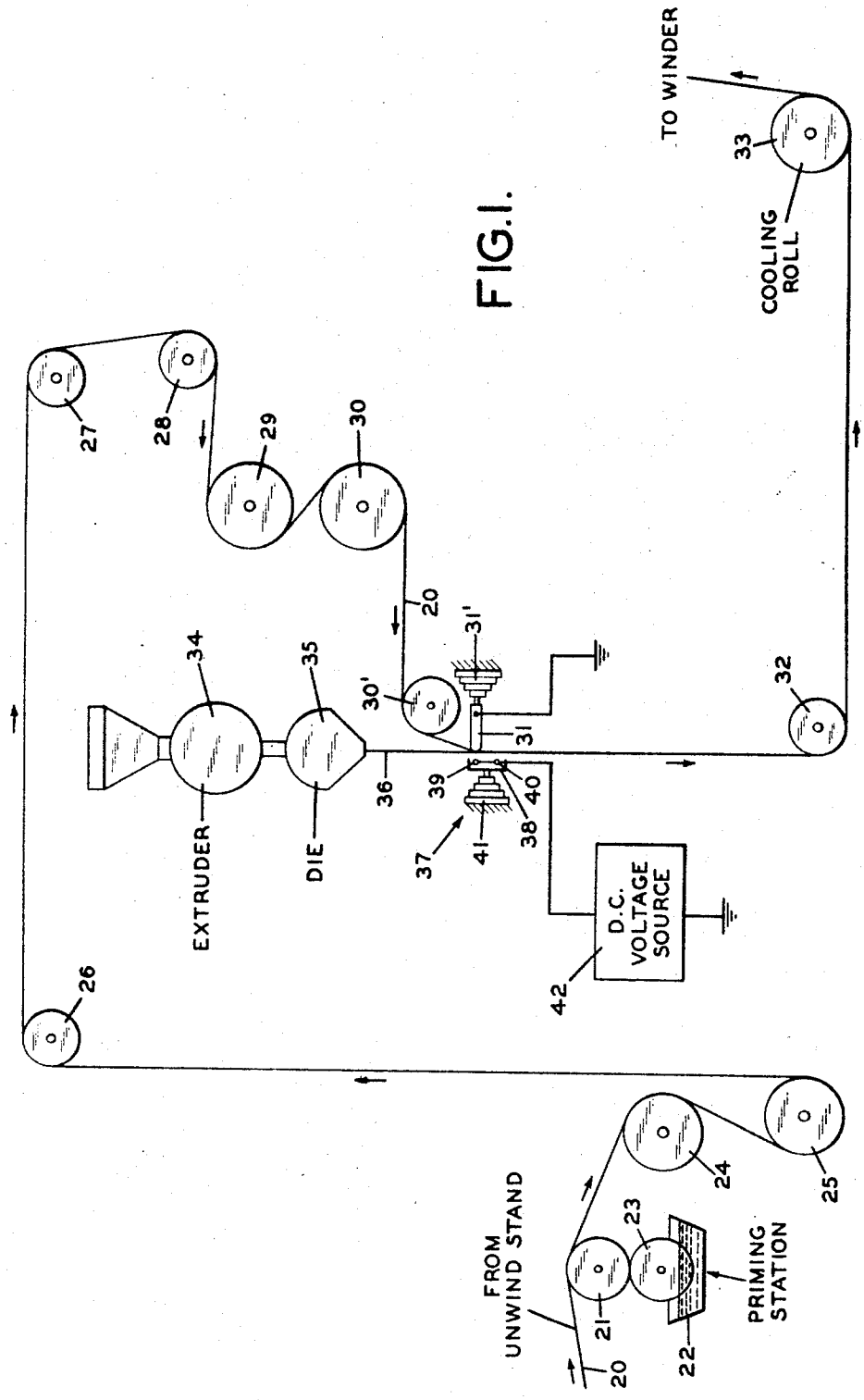
COATED PAPER AND METHOD OF PRODUCING THE SAME

Filed June 10, 1964

FIG. 1.



June 3, 1969 L. J. PAQUIN ETAL 3,448,000

COATED PAPER AND METHOD OF PRODUCING THE SAME

Filed June 10, 1964 Sheet 2 of 2

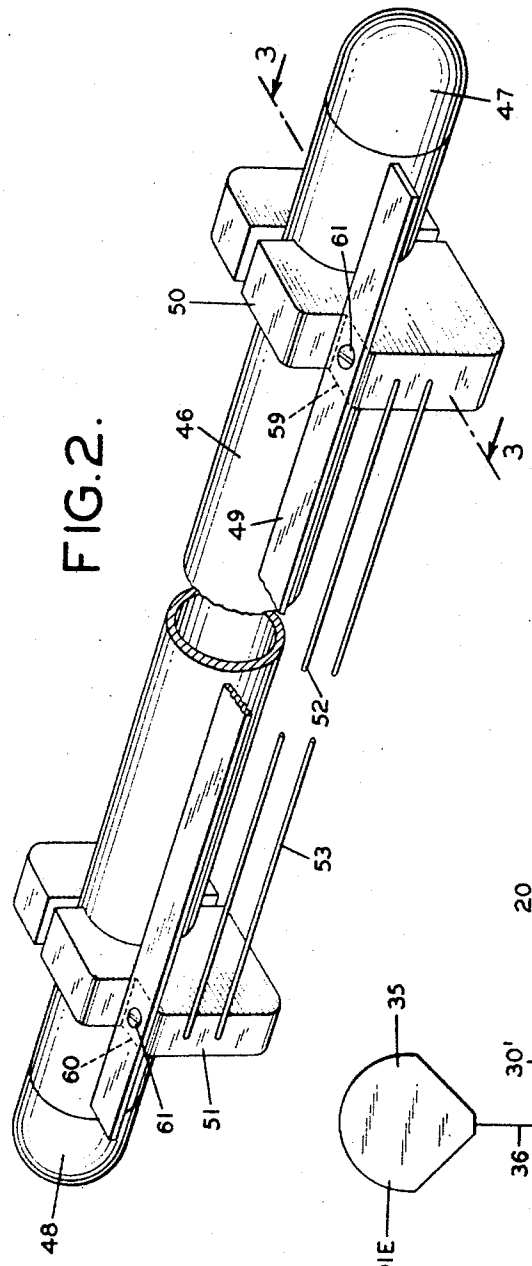


FIG. 2.

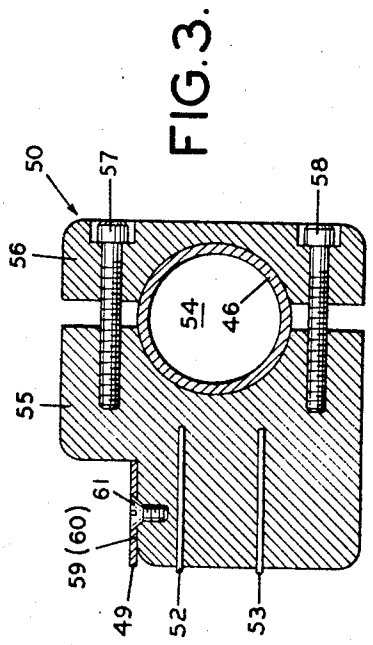


FIG. 3.

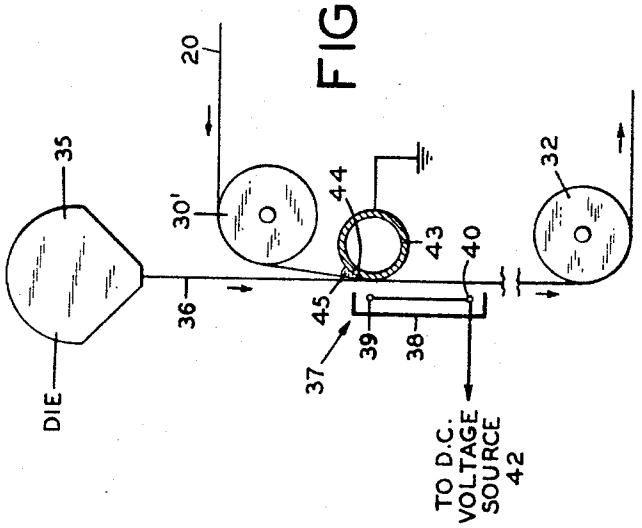


FIG. 4.

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COATED PAPER AND METHOD OF PRODUCING THE SAME

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Continuation-in-part of application Ser. No. 183,340, Mar. 28, 1962. This application June 10, 1964, Ser. No. 373,993

The portion of the term of the patent subsequent to July 20, 1982, has been disclaimed

Int. Cl. B32b *27/10, 29/00;* B29d *7/04*

U.S. Cl. 161—250

9 Claims

ABSTRACT OF THE DISCLOSURE

A method of apparatus for coating a paper substrate with a film of polyethylene, or other lower olefin polymer or copolymer, in which the paper is passed over a stationary, non-rotatable backing element and in which the extruded film is urged into bonding contact with the paper as the latter passes over the backing element by means of an electric field acting on the extruded film in the region of convergence thereof with the paper. Preferably the arc of contact of the paper and backing element is in the range of about 1/16" to 1/8". The back side of the paper may be contacted with a liquid coolant. The backing element may have a narrow elongated slot positioned so that the liquid coolant supplied through the backing element is directed into contact with the back side of the paper web.

The present invention relates to an improved method of producing coated paper and to the coated paper produced thereby, and more particularly to a method of producing polyolefin coated paper having heightened resistance, i.e., improved barrier properties, to the passage of gases such as water vapor and solvents such as fats and oils.

This is a continuation-in-part of our copending application Ser. No. 183,304, filed Mar. 28, 1962, now patent No. 3,196,063 granted July 20, 1965.

In recent years paper coated with polymers and copolymers of the lower olefins have been widely used in the packaging of products, including both solids and liquids. Polyethylene has been the most widely used material for this purpose, and the invention will be described primarily in connection with polyethylene. However, the principles of the invention are applicable generally to the polymers and copolymers of the lower olefins, e.g., propylene, ethylene and butylene, which may be extruded in molten form and deposited on a moving paper web. The term "lower olefins" as used herein is intended to mean the polymers and copolymers of propylene, ethylene and butylene. The principles of the invention are also applicable to substrate materials other than paper which have dielectric constants similar to paper.

The coating of a polyolefin, such as polyethylene, upon paper is usually accomplished by passing the extruded polyethylene film and the paper simultaneously between two pressure rolls and thereby bonding the hot film thoroughly to the paper. One of the pressure rolls is usually rubber-covered and is shielded by the paper web. The other of the pressure rolls is conventionally metal-covered, e.g., chrome-plated, and serves to secure the

release of the hot extruded polyethylene film. In this regard, it has been found that the use, on the permise that its excellent release properties are well known, of a hot pressure roll having a silicone rubber covering in place of the high cooling capacity chrome-plating does not successfully prevent the sticking of the hot extruded polyethylene to such pressure roll and the resultant production-halting breaking of the paper web. It has also been found that, even at relatively low speeds, the polyethylene film that forms the paper coating must be chilled from extruding temperatures of from about 260° to 315° C. to near room temperatures by the chrome-plated roll in a fraction of a second in order to release therefrom. It appears, therefore, that shock cooling is a requisite of the successful coating of paper with polyolefins.

A brief analysis of the nature of polyolefins, using polyethylene as a typical example, is necessary to a proper understanding of what the problem is. Polyethylene molecules are either linear or side-chained and compositions containing them are readily identifiable by their molecular weights, molecular weight distributions, densities, percentages of chain branchings, and melt indices. Polyethylenes made by low temperature, low pressure catalytic processes tend to contain higher percentages of linear molecules and, because such molecules lend themselves to the growth of compact, dense crystals as the polymers cool and solidify, they are known as linear or high density polyethylenes. Linear polyethylenes are from about 90% to 95% crystalline in structure with an amorphous remainder. Polyethylenes made by high pressure, high temperature processes tend to contain higher percentages of side-chained molecules and, because such molecules do not lend themselves to the growth of crystals as the polymers cool and solidify, they are only from about 60% to 70% crystalline with an amorphous remainder. The linearity of the molecules then is a factor in the crystallinity and the density of the solids they compose. It is not, however, the sole factor, so that, if it were possible to produce purely linear polyethylene with no molecules having side chains, it would be conceivable that the polymer would pass from being 100% amorphous when melted to being 100% crystalline and having a maximum density of 1.0 when cooled to a solid form. The thermal history of a polyethylene is also relevant and, if such thermal history is unfavorable to the growth of crystals therein, the solid will have a diminished crystallinity and density. It is typical, for instance, for a polyethylene having a high density in the range of 0.945 to 0.950, when supplied, to lose such density appreciably, i.e., down to 0.930 to 0.938, when coated on paper by customary extrusion methods. Polyethylenes of medium density (0.925 to 0.940) and of low density (0.918 to 0.925) show similar, if less dramatic, losses. Hence, it is on account of at least these two factors that all commercially available grades of solid polyethylenes are partly crystalline, partly amorphous mixtures having a density less than 1.0. Densities (other than for paper) set forth herein should be understood to be in grams per cubic centimeter.

Practical consequences flow from the mixed character of solid polymers and copolymers of olefins. Where, for instance, a solid polyethylene has a high amorphous content, it has superior gloss, transparency, and elongation properties. Such properties are desirable in free films, but they have little or no value in captive films, e.g., paper coatings. As paper coatings, polyolefinic films have value

almost only when they have good barrier properties, i.e., resistance to the passage of gases such as water vapor and solvents such as fats and oils, these agents being harmful either to the paper itself or to the products wrapped, covered, or contained thereby or perhaps being desirably prevented from escaping from the packaged goods out through the coated papers. Such barrier properties are, of course, a function of the density of the finished coated papers and therefore of the amount of crystallinity of the films coating the papers.

Short of seeking to produce purely linear polyethylenes capable of being 100% crystalline in the solid state, then the most immediate solution to the problem of improving polyolefinic coating films and their barrier properties must be and has been taken to lie in the direction of affording the films the thermal history most favorable to crystal growth possible and, throughout their production and application, in maintaining, in preventing any decline in, in restoring any decline in, or even in a heightening of the amount of crystallinity in any of the polymers and copolymers with which one can coat paper. More particularly, it has been taken to lie in the direction of ascertaining any bad effects on the thermal history of such coating films of their being shock-chilled to enable their release from the pressure roll bonding them and thereafter overcoming or at least mitigating such effects. So much then for the problem giving rise to and the objects satisfied by the present invention.

It has been found that, in a continuous process of coating paper with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, the pressure rolls commonly employed to bond the film to paper can be eliminated, thereby reducing equipment purchase and maintenance costs, and that shock chilling to obtain film release from one of the pressure rolls can be eliminated, thereby affording the film a thermal history consonant with either an effort to obtain improved barrier properties for smaller amounts of film raw material or an effort to maintain at or improve to a point approaching the theoretical maximum barrier properties of a given amount of film material. Thus, in our copending application Ser. No. 80,584, filed Jan. 4, 1961, now Patent No. 3,161,560, we have described and claimed a process for producing improved polyethylene film coated papers in which the hot extruded film is applied to the paper pneumatically.

In the method of our copending patent application Ser. No. 183,304, filed Mar. 28, 1962, electrostatic charges are created and used to apply the hot extruded film to the paper. This method has been found to yield results at least equal to those of our copending application Ser. No. 80,584 and far superior to those of the conventional practices described above, particularly as regards obtaining a high moisture vapor barrier at low coating weights. Another important advantage of the electrostatic method over the conventional practices and over the method of our copending application Ser. No. 80,584 has been in the ease of obtaining a good polyethylene-paper adhesion at low coating weights.

As pointed out in our copending application Ser. No. 183,304, some difficulty has been encountered in electrostatically bonding polyethylene to a paper substrate having a density greater than about 75 seconds per 100 cc., measured by official standard T460m–49 (April 1949) of the Technical Association of the Pulp and Paper Industry. Thus, heavier paper boards and coated paper boards have generally been difficult to coat in this manner, particularly with respect to avoidance of a patterned appearance in the coated paper.

A principal object of the present invention has been to provide a novel and improved method of coating higher density substrates of paper or the like with a film of a polymer or copolymer of the lower olefins, such as polyethylene.

Another object of the invention has been the provision of such a method which is applicable to high density or coated papers and which avoids or minimizes the formation of a patterned appearance.

Another object of the invention has been to provide a polyethylene coated paper having improved moisture-vapor barrier characteristics as compared to a like paper coated with the same thickness of polyethylene by prior processes.

Other and further objects, features and advantages of the invention will appear more fully from the following description of the invention.

The invention will now be described in greater detail with reference to the appended drawings, in which:

FIG. 1 is a schematic diagram illustrating one form of apparatus for practicing the method of the invention;

FIG. 2 is an isometric view illustrating one form of electrode structure for use in the apparatus of FIG. 1;

FIG. 3 is a cross-sectional view of one of the electrode wire holders of FIG. 2; and

FIG. 4 is a schematic diagram illustrating a modified form of apparatus for practicing the invention.

Referring now to the drawings and more particularly to FIG. 1, a continuous web **20** of paper from an unwind stand or other suitable source passes over a roll **21**. The roll **21** is provided to pre-coat a surface of the web **20** with an adhesion promoter or primer such as Adcote Chemical Company's Shawnad 313 which is a water-based solution containing 20% solids. The adhesion promoter, diluted to contain 1.5% solids, is contained in a trough **22** and is applied to one surface of web **20** as the web contacts roll **21**. The roll **21** is in turn provided with the adhesion promoter by contact with roll **23** which extends into the trough **22**. As the web **20** advances, rolls **21** and **23** rotate, keeping a fresh supply of adhesion promoter on the surface of roll **21**. The use of an adhesion promoter or primer is not essential, but it has been found desirable, particularly at low coating weights.

The web **20** leaving roll **21** passes around steam-heated rolls **24** and **25**, idler rolls **26**, **27** and **28**, steam-heated rolls **29** and **30**, a guide roll **30'**, an electrically grounded backing bar **31**, an idler roll **32** and a cooling roll **33**. The web leaving the cooling roll **33** goes on to a winding roll, although other treatment zones may be positioned between the cooling roll and the winder. The cooling roll **33** preferably is a driven roll and the steam-heated rolls may be driven if desired.

An extruder **34** and die **35** are positioned to extrude a thin film **36** of polyethylene or other plastic downwardly so as to contact a surface of the paper web **20** as the paper is contacting the bar **31**. If the paper has been pre-coated, the pre-coated surface faces outwardly of the bar **31** so as to contact the film.

The bar **31** is made from a conductive metal. Aluminum has been found desirable for this purpose, and an example of a particular bar **31** would be a ½" thick rectangular aluminum strip having the paper contacting edge rounded so that the circumferential length of the paper contacting aluminum surface is from 1/16" to ⅛". The length of the bar **31** should be equal to or slightly greater than the width of the paper web. Backing bar **31** may be insulated from the surrounding structures, as by a mounting insulator **31'**. The backing bar may be electrically connected to ground, as described above, or it may be connected to a positive or negative potential source, as described below.

The mounting of the backing bar **31** should be sufficiently rigid that little or no deflection or movement of the bar will occur under the forces acting thereon. In other words, the bar **31** should afford a rigid backing support for the paper web. However, it is desirable that contact between the paper and the backing bar be limited to a short arc, i.e., the 1/16" to ⅛" long arc described above.

From bar **31** onwardly, the paper web **20** has adhered to one surface thereof a thin film of polyethylene. The conventional practice in the past has been to cause the polyethylene film to adhere to the paper surface by calsing the paper and the film to pass between two pressure rolls, as described above. In the method of the copending application Ser. No. 80,584 referred to above, adhesion of the polyethylene film to the paper surface is produced by pneumatic means. In accordance with the method of the copending application Ser. No. 183,304 referred to above, and with the method of the present invention, an electric field is used to apply the hot extruded polyethylene film to the paper with sufficient pressure to produce adhesion of the film to the paper.

The electric field is produced between an electrode structure **37** and backing bar **31**. The electrode structure comprises a holder **38** and a pair of wires **39**, **40** which are parallel with the bar **31**. The wires **39**, **40** preferably extend across the full width of the paper web. The top wire **39** preferably is directly opposite, i.e., in horizontal alignment with the area of contact between the polyethylene film and the paper when the paper is traveling at a slow speed. The lower wire **40** preferably is vertically beneath the wire **39** and typically might be spaced about 1" therefrom. The spacing between the plane of the wires **39** and **40** and the vertical plane at the front edge of backing bar **31** may be of the order of ¼" to 2", depending on the film thickness and the applied voltage. The wires **39** and **40** typically might be .006" diameter tungsten wires.

The wire holder **38** should hold the wires **39** and **40** under sufficient tension to resist the substantial pull which will be experienced in the direction of the backing bar **31**. The holder **38** is supported by a suitable insulating structure **41**. The holder **38** may be electrically connected to wires **39** and **40**, or it may be insulated from the wires and be connected to ground as a personnel safety precaution. In either event, the wires **39** and **40** are connected to a source of voltage **42**, which may be of any suitable type and preferably provides a voltage of the order of 3,000 to 50,000 volts. The usable voltage for any given structural arrangement is limited by the requirement that arcing or sparking between the electrode wires and the backing bar be avoided. Either the negative or positive potential may be applied to the wires **39** and **40**, the other potential being connected either to ground or directly to backing bar **31**. An alternating voltage has been used successfully.

The high voltage on the wires **39** and **40** ionizes the air in the immediate vicinity of the wires, and under appropriate conditions this can be observed as a corona discharge in the immediate vicinity of the wires. The corona should be limited to the region of the wires and preferably should not extend to the polyethylene film. It is believed that ions migrate away from the vicinity of the wire and that some of them impinge on the polyethylene, resulting in an attractive electric field between the polyethylene film and the paper.

A substantial proportion of the ions produced in the vicinity of the wires **39** and **40** will tend to travel in directions in which they will not impinge on the polyethylene film or at least not in the region of convergence between the polyethylene film and the paper. Various means can be used to concentrate the ion flow so as to maximize the ion flow into the polyethylene film in the region of convergence thereof with the paper. For example, air flow may be used to direct the ions in the desired direction. Or charged shields may be provided to inhibit ion flow except in the desired direction.

The polyethylene film **36** leaving the die **35** will generally have a temperature of about 600° F., but will cool so as to contact the paper at a temperature in the range of about 450–475° F. The paper web which contacts the polyethylene preferably is heated by the steam rolls to minimize chilling of the polyethylene; typically, the paper temperature might be of the order of 150° F. to 240° F. at the backing roll **31**. Infrared or other heating elements may be used to heat the paper to a suitable temperature. The heating of the paper also promotes adhesion of the polyethylene film to the paper.

The attractive field between the polyethylene and the paper tends to cause the polyethylene to contact the paper at a point above the normal point of contact. However, this tendency is not great at relatively high paper speeds, e.g., 400' per minute or more.

In applying the polyethylene film to the paper substrate, there are two major factors to be accommodated. One is to achieve good adhesion of the polyethylene to the paper, and the other is to achieve a good moisture vapor transfer resistance (hereinafter termed "M.V.T.R.").

With respect to adhesion, for some applications of the product of the invention it is sufficient that the polyethylene film be tightly bonded to the paper substrate so that delamination will not occur. Such an application might be as an inner wall of a multi-wall bag construction. But for other applications, where appearance of the product is important, it is desirable that the adhesion be uniform so as to avoid a patterned appearance. A patterned appearance may be in the form of visible lines in the polyethylene surface, areas of dull appearance, or in general regions whose light reflectance differs from the remaining surface. The presence of such regions seems to have little or no relation to the overall polyethylene-paper adhesion or the product M.V.T.R., but is undesirable from an appearance standpoint for many packaging applications where a uniform surface appearance is desirable.

It is believed that this patterned effect results from areas having a different degree of adhesion to the substrate. It has been found that irregularities in the electrode structure relative to the film face are associated with the patterned effect and may have an important part in producing this effect, or at least vary the wrapping force on the polyethylene, which in turn produces the pattern.

The patterned effect has been found to be greater as the density of the paper substrate is increased. However, papers of higher density can be bonded to polyethylene without substantial patterning by use of a stationary backing element, such as the backing bar **31**, and by making the arc or length of contact between the paper and the backing element very short, preferably the 1/16" to ⅛" referred to above. It is believed that this short length of contact acts to concentrate the electric field and produces a uniform bonding force between the polyethylene and the paper. The short "length" or "arc" of contact should be considered in the direction of paper travel. In general, the short length or arc of contact and the use of a stationary backing element are desirable when the paper density is above about 75 seconds per 100 cc. (standard T460m–49). Such higher densities are characteristic of relatively heavy paper or board or coated paper or board.

Certain patterned effects and blisters in the polyethylene coating on denser paper or paper board are believed to be caused by hot gases (either air or moisture, or both) being forced out of the paper or board while the polyethylene is still molten. In accordance with an aspect of the invention, the back side of the paper or board may be cooled to prevent formation of such patterned effects or blisters. It is believed that cooling of the back side of the paper or board results in a pressure differential within the sheet of paper or board which lowers the gas pressure on the front side, i.e., the side against which the molten polyethylene is being bonded. When cooling the back side of very heavy boards, it will usually be found desirable to provide additional heating for the front side, as by use of infrared heaters or the like.

One form of apparatus for bonding polyethylene to paper with cooling of the back side of the paper is illus-

trated in FIG. 4. In FIG. 4, heated paper, for example, paper leaving the steam-heated roll **30** of FIG. 1, passes around a turning roll **30'**, contacts a stationary ½" diameter grounded copper or brass pipe **43**, and passes around a turning roll **32**, corresponding to the roll **32** of FIG. 1. The paper surface to be contacted by the polyethylene film is preferably additionally heated after the paper web leaves roll **30**, as by passing under infrared heaters or the like.

A molten polyethylene film **36** from extruder die **35** contacts the paper **20** at approximately the point of contact of the paper web and pipe **43**. The film **36** and web **20** converge toward this point of contact, as shown in FIG. 4.

An electrode structure **37**, which may be identical to the electrode structure **37** of FIG. 1, is provided to create a high electric field intensity in the region of convergence between film **36** and web **20** so that the polyethylene film will be bonded to the paper. The upper wire **39** is preferably located in horizontal alignment with the line of contact of the polyethylene and paper.

It will be evident that the pipe **43** is structurally similar to the rounded surface of bar **31** of FIG. 1. As in the case of bar **31**, it is preferable that the paper contact the surface of pipe **43** over an arc of about 1/16" to ⅛" in length. The length of this arc of contact can be adjusted by varying the position of turning roll **30'** with respect to the vertical plane tangent to the pipe **43** and roll **32** (or bar **31** and roll **32**).

The apparatus of FIG. 4, as so far described, operates in essentially the same way as the apparatus of FIG. 1. However, in order to cool the back side of the paper web **20** in the region of convergence of the web **20** and the polyethylene film **36**, the pipe **43** is connected to a cold water supply and is provided with a narrow, elongated slot **44** extending radially through the wall of pipe **43**. The slot **44** carries water from inside the pipe **43** to provide a bead **45** of water between the back side of the paper web **20** and the outer surface of pipe **43**. The slot **44** should be slightly shorter than the paper width and typically might be 24" long for a 25" wide paper web. A typical width for the slot **44** would be of the order of 0.018". The radial axis of the slot **44** relative to the longitudinal center line of the pipe **43** should be set at an angle to the plane of the paper web approaching the pipe **43**. This angle is preferably in the range of about 30 to 45°.

Water from the bead **45** is constantly carried off with the advancing paper, and the water pressure in pipe **43** should be adjusted to provide a relatively stable bead height. The bead height may be varied considerably, but typically the bead **45** might extend over an arc of about 45° from the point of contact of the paper web and the pipe surface.

Use of water cooling is generally limited to papers or boards that are fairly resistant to moisture penetration, since adverse effects on the polyethylene coating may occur if moisture reaches the polyethylene coated side of the paper before the bonding of polyethylene to paper is complete. By way of example, it may be taken as a rough guide that water cooling is applicable to uncoated paper from about 150 pounds (per ream) up. Water cooling would be applicable to lighter papers which had been specially sized to treated to be moisture-resistant.

One effect of water cooling the back side of the paper web has been to approximately double the current flow from the high voltage power supply (for the same power setting) which apparently substantially increases the attractive field urging the polyethylene film into bonding contact with the paper web.

An example of the method of the invention, using the water cooling arrangement of FIG. 4, will now be given. A 15 pt. 205 lb./ream white paraffin carton stock was coated with 6.6 lbs./ream of Bakelite 7501 high density polyethylene. The M.V.T.R. achieved was 0.88 gram, which represented an improvement of 52% over the M.V.T.R .of 1.82 to be expected from the standard method employing pressure rolling and shock chilling.

Another example, using the same paper, involved a coating weight of 7.2 lbs./ream and the same polyethylene. The M.V.T.R. achieved was 0.92 gram, which represented an improvement of 44% over the M.V.T.R. of 1.64 grams to be expected from the standard method.

By way of explanation, the term "ream" refers to 3000 square feet. "High density" polyethylene has a density of 0.945–0.950. M.V.T.R. is measured in terms of grams of moisture vapor transferred per 100 square inches of sample per 24 hours. The testing of M.V.T.R. was in accordance with recognized testing procedures using a General Foods cabinet held at 100° F. and from 90 to 95% relative humidity.

The two examples given above represent the best of a series of tests which yielded M.V.T.R. improvements on the 205 pound paper ranging from 9% to 52%. The paper, while referred to as paraffin carton stock, was not paraffin coated but rather was paper of a type intended for such service.

As mentioned above, using an arrangement as shown in FIG. 4 on realtively moisture-absorbent paper may result in moisture reaching the polyethylene-paper interface at the time of contact between the paper and the polyethylene. The presence of moisture at this point will substantially reduce or prevent the upgrading desired. By upgrading is meant an improvement in the M.V.T.R. as compared to the same paper and same polyethylene bonded in the standard method referred to. In order to obtain some of the benefits of the cooling and still obtain the desired upgrading, the cooling medium may be applied to the back side of the paper as it leaves the pipe **43**. For this purpose, water or other coolant may be applied to the back side of the paper from the interior of pipe **43**, or a separate spray or other coolant application arrangement may be used.

The coolant in FIG. 4 need not be applied from within the pipe, although this is preferable. Thus, a separate spray or other device may be used to establish and maintain the bead **45**.

The backing pipe of FIG. 4, when not used with water cooling, or the bar of FIG. 1, may be provided with a dielectric coating, e.g., nylon, Hypalon (a chlorosulforated polyethylene sold by E. I. du Pont de Nemours & Co.), Mylar (a polymerized ethylene glycol terephthalate), or Teflon (a tetrafluoroethylene plastic).

A variety of electrode structures may be used to create the electric field in the region of convergence of the polyethylene and paper. For example, the various electrode structures of the aforementioned copending application Ser. No. 183,304 may be used for this purpose. A more detailed illustration of a suitable electrode structure is shown in FIGS. 2 and 3.

The electrode structure of FIG. 2 comprises an aluminum tube **46** having rounded end caps **47** and **48**, an aluminum bar **49**, a pair of electrode wire holders **50** and **51**, and a pair of electrode wires **52** and **53**.

Typically, the tube **46** might be 2" in diameter and is clamped in central space **54** between the front and rear sections of electrode holders **50** and **51**. The front and rear sections of an electrode holder are designated **55** and **56**, respectively, in FIG. 3 and are held together by bolts **57** and **58** acting in holes in rear section **56** and threaded holes in front section **55**. The holders **50** and **51** may be suitably supported by insulating members to dispose wires **52** and **53** in the desired positions, as shown in FIG. 1 for the wires **39** and **40**.

The holders **50** and **51** have stepped notches cut in their front faces to provide shoulders **59** and **60** to support bar **49**. Screws **61** may be used to affix the bar **49** to the holders. Typically, the bar **49** might be ¼" high by 1" wide. The length of bar **49** is preferably somewhat greater than the lengths of the wires **52** and **53**.

Wires 52 and 53, which might be 0.006" diameter tungsten wires, have end portions held in deep holes in the holders. The wires are preferably spaced about 1" apart and lie in a vertical plane. The bar 49 and tube 46, which will be at the same potential as wires 52 and 53, serve as directing baffles to inhibit ion flow in an upward or rearward direction from wires 52 and 53.

While the invention has been described in connection with specific embodiments thereof and in specific uses, various modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. The continuous process of coating a paper substrate with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, comprising the steps of extruding the film, directing said paper along a first path over and in contact with a stationary non-rotatable backing element having a rounded conductive metal surface, the contact between said paper and said backing element being along said rounded surface and in the direction of advance of said paper, directing said extruded film along a second path through a region of convergence and into contact with said paper as the latter contacts said backing element, and applying a high voltage between an electrode structure and said backing element, said electrode structure being disposed in space adjacent the region of convergence of said film and said paper, said voltage being sufficiently high to ionize the air in the space adjacent said region of convergence whereby the electric field acting upon said extruded film in said region of convergence forces said film into intimate bonding contact with said paper.

2. The continuous process of coating a paper substrate with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, comprising the steps of extruding the film, heating said paper, directing said heated paper along a first path over and in contact with a stationary, non-rotatable backing element having a rounded conductive metal surface, the contact between said paper and said backing element being along said rounded surface and in the direction of advance of said paper, the length of said contact with said backing element lying in the range of about 1/16" to 1/8", directing said extruded film along a second path through a region of convergence and into contact with the front side of said paper as the back side of said paper contacts said backing element, and applying a high voltage between an electrode structure and said backing element, said electrode structure being disposed in space adjacent the region of convergence of said film and said paper, said voltage being sufficiently high to ionize the air in the space adjacent said region of convergence whereby the electric field acting upon said extruded film in said region of convergence forces said film into intimate bonding contact with said paper.

3. In the process set forth in claim 2, the step of contacting the back side of said paper with a liquid coolant, said contact between said coolant and the back side of said paper occurring adjacent the line of contact between said film and said paper.

4. The continuous process of coating a paper substrate with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, comprising the steps of extruding the film, heating said paper, directing said heated paper along a first path over and in contact with a stationary backing element having a rounded conductive metal surface, the contact between said paper and said backing element being along said rounded surface and in the direction of advance of said paper, the length of said contact with said backing element lying in the range of about 1/16" to 1/8", directing said extruded film along a second path through a region of convergence and into contact with said paper as the latter contacts said backing element, applying a high voltage between an electrode structure and said backing element, said electrode structure being disposed in space adjacent the region of convergence of said film and said paper, said voltage being sufficiently high to ionize the aid in the space adjacent said region of convergence whereby the electric field acting upon said extruded film in said region of convergence forces said film into intimate bonding contact with said paper, and directing a stream of water onto the side of said paper opposite the side contacted by said film thereby to form a bead of water between said paper and said backing element to cool said paper.

5. The continuous process of coating a paper substrate with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, comprising the steps of extruding the film, heating said paper, additionally heating the front side of said paper, directing said additionally heated paper along a first path over and in contact with a fixed hollow metal pipe, the contact between said paper and said pipe being in the direction of advance of said paper, the length of said contact with said pipe lying in the range of about 1/16" to 1/8", directing said extruded film along a second path through a region of convergence and into contact with the front side of said paper as the back side of said paper contacts said pipe, applying a high voltage between an electrode structure and said pipe, said electrode structure being disposed in space adjacent the region of convergence of said film and said paper, said voltage being sufficiently high to ionize the air in the space adjacent said region of convergence whereby the electric field acting upon said extruded film in said region of convergence forces said film into intimate bonding contact with said paper, supplying a liquid coolant under pressure to the interior of said pipe, and directing a stream of said coolant through an elongated slot in said pipe and onto the back side of said paper to form a bead of coolant between said paper and said pipe to cool the back side of said paper.

6. The process set forth in claim 5 in which said liquid coolant is directed into contact with the back side of said paper along an axis making an angle with said paper lying in the range of about 30° to 45°, said axis being considered radial with respect to the longitudinal center line of said pipe.

7. A paper web having a moisture resistant surface at least equivalent in moisture resistance to an uncoated paper having a weight of about 150 pounds per ream and being coated with a substantially unpatterned film of a compound selected from the group consisting of polymers and copolymers of lower olefins, produced by the process comprising the steps of extruding the film, directing the extruded film into contact with the front side of said paper web, subjecting said film and said web to the action of a high intensity electric field to force said film and said paper web into intimate bonding contact, and contacting the backside of said paper web with a liquid coolant adjacent the line of contact of said film and said web.

8. An apparatus for coating a paper web with a film of a compound selected from the group consisting of polymers and copolymers of lower olefins, the combination comprising a source of a heated paper web, a stationary hollow conductive backing element having a rounded surface, means to direct said heated web with the back side thereof in contact with said rounded surface over a small arc of contact, said backing element having a narrow elongated slot positioned so that a liquid coolant in said hollow backing element is directed into contact with the back side of said web in advance of contact of said web with said surface, a source of extruded film positioned to direct the extruded film into contact with the front side of said web as the latter passes over said surface, an electrode structure positioned adjacent said surface, and a source of high voltage connected to said struc-

ture and said backing element to create a high intensity electric field forcing said film into intimate bonding contact with said web.

9. Apparatus as set forth in claim 8 in which said backing element is a hollow metal pipe and in which said slot is radially arranged, relative to the longitudinal center line of said pipe, at an angle with respect to said web lying in the range of about 30° to 45° whereby a bead of coolant is formed between the back side of said web and the adjacent surface of said pipe.

References Cited

UNITED STATES PATENTS

3,196,063 7/1965 Paquin et al. ..... 161—250

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156—244, 272, 380, 500; 264—22

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,448,000 Dated June 3, 1969

Inventor(s) Paquin et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 8, "183,340" should be -- 183,304 --;
line 18, "of" should be -- and --.

Col. 2, line 2, "permise" should be -- premise --.

Col. 5, line 4, "calsing" should be -- causing --.

Col. 6, line 66, cancel "of" (first occurrence).

Col. 7, line 63, "to" (first occurrence) should be -- or --.

Col. 8, line 23, "realtively" should be -- relatively --.

Col. 9, line 19, after "ary" insert a comma (,).

Col. 10, line 4, "aid" should be -- air --;
line 57, "backside" should be -- back side --.

SIGNED AND
SEALED
MAR 3 - 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents