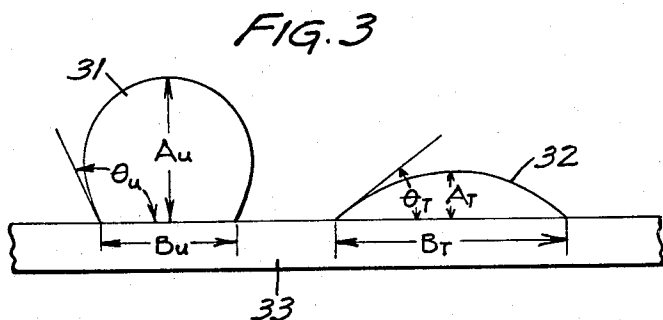
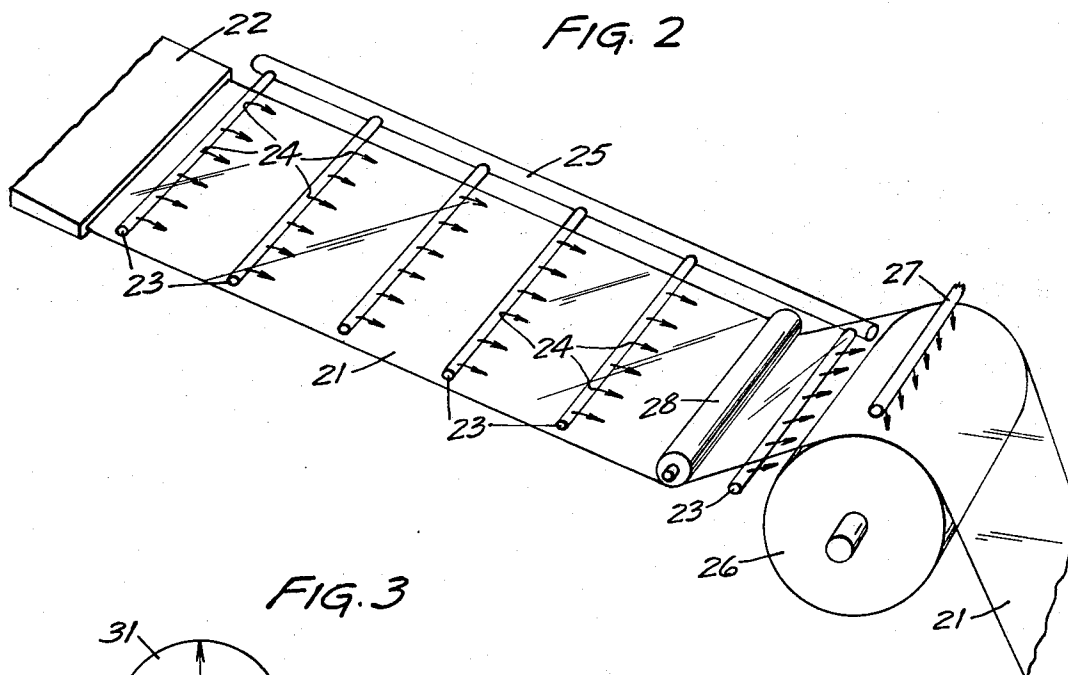
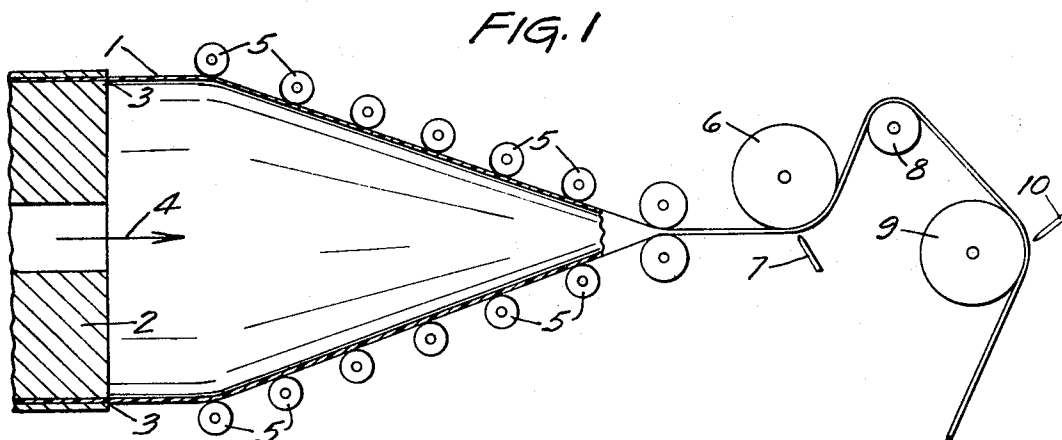


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A. W. MORGAN
METHOD OF SELECTIVELY TREATING A PLASTIC FILM
TO IMPROVE ANCHORAGE CHARACTERISTICS
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INVENTOR
ALBERT W. MORGAN
BY
Carpenter, Kinney & Boulter
ATTORNEYS

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METHOD OF SELECTIVELY TREATING A PLASTIC FILM TO IMPROVE ANCHORAGE CHARACTERISTICS

Albert W. Morgan, North St. Paul, Minn., assignor to Minnesota Mining and Manufacturing Company, St. Paul, Minn., a corporation of Delaware
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ABSTRACT OF THE DISCLOSURE

Method of confining corona treatment of plastic film by providing a surface free from readily energizable gases such as oxygen and blanketing said surface with a difficultly energizable gas such as nitrogen, and corona treating second surface portion on the opposite side of said film while the second surface portion is in contact with a readily energizable gas; one embodiment being maintaining a nitrogen atmosphere within an extruded tube, flattening tube and corona treating outside while in contact with air.

This invention relates to corona discharge treatment of plastic films and more particularly to confining such treatment of films to selected surfaces thereof.

Corona discharge treatment of plastic films is widely used to improve the receptiveness or anchorage characteristics of such films to inks and adhesives. Such treatment is generally disclosed in U.S. Patents 2,881,470, issued Apr. 14, 1959, to Berthold et al., and 2,939,956, issued June 7, 1960, to Parks. Even though such treatment is applied to one side only of a film, it has been found that significant amounts of treatment or activation occur on the back side of the film, particularly when heavy treatment is applied. Such back-side treatment is inconsequential in some cases where the condition of the back side of the film is not critical. However, it has been found in many cases that films containing a coating of ink on one side when wound into roll form will undergo a transfer of the ink from the printed side to the overlying unprinted back side of the next successive wrap in areas where unwanted back-side treatment has occurred. Such ink transfer results in an unsightly appearance in packages formed from the film.

In the case of films which are to be used as a removable liner for pressure-sensitive tapes or the like and where the liner is to be printed on one side, for example, with a trademark, it is critical that the back side be substantially untreated because any treatment thereof would not only result in transfer of ink during storage prior to application of the liner to the tape assembly, but would cause the adhesive to adhere with such tenacity that removal of the liner by the user would be nearly impossible. Thus, unwanted back-side treatment destroys the operability of such liners.

It has been attempted to prevent the back-side treatment of tubularly extruded films by flattening the extruded tube to prevent treatment by placing the inner surfaces of the film in very close face-to-face contact. However, this method produces spotty results because tiny bubbles of air or other readily energizable gases are trapped between the surfaces and cause the film to be treated in the vicinity of such trapped air bubbles.

The method of the present invention provides a commercially feasible way to overcome the above-noted problems. The present method affords positive and carefully controllable protection against corona treatment of selected areas of films. The present invention, moreover, provides a method by which heavy corona discharge treat-

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ment can be applied to one side of the film while the opposite side is maintained substantially free of any treatment.

The invention will be further explained with reference to the accompanying drawings in which:

FIGURE 1 is a schematic side view with portions broken away showing the method of the present invention applied to films extruded in tubular form,

FIGURE 2 is a schematic perspective view illustrating the application of the method of the present invention to films extruded in flat sheet form, and

FIGURE 3 is a cut-away magnified cross-sectional view of film having treated and untreated portions, each portion having a droplet of distilled water standing thereon.

Referring more particularly to FIGURE 1, there is seen a tubular column of extruded film 1 being extruded from extrusion die 2 which is provided with a circular orifice 3. The tubular column is inflated with a stream of difficultly energizable gas such as nitrogen indicated generally by arrow 4. This gas is introduced through the central portion of the die. A series of collapsing rolls 5 are provided on opposite sides of the extruded film column 1 to flatten the same prior to corona treatment thereof. The flattened tube is passed over the grounded backup roll 6 and corona discharge treated on one side by means of voltage applied to treater bar 7. The film may then pass over an idler 8 and then over a second grounded backup roll 9 for corona discharge treatment on the opposite side by treater bar 10. The film is then further processed, for example, by slitting and printing and may be wound into roll form after or intermediate to any of these steps.

In the embodiment shown in FIGURE 2 a flat sheet 21 of extruded film is formed by the use of an extrusion die 22 provided with a flat slit-like orifice. A blanket of nitrogen or other difficultly energizable gas is provided on one side of film 21 by means of discharge tubes 23 provided at spaced intervals along the path of travel of the film. Discharge tubes 23 are provided with a series of suitably spaced discharge orifices 24 along the length thereof and are attached to a source of gas, for example, through a manifold 25. Discharge tubes should be so located that the film is never permitted to come in contact with air or other readily energizable gas, i.e., the film surface portions to be protected from treatment are extruded directly into an atmosphere of difficultly energizable gas to prevent occlusion of readily energizable gases on such surface portions. The sheet of film passes over a grounded backup roll 26 for corona discharge treatment by means of treater bar 27 after passing idler 28. The upper surface being treated is in contact with a readily energizable gas such as oxygen, air being suitable. A blanket of nitrogen is maintained between the sheet of film and the ground roll as the film is fed under the treater bar.

The degree of treatment of a film surface may be measured approximately by means of a simple test illustrated in FIGURE 3. Droplets of distilled water 31 and 32 are deposited on the surface of untreated and corona discharge treated surface portions of a sheet of film 33 respectively. The distilled water does not readily wet the surface of the untreated film and therefore the sides of the droplet 31 contact the film surface at an angle θ_u which is 90° or more in the case of polyethylene and polypropylene. By comparison droplet 32 significantly wets the surface of the treated portion of the film and the sides of the droplet form an angle θ_t of less than 90° at the point of contact with the film surface. These angles can be approximately calculated by measuring the height A and the width B of the droplets and calculating

the contact angle θ approximately using the following formula:

$$\tan \frac{\theta}{2} = \frac{2A}{B}$$

The method of the present invention is particularly applicable to the control of corona discharge treatment of polyolefin and particularly polyethylene film. However, the method is also of utility in the treatment of other films which are susceptible of beneficial corona discharge treatment, for example, polypropylene, ethylene-propylene copolymers, polyurethanes, ethylene-vinyl acetate copolymers, polyamides, polyesters, polyethers, polyvinyl ethers, polyvinyl chlorides, and polyvinylidene chloride. Gases which produce useful corona activation when contacted with film surfaces are gases readily dissociable to form ions or free radicals such as O_2 , CO, NO and halogens. Such gases are generally strong oxidizing agents.

Difficultly energizable gases which have been found to be useful in protecting selected surface portions of films from corona discharge treatment include nitrogen, helium, argon, krypton, neon, xenon, nonionizing fluorocarbons, and water vapor, for example, in the form of steam. By "difficultly energizable" gases as the term is used herein are meant gases which have a high dissociation energy and thus do not tend to ionize to form free radicals under the conditions obtaining in conventional corona discharge treatment. Thus such gases are not reactive with polymeric film when contacted therewith in an electric field. Most of the suitable difficultly energizable gases are also inert and nonoxidizing. Difficultly energizable gases can also be described as "inert to the effects of corona discharge" or "nontreating" gases.

The invention will be further explained with reference to the following examples.

EXAMPLE I

4 mil thick white pigmented polyethylene was cut and formed into bags. The film was untreated on all surfaces, thus droplets of water placed thereon formed contact angles with the film surface of more than 90° as illustrated by droplet 31 in FIGURE 3. A number of bags were filled with air, nitrogen and steam, respectively, and sealed. The bags were carefully flushed with the gas to be sealed therein prior to sealing in order to insure the removal of occluded air from the surface of the film. Heating the film during flushing or flushing with a heated gas was found to improve the efficiency of the flushing process. A standard high frequency Tesla coil (E. H. Sargent & Company, Cat. No. S30978), operating on 115 volts A.C. was set so that a spark therefrom would jump 1 inch. The coil was held $\frac{1}{2}$ inch above the surface of the bags and the entire external surface of each bag was passed under the coil to treat the same. The degree of treatment was determined by opening the bags, placing droplets of distilled water on the various surfaces thereof, and calculating the angle with which the periphery of the drops of water contacted the surface of the film in accordance with the test described above. The average results of these measurements, tabulated in Table I, indicated that treatment of the inner surfaces of the bags occurred in the case of the bags containing air, but did not occur in the case of the bags which contained nitrogen or steam.

The experiments were conducted in an air atmosphere at 72° F. and 50% relative humidity.

TABLE I

Gas in Bag	θ Outside (deg.)	θ Inside (deg.)
Air.....	40	53.2
N ₂	41.2	>90
Water Vapor.....	46.8	>90

EXAMPLE II

The experiment of Example I was repeated on commercial scale equipment of the type shown in FIGURE 1. A tubular column of 4 mil thick white pigmented polyethylene was extruded flattened to form a 52 inch wide flattened tube and heavily corona discharge treated on its outer surface. First nitrogen, then air, was introduced into the column. The average contact angles are given in Table II.

TABLE II

Gas	Average Contact Angel (deg.)	
	Outside Surface	Inside Surface
Nitrogen.....	59	>90
Air.....	63	77

EXAMPLE III

Bags were made from 2 mil thick polypropylene and 5 mil thick polyethylene terephthalate film. The untreated film in each case was tested in accordance with the above-described "water drop" test. The distilled water droplets were found to form a contact angle with the untreated polyethylene terephthalate film of 75° and with the untreated polypropylene film (Hercules Andel, biaxially oriented) of more than 90° . Bags of each type were flushed to remove occluded gases, filled with nitrogen, water vapor or air and sealed with thermoplastic tape. The bags were then treated with a Tesla coil as in Example I. The bags were then opened and tested with the "water drop" test previously described. All bags displayed heavy corona activation on the outside surfaces. As shown in Table III, the bags filled with air also displayed significant treatment on the inside surfaces while those which contained water vapor and nitrogen did not.

TABLE III

Gas in Bag	Polyethylene Terephthalate Bag (deg.)		Polypropylene Bag (deg.)	
	θ Outside	θ Inside	θ Outside	θ Inside
Air.....	49	62	72	73
N ₂	47	70	74	>90
Water Vapor....	45	70	76	>90

What is claimed is:

1. A method of confining treatment of plastic film to improve the anchorage characteristics of selected surface portions thereof comprising:

- providing a sheet of plastic film having a first surface portion free from readily energizable gases;
- blanketing said first surface portion of said film with difficultly energizable gas;
- contacting a second surface portion on the opposite side of said film with readily energizable gas;
- applying a field of electric force to said second surface portion of said film while maintaining said film in contact with said gases to energize said readily energizable gas thereby confining significant improvement of the anchorage characteristics to said second surface portions.

2. The method of claim 1 wherein said plastic film is a polyolefin film.

3. A method of treating polyethylene film to improve the anchorage characteristics of one side thereof comprising:

- extruding a hollow tubular column of polyethylene film into an oxygen-containing atmosphere;
- maintaining a gaseous nitrogen atmosphere within said column;
- flattening said extruded film;
- applying corona discharge treatment to the outer surface of said flattened film to improve the anchorage characteristics of said outer surface without substantially altering the anchorage characteristics of the inner surface of said film.

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4. The method of claim 3 wherein said oxygen-containing atmosphere is air.

5. A method of treating plastic film comprising extruding molten plastic material into the form of a thin web, blanketing a first surface portion of said film while freshly extruded with a difficultly energizable gas, contacting a second surface portion on the opposite side of said film with air, subjecting said second surface portion of said film to corona discharge while continuously blanketing said first surface portion with said difficultly energizable gas to cause a confined treatment of said second surface portions to improve the anchorage characteristics thereof.

6. A method according to claim 5 wherein said diffi-

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cultly energizable gas is selected from the group consisting of nitrogen, helium, argon, krypton, neon, xenon, non-ionizing fluorocarbons, and water vapor.

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ARCHIE R. BORCHELT, *Examiner*.

S. SHEAR, *Assistant Examiner*.