

[54] METHOD AND APPARATUS FOR
ATOMIZING A LIQUID MEDIUM AND FOR
SPRAYING THE ATOMIZED LIQUID
MEDIUM IN A PREDETERMINED
DIRECTION

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[22] Filed: May 6, 1974

[21] Appl. No.: 467,230

[52] U.S. Cl. 239/220, 118/300, 118/324,
117/105.3, 117/111 R

[51] Int. Cl. F23d 11/06, B05b 3/02, B05b 13/02

[58] Field of Search 239/214, 219, 220; 346/93,
346/139 C; 431/354; 118/300, 324, 325;
117/101, 105.3, 111 R

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Primary Examiner—Robert S. Ward, Jr.
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[57] ABSTRACT

A coating method and apparatus with which a liquid medium is passed to the nip of two co-acting rolls and atomized therein. One of the rolls comprises a spreader roll having an elastomeric open porous lining, while the other comprises a pressure roll adapted to depress the spreader roll lining along the roll nip to change the kinetic state of the liquid passing through the nip.

5 Claims, 2 Drawing Figures

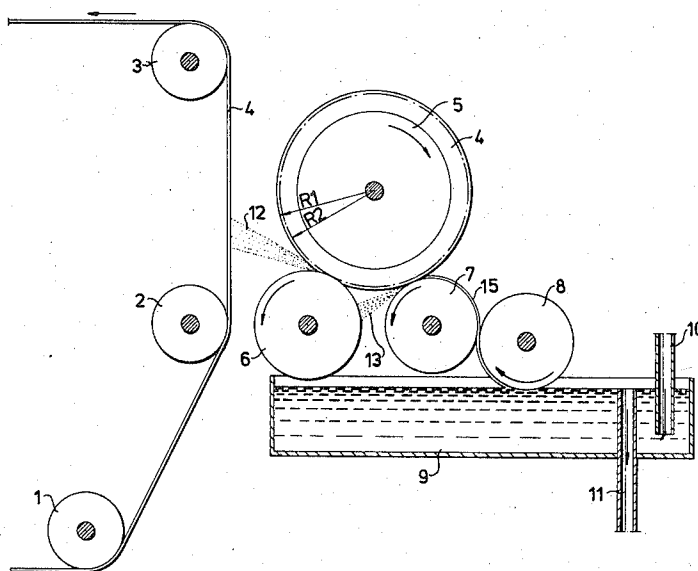


Fig. 1

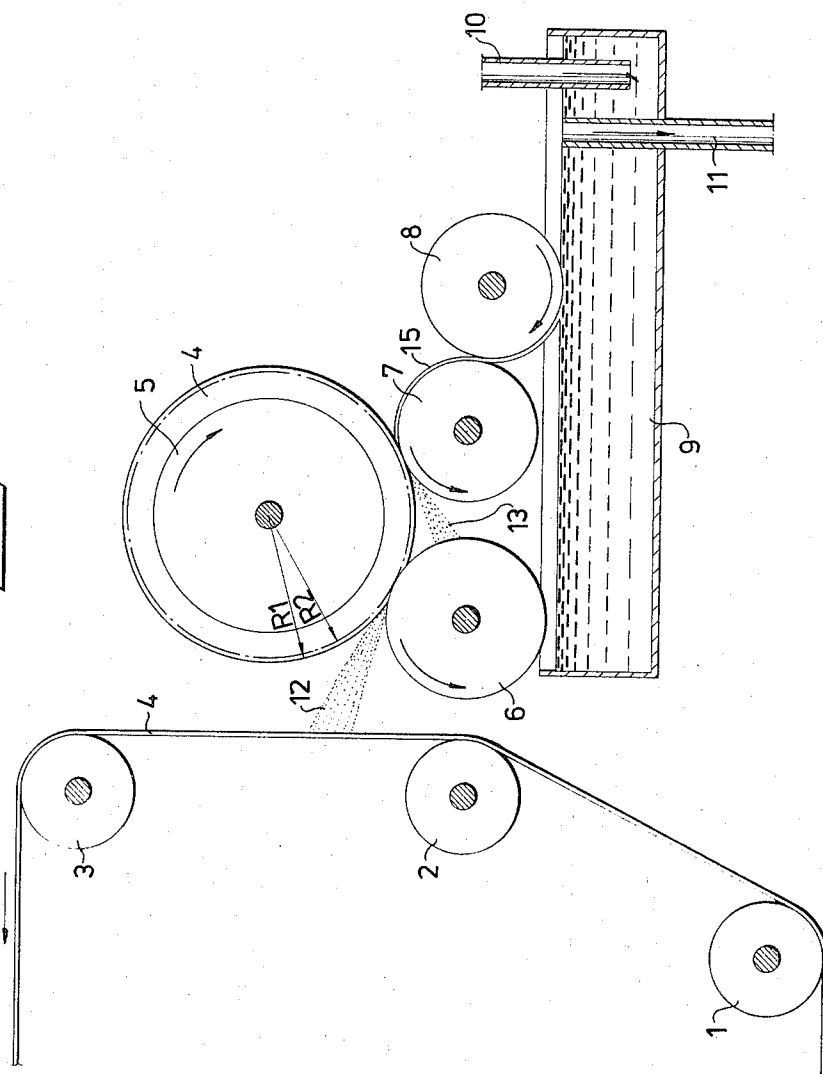
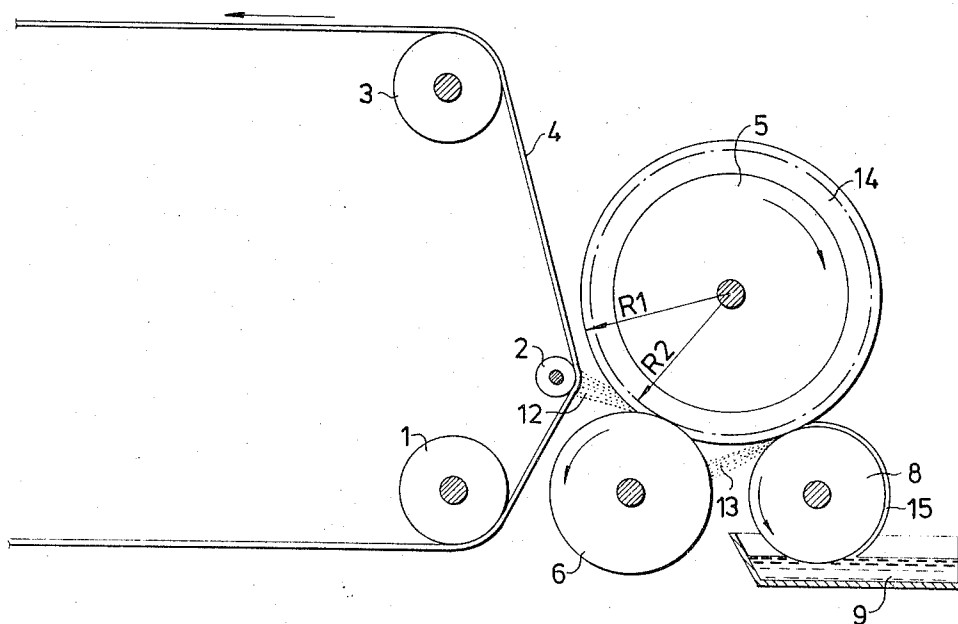


Fig. 2



METHOD AND APPARATUS FOR ATOMIZING A LIQUID MEDIUM AND FOR SPRAYING THE ATOMIZED LIQUID MEDIUM IN A PREDETERMINED DIRECTION

The present invention relates to a method and apparatus for atomizing a liquid medium and for spraying the atomized liquid medium in a predetermined direction, and particularly intended for coating or moistening material continually advancing in front of the atomized medium. The invention is particularly well suited for use when wishing to continuously provide a fine spray of liquid across a given length without the amount of liquid delivered per unit of time varying between different portions of said length. Owing to the uniform distribution of the liquid medium obtained hereby, the invention is particularly useful for continuously coating surfaces with a layer of liquid medium uniformly distributed over respective surfaces, without contacting the surfaces with anything but the liquid applied thereto. The surface to be coated and the aforementioned liquid spray are therewith displaced relative to each other at a predetermined speed, whereby the whole of the area of the surface in question can be provided with a uniform coating. As before indicated, when utilizing the method and apparatus of the present invention no direct contact is had between the means by which the liquid medium is sprayed and the surface to be coated. Such contact-free coating is primarily of interest when the surface to be coated is excessively sensitive to contact with an applying or spreading means, or if the structure of the surface is unsuitable for direct-contact coating methods for other reasons.

Before the advent of the present invention, different printing techniques were applied when the requirements on a uniform surface coating were particularly high, such printing techniques requiring the surface coating medium to be first applied to a transfer block and then to the surface in question by direct contact between the block and the surface. Such techniques provide a very uniform coating, but the direct contact between the block and the surface to be coated often renders it impossible to use such techniques. Further, the block will only transfer the coating medium to those portions of the surface with which it comes into direct contact, which means that an undulating or rough surface, for example, will only be coated at the crests of the undulations or raised portions, while large portions of the surface may remain uncoated.

If the surface to be coated is excessively sensitive to direct contact with a transfer block, or if the surface is too rough, it would appear an obvious solution to atomize the medium and spray the same against the surface to be coated through spray nozzles. It is difficult, however, to obtain in this way a fully uniform coating, inter alia because the cross section of such sprays contains different quantities of liquid per unit of time at different distances from the centre of the spray. Neither is it possible to overcome this problem by arranging a plurality of nozzles in a manner whereby the sprays partially overlap each other, among other things because it is impossible to arrange the nozzles in such relationship that the sprays do not disturb each other while providing the coating. Such overlapping may, for instance, cause the resultant coating to have a striped appearance. A relatively uniform coating can be obtained, however, if the spray nozzles are caused to move trans-

versely across the surface in a number of sequentially, partially overlapping paths, e.g., by causing the nozzles to oscillate over the surface being coated. Although this arrangement provides for a relatively satisfactory coating, the size of the surface which can be coated thereby per unit of time is restricted, since if the desired result is to be obtained the nozzles cannot be displaced at an angle to the emergent direction of the liquid with such a velocity that the air resistance disturbs the sprays.

In order for the uniformity of the obtained coating to be the highest possible, it is also necessary to use a number of nozzles each of which is of a limited capacity, which is perhaps the cause of the most serious disadvantage associated with the use of nozzles, namely that their fine outlet orifices are readily blocked, especially when coating with highly viscous liquid media, which solidifies rapidly or contains suspended substances such as pigment for example. Because of the tendency of the nozzle orifices to become blocked, it is difficult to operate a spraying process with which the medium is ejected through spray nozzles continuously, and it is often necessary to interrupt the spraying performance to clean the nozzles. Thus, an efficient spraying process of this type requires exacting and continuous cleaning of the apparatus. Another drawback of the spray nozzles is that they always have to work with the same capacity. The only way to change the amount of liquid is to change the number of nozzles or the speed of the surface on which the liquid is sprayed.

Another process which can be used in certain instances for supplying a liquid medium to a surface, is one in which the medium is splashed against the surface by means of a rotating brush roll. In this process a plate or a roll is arranged in the path of the brush so that the bristles of the brush are deflected and released to throw the liquid from the bristles of the brush as the brush rotates. This method, however, causes non-uniform coating of the material on said surface since the liquid is applied thereto in the form of large drops. Probably each bristle throws one drop. It has been proposed to use a smoothing roll for evening out the liquid on the material continually advancing in front of the rotating brush. This, however, means that the smoothing roll comes into direct contact with the surface. Even the brush roll has the drawback that it is difficult to change the amount of liquid sprayed on the surface.

The method and apparatus of the present invention, however, have been found particularly suited for contact-free coating of material surfaces with a liquid medium. The surface to be coated is therewith continuously moved at a given speed relative to a liquid spray means from which the liquid medium is issued in a finely divided form. Thus, by means of the invention it is possible to continuously apply to material surfaces a particularly uniform coating of liquid medium, even when coating large areas per unit of time and when large quantities of coating material are required to be supplied per unit of area. The invention enables continuous regulation of the amount of liquid supplied to the surface being coated and control of the drop size of the atomized liquid enabling a quite uniform coating. Another advantage afforded by the invention is that it is totally unreliant on spray nozzles and slots which can be blocked by liquid media having unsuitable viscosity, high solidification rates or which contain impurities or suspended substances such as pigment for example.

The method of the present invention is mainly characterized by passing liquid medium to a surface layer of elastomeric open porous material, i.e., the void of the pores being interconnected and the pores at the surface of the material open to the surrounding space, on a spreader roll, and by causing another roll to compress said surface layer along the extension of a roll nip between the two coating rotating rolls to cause rapid changes in the radial dimensions of the spreader roll, which results in the liquid being disintegrated into droplets which are ejected from the roll nip in the form of a continuous liquid spray. The liquid medium is spread from the roll nip in the form of a fine spray, the angle of spread of which is relatively restricted, since the liquid is progressively squeezed and disintegrated within a very restricted region and the droplets will hence continue to move mainly in a direction which generally coincides with the tangent to the periphery of said rolls at the point where the droplets leave the same. If such a rotating spreader roll is used to moisten or coat a surface with a liquid medium, the spreader roll can be said to correspond to the transfer block used with conventional printing processes, since the medium from the spreader roll can be transferred directly to the surface to be coated. As opposed to conventional printing processes, however, the liquid medium is transferred according to the present invention without direct contact between the spreader roll and the surface. The material selected for the surface layer of the roll, however, mainly depends on the properties of the sprayed medium. It must be possible to rotate the spreader roll at a relatively high and preferably variable speed. With a rotating spreader roll of the aforescribed type provided with an elastomeric porous surface layer, there is caused a change in the kinetic state of the liquid transported in the surface layer of the roll, owing to the fact that a pressure roll is brought into engagement with the periphery of the spreader roll adjacent the point where it is desired that the liquid medium shall leave the spreader roll, in a manner such that the pressure roll during a working revolution of the spreader roll locally depresses the periphery of the spreader roll along the whole of its length. The two rolls shall therewith rotate in time with each other. The extent to which the pressure roll enters the surface layer of the spreader roll is determined by the distance between the shafts about which the two rolls rotate. If the surface layer of the spreader roll comprises a highly compressible material and the roll is rotated at high rotational speeds, the dimensions of the surface layer of the roll will be changed to a certain extent by the forces acting thereon, such as to increase the diameter of the roll. This fact, renders it unnecessary for a spreader roll having an extremely soft surface layer to abut the pressure roll when said rolls are stationary in order for the pressure roll to be depressed into the surface layer of the spreader roll to the desired extent when said rolls are rotated. Even though the two rolls may themselves be made from a large number of different materials, it should always be ensured that one roll is so much harder than the other, so that the cylindrical surface of one roll is able to be pressed into the cylindrical surface of the other. The liquid to be transported in the surface layer of the spreader roll can be supplied to the roll in a suitable manner, for example via a rotating applicator roll, which transfers the liquid medium from a storage bath, alternatively via one or more pick-up rolls.

Upon rotation of the spreader roll, the kinetic state of the liquid transported in the outer layer of said roll will be rapidly changed at the point where the pressure roll compresses the surface layer of the spreader roll as a result of the changes in the radius of the roll caused by the compression of said roll and normally occurring within fractions of a second. With suitably selected peripheral speeds on the spreader roll and sufficient depth of depression of the pressure roll into the surface layer of the spreader roll, the rotary forces acting on the liquid will exceed the degree to which the liquid adheres to the surface layer of the spreader roll and to the forces binding the liquid particles together. Thus, the liquid film will be atomized into free droplets which leave the spreader roll tangentially to the direction of rotation immediately there is formed a gap of sufficient width between the two intercontacting rotating rolls. The thus resulting continuous liquid spray will extend along the whole of the abutting surfaces between the two rolls. The speed and surface structure of the spreader roll and its degree of compressibility are varied with respect to the properties of the liquid medium to be sprayed and with respect to the amount of medium to be distributed per unit of time and the desired droplet size of the sprayed liquid. The particle size of the droplets in the spray thus obtained is dependent on the specific properties of the liquid medium, the surface structure of the spreader roll and the speed of rotation, and also the extent to which the pressure roll depresses the surface layer of the spreader roll. Thus, a relatively lower rotary speed of the spreader roll will provide larger droplets than those obtained with a higher rotary speed. The amount of liquid sprayed per unit of time is controlled by regulating the quantity of liquid supplied to the spreader roll.

Thus, by means of the present invention it is possible to continuously deliver across a given length a particularly uniform liquid spray, the capacity of which can be varied within relatively wide limits. The size of the liquid particles delivered by the rolls can also be varied. The apparatus used in accordance with the invention contains no components which can be blocked and thereby give rise to interruptions in operation. By means of the apparatus of the invention it is also possible to adapt the spread pattern of the liquid within accurately defined limits, whereby wastage can be greatly reduced in comparison with known apparatus.

The invention can be used for coating surfaces with many different kinds of liquids, e.g., water, organic solvents, binder solutions, solutions of colouring substances from plastic emulsions, dispersions of colouring pigment etc. The drop size which is required in each special case is dependent on the amount of liquid to be applied per unit area. With a greater amount of liquid per unit area, larger drops can be allowed, while with very small amounts of liquid per unit area very fine drops are required for an even coating to be obtained. The smallest drop size usable is limited by the fact that too small drops are not thrown in any definite direction, but form a mist which spreads in to the machine. If the surface to be coated is porous, e.g., consists of a fiber layer, and it is desired to regulate the penetration depth of the applied liquid, this can take place by altering the size of the drops. Larger drops penetrate deeper than smaller drops. The material in the porous surface layer of the spreader roll must be chosen so that it will withstand the liquid used, and can be given a suitable

porosity with interconnected pores open to the surface. The pores in the elastomeric material should be evenly distributed and sufficiently large for the liquid which is to be carried in them to move freely in them. If there are too many pores in the material, it will be too weak and will not withstand the forces it is exposed to on rotation and compression. The thickness of the porous surface layer is dependent on the maximum amount of liquid which is to be conveyed per unit area. As previously mentioned, the drop size is determined by the rotational speed of the spreader roll and the impression on the surface layer which is made by the pressure roll. The amount of the liquid which is spread out can, on the other hand, be regulated by the supply of liquid to the spreader roll. How all these variables are to be selected will be illustrated in an embodiment example.

The invention will now be described in more detail with reference to the accompanying drawing, which illustrates two variations of the principle embodiment of a preferred apparatus according to the invention. In the drawing,

FIG. 1 is a cross sectional view through an apparatus for contact-free coating a moving surface with a liquid, and

FIG. 2 is a cross sectional view through a variation of the apparatus illustrated in FIG. 1.

FIG. 1 illustrates diagrammatically a continuously moved surface 4 passing over three guide rollers 1, 2 and 3 and passing an apparatus for spraying liquid thereonto. The liquid medium spray apparatus comprises a spreader roll 5, a press roll 6, an applicator roll 7 by which the binder is supplied to the spreader roll, a pick-up roll 8 for collecting proper quantities of the liquid from a storage bath 9 and for transferring the liquid to the spreader roll. With the illustrated embodiment, the rolls extend at right angles to the plane of the drawing. The storage bath 9 cooperates with a liquid inlet 10 and an overflow passage 11, arranged for maintaining the correct level of liquid in the bath.

As with corresponding rolls in a conventional printing press, the applicator roll 7 may have a smooth surface, which should be free from grease so that the roll is able to carry the liquid binder. The pick-up roll 8 suitably has a surface lining having a certain profile depth, so that upon rotation it is capable of picking up sufficient quantities of the liquid medium. The roll 8 is driven by a separate driving mechanism, the speed of which can preferably be varied, while the applicator roll 7 is arranged to be rotated by friction against the spreader roll 5. The reference numeral 15 in the Figures indicates a liquid film which is transferred by the roll 8 to the roll 7 and then to the spreader roll 5. The extent to which the rolls 7 and 8 abut each other is so adjusted that the liquid is transferred from the roll 8 to the roll 7 without the outer surface of the rolls being compressed. On the other hand, it can be to advantage if the applicator roll 7 is arranged to abut the periphery of the spreader roll in a manner such that a small compression is obtained in the outer layer of the latter roll during its working revolutions. The spreader roll 5 is provided at least in the regions thereof which come into contact with rolls 6 and 7 with a surface layer 14 of elastomeric open porous material. Since it is not suitable for the press roll 6, and also to a certain extent the applicator roll 7, to compress the outer lining of the spreader roll when the latter roll is at rest, the spreader roll is provided with a displaceable centre axis which

can be moved from a rest position to a working position.

If the spreader roll is provided with an elastic surface layer of sufficient softness and thickness, the surface layer will increase in diameter when the roll is rotated at a sufficiently high speed as a result of the centrifugal forces acting thereon, thereby coming into contact with the rolls cooperating with said spreader roll during a liquid medium applying operation. The distance between the rolls is adapted with respect to the softness of the outer lining of the spreader roll and the speed at which it is rotated. In the drawing R_2 indicates the diameter of the roll when stationary, while R_1 indicates the diameter of the roll at full working revolutions. As will be seen from the Figure, although the shafts of all rolls in this case are immovably mounted in the apparatus, the spreader roll when at rest will be spaced from the applicator roll 7 and at most just touches the press roll 6.

Thus, the apparatus of the present invention need only comprise fixedly mounted, rotatable rolls and is therefore of extremely simple construction and is extremely reliable in operation.

When the press roll 6 and the spreader roll 5 are rotated while in abutment with each other at a sufficiently high speed, preferably the same speed for both rolls, and the press roll as a result thereof presses into the periphery of the spreader roll to a sufficient depth while the liquid is supplied to the spreader roll via the rolls 7 and 8, the changes in the kinetic state of the liquid film transported along the periphery of the spreader roll, said changes being obtained along the portion of the surface lining of the spreader roll depressed by the press roll, will cause the liquid film to be atomized into fine droplets and the spray will leave the spreader roll generally tangentially to the direction of rotation of said roll immediately the distance between opposing roll surfaces on the exit side of the nip between the two rolls 5, 6 is sufficiently large. The resulting spray is marked with the reference numeral 12 in the Figure. When visually checking a test machine constructed according to the illustrated embodiment, it was established that the liquid particles along the whole of the gap formed between the spaced apart peripheries of the rolls 5, 6 were distributed within a restricted spread zone of roughly 30° .

The applicator roll 7 of the illustrated example is also pressed into the periphery of the spreader roll to a minor extent, which means that upon mutual contact of the rolls 5, 7 a limited spread of the liquid medium is also obtained, this liquid spray being shown at 13 in the drawing. Since the press roll 6 is arranged in the path of the first spray 13, as shown in the drawing, the press roll 6 will also function to a certain extent as an applicator roll. This initial atomization of the liquid enables a very uniform coating of the liquid to be obtained on the spreader roll and a consequently still more uniform spread of the liquid medium, despite the fact that the number of rolls in the apparatus is very small, especially when compared to the number of equalizing rolls required in a conventional printing press before the ink can be transferred to the block.

FIG. 2 illustrates diagrammatically a cross section through a modification of the apparatus illustrated in FIG. 1, in which the pick-up roll 8, also functions as applicator roll. It is driven by a separate driving mechanism, the speed of which can preferably be varied,

thereby controlling the amount of liquid transferred to the spreader roll. The pick-up roll 8, makes no impression in the surface layer 14 of the spreader roll 5, but the difference in speed may cause some spraying, which will be taken up by the press roll 6 and transferred to the spreader rolls. The remaining components of the apparatus of FIG. 2 are the same as the components identified with the same reference numbers in FIG. 1. The apparatus also operates in the manner described with reference to FIG. 1.

EXAMPLE

In an experimental plant, the spreader roll had a diameter of 200 mm and was coated with a 20 mm thick layer of foam polyether with a volumetric weight of 35 kg/m³. The pores were about 1 mm in diameter, connected to each other and open at the surface. The pressure roll had a diameter of 100 mm and the pick-up roll which also served the purpose of an applying roll had a diameter of 70 mm. With this apparatus a paper strip was dampened with water, whereat it was found that the spreader roll could be given a revolution speed of between 700 and 1,300 rpm. With rotational speeds lower than 700 rpm uneven dampening was obtained and at greater speeds than 1,300 rpm the water was reduced to a mist which spread in all directions. The amount of water which was transferred to the paper strip could be varied from nearly 0 to very great amounts by altering the speed of the pick-up roll. In one test run, a spreader roll speed of 1,180 rpm was used, the foam plastic layer increasing its diameter by 10 mm. The pressure roll was thereby pressed into the foam plastic by nearly 5 mm. The pick-up/applicator roll had a speed of 45 rpm. The amount of water sprayed was varied from 0 up to an amount saturating the paper strip, and the test was carried out for a longer period of time with a water amount of 2,900 ml/min. and one meter width on the treated surface. It was found here that the sprayed amount of water was very even over the width (sideways) of the paper and that it did not alter with time. As a comparison it can be mentioned that with trials using a spreader roll having a diameter of 600 mm, the remaining conditions being similar, the roll was found to function within the rotation speed range of 350 - 650 rpm.

The invention has been found particularly suited for moistening and coating fiber webs, particularly for coating continuously advanced adhesive-free fibre webs with a binding agent and/or colouring agents, which webs owing to their sensitive surface structure cannot be coated with the medium in question by direct contact, e.g., by a rotating transfer block. When colouring agents are to be applied at the same time, the requirements of a uniform liquid supply are further enhanced, since the colouring agents used are not covering agents but absorbing inks which give rise to different colour shades, depending on the quantity of ink applied, and which therefore reveal extremely slight variations in the amount of ink applied to adjacent surfaces per unit of area. With conventional spraying apparatus, such media would tend to block the exit orifices of the

nozzles, as before mentioned. This problem, however, is circumvented with the apparatus of the present invention.

The method and apparatus of the invention are not restricted to the described embodiment, but can be modified within the scope of the accompanying claims.

I claim:

1. A method for spraying an atomized liquid medium in a predetermined direction, particularly for coating or moistening a material continuously advanced in the path of the atomized medium, characterized in that the liquid medium is passed to a surface layer of elastomeric open porous material on a spreader roll, rotating this roll, passing said surface layer through the nip between said spreader roll and a press roll, thereby causing said press roll to compress said surface layer along the roll nip to atomize the liquid film into free droplets which are ejected from the roll nip in the form of a continuous liquid spray, as a result of rapid changes in the radial dimension of the spreader roll.

2. An apparatus for spreading an atomized liquid medium in a predetermined direction, characterized in that said apparatus comprises a spreader roll, the speed of which can be regulated and which is provided with a layer of elastomeric open porous material, means for continuously applying to the periphery of the spreader roll a uniform supply of the liquid medium to be spread, and a press roll which rotates in abutment with the periphery of the spreader roll and which at least during a working revolution of said spreader roll is pressed into the outer surface layer thereof to a limited extent, the depression extending linearly along the whole length of the spreader roll and being of such magnitude that the liquid medium, owing to the change in the kinetic state of the liquid film as a result of said depression, is torn from the surface of the spreader roll in the form of droplets and forms a continuous spray directed from the spreader roll.

3. An apparatus according to claim 2, characterized in that the distance between the spreader roll and the press roll is so adapted that when stationary the two rolls at the most just touch each other, the surface lining of the spreader roll being comprised of a material of such elasticity that when the spreader roll rotates at full working speed an increase in diameter is obtained which provides the requisite abutment of said spreader roll with the surface of the press roll.

4. An apparatus according to claim 2, characterized in that the spreader roll has a displaceable centre axis for controlling the distance between the centre axes of the press roll and the spreader roll.

5. An apparatus according to claim 2, characterized in that said means for supplying the liquid medium to the spreader roll comprises an applicator roll, which is arranged to be pressed at least to a limited extent into the surface of the spreader roll at its point of contact therewith, and that the press roll is arranged generally opposite the nip between the spreader roll and the applicator roll on the exit side of said nip and adjacent to but free from the applicator roll.

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