United States Patent [19]

Butcher, Jr.

[11] **3,871,980**

[45] **Mar. 18, 1975**

[54] **METHOD FOR IMPROVING THE WETTABILITY OF A SHEET MATERIAL**

[75] Inventor: **Louis M. Butcher, Jr.**, New Kensington, Pa.

[73] Assignee: **Aluminum Company of America**, Pittsburgh, Pa.

[22] Filed: **Oct. 12, 1972**

[21] Appl. No.: **296,822**

[52] **U.S. Cl.** **204/164,** 204/165, 204/168, 250/531, 250/542, 250/544, 250/545

[51] **Int. Cl.** **B01k 1/00**

[58] **Field of Search** 204/165, 168, 169, 164; 250/542, 544, 545, 531

[56] **References Cited**

UNITED STATES PATENTS

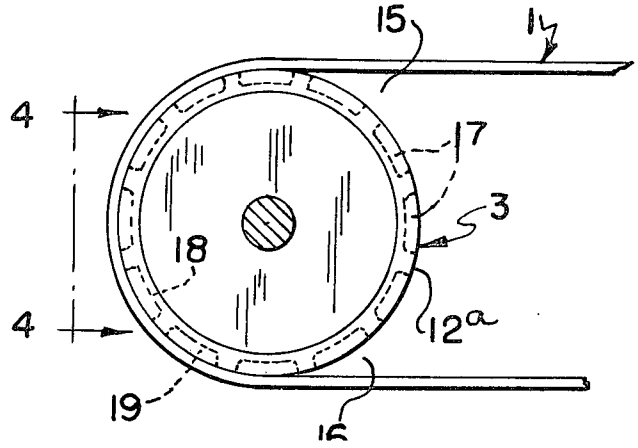
3,179,482	4/1965	Kassenbeck	8/2
3,255,099	6/1966	Wolinski	204/169
3,257,303	6/1966	Gould et al.	204/168
3,274,088	9/1966	Wolinski	204/165
3,397,132	8/1968	Wolinski	204/165
3,435,190	3/1969	Schirmer	250/542 X

Primary Examiner—F. C. Edmundson
Attorney, Agent, or Firm—Teare, Teare & Sammon

[57] **ABSTRACT**

An electrode and method for electrostatically treating the surface of a substrate of continuous sheet metal material, wherein the electrode comprises a rotatable, electrically conductive cylindrical member onto and off of a segmental portion of the peripheral surface of which the substrate is continuously wrapped. The cylindrical member has its peripheral surface encompassed by a non-conductive material for engaging the substrate as it passes around the cylindrical member. The non-conductive material includes an insulating barrier for insulating the substrate from the cylindrical member, and outwardly opening cavities to provide an air space between the substrate and the cylindrical member, in the area of the substrate wrapped on the cylindrical member, to enable ionization of the air in such air space for treating the substrate surface wrapped on the cylindrical member upon application of a potential difference between the cylindrical member and the substrate.

6 Claims, 4 Drawing Figures



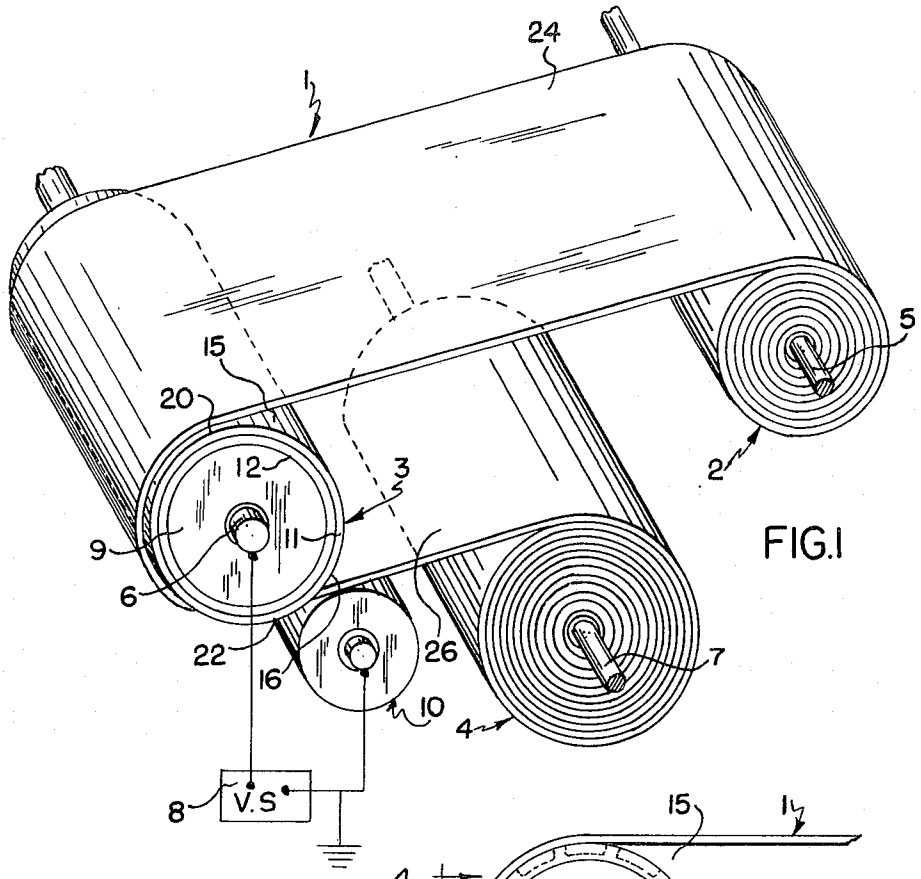


FIG.1

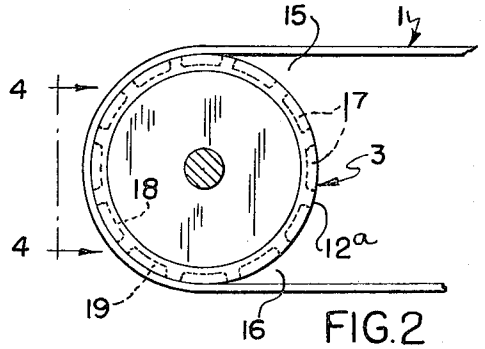


FIG.2

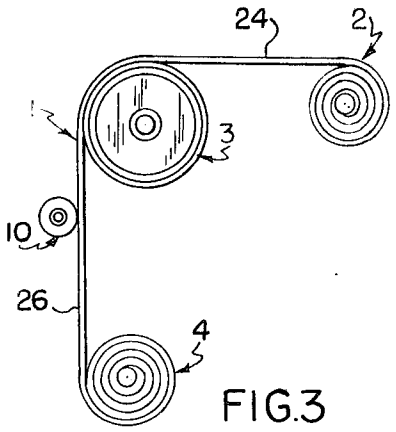


FIG.3

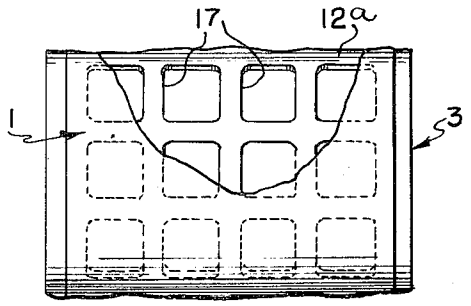


FIG.4

METHOD FOR IMPROVING THE WETTABILITY OF A SHEET MATERIAL

BACKGROUND OF THE INVENTION

The present invention is related to an electrode and method for the treatment of the surface of a substrate of thin, sheet material for improving the wettability thereof, and more particularly, to an electrode and method for electrostatically treating the surface of a thin metal foil, such as aluminum or the like, by subjecting the foil surface to an ionized atmosphere or corona for making the surface more receptive to coatings, such as printing inks, various organic solutions, extrusion resins, adhesives, and so forth.

Conventionally, in the known method and apparatus for electrostatic treatment or corona treatment of aluminum foil, the foil was continuously fed from a feeder roll onto a treater roll, and then fed to a take-up roll.

In such prior apparatus and method, the treater roll comprised a rotatable metal drum which was connected to a high voltage source and formed one electrode. The foil was passed over a grounded roll thus forming another electrode to create a potential difference between the foil and the drum as it moved around the drum. A dielectric coating was disposed in encompassing relation about the periphery of the drum for insulating the foil from the drum.

In the foregoing arrangement, the foil was wrapped directly on the dielectric coating, and thus, the only air available for ionization or corona formation was in the space defined by the periphery of the drum and the foil just prior to the foil engaging the drum and just subsequent to the foil leaving the drum. The dielectric strength of the dielectric coating was selected to prevent arcing between the foil and drum when a potential difference was applied to the drum which was sufficient to ionize the air in such air spaces. As a result, the foil received treatment only in a limited area which confronted such air spaces and received no treatment in the area of the foil which was in contact with the drum. In addition, the range for selection of the dielectric material was quite limited by the former arrangement as a result of the direct contact of the foil with the dielectric coating. The direct contact made it necessary to provide a dielectric material having good mechanical strength to avoid damage or excessive wear thereto. Still further, the treatment by the former arrangement did not result in any high degree of reproducibility in the wettability characteristics of the treated foil surface. Still further, the former apparatus was subject to overheating which tended to shorten the operating life of the treater roll, and hot spots were developed in the operation which resulted in the formation of pin holes in the foil.

SUMMARY OF THE INVENTION

The present invention contemplates providing an improved electrode and method for electrostatically treating the surface of a substrate of sheet material, such as aluminum foil or the like, for improving the wettability thereof so that coatings will adhere more firmly and tenaciously thereto. The electrode is provided in the form of an electrically conductive cylindrical member or drum for receiving the substrate, which is in the form of a continuous sheet or web, in wrapped relation about a segmental portion of its peripheral surface. The cylindrical member is arranged for connection to a source of electrical energy for creating a potential difference between the substrate and the cylindrical member. A non-conductive means is disposed in surrounding relation about the peripheral surface of the cylindrical member and includes an insulating barrier for insulating the substrate from the cylindrical member as it passes about the periphery thereof, and further includes cavities which open outwardly away from the cylindrical member so that an air space will be formed between the juxtaposed surface area of the substrate wrapped and supported on the peripheral surface of the cylindrical member. The dielectric strength of the insulating barrier is selected so as to prevent arcing between the substrate and the cylindrical member when a potential difference is created therebetween which is sufficient to ionize the air in the air spaces. More specifically, the treating assembly comprises a cylindrical member or drum which is rotatably mounted on a support for continuously receiving the substrate in wrapped relation thereon. Still further, the non-conductive means is of a thermally conductive material for transmitting the heat generated during the treating process from the cylindrical member to the substrate. Still, more specifically, the non-conductive means comprises an inner dielectric coating or layer and an outer sleeve or layer of open-pore material disposed circumferentially of the cylindrical member for area contact with the substrate and is of a generally uniform thickness for uniformly and precisely spacing the substrate with respect to the cylindrical member as it passes thereabout.

By foregoing arrangement, the substrate surface is treated, during any period of time, in that area which is supported by the cylindrical member, and then, treatment is not limited to those areas of the substrate surface which are immediately out of supporting engagement with the cylindrical member. Further, by the present arrangement, the continuous rotation of the cylindrical member causes the constant replenishing of the air in the air space between the substrate and the cylindrical member for maximizing the ionization of such air for more effective treatment of the substrate surface. In addition, the substrate is maintained at a more precise, uniform distance from the peripheral surface of the cylindrical member, and thus, the air space is of a uniform dimension over the entire area of contact of the substrate resulting in a more uniform, high level of treatment at normal power requirements. Further, such an arrangement results in a high grade true corona and a high degree of reproducibility. As another feataure of the invention, hot spots are substantially reduced and there is an effective transfer of the heat developed by the operation away from the cylindrical member to the substrate to prevent a dangerous heat build up which could cause roll failure. As still another feature of the invention, the substrate is maintained out of contact with the insulating barrier of dielectric material, and thus, enables the selection of an increased number of dielectric materials for covering the cylindrical member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration showing one form of the electrode and method;

FIG. 2 is a fragmentary, partially in section, end elevation view of another form of electrode of the present invention;

FIG. 3 is a schematic illustration of another form of the present invention, and

FIG. 4 is a fragmentary, partially cut-away, side elevation view taken along the line 4—4 in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring again to FIG. 1, a substrate 1 is shown in the form of a continuous web of sheet material, such as aluminum foil or the like, and is shown being fed from a supply roll 2 onto a treater roll 3, and then onto a take-up roll 4. The rolls 2, 3 and 4 are shown mounted on shafts 5, 6 and 7, respectively, which may be supported for rotation on a suitable frame (not shown) in a manner well known in the art. The treater roll 3 may be operably connected to any suitable drive mechanism (not shown) for controlling the speed of rotation thereof, and thus, the feed rate of the web around the treater roll 3.

Referring now to FIG. 1, the treater roll 3 is shown as including one electrode 9 in the form of a generally cylindrical member or drum which is mounted for rotation on the shaft 6. The electrode 9 may have its periphery made of electrically conductive material, such as stainless steel or the like, which is connected to a suitable high voltage source, such as is indicated at 8 (FIG. 1). A supporting roller 10 of electrically conductive material, such as steel or the like, may be mounted on the frame for supporting the web 1 as it leaves the treater roll 3, and as shown may be connected to the ground side of the voltage source for grounding the web 1, and creating a high potential electrostatic field between the web 1 and the electrode 9 as the web 1 moves about the roll 3. The voltage source 8 should be such as is capable of impressing a direct or alternating potential difference between the electrode 9 and web 1 sufficient to cause ionization of the air adjacent to the periphery of the treater roll 3 for a reason which will become more apparent hereinafter.

The treater roll 3 further includes a spacer layer or sleeve 11 which is disposed circumferentially of the electrode 9 for engaging the web 1 as it passes about the treater roll 3. The sleeve 11 is made of a prous, non-conductive material which includes cavities therein to provide an air space between the electrode 9 and the confronting juxtaposed area of the substrate 1 supported on the peripheral surface of the treater roll 3. For purposes of description, such supported area will be referred to hereinafter as the "area of contact" even though it is understood that portions of the juxtaposed area of the substrate and treater roll are not in contact with another as will be described more fully hereinafter.

The sleeve 11 may be made of any suitable material which is of an open-pore construction such that the pores or cavities therein open outwardly away from the electrode 9 and open onto the confronting surface of the web 1 in the area of contact between the web 1 and the treater roll 3. For example, such material as spun-bonded polyester (Remay) or any similar organic spun-bonded materials, such as polyolefins, ethers, urethanes, or the like could be used. Woven fabrics, such as cloth or the like, or other open-pore materials, such as paper or sponges, either synthetic or natural, could also be utilized as the only criterion for effective treatment is that the material be sufficiently open to enable exposure of the surface of the web 1 to the air in the space between the web 1 and the treater roll 3.

As further shown in FIG. 1, the treater roll 3 includes a dielectric coating or layer 12 which is also disposed circumferentially and in encompassing relation about the periphery of the electrode 9 between the spacer layer 11 and the electrode 9 for insulating the web 1 from the electrode 9. The dielectric strength of the dielectric coating 12 should be selected such that it is capable of preventing arcing over between the electrode 9 and the web 1 when a voltage is applied to the electrode 9 which is sufficient to ionize the air in the area immediately surrounding the periphery of the treater roll 3. Further, the width of the roll 3, and thus the dielectric coating 12 on the electrode 9, should be sufficiently wide to prevent arcing around the outer ends of the dielectric coating 12 between the electrode 9 and the outer edges of the web 1. The dielectric coating or layer 12 should be a non-porous, non-electrically conductive material. For example, a material such as chloride rubber has been found to perform extremely satisfactorily as the dielectric coating 12. Such a spacer-dielectric arrangement extends the treatment to the entire area of the surface of the web 1 which is wrapped on the roll 3 during any instant of time and does not confine the treatment to only those areas of the surface of the web 1 in the immediate vicinity of where the web 1 enters onto the treater roll 3, as at 15, or where it leaves the treater roll 3, as at 16. Further, as the spacing between the substrate is precisely maintained to provide uniform spacing, a more uniform treatment of the substrate surface may occur. Another important consideration in the present invention is that the material comprising the spacer layer 11 be of a heat conductive material, such as a spun bonded polyester material, to enable transfer of the heat generated during the treatment process from the treater roll 3 to the web 1 when the web 1 is in contact with the treater roll 3.

It has been found that while employing an apparatus which was constructed in accordance with the present invention, the wettability of rolled H-19 aluminum foil containing rolling oils was increased from I to A on the well known wettability scale or the same as the fully annealed state. On such scale A indicates that the metal surface can be wet with 100 percent of distilled water. B indicates that the metal surface can be wet by a mixture of 90% water and 10% ethyl alcohol. The progression continues through C, D, E, etc. to K by decreasing the water in 10 percent increments and increasing the ethyl alcohol in 10 percent increments, so that K indicates that the metal can be wet with only 100 percent ethyl alcohol.

In an apparatus embodying the present invention the treater roll 3 had a diameter of approximately 4 inches and was provided with a dielectric coating 12 of chloride rubber material having a thickness of one-eighth of an inch and a spacer layer 11 made of spun bonded polyester material having a generally uniform thickness of approximately one sixteenth of an inch. The feed rate of the web 1 was approximately 200 feet per minute, and the potential difference applied across the air gap between the treater roll 3 and the web 1 was in the range of 1,000 volts to 1,500 volts. On the other hand, treatment by the aforementioned prior art apparatus and method did not produce any consistent or repro-

ducible results, although there was an improvement in wettability of the aluminum foil to various degrees, such as H.G. and F. on the wettability scale.

Another embodiment of the present invention is shown in FIGS. 2 and 4 which includes a dielectric coating or layer 12a which serves a dual function of insulating and spacing the web 1 from the electrode 9. As shown, the dielectric coating 12a is provided in the form of a unitary one-piece layer or sleeve which is disposed circumferentially of and in encompassing relation about the electrode 9 in generally the same manner as the aforementioned dielectric coating 12. The dielectric layer 12a is shown as including a series of cavities or recesses, such as at 17, on one side remote from the electrode 9. As shown, the recesses 17 open outwardly toward the confronting surface of the web 1. The dielectric layer 12a may be made of the same material as the aforementioned dielectric layer 12 and includes a portion, such as at 18, adjacent the electrode 9 which serves as a non-porous dielectric to prevent arcing between the electrode 9 and the web 1 while the cavities or recesses provide an open air space, as at 19, which is exposed to the confronting surface of the web 1 in the area of contact between the web 1 and the treater roll 3.

Referring now again to FIG. 1, the treater roll 3 may be arranged with respect to the feed roll 2 and the take-off roll 4 such that the web 1 enters onto and leaves the roll 3 at generally diametrically opposed points on the roll 3, as at 20 and 22, and the general plane of the upper run 24 of the web 1 being fed to the feeder roll 3 is generally parallel to the general plane of the lower run 26 leaving the treat roll 3. In such an arrangement, the web 1 is in contact with the roll 3 over an arcuate segment of approximately 180°, or ½ of the peripheral surface area of the treater roll 3. In FIG. 3, the feed roll 3 and take-off roll 4 are arranged with respect to one another such that the general plane of the upper run 24 extends generally normal to the general plane of the lower run 26 and the web 1 is in contact with the roll 3 over an angle of approximately 90°, ¼ of the peripheral surface area of the treater roll 3. As can be seen, an arrangement having the treater roll 3 as one electrode and the web 1 as the other electrode enables the size of the treatment area to be varied, as desired, depending on the particular roll arrangement which is used. It is to be understood that other roll arrangements could be provided which result in the web 1 being in contact with the treater roll 3 over an area exceeding ½ or less than ¼ of the peripheral surface area of the roll 3.

I claim:

1. A method of treating the surface of a substrate of sheet metal material in a treater assembly to improve the wettability thereof, the assembly including a pair of electrodes having conductive portions connected in circuit with a source of electrical energy, and wherein one electrode has its conductive portion covered by non-conductive material, said method comprising the steps of,

moving said substrate into engagement with said treater assembly,

supporting said substrate in spaced relation from said conductive portion of said one electrode by supporting said substrate in contact with said non-conductive material,

maintaining an air space between said substrate and said one electrode in the area of contact therebetween by supporting said substrate in contact with a cavitated portion of said non-conductive material

supporting said substrate in contact with said conductive portion of said other electrode,

creating a potential difference between said substrate and said conductive portion of said one electrode by establishing a potential difference between said conductive portion of said one electrode and said conductive portion of said other electrode sufficient to cause ionization of the air in the cavities forming said cavitated portion of said non-conductive material for electrostatically treating the surface of said substrate confronting said cavities over the area supported in contact with said cavitated portion of said non-conductive material, and

insulating said conductive portion of said one electrode from said substrate by separating said cavitated portion of said non-conductive material from said conductive portion of said one electrode with a non-cavitated portion of said non-conductive material having a dielectric strength sufficient to prevent arcing between said substrate and said conductive portion of said one electrode while applying said ionizing potential difference therebetween.

2. A method in accordance with claim 1, including

providing said treater electrode in the form of a roll, and

rotating said roll for continuously wrapping said substrate thereon for replenishing the air supply in the air space formed by said cavities.

3. A method in accordance with claim 2, including

wrapping said substrate about a segmental arcuate portion of the peripheral surface of said roll.

4. A method in accordance with claim 3, including

supporting said substrate in contact with said other electrode at a point on said substrate other than said segmental arcuate portion in contact with said one electrode.

5. A method in accordance with claim 1, including

providing the other electrode in the form of another roll, and

continuously rolling said substrate along said other roll and said one roll for maintaining said potential difference between said substrate and said one electrode to continuous treat the surface of said substrate.

6. A method of treating the surface of a substrate of sheet metal material in a treater assembly for improving the wettability thereof, the assembly including a treater electrode and a grounded electrode connected in circuit with a source of electrical energy, and wherein the treater electrode includes a conductive portion covered by a non-conductive material and the grounded electrode includes a conductive portion, said method comprising the steps of,

providing said treater electrode in the form of a first roll,

moving said substrate from a supply source into engagement with said first roll,

wrapping said substrate about a segmental arcuate portion of the peripheral surface of said first roll,

providing said grounded electrode in the form of a second roll,

providing said non-conductive material in the form of a continuous layer of substantially uniform thickness about the circumference of said first roll,

supporting said substrate in uniform, spaced relation from said conductive portion of said treater electrode by supporting said substrate in contact with said non-conductive material,

maintaining an air space between said substrate and said conductive portion of said treater electrode by supporting said substrate in contact with a cavitated portion of substantially uniform thickness in said non-conductive material,

creating a potential difference between said substrate and said conductive portion of said treater electrode by establishing a potential difference between said conductive portion of said treater electrode and conductive portion of said grounded electrode sufficient to cause ionization of the air in the cavities forming said cavitated portion for electrostatically treating the substrate over the area supported in contact with the cavitated portion of said non-conductive material and confronting said cavities therein,

insulating said conductive portion of said treater electrode from said substrate by providing said non-conductive material with a non-cavitated portion between said conductive portion of said treater electrode and said cavitated portion which has a dielectric strength sufficient to enable ionization of the air in the air space between said substrate and said non-cavitated portion of said non-conductive material for electrostatically treating the surface area of the substrate confronting said air space but sufficient to prevent arcing between said substrate and said conductive portion of said treater electrode while applying said ionizing potential difference therebetween, and

replenishing the air in said air space by rotating said rolls for continuously moving said substrate therebetween for continuously treating the confronting surface of said substrate.

* * * * *