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APPARATUS FOR COATING PAPER

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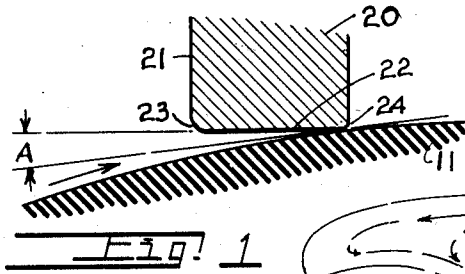


Fig. 1

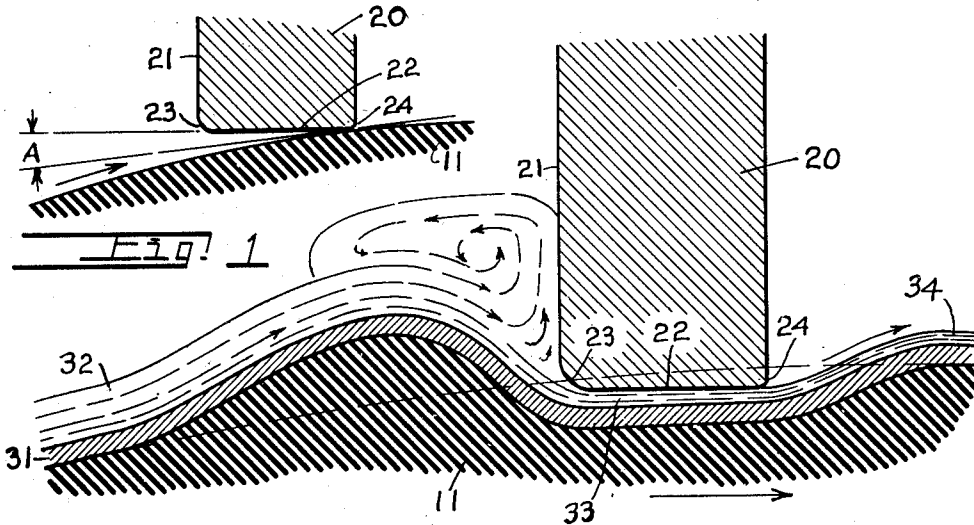


Fig. 2

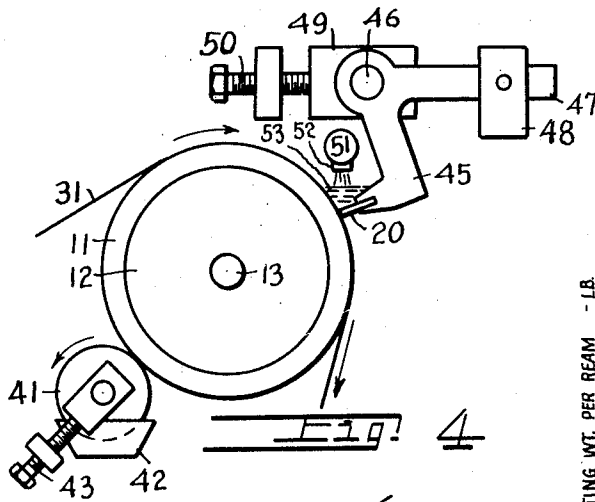


Fig. 4

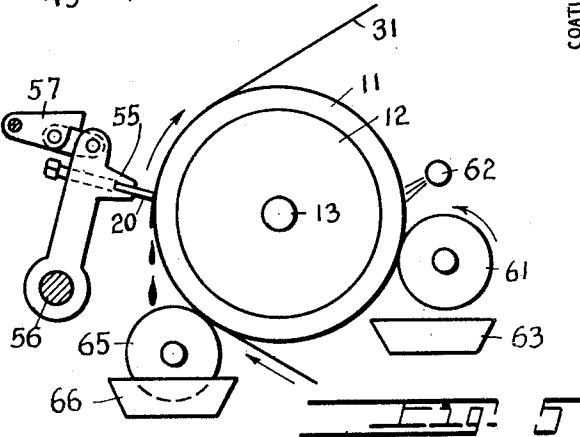


Fig. 5

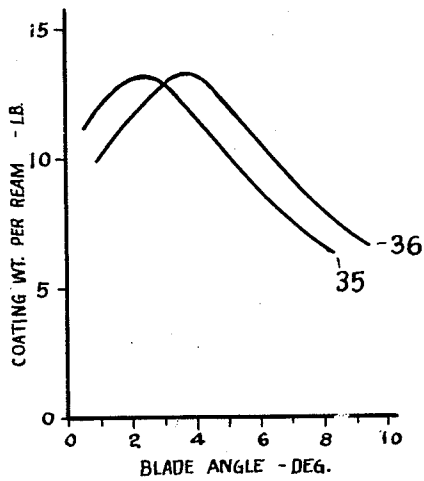


Fig. 3

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APPARATUS FOR COATING PAPER

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3 Claims. (Cl. 91—53)

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This invention relates to the application of coating materials to paper and has especial reference to the application of coating compositions composed of pigment and adhesive usually in aqueous suspension for the purpose of giving to paper a better surface for the reception of high grade printing.

In the past, coatings of various kinds have been applied to paper and fabric webs by the use of blade or knife spreading and smoothing devices. In most of these a definite clearance was provided between the blade and a web carrier roll or belt, though in some cases pressure was exerted between the blade and the web. Usually the web carrier was rigid but in some cases rubber, leather, or similar supports have been used. Most of these devices have been found unsuited to the coating of paper with aqueous compositions of pigment and adhesive of the type required to provide a desirable printing surface in a suitably smooth, uniform, and continuous layer of the required thickness, to produce such printing surface.

The primary object of the present invention is to provide apparatus which is adapted to the application to paper webs of suitable paper coating compositions in layers of such thickness, uniformity, smoothness, and continuity as to constitute a suitable base for high grade printing. A further object is to provide apparatus which will be simple in operation and construction, which will be easily controlled, and which can be operated at speeds up to those common in high speed papermaking machines. Another object is to provide apparatus which can be used to coat the web during its manufacture on a papermaking machine, or to coat a previously made and dried web separate and apart from the paper machine. A still further object is to provide apparatus which can be used to apply coatings of normal or of unusually high solids content. Another object is to provide apparatus which will apply aqueous coatings to paper without tearing, wrinkling, or breaking down the web. Other objects and advantages of the invention will be apparent from the following detailed description.

For the attainment of these objects I find that a blade can be used to limit the thickness and smooth the surface of coating on a paper web where it is supported on a roll or belt carrier, by specially forming and positioning the blade, by using a carrier having hardness and resilience within specific limits, by holding the blade in a manner to apply pressure to and to deform the resilient carrier surface, and by causing the paper

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web to adhere to the carrier temporarily where it passes under the blade.

The roll or belt carrier, I find, is desirably made of rubber or a synthetic rubber-like compound having a density of from 60 to 150. The term "density" as used herein refers to the softness as measured by the Pusey and Jones Plastometer, using a $\frac{1}{8}$ inch ball. The term "rubber" as used herein is to be understood as referring to either natural rubber or a similarly yielding and resilient rubber-like composition.

The blade or doctor member is of special form having one face which forms a barrier to the passage of excess coating material along with the moving surface of the web and a second face which is parallel to the moving surface of the paper carrier in a transverse direction but converges slightly towards it in its direction of movement. Due to this convergence, the fluid coating material is drawn in between the blade and the paper in the form of a thin wedge-shaped film in a manner analogous to that in which an oil film is drawn in between the bearing surfaces in the so-called Kingsbury bearing. In bearings of that type, one of the bearing surfaces is allowed to pivot and assume a position of equilibrium under the hydrostatic forces in the wedge-shaped oil film. In the case of the present invention, the blade is held against the coated surface of the web on the carrier by a fixed pressure, or by pressure holding it in a fixed position, and the yielding resilient surface of the moving rubber or rubber-like carrier is deformed under the blade into a position of equilibrium under the hydrostatic forces in the wedge-shaped film of coating material. The present coater differs from the Kingsbury bearing in that in the bearing a stationary surface of fixed form assumes a position of equilibrium under the hydrostatic forces, whereas in the present coater the moving surface is continuously distorted in form by the hydrostatic pressure as it passes under the blade.

I have discovered that the angle of convergence between the wiping surface of the blade and the surface of the web carrier has a definite effect on the weight of coating material applied to the web as hereinafter more fully described, and, if made adjustable, can be used as a coating weight control. In addition to this angle of convergence I have found that the coating weight is affected by a variety of other factors such as the thickness of the blade, the pressure of the blade on the web, the hardness or "density" of the carrier surface, the viscosity and solids content of the coating material, the speed of operation, etc. In prac-

tice the weight of coating applied to the web may be varied by varying any one or combination of these factors as may be convenient.

In passing over blade coaters, particularly where, as here, the paper and coating pass between a blade and a backing or carrier surface, the paper is often drawn into wrinkles. Especially when the web has what is known in the trade as a slack or loose edge (one edge which is slightly longer than the other portions of the web), or as buckles (when the longer portion lies between the edges of the web), the excess length tends to accumulate in front of the blade until it is drawn through as a wrinkle or fails to pull through and starts a tear in the paper, which usually breaks down the web and requires washing up and re-threading the coater. In order to avoid this difficulty and to further improve the coating operation itself, I have found that if the paper is caused to adhere to a rubber carrier surface which is continuously deflected where it passes the blade, such defects as buckles and slack edges are carried through with the carrier surface and, due to the stretching of the rubber surface caused by its deformation, the paper thereon is held under increased tension as it passes the blade, resulting in a superior smoothness and uniformity of the coating. This improvement is more fully described and claimed in a co-pending application Serial No. 670,276, filed May 16, 1946 and entitled "Coating Method and Apparatus," and is not specifically claimed herein.

Adhesion of the requisite degree can, I find, be secured by dampening the carrier surface prior to the contact of the paper web therewith. The surface is advantageously dampened with clear water, though the water may contain small percentages of adhesive, usually the adhesive used in the coating composition, since the surface is not, during the coating operation, ordinarily allowed to become dry. The degree of dampness required can, I find, be obtained by thoroughly wetting the surface and squeezing off the excess by a roll pressed thereagainst. The paper web is then laid smoothly on the moist carrier surface either by tension or by pressure, and adheres thereto to an extent which will strongly resist any tendency to slide along the surface but will permit the paper to be readily stripped therefrom.

Another advantage which I am able to secure by this moistening of the roll is the fact that the moisture lubricates the roll beyond the edges of the paper web so that it readily slides under the blade in spite of the pressure of the blade on the surface. This also prevents any coating material which may spread over the face of the roll where not covered by the web, from being carried around with the roll and building up to form an objectionable deposit.

The invention will be better understood by reference to the accompanying drawing, in which:

Fig. 1 is an enlarged fragmentary detail cross section of the blade and web carrier illustrated as though in contact but free from the pressure which causes the blade to distort the surface of the carrier when in operation.

Fig. 2 is a greatly enlarged and distorted fragmentary cross sectional view showing the cooperation between the blade and the paper carrier surface and indicating diagrammatically the manner in which the paper and coating material are thought to be drawn through between the carrier and the blade, and the distortion of the carrier surface, which is believed to be caused

by the hydrostatic pressure in the wedge-shaped film of coating material being drawn under the blade.

Fig. 3 is a graphical representation of the qualitative effect on coating weight of variations in the angle of convergence between the blade and the web carrier, and of variations in blade pressure, other conditions remaining unchanged.

Fig. 4 is a diagrammatic representation of an arrangement of parts by which the process of the present invention can be carried out.

Fig. 5 is a diagrammatic representation of another arrangement of parts for the same purpose.

Referring to the drawing, Fig. 1 shows the rubber of rubber-like carrier surface 11 with the direction of its motion indicated by the arrow. This may be considered to be a traveling belt or a surface layer on a roll 12 adapted to rotate on journals 13 as indicated in Figs. 4 and 5. In accordance with the present invention it is necessary that the carrier surface 11 be indented by the blade 20, as hereinbefore set forth. For this purpose I have found that the density of the carrier surface should not be less than 60 or more than 150 since surfaces harder than 60 and those softer than 150 have not been found satisfactory for this purpose.

The blade or doctor member 20 is advantageously of a thickness from one-eighth to about one-half inch and has a forward surface 21 which forms a large angle with the carrier surface 11. This angle is advantageously near 90 degrees but may be any desired angle from about 45 to about 135 degrees. The working or wiping surface 22 of the blade is advantageously planar or cylindrical with a radius of curvature not widely different from that of the surface of carrier 11. When in pressureless contact with the carrier surface 11, the surface 22 should converge towards said surface 11 in the direction of its movement at an angle not exceeding about ten degrees and advantageously of the order of 2 to 4 degrees. From geometrical considerations, it will be apparent that, if the surface 22 is flat, the angle of convergence will decrease from its leading edge 23 to its trailing edge 24 by an amount equal to the angle subtended by the flat portion of surface 22, at the center of roll 12, and that, if the surface 22 is cylindrical, the angle of convergence will decrease from edge 23 to edge 24 by an amount equal to the angle subtended by the cylindrical portion of surface 22 at the center of roll 12, minus the angle subtended by said cylindrical portion at its own center. It is evident from the drawing that this decrease in the angle of convergence from one edge of the surface 22 to the other is at most very small since, as shown in Figs. 4 and 5, the angle at the center of roll 12 subtended by the entire thickness of blade 20, is itself very small, and, if the surface 22 is cylindrical in form, as above set forth, or does not extend entirely across the thickness of blade 20, as illustrated in Figs. 1 and 2, the change in the angle of convergence from one edge of surface 22 to the other, will be even less than this small subtended angle. Because of the smallness in the change in the angle of convergence, this angle can be said to be nearly constant across the width of surface 22, and the term "nearly constant" as used in the present specification and claims to define the angle of convergence is to be understood as defining constancy within limits of the order of magnitude as illustrated and described and as specifically excluding changes such as encoun-

tered in the use of a round rod or a blade with a half round or quarter round edge with which the angle of convergence may change by as much as ninety degrees in a distance equal to the radius of the rod.

The angle of convergence, as defined in the present specification and claims, is measured by its nominal value, that is the angle A (Fig. 1) between the plane of (or tangent to) surface 22 and the tangent to surface 11, at the trailing edge 24 of the blade when, as in Fig. 1, there is no pressure between the blade and the carrier surface. The term "blade angle" as hereinafter used is to be understood as referring to this nominal value A of the angle of convergence. The actual angle of convergence, when the device is in operation, probably differs from the nominal angle as above defined by some unknown and not readily ascertainable amount which is dependent on a variety of factors such as the diameter and the hardness or "density" of the rubber carrier surface, the pressure of the blade thereon, the thickness of the blade, the characteristics of the web being coated, the composition and viscosity of the coating material, the speed of operation, etc.

As has been stated, the working surface 22 may be either planar or cylindrical with a radius of curvature not far different from that of the surface of carrier 11, since, as is apparent from Figs. 1, 2, 4, and 5 of the drawing, curvature to such a radius will not involve any conspicuous deviation from a true plane in a surface which is so narrow as is surface 22, in comparison with the radius of surface 11. The term "substantially plane" as used in the present specification and claims to describe surface 22 is, accordingly, to be understood to include cylindrical curvature to any radius not materially smaller than the radius of surface 11.

The sharp edge where the planes of surfaces 21 and 22 meet may be advantageously rounded off to some extent as indicated at 23. The surface 22 should terminate abruptly at 24 though the sharp edge should be smoothed off, "broken" or slightly rounded at a radius not to exceed about $\frac{1}{8}$ inch, to avoid any "wire edge" with its accompanying roughness or sharp knife edge with its tendency to nicking and roughening.

When in operation, the paper web 31 carrying fluid coating material 32, is carried on and adheres to the surface of carrier 11, and the blade 20 is held against the coated surface of the web with sufficient pressure to indent and deform the surface of the yielding and resilient carrier 11 as it passes thereunder. (See Fig. 2.) The forward face 21 of the blade 20 pushes back the excess coating material while that remaining on the web is drawn as a film 33 of decreasing thickness into the wedge-shaped opening under the surface 22 of the blade. The yielding surface of carrier 11 then assumes a form in dynamic equilibrium with the hydrostatic pressure in the wedge-shaped layer of coating being drawn under the blade, as indicated in Fig. 2 where the broken line indicates the undeformed surface of the carrier. As is apparent from the position of the undeflected surface, the indentation and deformation are limited to the immediate vicinity of the blade 20, and the web-carrier 11 itself is not bodily displaced, being held against such displacement by a firm support (illustrated in Figs. 4 and 5 as the metallic body 12 of the web-carrier roll). It is also apparent that the deflected surface is longer than the undeflected surface, so that the paper web, because it adheres thereto, is locally held under

increased tension and slightly elongated at the time it is being carried under the wiping surface 22 of blade 20. As it emerges at 24 from under the surface 22 of the blade 20, the coating is in the form of a uniform, thin, and continuous layer 34 on the surface of the paper web which is then ready to pass to dryers of suitable type. Since the dryers may be of known type and form no part of the present invention, they are not further illustrated or described.

It should be noted that the thickness of paper and coating is greatly exaggerated in the figure and the broken line does not necessarily indicate the true position of the undeflected surface relative to the blade, and further that the illustration of the deflected position of the carrier surface and the form of the coating layer are based largely on theoretical considerations since the actual form and position cannot be readily determined in the case of the rapidly moving surface beneath the blade.

Fig. 3 shows qualitatively the manner in which the weight of coating applied per ream of the paper web is affected by variations in the angle of convergence A between the wiping surface 22 of the blade and the web carrying surface 11. Curves marked 35 and 36 show the weight variation due to changes in the angle of convergence when the pressures per linear inch between the blade and the web carrying surface were 5 and 13 pounds respectively. As shown in the figure, while all other conditions remain unchanged, with pressures under the blade equal to 5 and 13 pounds per linear inch, maximum coating weights were secured at angles of convergence equal to about $2\frac{1}{2}$ and $3\frac{3}{4}$ degrees respectively. The figure also shows that at angles less than about 3 degrees an increase in pressure under the blade results in a decrease in coating weight, whereas at angles greater than about 3 degrees an increase in pressure under the blade results in an increase in coating weight, while at angles of about 3 degrees changes in blade pressure result in relatively slight changes in coating weight.

It should be noted that Fig. 3 shows the relation of coating weights to blade angles and pressures only when using a $\frac{1}{8}$ inch thick blade and a 12-inch diameter rubber roll of 60 density as measured on the Pusey and Jones Plastometer with a $\frac{1}{8}$ inch ball, to apply a specific paper coating composition to a specific coating raw stock at a speed of 600 feet per minute. Under other conditions the relationships illustrated in Fig. 3 are only qualitatively valid.

The effect of operating speed on coating weight varies with the blade angle, pressure, and thickness, the roll diameter and density, the coating composition and viscosity, etc., but in general increased speed results in increased coating weight.

Blade thickness, pressure, and roll density are to some extent interrelated, thinner blades requiring harder (lower density) rolls and/or lower pressures for equivalent results. Care should be taken that the blade does not so embed itself in the roll that its forward edge acts as a scraper. Rounding of the forward edge will sometimes aid in preventing such action.

The application of the coating material to the paper, the pressing of the blade against the coated surface, and the moistening of the carrier surface can be carried out in the manner most convenient in the particular installation. One arrangement of parts which may be used for this purpose is illustrated in Fig. 4. In this arrangement the paper carrier is a rubber layer 11 on

the surface of roll 12 which is mounted to rotate on journal bearings 13 and is driven by conventional driving means, not shown. The carrier surface is moistened by a moistening roll 41 which picks up water from a pan 42 and transfers it to the surface 11. Pressure, which may be adjusted as by screws 43, of the roll 41 against surface 11 squeezes off the water, leaving the carrier surface slightly moist so that the paper web 31 will adhere thereto as described.

The blade 20 is carried in a blade holder 45 which is mounted to swing on a pivot 46, so that the blade may be readily withdrawn from contact with the roll when desired. The blade holder is provided with one or more lever arms 47 and weights 48 for creating the desired pressure between blade 20 and paper carrier 11. The pivot 46 may be fixed on a block 49 for adjustment as by a screw 50 if it is desired to have the blade angle adjustable for adjustment of the coating weight or other purpose. Coating material is introduced to the paper through a pipe 51 with suitable nozzles 52, and forms a pool 53 before the blade. The coating material in this pool is circulated and agitated by the backward flow of the coating material which is wiped off of the paper web by the leading face 21 of blade 20.

Another arrangement is illustrated in Fig. 5. In this case also the paper carrier 11 is illustrated as in the form of a rubber covering on a roll 12 mounted for rotation on journals 13. The blade 20 is held in a holder 55 which is mounted to swing on a fixed pivot 56 in a manner analogous to that described in connection with Fig. 4. In the present case, however, the blade is adapted to be removably locked in a fixed position by a toggle or other suitable device 57. This position is so fixed that the blade 20 indents the rubber surface of carrier 11 to the desired degree, and the pressure exerted by the blade is that required to deflect the surface to the given degree, and the pressure can be adjusted by suitably adjusting the fixed position to which the blade is pressed when in operation.

The moistening of the rubber surface of the carrier roll is controlled as before by the pressure of a roll 61 but the water is applied prior to the contact with roll 61 by means of a spray pipe 62, a pan 63 being provided to catch any drip.

A positively driven roll 65 dips into a pan 66 containing coating material and carries it up and deposits it on the paper web. The excess coating material which is scraped off of the surface of the web drops back into supply pan 66.

It will be readily understood that the methods of holding and providing pressure on the blade, of moistening the web carrier, and of applying the excess coating material to the web, can be interchanged between the combinations illustrated in Figs. 4 and 5 or equivalent methods substituted and other arrangements of parts can be provided without in any way departing from the present invention.

In applying coatings of pigment and adhesive to paper to improve its surface for the reception of high grade printing, or for other purposes, I have found the method and apparatus of the present invention useful in applying coating

compositions varying from the normal solids content of about 40 percent up to solids contents as high as about 75 percent. Such coatings can be applied, in accordance with the present invention in uniformly smooth layers the dry weight of which can be controlled, as described, within the customary range used for such coatings, and at speeds up to those common in high speed paper making machines.

10 What is claimed is:

1. A device for applying fluid coating compositions to paper webs, which comprises: a rotatably mounted roll which is provided with a yielding resilient rubber covering having a density between 60 and 150, as measured on the Pusey and Jones Plastometer with a $\frac{1}{8}$ inch ball, for carrying a freshly coated web of paper past a location where the coating on the paper is subjected to a doctoring operation; means for rotating said roll in a predetermined direction; a doctor blade in the form of a flat, laterally substantially inflexible prismatic bar having one broad lateral face 21, the plane of which forms an angle of from 45 to 135 degrees with the surface of said roll, and an adjacent narrow lateral face 22, which is nearest said roll, is substantially planar, is between $\frac{1}{8}$ inch and $\frac{1}{2}$ inch in width, and continuously converges at a nearly constant angle towards the surface of said roll, in the direction of its rotation, and terminates in a substantially sharp edge 24, where it forms with the surface of said roll an angle A of from zero to ten degrees, when the two are in pressureless contact, the edge 23 between said broad face 21 and said narrow face 22, being slightly rounded; a support for holding said doctor blade in position adjacent the surface of said roll, said support being adapted to permit movement of said doctor blade toward and away from said roll; and pressing means associated with said support for holding said doctor blade in a position to cause indentation of the rubber covering of said roll.

2. The device of claim 1 wherein the plane of the broad face 21 of the doctor blade is within about ten degrees of perpendicular to the undeflected surface of the roll, and the angle A between the narrow face 22 of the doctor blade and the surface of the roll is of the order of 2 to 4 degrees.

3. The device of claim 1 wherein the blade support is provided with screw threaded connections for adjusting the magnitude of the angle A between the values of zero and ten degrees.

WILLIAM PALMER TAYLOR.

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60 The following references are of record in the file of this patent:

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