof to deflect toward undercut roll sections 16, 17. This deflection is indicated by the reference "d" in Fig. 2. The edges at each end of central section 15 are slightly slanted or rounded rather than being sharp so as to prevent these edges from cutting web 25.

To determine the maximum width of roller 12 that may be undercut, it is necessary to determine the critical stress for web 25. When this critical stress exceeds the yield strength of the web material the web permanently deforms. This critical stress and the slight shape difference "d" between the supported and unsupported portions of web 25 are functions of web material, width of central portion 15, undercut height or difference in radii between roll portions 15 and 17, web tension as determined by tension service 29, and web thickness. It appears that the angle of wrap of web 25 around central portion 15, and the width of the unsupported edge portions of web 25 are not important in determining web stress. Thus, web stress is approximated by the following formula

$$P=F/W\times T$$

where: P = web stress
F = total web force or tension provided by brake 29
W = width of central portion 15
T = thickness of web 25.

Web stress P should be reasonably below the yield strength of the web material, which is approximately 16,000 psi for aluminum. Thus, with a fixed total web force and fixed web thickness, the less the width of central portion 15 the greater will be the web stress P.

The height of the step between roll portions 15 and 17 is preferably at least 1/8″ to prevent formation of a meniscus between the web 25 and either of the undercut portions 16, 17. In practice the undercut height is between 1/8″ and 1/2″ to 5% of the diameter of central portion 15.

Edge deflection "d" is approximated by the following formula

$$d=PxD/2M$$

where: d=radial distance between web edge and the periphery of central portion 15
D=diameter of central portion 15

M = modulus of elasticity for the web material, which is 10^7 psi for aluminum.

In a practical example a web of lithographic aluminum 27 inches wide and 0·008 inches thick is partially wrapped around a 10 inch diameter central portion 15 of backing roller 12. The total web force set by brake 29 is 600 pounds and the width of central portion 15 is 26 inches. Thus, the web stress is calculated as:

$$P = 600/26 \times 0{\cdot}008 = 2880 \text{ psi}$$

This web stress of 2880 psi is well below the 16,000 psi yield strength of lithographic aluminum.

The slight shape level difference "d" is calculated for a molulus of elasticity of 10^7 psi as:

$$d = 2880 \times 10/2 \times 10^7 = 0{\cdot}0014 \text{ inches.}$$

With the undercut kept to this low value, meniscus coating of undercut portions 16, 17 may easily take place. Therefore, the cutoff height should be made at least 1/8″ which is considerably greater than the shape level difference "d", so that the edges of web 25 are spaced from undercut portions 16, 17.

WHAT WE CLAIM IS:—

1. A method for applying a film of coating material on to a substantially non-porous web having predetermined dimensional characteristics, comprising the steps of moving said web lengthwise under a predetermined operating tension with one surface of the web engaged with and supported over the major part of its width by a central portion of a backing roll which has reduced diameter end portions each co-operating with said central portion to define a radial step having a radial height not exceeding 5% of the diameter of the central roll portion applying a coating material in liquid form to the other surface of the web in the vicinity of the backing roll by providing a meniscus supported solely by surface tension, and inter-relating said operating tension and the radial height of said steps to maintain the lateral edges of the web isolated from said backing roller while said operating tension retains its predetermined value, said roller reduced diameter end portions acting to limit deflection of the web about said steps consequent upon transient increases in web tension.

2. Apparatus for applying a film of coating material on to a substantially non-porous web having predetermined dimensional characteristics, said apparatus comprising a backing roll including a central portion and a portion of reduced diameter at each end of the central portion, said central roll portion co-operating with each of said reduced diameter portions to define a step having a radial height not exceeding 5% of the diameter of said central portion, means for moving said web lengthwise under a predetermined tension with one surface of the web engaged with and supported over the major portion of its width by said central roll portion, and means in the vicinity of the backing roll for applying coating material in liquid form to the other surface of the web by providing a meniscus supported solely by surface tension, said step isolating the lateral edges of said web from the remainder of said backing roller while said web moves under said predetermined tension and the reduced diameter end portions of the roller acting to limit deflection of said lateral edges in the event of transient increase in web tension.

3. Apparatus as claimed in 2, in which the step height is at least one eighth inch.

4. A method for applying a film of coating material on to a substantially non-porous web having predetermined dimensional characteristics, substantially as hereinbefore described with reference to the accompanying drawings.

5. Apparatus as claimed in claim 2 or claim 3, constructed, arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1579943 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

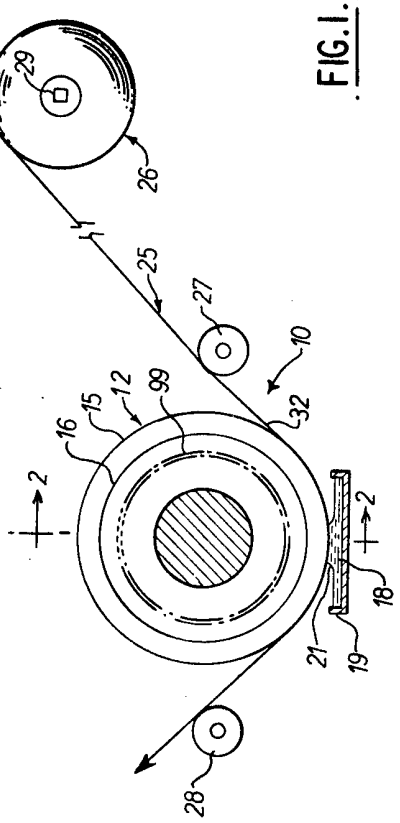

FIG. 1.

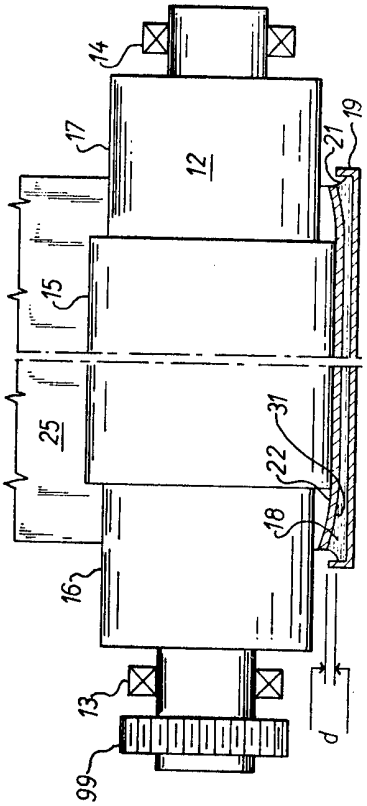

FIG. 2.