May 20, 1969 F. L. LORCK 3,445,270

AIR KNIFE METERING APPARATUS AND METHOD

Filed May 12, 1965 Sheet 1 of 2

FIG. 1

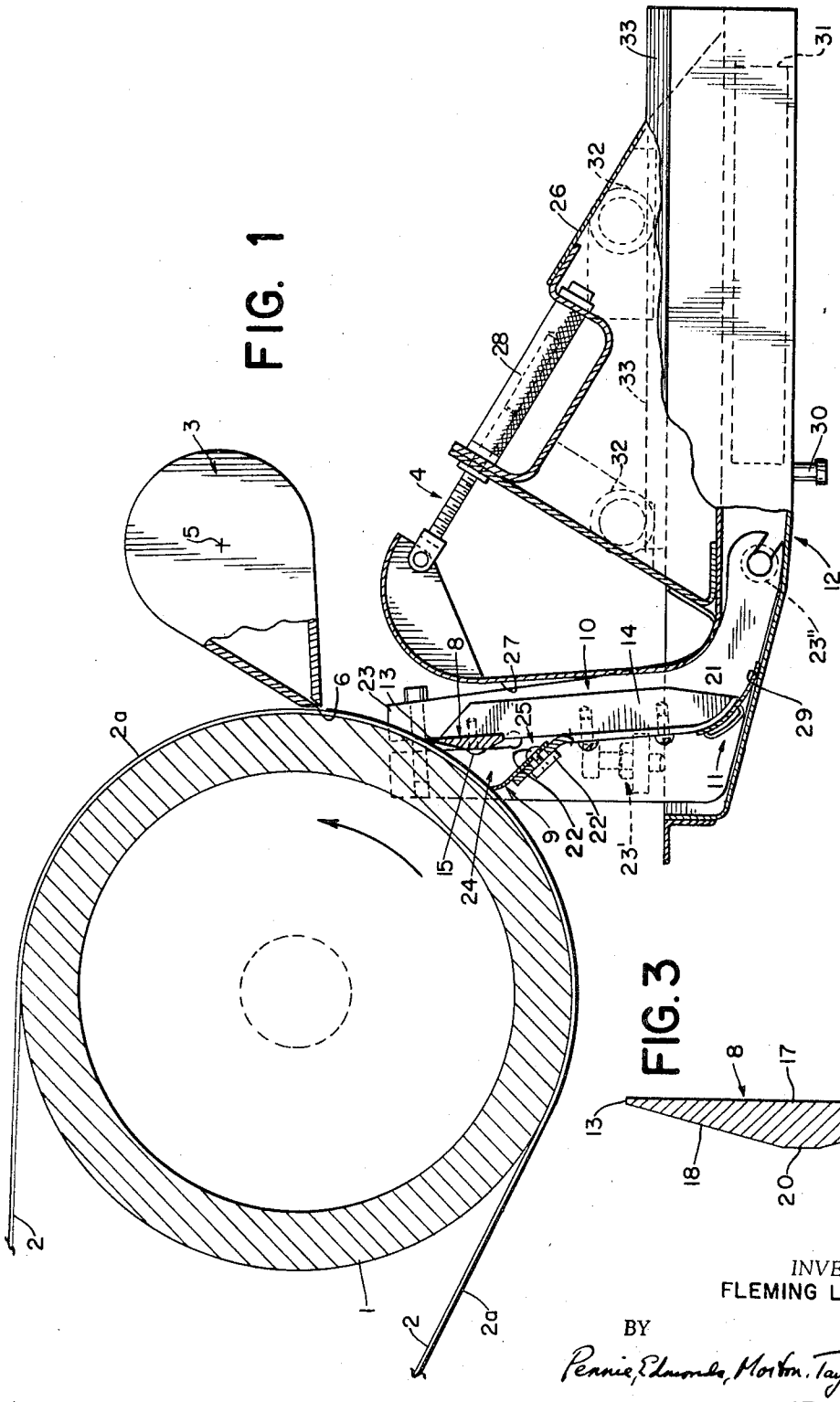


FIG. 3

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AIR KNIFE METERING APPARATUS AND METHOD

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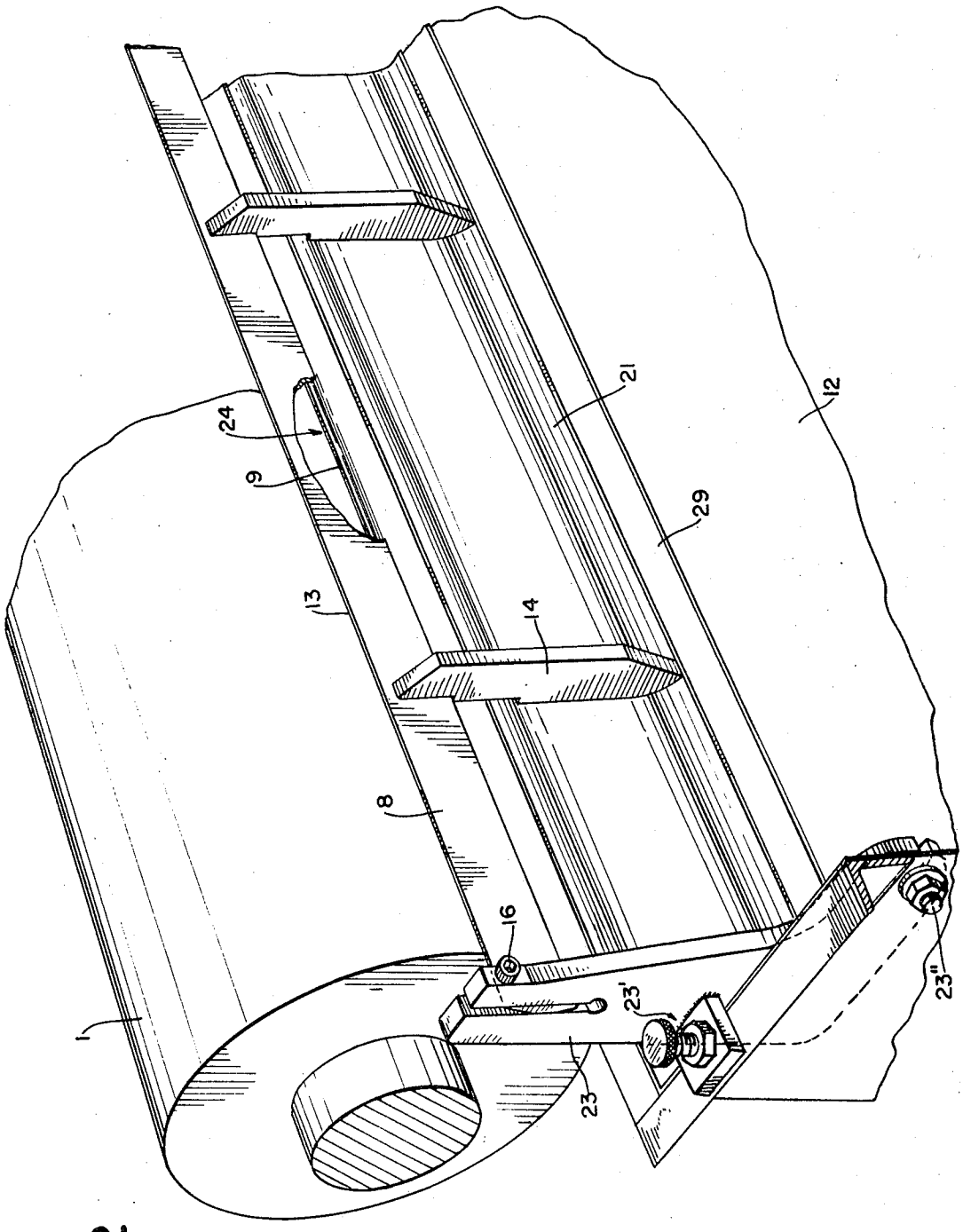


FIG. 2

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AIR KNIFE METERING APPARATUS AND METHOD

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ABSTRACT OF THE DISCLOSURE

A metering system for metering the thickness of a web coating, the system including an air knife doctor for directing a metering stream of air against the coating to remove the excess therefrom and a series of baffles located adjacent to the coated web on the downstream side of the air knife. The stream of air laden with excess coating is first separated into primary and secondary paths and thereafter the laden air contained in the secondary path is drawn into the primary path and through an exhaust passage with the laden air of the primary path.

The present invention relates to a web coating system and more particularly to an air knife coating system for metering the thickness of a coating applied to a running web while assuring that the air issuing from the air knife and any excess coating removed from the web by the action of the air knife are prevented from escaping into the surrounding atmosphere.

In presently constructed web coating apparatus employing air knives for metering the thickness of a web coating, the web material is first provided with an excess amount of wet coating and then the air knife is used to direct a stream of air at the coated surface to remove such excess until the desired thickness is obtained. In construction, the air knife is provided with an elongated air nozzle and is positioned adjacent to the path of movement of the coated web with the nozzle extending across the entire width of the web. By controlling the spacing of the air knife nozzle from the coated web surface, its angle of orientation with respect to such surface, the size of the nozzle opening of the air knife, and the pressure at which the air issues from the nozzle, the amount of excess coating removed may be regulated within fine limits to produce a finished product having a smooth and uniform thickness of coating over the entire coated surface.

One important disadvantage inherent with air knives of this type, however, relates to the containment and recovery of the excess coating after it has been removed from the web by the air issuing from the knife. The jet of air striking the coated web is under high velocity and pressure and tends to cause the excess coating to form minute particles that become suspended in the issuing stream of air. Unless these particles are restricted in their movement and directed to some station where they can be trapped, they become airborne in the atmosphere surrounding the coating apparatus and thus contaminate this atmosphere by forming an atomized smog or mist. The effects of this are apparent; an unpleasant and unhealthful working area is developed and adjacent machinery, as well as the coating machine, becomes coated by this mist as it settles to the ground.

One way of lessening these adheres affects is to lessen the air knife pressure and the volume of air issuing from the air knife so as to, in turn, lessen the velocity with which the air issuing from the air nozzle impinges upon the coated web. This, however, seriously decreases the efficiency of the air knife since its successful operation is predicated upon developing a stream of air across

the width of the coated web that is restricted in extent longitudinally of the web so as to produce a sharp knife like edge for cutting the coating down to proper thickness; and this, in turn, is dependent on air issuing from the air knife at a high pressure and high velocity. Of course, it is possible to use lower pressures and velocities where the viscosity of the coating material is low and the excess more easily removed; but in such situations, the coating is inherently more susceptible to becoming airborne, thus negating the effects of the lower air pressure and velocity.

Another disadvantage of presently constructed air knife systems relates to the contamination of the internal parts of the coating apparatus, and in particular, to the accumulation of coating material on the underside of the air knife and on the various baffles that are included in the system for directing the air away from the web after it has removed the excess coating. In present constructions, these parts tend to become coated during the continuous removal of excess coating from the web, and as the coating on these parts builds up, it causes a change in the air flow pattern originally established for removing and subsequently collecting the excess coating and thus decreases the efficiency of the apparatus.

In accordance with the teachings of the present invention, the improved air knife coating system is provided with a blowoff portion having a plurality of baffles oriented with respect to each other and with respect to the coated web and air knife whereby predetermined primary and secondary air flows are established. These air flows are, in turn, used to effectively control the path of movement of the air after it has removed the excess coating and to effectively contain the removed coating and prevent it from becoming airborne.

Generally, the apparatus of the present invention includes an air knife positioned adjacent to and extending transversely across the coated web as the latter is fed around a back-up or breast roll at the terminal end of a coating apparatus. A primary baffle, also extending across the coated web, is provided on the downstream side of the air knife at a position spaced from the coated web so as to divert the majority of the air flow away from the web after the air has become laden with coating particles. The spacing of the primary baffle from the coated web is, however, great enough as not to cause any interference with the passage of the web around the breast roll. A secondary baffle positioned on the downstream side of the primary baffle in spaced relationship with respect to the coated web cooperates with the web and primary baffle to define an area into which any coating particles passing between the primary baffle and breast roll will be carried. In addition, a throat plate which is spaced from the primary baffle on the side facing away from the coated web is positioned in substantially parallel relationship with the primary baffle to contain the laden air being diverted by the primary baffle into a primary air flow.

With this arrangement, the primary air flow as it passes beyond the primary baffle, will create a venturi action and draw the air originally passing between the primary baffle and the breast roll back into the primary air flow. This venturi action will also draw air into the system through the gap between the coated web and secondary baffle; and this incoming air will, in turn, aid in directing the laden air escaping between the primary baffle and coated web into the primary air flow on the downstream side of the primary baffle. As a result, effectively all the coating removed from the web is captured and contained in the primary air flow which may then be easily directed to suitable separator mechanism for separating the coating from the air for disposal or re-use. Also, the orientation of the air knife and baffles described above permits the use of air knife pressures higher than those permissible

with present constructions and this effectively increases the efficiency of the air knife and also permits the use of coatings of higher viscosities.

In addition to the above, the air knife blowoff system of the present invention provides a controlled air flow directly beneath the air knife so as to prevent the air knife from becoming coated with the excess coating material that is removed from the web; and the various parts of the blowoff system are constructed and connected together in such a way whereby access to the interior thereof is easily effected so as to facilitate any desired adjustment and cleaning of the parts.

A more complete understanding of the present invention will be obtained from a reading of the following detailed description with reference being made to the accompanying drawings of which:

FIG. 1 is a sectional view of a web metering apparatus incorporating the features of the present invention;

FIG. 2 is a perspective view of the interior baffle system of the present invention; and

FIG. 3 is a cross-sectional view of the primary baffle shown in FIG. 1.

As shown in FIG. 1, the metering apparatus of the present invention generally includes a breast roll **1** about which is fed a coated web of material **2**, such as paper or the like; an air knife **3** for metering the thickness of the coating; and a blowoff mechanism **4** for controlling the coating removed from the web by the action of the air knife. In construction, the air knife is pivotally mounted in the system for movement about the horizontal axis **5** and includes an elongated air nozzle **6** extending across the width of the web. The angular orientation of the air knife relative to the coated web may be adjusted to vary the angle at which the air impinges upon the coated surface **2***a* of the web and the knife includes conventional mechanism for varying the volume and velocity of air issuing from the nozzle.

In operation, the air knife will direct a stream of air against the coated surface of the web **1** along a line extending transversely across the web; and this air, as it impinges upon the coating, will act in a manner similar to a knife to remove the portion thereof that is present in excess of a given thickness. At the same time, the air striking the coated surface will tend to smooth out the coating evenly across the web; and by adjusting the air pressure of the air issuing from the air knife, the amount of coating removed and the extent to which the remaining coating is smoothed out may be accurately controlled. As the excess coating is removed from the web by the action of the air striking the coating at a high pressure and velocity, it tends to form into minute particles which become suspended in the air. In order to prevent these particles from becoming airborne in the surrounding atmosphere, the metering system of the present invention is provided with the blowoff portion **4** disposed on the downstream side of the air knife.

Generally, the blowoff portion of the metering apparatus comprises a primary baffle **8** disposed adjacent the coated web for dividing the air issuing from the air knife into a primary flow and a secondary flow, a secondary baffle **9** positioned adjacent the coated web on the downstream side of the primary baffle for creating a counter flow of air into the system, a throat plate **10** positioned under the air knife opposite the primary baffle for containing the air in the primary path against movement into the surrounding atmosphere, a backing member **11** defining a continuation of the secondary baffle for directing the secondary flow of air back into the primary flow, and conduit means **12** for directing all the laden air into a separator where the coating particles may be removed from the system.

As shown in FIG. 2, the primary baffle **8** extends across the width of the web **2** and is supported in a position with its leading edge **13** spaced from the web by means of the members **14**. Bolts **15** are employed for connecting the baffle onto the members **14**. The spacing of the primary baffle from the web is made variable as more fully set out below. In accordance with the teachings of the present invention, the spacing between the primary baffle and the coated surface **2***a* of the web **2** is maintained at a practical minimum, close enough to deflect substantially all (about 90–95%) of the air stream issuing from the air knife away from the surface of the moving web and into a primary flow, but sufficiently large enough to eliminate any contact between the baffle and the coated surface **2***a* of the web. In practice, the dimension may vary from about $\frac{1}{32}$ of an inch to about $\frac{1}{4}$ of an inch depending on the particular operating conditions of the system and a preferred gap has been found to be about $\frac{1}{8}$ of an inch.

As shown in FIG. 3, the baffle **8** is generally wedge-shaped and provided with a flat deflecting or working surface **17** facing the primary flow of air. The opposite side of the baffle is provided with the tapered surface portions **18** which taper towards the ends of the baffle at an angle of about 15°. The leading edge **13** is formed with a radius of about $\frac{1}{16}$ of an inch and the trailing end **19** is, in turn, formed with a straight surface of about $\frac{1}{8}$ of an inch in thickness. The tapered surfaces of the baffle terminate intermediate the ends of the baffle to provide a flat back surface **20** through which the attaching bolts **15** may pass, and the overall thickness of the baffle as represented by the embodiment shown in FIG. 3 and as measured from the opposite surfaces **17, 20** is about $\frac{3}{8}$ of an inch.

Although substantially all of the air issuing from the air knife will be deflected into a primary flow by the action of the primary baffle, some amount of air and coating will inevitably escape between the primary baffle and coated web due to the fact that these parts of the system are in fact spaced from each other to some degree. In order to recapture this laden air, the secondary baffle **9** is provided. As shown in FIG. 1, the secondary baffle has a deflecting or working surface extending toward the primary flow of air at a point below the primary baffle and is mounted on the upper end of the member **21** by means of the bolts **22** extending through elongated slots **22'**. With this construction, the spacing of the secondary baffle from the coated web may be adjusted as desired. In addition, the ends of the member **21** are pivotally secured to the framework of the apparatus by means of the arms **23**, one of which is shown in FIG. 2 as being provided with adjusting mechanism **23'** for causing pivoting movement thereof about the axis **23''**. Accordingly, both the primary and secondary baffles may be swung toward and away from the breast roll **1** as a unit. In addition, the ends of the primary baffle are secured in longitudinal slots in the arms **23** by means of the bolts **16** as shown in FIG. 2 whereby the spacing of the primary baffle from the coated web may be adjusted independently of the secondary baffle.

It will be noted from FIG. 1 that the orientation of the two baffles relative to each other and relative to the breast roll creates a zone **24** into which the secondary flow of laden air is directed. This zone is, however, open at three points, the first and second openings being defined by the spaces provided between the primary and secondary baffles and the adjacent portions of the breast roll, and the third opening being defined by a gap **25** provided between the lower edge **19** of the primary baffle and the secondary baffle **9**. The function of these openings is set out below.

For purposes of initially restraining the laden air in the primary flow from escaping into the ambient atmosphere and for providing part of the control mechanism for the system, the throat plate **10** is positioned in the system at a point spaced from and facing the primary baffle **8**. This throat plate is attached to the front portion of a pan assembly **26** used for separating the coating particles from the air after it has been removed from the

area adjacent the breast roll and coated web; and is provided with a working surface **27** oriented in a generally parallel relationship with respect to the surface **17** of the primary baffle so as to provide an area of substantially uniform cross-section for the primary flow of laden air as it passes the primary baffle. The dimension by which the throat plate will be spaced from the primary baffle is desirably such as to create a maximum air velocity past the gap **25** beneath the primary baffle for the particular operating conditions under which the system is being run. To effect this result, a turn buckle connector **28** is employed for regulating and setting the angular orientation of the throat plate with respect to the baffle. The turn buckle connector **28** pivotally connects the upper end of the throat plate to the pan assembly **26** and to permit angular movement of the throat plate in the desired manner, it may, for example, be constructed of flexible material or pivotally mounted to the pan assembly at its lower end.

With the positioning of the throat plate as shown in FIG. 1, the air in the primary flow as it passes below the primary baffle and across the gap **25** will create a venturi effect tending to draw air into the primary flow from the zone **24**. In order to utilize this property of the system to control the flow of laden air, the spacing of the primary and secondary baffles from the coated web are correlated to each other so that a negative pressure is created in the zone **24** and fresh air drawn into the system through the spacing between the secondary baffle and coated web. As indicated above, the spacing of the primary baffle from the coated web is merely sufficient to prevent the baffle from touching the coated surface *2a*. In order, however, to permit the creation of a negative pressure within the zone **24**, this spacing has a maximum limit. If too much air is allowed to pass behind the primary baffle, it is apparent that a negative pressure will be prevented from being formed. Accordingly, the spacing of the primary baffle is maintained at a low enough value so that the required negative pressure will be created; and in practice, the actual spacing will depend on the particular operating conditions, including the velocity and volume of air issuing from the air knife, under which the system is used.

For aiding in directing the laden air in the secondary flow out of the zone **24** and into the primary flow, and at the same time, to prevent the escape of this air into the surrounding atmosphere, the secondary baffle **9** is spaced from the coated surface of the web by a small distance whereby a suction will be created at this point to draw air into the system in a direction opposing or counter to the flow of the secondary air. The distance by which the secondary baffle is spaced from the coated web is advantageously maintained at a practical minimum. Maximum air velocity through this gap into the zone **24** is desired and since the zone **24** defines a low pressure area, the valve of which is determined by the geometry and spacing of the throat plate from the primary baffle and by the particular operating conditions of the system, the air velocity through the space behind the secondary baffle will be inversely proportional to the cross-sectional area of this spacing. Accordingly, the smaller the spacing behind the secondary baffle, the higher the velocity of the incoming air. High velocity air entering the system at this point will assure that the laden air in the zone **24** is prevented from escaping behind the secondary baffle; and the energy possessed by this incoming air will, in turn, aid in deflecting the laden air in the secondary flow away from the opening and toward the gap **25** leading into the primary flow. Of course, the volume of air entering the system from behind the secondary baffle should be maintained small enough so as not to destroy the negative pressure; and as with the spacing of the primary baffle from the coated web, the spacing of the secondary baffle will vary as the operating conditions of the system vary. Generally, however, a minimum spacing is desirable and in practice the range may vary from $\frac{1}{32}$ of an inch to $\frac{3}{16}$ of an inch.

The air entering the system behind the secondary baffle, in addition to being drawn toward the gap **25**, also operates to keep the working edge of the secondary baffle clean; and thus, the spacing originally provided between this baffle and the coated web will not change due to any accumulation of coating droplets that might otherwise deposit on the baffle.

As will be seen from FIG. 1, the member **21** is provided at its lower end with a curved seal strip **29** extending into engagement with the pan **26**. In effect, the member **21** and the seal strip **29** together act as the backing member **11** for containing all of the laden air against escape into the ambient atmosphere after the merging of the primary and secondary flows. The spacing of the backing member from the throat plate is made greater than that between the primary baffle and throat plate so as to form a diffuser in which the pressure of the system will build up sufficiently to aid in diverting the coating particles to the bottom of the pan where they can be removed from the apparatus through the drain **30**. Also, as the air enters the interior of the pan through the conduit portion **12**, removal of coating particles from the air is effected by passing the air through suitable separator means such as schematically shown at **31**. The coating removed from the air may be advantageously returned to the coating apparatus and the air remaining in the pan after passing through the separator means may then be fed into the surrounding atmosphere without contaminating the area.

In order to permit access into the pan and into the area around the primary and secondary baffles, the top of the pan assembly is provided with a plurality of wheels **32** rotatably mounted at the sides thereof and adapted to ride on the tracks **33**, one of which is shown diagrammatically in FIG. 1. This construction also permits initial adjustment of the spacing between the primary baffle and throat plate as is readily apparent from FIG. 1.

As indicated in the above description, all coating particles contained in the air directed downwardly into the primary and secondary flows will be effectively prevented from becoming airborne in the surrounding atmosphere. However, to further assist in preventing any escape of the coating particles from the system, the spacing between the top of the throat plate and the undersurface of the air knife is such as to create an auxiliary flow of air into the system at this point. In practice, the air is drawn into the system at this point in a manner similar to the air entering the system from behind the secondary baffle **9** and in addition to assisting in containing the coating against escape into the ambient atmosphere, the air entering the system under the air knift in this manner will provide the further advantages of maintaining the undersurface of the air knife free from any deposit of coating.

With the embodiment of the invention described above, it is possible to use higher air pressures than permitted with conventional air knife metering apparatus and thus coatings having higher viscosities may readily be metered without contaminating the surrounding atmosphere. In addition, the air flows created in the system greatly aid in maintaining the working surfaces of the baffles free from coating so that once the system is set up for a particular operation, it will uniformly control the metering of the coating on the running web over extended periods of time without requiring repeated adjustments and cleaning.

I claim:

1. The method of metering the thickness of a wet coating applied in an excessive thickness to a web material comprising the steps of:

(a) moving said web material along a predetermined path;

(b) directing a metering stream of air against the web coating at a line extending across said web material

and along a direction extending at an acute angle with respect to said path of movement to remove excess coating into said stream and meter the thickness of said coating to the desired value;

(c) dividing the stream of air laden with said excess coating into a restrained primary path extending in a direction away from said web material and a secondary path extending along the path of movement of said web material, said primary path containing between about 90 to 95% of said metering stream of air;

(d) passing the laden air in said restrained primary path into open communication with the laden air in said secondary path; and

(e) placing the laden air in said secondary path under a negative pressure to draw it into said restrained primary path.

2. The method of metering the thickness of a wet coating applied in an excessive thickness to a web material comprising the steps of:

(a) moving said web material along a predetermined path;

(b) directing a metering stream of air against the web coating at a line extending across said web material and along a direction extending at an acute angle with respect to said path of movement to remove excess coating into said stream and meter the thickness of said coating to the desired value;

(c) dividing the stream of air laden with said excess coating into a restrained primary path extending in a direction away from said web material and a separate secondary path extending along the path of movement of said web material, said primary path containing about 90 to 95% of said metering stream of air;

(d) directing a separate stream of air along said path of movement in a direction opposite the flow of laden air in said secondary path and with a force sufficient to divert the laden air in said secondary path away from said web material; and

(e) directing the laden air from said secondary path along a direction merging with the flow or laden air in said restrained primary path.

3. The method of metering the thickness of a web coating as set forth in claim 2 wherein:

(a) said metering stream of air is directed against said web coating in a direction counter to the direction of movement of the web material along its path of movement.

4. The method of metering the thickness of a web coating as set forth in claim 3 wherein:

(a) said metering stream of air is directed against said web coating at a line extending transversely across said web material.

5. The method of metering the thickness of a web coating as set forth in claim 4 further comprising the step of:

(a) separating the coating from the air in said primary path after the laden air from said secondary path has merged therewith.

6. The method of metering the thickness of a wet coating applied in an excessive thickness to a web material comprising the steps of:

(a) moving said web material along a predetermined path;

(b) directing a metering stream of air against the web coating at a line extending across said web material and along a direction counter to the direction of movement of said web material to remove excess coating into said stream and meter the thickness of said coating to the desired value;

(c) dividing the stream of air laden with said excess coating at a first point along said web material into a primary path extending in a direction away from said web material and a secondary path extending along the path of movement of said web material, said primary path containing between about 90 to 95% of said metering stream of air;

(d) separating the laden air in said primary path from contact with the laden air in said secondary path along a first portion of said primary path;

(e) blocking movement of the laden air in said secondary path at a second point along said web material spaced from said first point whereby the laden air is confined to movement in a direction toward a second portion of said primary path or along a path immediately adjacent said web material;

(f) directing the laden air in said primary path into a position exposed to the laden air in said secondary path along said second portion of said primary path;

(g) controlling the relative volume and velocity of the laden air in said primary and secondary paths to create a negative pressure on the laden air in said secondary path to draw a separate counter stream of air into said secondary path at said second point and to draw the laden air in said secondary path into said primary path.

7. In an apparatus for metering the thickness of a wet coating applied in an excessive thickness to a web material passing along predetermined path, the combination comprising:

(a) an air knife doctor for directing a metering stream of air against the coating to remove the excess into the stream and thereby meter the coating thickness to the desired value;

(b) means for separating said stream of air after it has become laden with excess coating into primary and secondary paths, said primary path containing between about 90 to 95% of said metering stream of air;

(c) means for containing the laden air in said primary path against movement into the ambient atmosphere; and

(d) means for creating a negative pressure on the laden air in said secondary path to draw such laden air into said primary path.

8. In an apparatus for metering the thickness of a wet coating applied in an excessive thickness to a web material passing along a predetermined path around a support roll, the combination comprising:

(a) an air knife doctor having an air nozzle positioned adjacent the moving web material for directing a metering stream of air of predetermined volume against the coating at a predetermined velocity to remove said excess coating into said stream of air and meter the thickness of said coating to the desired value;

(b) a primary baffle located at a position spaced from the coated surface of said web material on the downstream side of said air knife for dividing the stream of air laden with said excess coating into a primary path extending away from said web material and a secondary path extending between the coated surface and said primary baffle, said primary path containing between about 90 to 95% of said metering stream of air;

(c) a secondary baffle located at a position spaced from said coated surface on the downstream side of said primary baffle for deflecting the laden air in said secondary path toward said primary path;

(d) a throat plate positioned in a plane spaced from and facing said primary baffle and coated web material for containing the laden air in said primary path against movement into the ambient atmosphere;

(e) a backing plate positioned on the downstream side of said primary baffle facing said throat plate and away from said coated web material at a position spaced below said primary baffle; and

(f) the spacing between said throat plate and primary baffle and the spacing of the primary and secondary

baffles from the coated surface of said web material being correlated with respect to the predetermined volume and velocity of metering air and with respect to each other whereby the flow of air in the primary path below said primary baffle creates a negative pressure in the area adjacent said web material and between said primary and secondary baffles to draw a separate stream of air into said area through the space between said web material and secondary baffle and to draw the laden air in said secondary path into the primary path.

9. In an apparatus for metering the thickness of a wet coating applied in an excessive thickness to a web material passing along a predetermined path around a support roll the combination comprising:

(a) an air knife doctor having an air nozzle positioned adjacent the moving web material for directing a metering stream of air of predetermined volume against the coating at a predetermined velocity and at a line extending across said web material to remove said excess coating into said stream and meter the thickness of said coating to the desired value;

(b) a primary baffle located at a position spaced from the coated surface of said web material on the downstream side of said air knife and having a deflecting surface lying in a predetermined plane extending away from said web material for dividing the stream of air laden with said excess coating into a primary path extending along said deflecting surface and away from said web material and a secondary path extending between the coated surface and said primary baffle, said primary path containing between about 90 to 95% of said metering stream of air;

(c) a secondary baffle located at a position spaced from said coated surface on the downstream side of said primary baffle and having a deflecting surface extending from a position immediately adjacent said web material toward said primary path at a position spaced below said primary baffle;

(d) a throat plate position in a plane facing the deflecting surface of said primary baffle, said throat plate extending in a downstream direction from a position opposite said primary baffle to a position on the downstream side of said secondary baffle;

(e) a backing plate positioned on the downstream side of said primary baffle facing said throat plate and extending in a downstream direction from the position spaced below said primary baffle where the deflecting surface of said secondary baffle meets said primary; and

(f) the spacing between said throat plate and primary baffle and the spacing of the primary and secondary baffles from the coated surface of said web material being correlated with respect to the predetermined volume and velocity of the air in said metering stream and with respect to each other whereby the flow of air in the primary path below said primary baffle creates a negative pressure in the area adjacent said web material between said primary and secondary baffles to draw a separate stream of air into said area through the space between said web material and secondary baffle and to draw the laden air in said secondary path at the position where the deflecting surface of said secondary baffle meets said primary path.

10. In an apparatus for metering the thickness of a wet coating as set forth in claim **9** wherein:

(a) the spacing of said throat plate from said air knife is correlated with said predetermined volume and velocity of the air in said metering stream to create an auxiliary flow of air leading into said metering stream as it passes toward said primary baffle.

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U.S. Cl. X.R.

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