

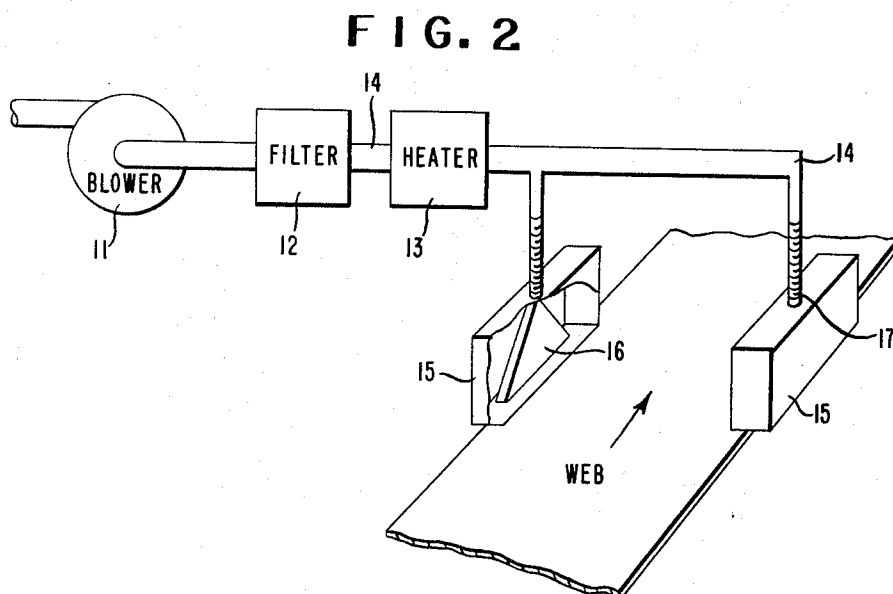
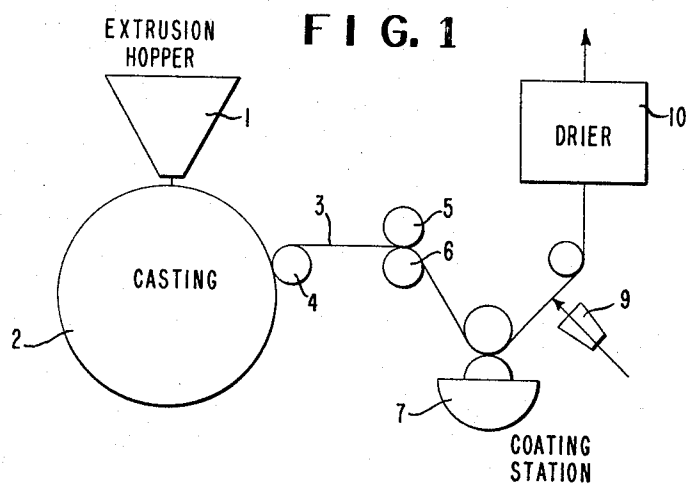
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D. A. CHRISTMAN, JR.
AIR IMPINGEMENT APPARATUS AND PROCESS TO CONTROL
EDGE FLOW IN COATING PROCEDURES

3,383,239

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2 Sheets-Sheet 1



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FIG. 3

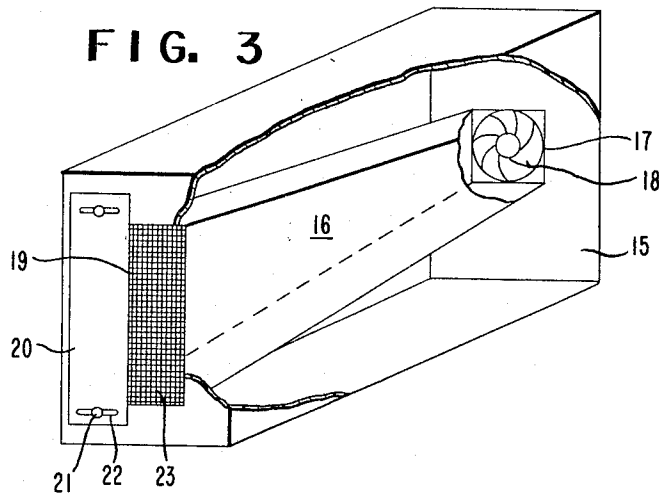
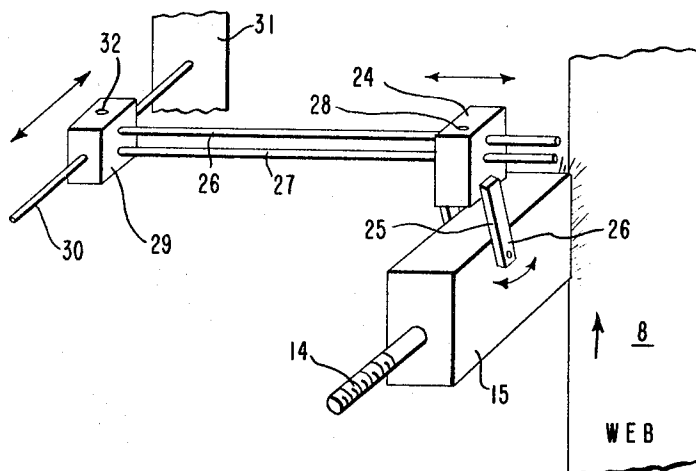


FIG. 4



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ABSTRACT OF THE DISCLOSURE

A web coating apparatus having a coating applicator and a drying area which additionally contains before said drying area a device to direct a flow of air along a lengthwise portion of the edge of a web having a coating dispersion thereon. This air flow is directed only upon the edge of the coated web and does not disturb the coating upon the web.

This invention relates to improvements in a web coating operation and, more particularly, to improvements in aqueous polymeric coatings of hydrophobic webs.

In manufacturing photographic films it is known to employ aqueous dispersions of copolymers as coatings for photographic film bases. These coatings are usually for the purpose of providing an anchoring layer to improve the anchorage between the film base and the layer or layers of light-sensitive silver halide emulsion that are subsequently coated on the web. One such process is described in Alles et al. U.S. Patent 2,627,088. In the rapid drying of these coatings by radiant heat, visible streaks occurring at the edges of the dried coating have been observed. These streaks render this portion of the coated web unusable.

The streaks are generally formed near the edges of the coating on the web, and are essentially parallel to the edge of the web. The streaks are the result of the polymeric coating shrinking from its coated width during the radiant heat drying. The reason for this shrinkage is not exactly known, but it is thought to be flow caused by changes in the surface-energy relationship, i.e., surface tension balance, between the non-permeable web and the polymeric coating during the drying operation.

During radiant heat drying, it is believed that the web of film base heats up faster than the polymeric coating on the web due to the evaporation of water from the coating. Thus, during drying the temperature of the base increases, while the coating temperature remains essentially constant during most of the drying. This temperature differential is believed to cause the shrinking, i.e., the differential creates differences in the surface characteristics between the web and the coating that are sufficient to repel the coating.

Basis for the above belief is that there is no streaking problem when the coating is initially applied and streaks are observed only after the radiant heat drying operation. Also, it has been observed that the severity of the streaking increases with an increase in web temperature.

Therefore, it is an object of this invention to improve the quality of aqueous polymeric coatings by eliminating production defects caused by radiant drying. It is a further object to increase coating yields. Other objects will be apparent from the drawings and description appearing hereinafter.

These and other objects are accomplished by the invention as defined in the appended claims and the following discussion.

The invention is best illustrated by reference to the

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accompanying drawings wherein the same reference numerals relate to similar parts throughout the several figures.

FIG. 1 is a schematic diagram of an exemplary process of the invention.

FIG. 2 is a view, with parts cut away of suitable apparatus for carrying out the process of the invention.

FIG. 3 is a view of the air plenum of the apparatus of FIG. 2.

FIG. 4 is a view of suitable means for adjusting the position of the air plenum of FIG. 2.

The process will be illustrated and described in connection with the application of a resin substratum layer to a photographic film base of polyethylene terephthalate to improve the adhesion between the base and photographic emulsion layers subsequently applied. It should be understood that such illustration and description are merely exemplary in that the invention is applicable to other coating operations wherein the drying of an aqueous polymeric coating on a non-permeable polymer base by radiant heat creates coating defects such as streaks in the edges of the coated materials.

Referring to FIG. 1, filtered, molten polymer is extruded through a slot in a hopper 1 onto a rotating, cooled casting wheel 2 where it solidifies to form a web 3 of the polymer, e.g., polyethylene terephthalate. The casting wheel may be cooled by circulating water within its interior. The thickness of the cast-web 3 is controlled by adjusting the rate of flow of polymer onto the casting wheel.

After the polymer has cooled and solidifies, it is stripped from the wheel by a stripping roller 4. The web is transported for further processing by two pull rolls 5 and 6.

The web 3 then enters a coating station 7 where a resin substratum layer of a tri-component copolymer such as described in U.S. patents, Alles et al., 2,627,088, and Swindells 2,698,235, e.g., a reaction product of 90 parts vinylidene chloride, 10 parts methacrylate, and 2 parts itaconic acid in aqueous dispersion is applied to the web.

FIG. 1 illustrates applying the coating to one side of the web. In some embodiments it is desirable to apply the coating to both sides of the web. This can be accomplished using multiple coating and drying stations. The coating may be applied as an aqueous dispersion utilizing any conventional apparatus such as a "bead roll" coater, i.e., a coater consisting of an applicator roller which dips into a coating pan containing the dispersion and then transfers a layer of the coating material onto the moving web.

Immediately after the coated web 8 leaves the coating station, the air slots or apertures of an air plenum 9 direct the passage of conditioned air to impinge on the edges of the coating on the web. This spray or wide blast of air serves to dry or set a thin surface film of the polymeric coating at the edges of the web which is strong enough to resist the forces inducing flow of the coating during the rapid drying operation. After being treated by the conditioned air the web passes through a radiant heat drier 10 wherein the coating is completely dried. Radiant heaters produce efficiently controlled heat ranges and eliminate physical contact with the web, thereby avoiding scratching the web. The web is then ready for subsequent operations, such as coating a resin substratum on the opposite side, or orientation by a biaxial stretching process such as described in U.S. patents, Alles et al., 2,627,088 and Alles 2,779,684. Conditioned air refers to filtered air which can optionally be heated. This type of air is necessary to reduce contamination of the coating in preparation of photographic film; however, certain uses of this invention for preparing webs can avoid the necessity of conditioning the air.

By impinging conditioned air on the proximity of the edge of the coating before radiant drying, the coating is able to withstand the stresses induced by rapid radiant drying, the edge streaks are eliminated and a uniform coating weight is maintained. The impinging air must be of such a nature that it does not disturb the distribution of the existing coating; this is accomplished by controlling the velocity of the impinging air and distributing the air from a wide slot, thus producing a wide blast of air instead of a sharply focused air stream.

The air is conducted by blowing through absolute filters (removes virtually all contaminating particles; i.e., removes 99.97% of all particles greater than 0.3 micron) and heating. It is not necessary to heat the air to reduce the severity of the streak, however, since heated air having a low relative humidity is more effective in removing water and forming a film it is preferable to use heated air. Other variables that influence the effectiveness of the process are the velocity of the impinging air and the geometric relation of the air stream to the web, i.e., the width of the air stream, the point of focus, and the distance between the slot and the coated web. These variables will largely depend upon the particular coating being applied to the support and can be empirically determined by one skilled in the art.

Suitable apparatus for producing and directing the stream of conditioned air are illustrated in more detail in FIG. 2 and FIG. 3.

Air is introduced into the process apparatus by a blower 11, which can be a radial blade type blower. The air is then filtered by an absolute filter 12 and heated by a suitable heater 13, e.g., an electrical air heater with thermostatic control to adjust the temperature of air. The temperature to which the air is heated is dependent upon the coating being applied, and should be sufficient to form a thin film on the surface of the coating at the film edge.

The air is transported through conduits or duct work 14 between the above units to plenum housings 15. As the position of the plenum housings should be adjustable, portions of the conduit or duct should be made of flexible material, such as a flex hose. The housings contain air plenum chambers 16. These plenum chambers are designed to provide a smooth, even air flow at the desired air velocity. Thus the plenum chamber should avoid sharp changes in air direction to reduce air turbulence. The conditioned air enters the plenum chamber 16 through suitable openings 17 in the housings. As it is desirable to control the volume and velocity of the air within the plenum chamber, a suitable damper such as an iris damper 18 or slide damper should be used to regulate the size of this opening 17.

The opposite end of the plenum chamber communicates with a slot or aperture in the housing. It is through this slot that the impinging air is directed onto the edges of the coating. The size of the slot should be adjustable to provide the optimum flow of air during the process. This optimum flow of air is that which will form a thin film on the edge of the coating sufficient to resist flow but which will not disturb the uniformity of the coating. The slot size can be adjusted by a slide shutter or damper 20 that is attached to the housing. The attachment can be by screws 21 that extend through slots 22 in the shutter and threaded into the housing. Additionally, to improve the uniformity of the air flow through the slot, it is preferred that a pressure equalizing screen 23 be mounted across the slot. The screen will serve to even out the pressure drop across the slot and to improve the velocity profile of the air impinging on the coated web. The screw can be made of any porous material that will equalize the pressure drop, e.g., porous mesh, wire mesh, perforated metal plate, etc. It is preferable to locate the screen across the slot to avoid pressure differences caused by the sharp edges of the slot; however, it can be located further back within the plenum chamber. Additionally, if desired, a fun-

nel can be located within the plenum to reduce the turbulence and smooth the air flow.

As shown in FIG. 4, the housings are mounted on suitable frame work which supports the plenums in operating position adjacent to the edges of the web. The method of mounting should be adjustable to allow adjustment of the distance between the slot and the web, the lateral position of the plenum with respect to web, and the angular position of the plenum to obtain the optimum air stream conditions.

Referring to FIG. 4, the plenum housing 15 is linked to a mounting block 24 by brackets 25 fixed to and extending from the block. The brackets are attached to the housing by screws 26. By loosening the screws and rotating the plenum housing, angular adjustment of the slot (not shown in FIG. 4) can be made with respect to the web.

Mounting block 24 is slidably mounted on guide rods 26 and 27. A set screw 28 is used to fix the location of the block on the rods. With respect to the web, block 24 is stationary as to angular adjustment, and movement in the direction of web travel. However, the block can be adjusted transversely across the web, thus moving the plenum 15 across the web. This adjustment can be used to position the plenum for different widths of webs or coatings.

A similar mounting block 29 is fastened to the guide rods 26 and 27. This block 29 is slidably mounted on guide rod 30 that is fixed to a suitable frame 31. The location of the block on the rod can be fixed by set screw 32. Thus by moving block 29 up and down rod 30, the distance between the plenum 15 and the web can be adjusted.

The various parts of the apparatus according to this invention may be constructed from one or more parts secured together to form the essential features as set forth in the claims. The plenum, ductwork, and housing may be constructed of metal, e.g., stainless or plates of steel, brass, copper, but preferably of stainless steel to reduce the product contamination potential and increase corrosion resistance. Although the process refers to conditioned air, other gaseous fluids such as inert gases, e.g., nitrogen, helium, etc., may be used depending on the nature of the coating.

The invention will be further explained, but it is not intended to be limited by the following example involving the coating of a photographic film base with a resin substratum.

A 40 mil thick web of polyethylene terephthalate, photographic film base is coated with an aqueous dispersion of the copolymer of 90 parts vinylidene chloride, 10 parts methyl-acrylate and 2 parts itaconic acid copolymer as described in U.S. Patent, Swindells 2,698,235. The coating is applied by the bead roll technique at a speed of 35 feet per minute to obtain a dry coating weight of 45 mg./dm.².

Air plenums such as illustrated in FIG. 2 and FIG. 3 are located above the coating on the web and immediately after the coating station in terms of web travel. The plenum chambers are designed such that the ratio of the length of the plenum, from the opening 17 to the slot 19, with respect to the length of the slot is preferably about six to one. The slots of the plenum are located parallel with and at a distance one inch from the web. The slot has a length of three inches, the length being the dimension in the direction of web travel, and a width of one-half inch.

An air stream having a velocity of about 2,000 feet per minute and a temperature of about 140° F. is directed on the edges of the coating through the slots.

After the coated web was treated by the conditioned air, the coating was dried by radiant heat. The dried coating was free from streaks and there was no adverse effect on its anchoring properties.

A similar web of polyethylene terephthalate film base was also coated with the same copolymer. However, the air plenum was not in operation and this web was dried by radiant heat means without the air impingement process. The resulting dried coating had visible streaks formed at the edge of the coating.

A variety of film-forming aqueous, polymeric, coating compositions may be treated in accordance with the present invention, e.g., the copolymers disclosed in U.S. patents, Swindells 2,698,235, Alles et al. 2,627,988, Saner 2,698,242 and Alles 3,043,695. Other polymeric coatings containing at least 35% by weight of vinylidene chloride that can be treated are disclosed in U.S. patent, Alles et al. 2,491,023.

The non-permeable, hydrophobic polymeric support web upon which the coating is applied can be any of the hydrophobic cellulose carboxylic acid esters including cellulose acetate, cellulose acetate butyrate, cellulose nitrate, the highly polymeric linear ester of a dicarboxylic acid and a dihydric alcohol, i.e., polyethylene terephthalate, a superpolyamide (nylon), and polyvinyl chloride, etc.

The main advantage of this invention is that it produces polymeric coatings free from defects caused by undesired flow during the rapid radiant drying of the coating. The process also helps to maintain a uniform coating weight thus increasing the over-all coating quality. Additionally, the apparatus to carry out the novel improved process can easily be adapted to existing coating facilities.

As many widely different embodiments and modifications of the invention can be made without departing from the spirit thereof, the invention is not being limited except as defined in the claims.

What is claimed is:

1. An apparatus for removing edge streaking in a web having an aqueous film-forming polymeric coating on a moving hydrophobic polymeric base which comprises in combination:

- (A) coating means for placing said aqueous coating on said base;
- (B) radiant drying means to dry said coating on said base; and
- (C) gas impingement means located adjacent to and along the lines of travel of said web between said coating and drying means, said impingement means being positioned to supply a flow of air along a lengthwise portion of the edge of said coating on said web and having an air conduit feeding forced air into a plenum chamber and an air outlet to provide an air flow only along said edge.

2. An apparatus as described in claim 1 where said plenum has a screen in the air flow path.

3. An apparatus as described in claim 1 having adjusting means to change the impingement of said air on said coated web.

4. In an apparatus for preparing a coated web of a hydrophobic polymeric base and an aqueous polymeric coating having a coating applicator and a radiant heat drier, a device for setting the edge of the coated web before it enters the drier comprising a conduit for conducting air, a plenum chamber attached to said conduit and having an air outlet adjacent to and along a lengthwise

portion of said web edge and an adjustable orifice between said conduit and plenum chamber.

5. In an apparatus for preparing a coated web of a hydrophobic polymeric base and an aqueous polymeric coating having a coating applicator and a radiant heat drier, a device for setting the edge of the coated web before it enters the drier comprising means for filtering and heating a flow of air, a flexible conduit for conducting said air, a plenum chamber attached to said conduit and having a screened air outlet adjacent to and along a lengthwise portion of said web edge, and an adjustable orifice between said conduit and plenum chamber.

6. A process for preparing a coated web comprising:

- (A) coating a hydrophobic polymeric support with a film-forming aqueous polymeric dispersion;
- (B) impinging air only upon a lengthwise portion of the edge of said coated web to set the part of said dispersion contacted by said air without disturbing the distribution of said coating on said support; and
- (C) drying said coated web with radiant heat.

7. A process as defined in claim 6 where said impinged air has been conditioned to remove contaminants.

8. A process as defined in claim 6 where said air has been heated.

9. In a process for preparing a coated web of a hydrophobic polymeric support with a film-forming aqueous polymeric dispersion by coating said support with said dispersion and drying said coated web with radiant heat, the improvement which comprises filtering a supply of air, and impinging said filtered air only on a lengthwise portion of the edge of said coated web without damaging said coating.

10. In an apparatus for preparing a coated web of a hydrophobic polymeric base and an aqueous polymeric coating having a coating applicator and a radiant heat dryer the improvement which comprises inserting before said dryer a device having a blower for delivering a positive flow of air, a conditioning means for filtering and heating said air flow, a conduit for conducting said conditioned air flow, a plenum chamber connected to said conduit and positioned adjacent to an edge of said coated web, said plenum having an elongated, screened outlet located with the largest dimension of the outlet being situated over a portion of the web edge which is lengthwise to the direction of travel of said web edge to insure an air flow only on said web edge.

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