

[54] **APPARATUS FOR COATING A CONTINUOUS WEB**

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[58] Field of Search **118/50, 410, 411, 118/412, 407; 117/34, 61**

[56]

References Cited

UNITED STATES PATENTS

3,347,962	10/1967	Dieck et al.	264/90
3,503,370	3/1970	Mamoru Ishiwata et al.	118/50
2,521,666	9/1950	Knight et al.	118/50
2,681,294	6/1954	Beguin.	117/61 X

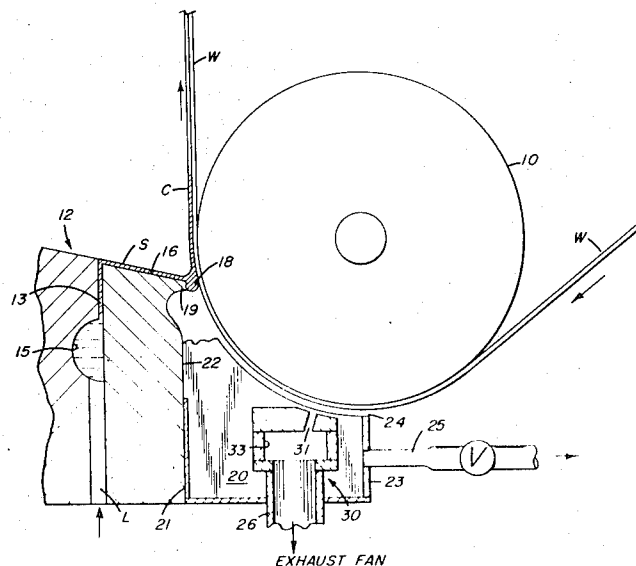
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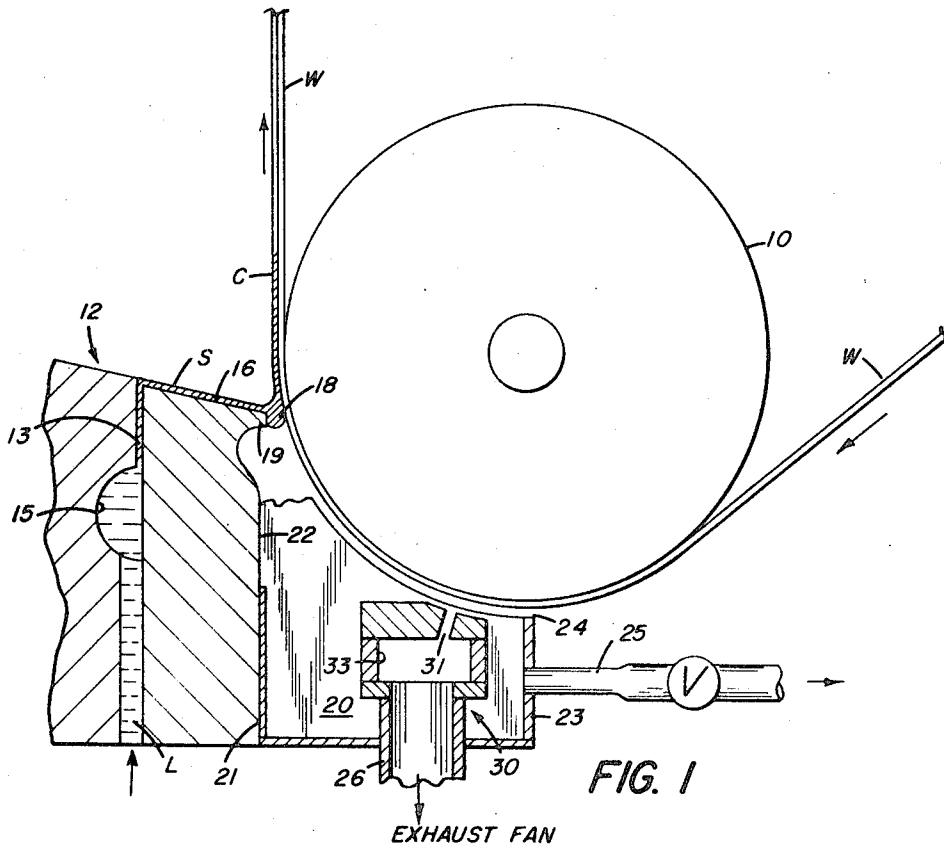
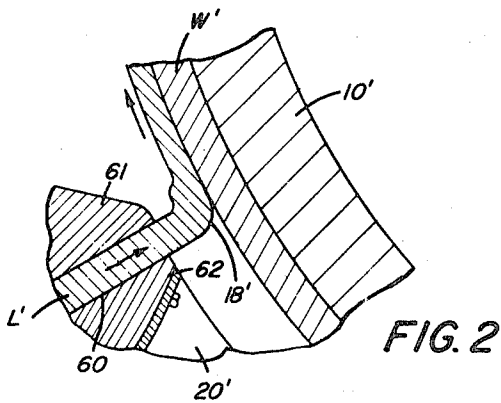
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ABSTRACT

An apparatus for applying fluid materials to a moving strip of material to be coated wherein a stream of coating liquid is maintained in bridging relation between a hopper and a surface of the strip moved in spaced relation relative to the hopper and a differential pressure is maintained on opposite sides of the stream of coating liquid. The apparatus includes the improvement of separate means for vacuuming the surface of the strip just ahead of the stream to remove the laminar layer of air carried along by the strip.

8 Claims, 2 Drawing Figures





APPARATUS FOR COATING A CONTINUOUS WEB

This is a division of Ser. No. 749,109 filed July 31, 1968, now abandoned.

This invention relates to an apparatus for applying fluid materials to a moving strip of material to be coated, and particularly to an improvement in known coating apparatus, which improvement increases the speed at which webs may be coated.

It has been shown in U.S. Pat. No. 2,681,294, Beguin, that in coating procedures where a stream of coating solution is continuously fed from a hopper onto a web moved relative to and in spaced relation with the hopper the speed of coating can be considerably increased, and the thickness of coating that can be successfully applied can be decreased, by the application of a differential pressure across the stream of coating liquid bridging the span between the hopper and the web surface. The pressure on the side of the stream of coating liquid from which the web approaches is maintained lower than that on the side of the stream from which the web leaves, and in the usual form of this procedure the pressure differential on the opposite sides of the stream of coating is achieved by constructing a trough on the side from which the web approaches the stream of coating and applying a reduced pressure to the trough, between 0.1 and 5 inches of water, by means of a suitable suction fan.

One of the difficulties of such a coating procedure, particularly when coating paper webs, has been that the stream of coating bridging the span between the hopper and the surface of the web becomes disturbed at some critical coating speed. The creation of the disturbance depends on a number of factors, such as the precise nature of the web surface being coated, and the physical and chemical properties of the coating liquid. At this critical speed the stream of coating liquid spanning the space between the hopper and the web is not completely broken, but rather, oscillates in a random fashion producing gross unevenness in the coating and sometimes trapping bubbles of air in the coating layer. The exact causes of this undesirable effect are uncertain but a number of contributing effects have been identified and are overcome by the present invention.

The primary object of the present invention is to provide an improved apparatus for coating a continuously moving surface where the top critical coating speed is increased by a factor of fifty percent or more beyond that obtainable with certain apparatus of the type known in the prior art.

A further object is to provide an improved apparatus of the type referred wherein existing coating apparatus can be readily and inexpensively modified to achieve the advantages described herein.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its mode of operation, together with additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIG. 1 is a schematic side elevation, partially in section, of a preferred form of apparatus with which my invention may be carried out; and

FIG. 2 is a greatly enlarged fragmentary sectional view showing the form of the stream of coating compo-

sition which could be applied to the web surface using another type of hopper.

Generally speaking, the present invention concerns the discovery that the top critical coating speeds of conventional methods of coating, wherein a stream of coating liquid is maintained in bridging relation between a hopper and the surface of a web moved in spaced relation relative thereto and a differential pressure is maintained on opposite sides of the stream of coating liquid, can be increased as much as 50 percent if the surface of the web is vacuumed just ahead of the stream to remove the laminar layer of air carried along by the web. Preferably, to be most effective, this vacuuming operation should be carried out within the suction trough which reduces the pressure on the leading side of the stream.

Referring to FIG. 1, a coating apparatus according to the present invention may comprise a coating roller 10 on the surface of which a web W to be coated is supported as it is continuously advanced by suitable means, not shown, in the direction indicated by the arrows alongside of the web. Spaced from the surface of the web supported by roller 10 is a coating hopper 12 having a vertical discharge slot 13 which extends transversely of the web and whose length is equal to the width of the web to be coated. A liquid coating composition L fed into a cavity 15 of the hopper by a constant discharge pump, not shown, is discharged from the slot 13 in a fairly uniform thin stream S which then flows by gravity down the inclined surface 16. As the stream of liquid gravitationally flows down the surface 16 its widthwise uniformity is improved until it flows into a stream 18 bridging the space between the lip 19 of the hopper and the web surface. As shown in FIG. 1, the stream 18 is in the form of a "puddle" or bead which extends the full width of the web, and across and in contact with which bead the web moves to pick up a uniformly thin layer C of coating liquid by capillary attraction. This bead of coating liquid may be initially formed either by momentarily pumping an excess of coating solution from the hopper, or by moving the hopper close enough to the web surface to initially form the bead and then backing it off from the web until the desired bead is formed. After the bead of coating liquid is formed, the constant discharge pump feeding coating liquid to the hopper is adjusted to feed solution into the bead at the rate at which it is taken away from the bead by the web.

In order to hold the bead from moving with the web and becoming ruptured it has been customary, as shown in U.S. Pat. No. 2,681,294, to reduce the pressure on that side of the bead which the bead approaches. To this end a suction trough 20 is positioned ahead of the stream or bead of coating liquid bridging the span between the hopper and the web surface. This suction trough comprises a generally box-shaped enclosure except that it has no top wall. The suction trough may be attached at 21 to the coating hopper and a portion of the wall 22 of the hopper to which it is attached may form a part of the end wall of the enclosure. The forward wall 23 of the trough may be spaced at 24 from the surface of the web to be coated by a slight distance, e.g., 0.015 inch on the incoming side. Thus the coating roller 10 and/or the web W supported thereon in effect forms the top wall of the suction trough. The trough is connected to a pipe 25 which may lead to a means, not shown, for reducing the pressure therein. A valve V

may be connected in the pipe 25 to regulate the degree of pressure reduction in the suction trough 20.

As taught by the above-noted Beguin patent, a partial vacuum of 0.1 inch to 5 inches of water may be maintained in the suction trough, depending upon the speed of coating and/or the viscosity of the coating liquid, to hold the stream or bead of coating solution from being dragged along with the web and being ruptured.

Coating apparatus of the type described up to this point is well known and has been found to have definite advantages so far as increasing the speed of coating and reducing the thickness of coatings which can be applied to a moving surface is concerned. Such apparatus, however, has been found to have a critical top speed of coating above which the stream or bead 18 of coating begins to oscillate in a random fashion producing a gross unevenness in the coating and sometimes trapping air bubbles in the coated layer. Offhand, it would seem that this undesirable condition could be overcome by merely increasing the reduction of pressure in the suction trough. When this was tried it was found that this was not the answer because the stream or bead would be sucked into the suction trough and thus be broken before any beneficial results would appear in this top critical coating speed. It was thus discovered that there was a definite limit to the amount of pressure differential that can be maintained on the two sides of the stream or bead of coating liquid without sucking the bead into the suction trough and breaking it.

According to the present invention the top critical coating speed of this type of coating apparatus is increased as much as fifty percent by vacuuming the surface of the web immediately ahead of the coating point. This is done by providing a suction knife 30 within the conventional suction trough 20. As shown, this suction knife consists of a narrow slot 31 positioned close to the web, and extending across the entire width of the coating hopper. Suction is applied to the slot 31 by means of a suitable manifold 33 and a suction source which is separate from that producing the suction in trough 20. As shown in FIG. 1, the pipe 26 on the bottom of the manifold 33 may be connected to an exhaust fan, not shown, which is separate from that evacuating the trough 20. The slot 31 may be spaced from the surface of the web W by 0.030 inch and that portion of the wall of the manifold through which it extends is preferably concentric to the supporting roll to achieve the best vacuuming action.

In FIG. 1 the suction knife is shown as being mounted inside of the conventional suction trough 20 but its position in relation to the coating stream or bead 18 is not critical so long as it is either within or forms the forward wall (entry plate) 23 of the trough. It has been discovered that the suction knife must cover the full width of the coating hopper even though only a fraction of the available width of the hopper is being used for coating.

EXAMPLE 1

In this example the suction knife 30 was mounted so as to form the forward wall 23 of the suction trough 20 and the slot 31 was positioned so that it was 0.020 inches from the web W being coated. The slot itself was 0.030 inches wide and extended across the full width of a 15 inch hopper 12, even though the web being coated occupied only the center 5 inches of the hopper. Consequently, the spacing of the suction knife from the

coating roller where there was no web was 0.030 inches, the web being 0.010 inches thick. For combination of a coating liquid consisting of a light-sensitive silver halide dispersion having a viscosity of 10 c.p. and a web consisting of a paper base, which had a top critical speed of between 80 and 90 ft./min. when using the conventional coating system having only a suction trough, the critical speed of the conventional system with a suction knife added according to the present invention was raised to between 120 and 130 ft./min., and the suction knife was removing 18 cu. ft./min. free air at the manifold pressure of 22 inches of water vacuum.

EXAMPLE 2

In a second example using the same liquid coating composition and a paper web the spacing of the suction knife was increased to 0.030 inch from the paper (0.040 inch from the coating roller) with the result that the critical top speed was raised by the same amount as in the first example.

EXAMPLE 3

In a third example, the width of the slot of the suction knife was increased to 0.050 inches and this resulted in the top critical speed being raised to between 150 and 160 ft./min. Under these conditions the suction knife was removing 22 cu. ft./min. of free air at a manifold pressure of 17 inches of water vacuum.

It has been discovered that the suction knife operates with increased efficiency as the slot width is increased by virtue, it is believed, of increasing removal rates of air. However, when the width of the suction slot is increased beyond 0.050 inch the efficiency of the device as at present designed falls off markedly for reasons that are not yet known. The spacing of the suction knife from the web to be noted may vary between 0.020 inches and 0.030 inches without affecting the performance of the system. Spacings outside of this range have not been investigated.

It appears that air flow is the important parameter since for a certain slot size the critical speed is lowered when the air flow is reduced. Within experimental error there is a direct proportionality between the percentage increase in critical speed and air flow rates over ranges which have been tried to date, e.g., between 10 and 22 cu. ft./min.

When web materials are transported, it is known that a lamina layer of air travels with them and that as the transport speed of the web is increased the amount of air drawn along with the web also increases. The volume of this lamina layer of air also varies with the surface characteristics of the web being coated, e.g., increasing with the roughness of the web surface. For this reason a paper web will have a heavier lamina of air at a given transport speed than a plastic film base because it has a rougher surface. It is believed that this lamina layer of air is directed at the stream or bead of coating in the conventional coating system, enhanced by the flow of air into the region of low pressure just prior to the coating point, and that if the pressure so generated immediately below the coating stream is large enough, instability of the coating stream will result. The exact level of pressure, which will increase with coating speed, for instability of the coating stream to result will depend on a number of properties of the web being coated and the liquid coating composition, e.g., rough-

ness of the surface of the web, viscosity of the coating composition, wetting characteristics of both the web surface and the coating liquid, etc. The function of the suction knife is to eliminate, or severely limit, the flow of the lamina layer of air with the web to the coating point. This not only reduces the possibility of air being entrained under the applied coating, but, in addition, reduces the air pressure immediately below the coating stream or bead, or at the point where the stream of coating composition actually contacts the web surface. By reason of its disposition close to the web surface this suction knife removes air primarily from the web surface and does not seem to have any significant effect in reducing the pressure in the suction trough as a whole. Any tendency the suction knife might have to reduce the pressure in the suction trough to a point where the coating stream might be broken thereby can be overcome by adjusting the valve V in the exhaust line to the suction trough to maintain the desired reduced pressure therein, e.g., 0.1 inch to 5 inches of water vacuum.

While in FIG. 1 there is shown a coating hopper of the type which continuously feeds a layer of liquid coating composition to a bead of solution bridging the gap between the hopper and the surface of the web to be coated, the present invention is not limited to use with such a coating apparatus. For example, the hopper could be one of the extrusion type as shown in FIG. 1 of the above noted Beguin patent wherein, as illustrated in FIG. 2 of the present application, a stream of coating liquid 1' is fed under pressure from a hopper slot 60 formed between two spaced lips 61 and 62 of a hopper spaced from the web W' moving past the hopper in engagement with a coating roll 10'. In this case, the stream of coating solution bridging the gap between the hopper and the web surface is in the form of a ribbon 18' to opposite sides of which a pressure differential is applied by the suction trough 20'. So far as the present invention is concerned it is immaterial what shape the stream of coating liquid bridging the gap between the hopper and the web surface takes so long as it is continuously maintained. Therefore, throughout the specification and claims, when the mass of liquid maintained between the hopper and the web surface is referred to as a continuous stream, such terminology is intended to include a mass of liquid regardless of its shape, e.g., a bead or "puddle" of solution as shown in FIG. 1, a ribbon of solution as shown in FIG. 2, etc.

While I have shown and described certain specific embodiments of my invention, I am aware that may modifications thereof are possible. My invention, therefore, is not to be limited to the precise details shown and described but is intended to cover all modifications coming within the scope of the appended claims.

I claim:

1. In a web coating apparatus comprising a supporting surface on which a web to be coated is supported as it is continuously advanced; a coating hopper spaced from said supporting surface and the surface of the web supported thereon for continuously feeding a stream of liquid coating composition to the surface of the web passing over said supporting surface and causing the stream to bridge the distance from the hopper to the surface of the web being coated; means for defining a suction chamber contiguous to and ahead of said coating hopper in the direction of movement of said web and having an opening facing one side of said stream

and a length of the web surface to be coated as it approaches said stream; first suction means connected to said chamber for establishing a gaseous pressure at the side of said stream of liquid composition adjacent said chamber that is less than that on the other side of said stream; the improvement which comprises:

means for defining a suction knife that is located within said suction chamber, said suction knife having a relatively narrow elongated slot adapted to extend transversely across the full width of the surface of the web to be coated in slightly spaced relationship relative to the web surface; and second suction producing means substantially separate from said first suction producing means and coupled with said slot for applying suction to said slot so that the boundary layer of air flowing with said moving web may be removed through said slot.

2. Coating apparatus according to claim 1 wherein said slot is spaced between 0.020 inch and 0.030 inch from the surface of the web to be coated, and has a width no greater than 0.050 inch.

3. Coating apparatus according to claim 2 wherein said slot extends transversely across the full width of the coating hopper.

4. In a web coating apparatus comprising a supporting surface on which a web to be coated is supported as it is continuously advanced; a coating hopper spaced from said supporting surface and the surface of the web supported thereon for continuously feeding a stream of liquid coating composition to the surface of the web passing over said supporting surface and causing the stream to bridge the distance from the hopper to the surface of the web being coated; means for defining a chamber contiguous to and ahead of said coating hopper in the direction of movement of said web and having an opening facing one side of said stream and a length of the web surface to be coated as it approaches said stream; pressure-differential establishing means connected to said chamber for establishing a gaseous pressure at the side of said stream of liquid composition adjacent said chamber that is less than that on the other side of said stream; the improvement which comprises;

means for defining a suction member that is located within said suction chamber, said suction member comprising a narrow elongated slot extending transversely of and slightly spaced from the surface of the web to be coated; and

suction producing means substantially independent of the pressure-differential establishing means and connected to said member for reducing the pressure therein below that within said suction chamber so that said suction member is adapted to vacuum the boundary layer of air flowing with said moving web.

5. Coating apparatus according to claim 4 wherein said slot is spaced between 0.020 inch and 0.030 inch from the surface of the web to be coated, and has a width no greater than 0.050 inch.

6. Coating apparatus according to claim 5 wherein said slot extends transversely across the full width of the coating hopper.

7. An apparatus comprising:

means for continuously feeding a stream of liquid composition towards a moving surface of a member so that the stream bridges at least a portion of the distance between said feeding means and said moving surface;

means for defining said surface and for moving and supporting said surface in proximately spaced relationship relative to said feeding means;
means for defining a suction chamber contiguous to and ahead of said feeding means in the direction of movement of said surface and including an opening facing one side of said stream and a length of said surface, said chamber including a transversely extending forward wall that has an edge thereof located closely to said surface so that said length of said surface is located substantially between said forward wall and the stream of liquid composition;
first suction producing means connected to said chamber for establishing an air pressure at the side of said stream of liquid composition adjacent said chamber that is less than that on the other side of said stream;
means defining a suction knife at said forward wall of said suction chamber, said suction knife comprising an elongated slot extending transversely across the full width of said surface and slightly spaced therefrom; and
second suction producing means substantially separate from said first suction producing means and communicating with said slot for vacuuming a layer of air flowing with said moving surface.

8. An apparatus comprising:
means for continuously feeding a stream of liquid

composition toward a moving surface of a member;
means defining a surface of the member and for moving and supporting said surface in proximately spaced relationship relative to said feeding means so that the stream of liquid composition is adapted to bridge at least a portion of the distance from said feeding means to said surface of said member;
means for defining a suction chamber contiguous to and ahead of said feeding means in the direction of movement of said surface and including an opening facing one side of said stream and a length of said surface;
first suction producing means connected to said chamber for establishing an air pressure at the side of said stream of liquid composition adjacent said chamber that is less than that on the other side of said stream;
means defining a suction knife that is located within said suction chamber, said suction knife comprising an elongated slot extending transversely across the full width of said surface and slightly spaced therefrom; and
second suction producing means substantially separate from the first suction producing means and communicating with said slot for vacuuming a layer of air flowing with said moving surface.

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