Feb. 20, 1968 J. F. ALIX 3,369,522

CURTAIN COATING APPARATUS

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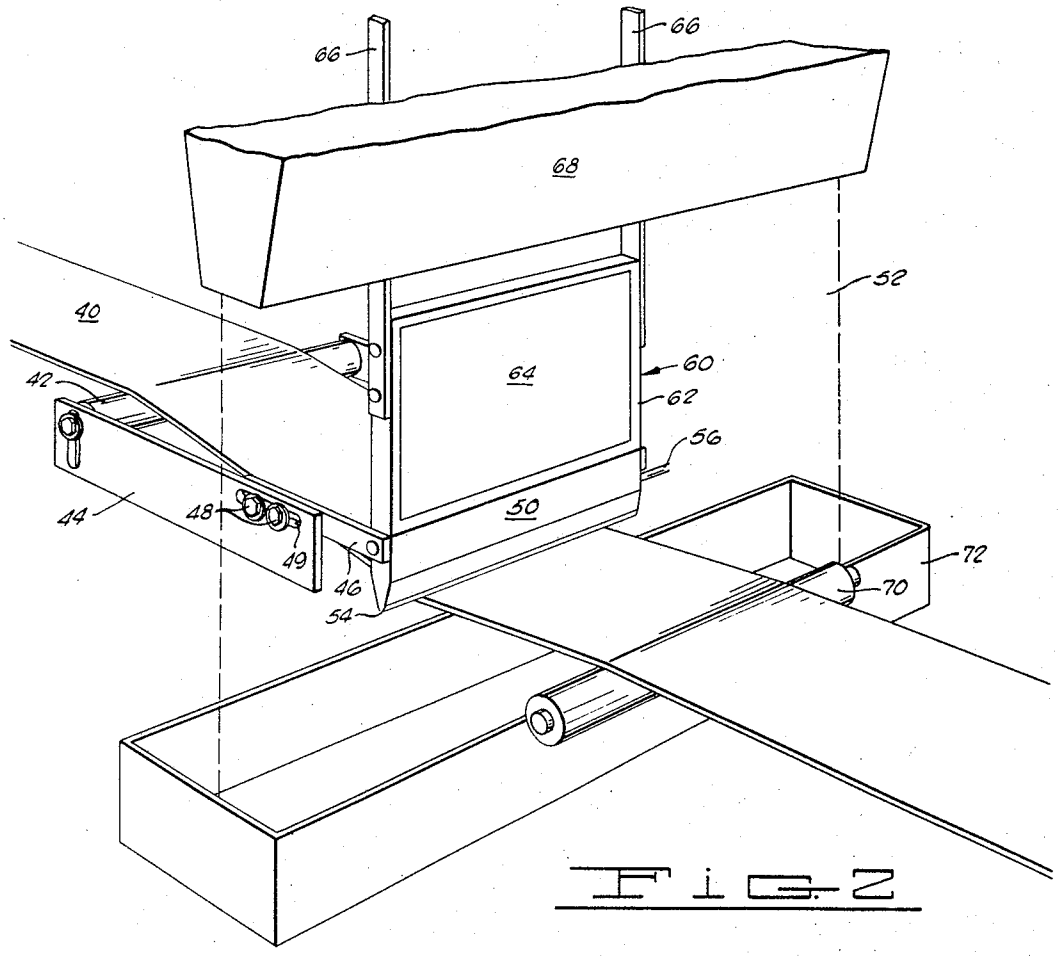

Fig. 2

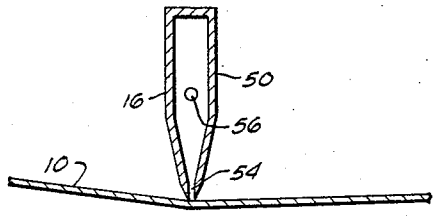

Fig. 3

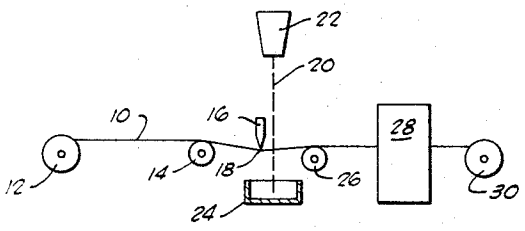

Fig. 1

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CURTAIN COATING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A curtain coating apparatus capable of coating a substrate with relatively thin coatings and comprising a rigid knife blade spaced closely to and on the upstream side of a gravitating curtain of coating material, said knife blade having an air shield attached above the knife blade and forming a continuous shield from the top surface of the substrate to a position near the same horizontal plane from which said curtain of coating material emanates. The knife blade can be hollow and have vacuum means communicating therewith for creating a vacuum at the edge of the blade.

This invention relates to improvements in apparatus for providing a descending curtain of a liquid coating material for deposition on a substrate moved through the curtain. More particularly, the present invention relates to curtain coating apparatus which includes structure facilitating the positioning of a thinner film of coating material upon a substrate than has been possible using curtain coating apparatus of the type heretofore available.

In conventional curtain coating machines now in use, such as the Steinemann curtain coater, the basic elements of the machine generally comprise a coating head from which emanates a thin gravitating film of a liquid coating composition, a receptacle or container of some type disposed below the coating head for receiving the coating composition as it gravitates from a coating head, and apparatus for moving a substrate material to be coated through the film or curtain of coating composition emanating from the coating head. In the usual operation of such curtain coating machine, the coating composition is allowed to gravitate from the coating head, or is ejected therefrom under a pressure slightly exceeding atmospheric pressure, and moves through the air as a thin film or curtain extending vertically between the receiving receptacle or trough and the coating head. The liquid coating composition is recirculated from the receiving trough to the head after being passed through suitable heating and degassing equipment.

The apparatus which is employed in conjunction with the coating head and receiving trough for completing the coating operation includes some suitable type of conveyor mechanism for moving a substrate to be coated through the gravitating film or curtain. In some instances, as, for example, where it is desired to move a flat, substantially monoplanar discontinuous substrate through the curtain, a pair of endless conveyor belts may be disposed on opposite sides of the curtain and the belts moved in the same direction so that a substrate, such as milk carton stock or the like, can be passed through the curtain by movement across the gap or open space existing between the two conveyors. In other applications of the curtain coating machinery, an elongated continuous web is to be coated. In this instance, suitable feed and take-up rolls are provided on opposite sides of the vertical plane of the gravitating curtain, and the web is transferred between the feed and take-up rolls so that its span between the rolls passes through the gravitating curtain.

Whether the curtain coating device is to be employed for coating a discontinuous, relatively short substrate, such as milk carton stock and the like, or is to be used for

coating continuous webs, the thickness of the deposited layer or coating is frequently critical and always a major concern. The thickness of the coating laid down on the substrate will generally be dependent upon the speed at which the substrate is moved through the gravitating curtain and the rate at which the coating composition is being released from the coating head. In general, the first evidence which is observed that the limit of thinness of the applied coating has been reached is the appearance of discontinuities, breaks and fractures in the applied coating. Once the coating fails to completely cover the substrate and bare spots or breaks appear in the coating, any further attempt to reduce the thickness of the coating by control of the flow of coating composition, or increasing the speed of the substrate through the curtain, will only result in aggravation of the coating discontinuity and the increasing frequency of breaks and imperfections in the coating.

The present invention comprises an improvement in curtain coating apparatus which permits the minimum thickness of coatings which are applied to substrates moved through the gravitating curtain to be further reduced, and yet thinner coatings to be applied. Broadly described, the invention comprises a thin rigid edge or knife blade which can be brought into contact with a moving substrate along a line which extends generally parallel to the vertical plane of the gravitating curtain and is spaced therefrom by a distance of from about 1 to about 5 inches. Preferably, the knife blade is spaced from the gravitating curtain by about 1½ inches, or as close to the gravitating curtain as possible, and is adjusted to bear lightly against the surface of the substrate which is to be coated. The advantageous effect of employing the described structure which constitutes the present invention is to permit relatively thin coatings to be applied to the substrate with a consequent saving in the cost of coating material, and an improvement in the functional capabilities of coated substrates for some uses which require a very thin film of the coating material on the substrate.

In a preferred embodiment of the invention, a rigid member carrying a knife edge which is placed in contact with the substrate to be coated is used conjunctively with a shield which is brought into contact, and cooperates, with the knife edge bearing member to form a continuous shield or obstruction extending vertically and parallel to the gravitating curtain so as to block the movement of air currents toward the curtain.

In yet another embodiment of the invention, the member which carries the knife blade or elongated edge of reduced thickness is hollow, with the hollow interior thereof opening at the knife edge so that a vacuum may be drawn through the member, or air or other suitable gas under pressure may be forced through the member and out through the opening adjacent the knife edge. In this embodiment of the invention, a force developed by reduction or increase in pressure can be brought to bear on the substrate to be coated along the line thereof which is contacted by the knife edge.

From the foregoing description of the invention, it will be perceived that a major object of the invention is to provide an improved curtain coating device which can be effectively employed for depositing relatively thin coatings of a molten coating composition on a substrate material.

An additional object of the present invention is to provide a device for reducing the thickness of uniform continuous coatings which are applied to substrate materials by a curtain coating procedure.

Another object of the present invention is to provide an improved curtain coating device which is mechanically strong, relatively easy utilized and characterized by a long and trouble-free operating life.

In addition to the foregoing objects and advantages, additional objects and advantages will become apparent as the following detailed description is read in conjunction with the accompanying drawings which illustrate the invention.

In the drawings:

FIGURE 1 is a schematic illustration of the manner in which the apparatus constituting the improvement of the present invention is utilized in conjunction with the basic elements of a curtain coating apparatus.

FIGURE 2 is a perspective view of an improved curtain coating apparatus constructed in accordance with the present invention.

FIGURE 3 is a transverse sectional view taken through the knife edge carrying member in the curtain coating apparatus illustrated in FIGURE 2.

Referring now to the drawings in detail, the relative position in a curtain coating apparatus of the structure constituting the improvement provided by the present invention, and its principles of operation, can best be understood by referring to the schematic illustration of FIGURE 1. A continuous elogated web which is to be coated by passage through the curtain coating machine is designated by reference character **10**. The web **10** originates at a suitable conventional feed roll **12**, is passed over an idler roll **14**, and then is passed beneath a member **16** which extends transversely across the web **10**, and is provided with an edge of reduced thickness or knife edge **18** at the lower side thereof. The knife edge **18** is in contact with the surface of the web **10** which is to be coated. In the schematic illustration of FIGURE 1, this is the upper surface of the web.

After passing beneath, and in contact with, the knife edge **18** carried by the member **16**, the web is passed through a gravitating curtain **20** of a molten coating composition. As is well understood in the art, the curtain **20** originates at a hollow coating head **22** which is provided with a slot (not seen) in the lower portion thereof to pass the composition. The molten coating composition is received in a receptacle or trough **24** which is positioned beneath the path of movement of the web **10** and in vertical alignment with the coating head **22**. Suitable means (not shown) are provided for recycling the coating composition from the trough **24** through suitable preheater and degassing apparatus to the coating head **22**.

After passing through the gravitating curtain **20**, the continuous web **10** is passed over an idler roller **26**, through chilling apparatus **28** and to a take-up or rewind roll **30**.

The portion of the illustrated apparatus which constitutes the improvement of this invention is the member **16** carrying the knife edge **18** which contacts the web **10**. We have found that when a structural element of this type is used in combination with the curtain coating apparatus and is positioned from about 1 to about 5 inches from the gravitating curtain **20** in the direction from which the web is moving, coatings which are considerably reduced in thickness, and yet which are continuous and defect-free may be laid down on the moving substrate. Preferably, the member **16** and the knife edge **18** which it carries are positioned so that the knife edge extends parallel to the gravitating curtain **20**, and is positioned as close thereto as possible to yet avoid interference with the curtain. A spacing of about 1½ inches from the curtain is usually desirable.

In tests which we have conducted, we have found that in the absence of the member **16** and the knife edge **18** placed in contact with the substrate, coatings of lesser thickness than 7.5 pounds of coating composition per ream (3000 feet square) cannot be uniformly deposited on typical cellulosic substrates. In any attempt to further decrease the thickness of the coatings by increasing the web speed through the curtain **20**, or by decreasing the rate of flow of coating material from the coating head **22** to the trough **24**, the coating fails to cover the web completely, and discontinuities, cracks or craters are formed therein. On the other hand, when the knife edge structure is included in the apparatus, and the knife edge **18** is brought to bear lightly upon the substrate in the position depicted in FIGURE 1, uniform continuous coatings having a thickness equivalent to the distribution of 5 pounds of the coating composition per ream of substrate have been applied. No discontinuities or imperfections have been noted in these relatively thin coatings.

The principles by which the thinner coatings are achieved are not known with exactness, but it is believed that the member **16** and its associated knife edge **18** accomplish at least two functions which greatly assist in permitting the coating thickness to be reduced. First, the member **16** acts as a shield which prevents air currents and perhaps thermal conduction currents from impinging on the gravitating curtain **20**, causing the curtain to waver or become thinner in one location along its transverse extent than in another. The blockage or air currents which is accomplished by the member **16** is particularly important, since air currents moving toward the curtain **20** are developed by the rapid movement of the substrate toward the curtain, and this is particularly true in the case of continuous substrates or webs of the type illustrated in FIGURE 1. The need for blocking or damping out the air currents moving with the substrate or continuous web is greatest closely adjacent the surface of the substrate which is to be coated, since the impingement of these air currents on the curtain at this point will have greater effect upon the uniformity of the coating laid down than will the impingement of such forces at points further removed vertically from the substrate. To the end of completely blocking the air movement immediately adjacent the surface of the substrate, the knife edge provides a continuous seal between the member **16** and the substrate and prevents flow of any air under the member **16** and into the gravitating curtain **20**.

The second function which it is believed is provided by the member **16** and its associated knife edge **18** is that of damping out mechanical vibrations which are transmitted along the span of the web which extends through the gravitating curtain **20**. Thus, as the knife edge **18** bears against the upper surface of the substrate, any vibrations or mechanical wave forms which may be progressing along the substrate between the points of support thereof on opposite sides of the curtain **20** are at least partially damped out or suppressed with the result that the coating composition makes initial contact with the substrate in a more uniform manner throughout the transverse extent thereof.

A preferred embodiment of the present invention as the same may be actually constructed for use in applying a coating composition to a moving substrate is illustrated in FIGURE 2 of the drawings. An elongated continuous web **40** constituting the substrate to be coated originates at feed rolls (not shown) and is passed over an idler roll **42** supported between generally horizontally extending side brackets **44**. The idler roll **42** is vertically adjustable in the side brackets **44** for a purpose hereinafter to be explained. The side brackets **44** can be mounted on the framework (not shown) of the curtain coating apparatus in any suitable manner.

At the opposite ends of the side brackets **44** from the ends carrying the idler roll **42**, the side brackets are longitudinally slotted so as to permit adjustable mounting of a pair of horizontally extending, spaced supporting arms **46**. The supporting arms **46** may be adjustably mounted on the side brackets **44** by the use of bolts **48** extending through an elongated slot **49**. The supporting arms **46** carry an elongated bar **50** which extends transversely across the web **40** and parallel to the gravitating curtain of coating composition which, in FIGURE 2, is designated by reference character **52**. The elongated bar **50** is preferably adjustably supported in the arms **46** so that it may be moved vertically with respect thereto.

The lowest side of the elongated bar **50** is converged to a knife edge **54** which bears against the upper surface of the continuous web **40**. In a preferred embodiment of the invention, the elongated bar **50** is hollow in construction with the hollow interior thereof communicating with a narrow, elongated opening in the knife edge **54** as best illustrated in FIGURE 3. A vacuum connection **56** is provided adjacent one end of the bar **50** to permit the hollow interior thereof to be evacuated. Alternatively, the connection **56** may be used for introducing air under pressure to the interior of the elongated, hollow bar **50** for purposes hereinafter discussed in greater detail.

Positioned above and in vertical alignment with the elongated bar **50** is an extension shield designated generally by reference character **60**. The extension shield **60** is of a length which generally corresponds to the length of the elongated bar **50**, and includes a rigid supporting frame **62** which supports and encloses a rigid, preferably transparent sheet of material **64**, such as glass or a transparent plastic such as Plexiglas. The frame **62** of the extension shield is mounted on vertically extending rods **66** which extend upwardly from the extension shield **60** and are slidably supported on the framework (not shown) of the curtain coating apparatus. The rods **66** may thus be slidably adjusted in a vertical direction so that the extension shield **60** can be lowered until the lower edge thereof abuts the upper edge of the elongated bar **50**.

At this point it should be noted that the extension shield **60** is currently provided on some types of curtain coating apparatus for the purpose of partially shielding the gravitating curtain of coating composition. In the arrangement which has been described wherein the knife edge carrying structure of the present invention is used conjunctively with this shield, the primary reason for such arrangement is the present existence of the extension shield. In instances where the extension shield is not provided on the curtain coating apparatus, a continuous vertically extending shield structure may be formed integrally with the elongated bar **50**, or may be secured to the top of this bar to function in substantially the same manner as the extension shield **60**, that is, to provide additional shielding against air currents moving in the same direction as the direction of travel of the web **40**, but displaced further vertically from the web **40** than the vertical dimension of the elongated bar **50**.

After passing beneath the elongated bar **50** and in contact with the knife edge **54**, the continuous web **40** moves through the gravitating curtain **52** of coating composition which descends from a hollow coating head **68** to a receptacle **72**. The web **40** then passes over an idler roll **70** provided on the opposite side of the curtain **52**. From the idler roll **70**, the web passes through a suitable chilling chamber (not shown) where the molten composition is further set up or hardened by temperature reduction. The web is finally taken up on suitable take-up rolls (not shown).

In the operation of the apparatus of the invention, the substrate is passed beneath the elongated bar **50** and its associated knife edge **54** in a manner such that the surface of the substrate is in contact with the knife edge over the entire transverse width of the substrate. In the case of the continuous web **40** illustrated in FIGURE 2, this is accomplished by positioning the knife edge **54** slightly below the common plane which contains the upper surfaces of the idler rolls **42** and **70** while maintaining tension on the web. As the substrate passes beneath the elongated bar **50** in contact with the knife edge **54**, vibrations of the substrate are damped out, and its surface receiving the coating composition is more quiescent and vibration-free. Moreover, the elongated bar **50** blocks air and thermal conduction currents moving with the web **40** toward the gravitating curtain **52** and prevents their impingement on the curtain. More complete blocking is obtained when the extension shield **60** is employed, or when a similar vertically extending structure is positioned superjacent the elongated bar **50**.

The elongated bar **50** can be either a solid bar or can be the hollow construction illustrated in FIGURE 3. The hollow construction is preferred since by use of the hollow bar **50** in conjunction with the vacuum connection **56**, the interior of the bar **50** may be evacuated, thus drawing the substrate against the knife edge **54** and maintaining a vacuum seal against air currents passing beneath the knife edge. Moreover, in some instances, it may be desired to permit the vacuum to act along the substrate or that portion of the substrate between the knife edge **54** and the gravitating curtain **52**. In this way, the tendency of the moving web to generate turbulence and moving air currents between the knife edge and the web is damped out by a slight suction or vacuum which draws air currents, which otherwise would tend to move toward the web, back into the hollow interior of the bar **50**.

From the foregoing description of the invention, it will have become apparent that the present invention provides an improved curtain coating apparatus which permits thinner, continuous coatings to be applied to moving substrates than the coatings which can be applied with curtain coating apparatus heretofore in use. The structure is simple and easily constructed and maintained, and yet is characterized by mechanical strength, and a long and trouble-free operating life.

Although certain specific embodiments of the invention have been hereinbefore described as exemplary of the manner in which the invention can be practiced, various changes and innovations can be made in the depicted and described structure without departure from the basic principles which underline the invention. All such changes and innovations which do not entail departures from the basic principles of the invention are therefore deemed to be circumscribed by the spirit and scope of the present invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

I claim:

1. In a curtain coating apparatus having a slotted coating head, a receptacle spaced vertically below the coating head to receive a gravitating curtain of a liquid coating composition emanating from the slot in the coating head, and means for conveying a substrate through the space between said receptacle and the coating head in a direction extending substantially normal to said gravitating curtain, the improvement which comprises:

a horizontally extending rigid member tapered to a rigid knife edge extending generally parallel to a vertical plane containing the slot in said coating head and horizontally spaced about 1 to about 5 inches upstream from said plane, said knife edge being positioned at a vertical level to contact the upper surface of said substrate as it is moved through said gravitating curtain by said conveying means.

2. The improvement claimed in claim **1** and further characterized to include shield means extending vertically upwardly from said knife edge for blocking air currents moving in a direction normal to said vertical plane.

3. In a curtain coating apparatus having a slotted coating head, a receptacle spaced vertically below the coating head to receive a gravitating curtain of a liquid coating composition emanating from the slot in the coating head, first support means on one side of a vertical plane extending between the slot in said coating head and said receptacle for supporting a portion of a substrate as it is passed through said vertical plane in a direction normal thereto, and second support means on the opposite side of said vertical plane from said first support means, said second support means supporting a portion of a substrate as it is passed through said plane in a direction normal thereto, the improvement which comprises:

a rigid horizontal member tapered to a rigid knife edge extending generally parallel with, and spaced about

1 to about 5 inches upstream from, said plane, said knife edge being positioned in a horizontal plane lower than a horizontal plane extending between the portion of said first and second support means contacted by said substrate whereby said knife edge contacts the upper surface of said substrate as it is passed through said gravitating curtain.

4. The improvement claimed in claim 3 and further characterized to include means for adjusting the vertical position of said knife edge relative to said first and second support means.

5. The improvement claimed in claim 3 and further characterized to include vertically adjustable shield means cooperating with said knife edge to form a continuous, vertically extending air current barrier extending parallel to said vertical plane.

6. Apparatus for applying a coating to a substrate comprising:

a hollow coating head for containing a molten coating composition, said coating head having a downwardly opening, generally horizontally extending slot therein to pass said coating composition;

a receptacle below said coating head and spaced therefrom for receiving the coating composition passed through the slot in said coating head;

first substrate supporting means positioned on a vertical level higher than said receptacle and to one side of a vertical plane extending between said receptacle and slot for supporting a substrate to be coated as it moves perpendicularly through said coating composition as the composition gravitates in said vertical plane;

second substrate supporting means positioned at a vertical level higher than said receptacle and on the opposite side of said vertical plane from said first substrate supporting means for supporting with said first substrate supporting means, a substrate as it moves perpendicularly through said coating composition; and

a vertically adjustable, horizontally extending rigid member tapered to a rigid knife edge spaced about

1 to about 5 inches upstream horizontally from said vertical plane and extending generally parallel thereto, said knife edge being vertically adjustable between vertical levels which are above and below a line extending between the portions of said first and second substrate supporting means which contact and support said substrate whereby said knife edge will contact the surface of a substrate supported by said first and second substrate supporting means as the substrate is moved through said coating composition as the coating composition gravitates in said vertical plane.

7. In a curtain coating apparatus having a slotted coating head, a receptacle spaced vertically below the coating head to receive a gravitating curtain of a liquid coating composition emanating from the slot in the coating head, and means for conveying a substrate through the space between said receptacle and the coating head in a direction extending substantially normal to said gravitating curtain, the improvement which comprises:

a horizontally extending rigid member tapered to a rigid knife edge extending generally parallel to a vertical plane containing the slot in said coating head and horizontally spaced about 1 to about 5 inches upstream from said plane, said knife edge being slotted and positioned at a vertical level to contact the upper surface of said substrate as it is moved through said gravitating curtain by said conveying means, and means for drawing air through the slot in said knife edge.

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