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ELECTROSTATIC COATING PROCESS AND APPARATUS

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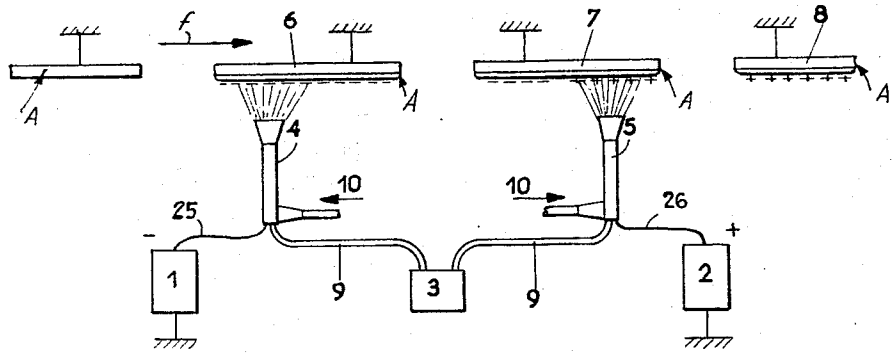

Fig. 1

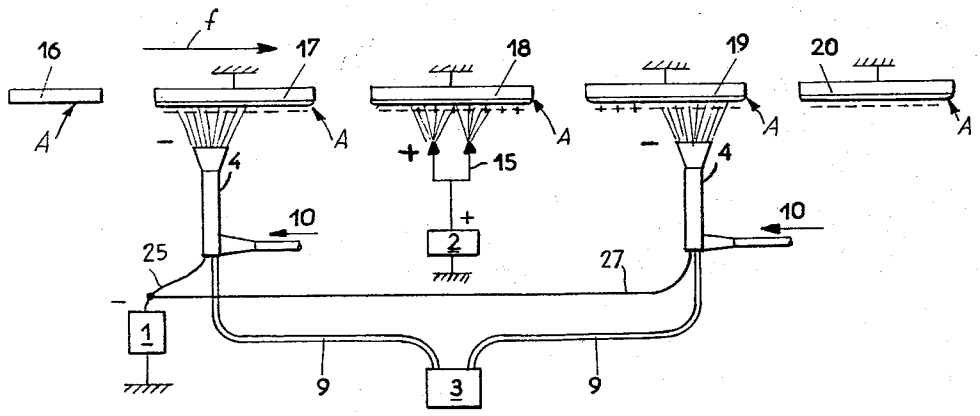

Fig. 2

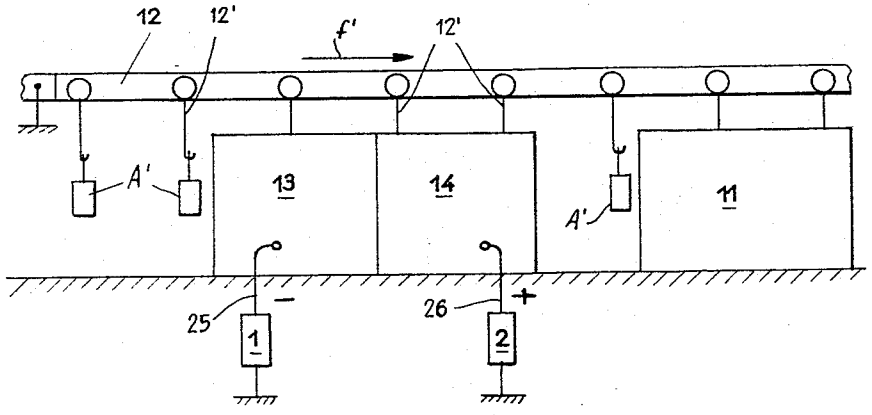

Fig. 3

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ELECTROSTATIC COATING PROCESS AND APPARATUS

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14 Claims. (Cl. 117—17)

This invention relates to a coating method and apparatus and more particularly to a method and apparatus for electrostatically coating the surfaces of articles with divided substances, such as pulverulent solids or divided liquids, for example, by precipitation.

There has been developed an electrostatic-type system for coating various articles which is extremely rapid in action and highly efficient. Representative methods and apparatus in accordance with this system are disclosed, for example, in French Patents 1,302,965 and 1,302,415. In such methods and apparatus, the particles of the coating substance are electrically charged and are deposited on the surface to be coated by the action of an electrostatic field. The deposited coating is then customarily subjected to heat or other bonding treatment to partly fuse the particles and bond them to the surface.

In the practice of electrostatic coating methods and apparatus of the type employed heretofore, difficulties often have been experienced in applying coatings having thicknesses exceeding certain limits. It has been found that, after the coating layer builds up to a particular depth on the surface being coated, further amounts of material in many cases are not retained on the surface. This has resulted from the fact that electrostatic charges carried by the individual coating particles are retained thereby subsequent to the time the particles are applied to the surface. An electric field is thus created which progressively increases in strength and is in opposition to the field attracting the particles to the surface. After a quantity of the particles is applied, a state of electrical equilibrium is reached and further particles are repelled from the surface.

Although attempts have been made to alleviate the foregoing difficulties, for some applications these attempts proved deficient in providing a smooth and uniform coating of particles having the requisite thickness. In addition, such attempts in many cases necessitated the use of comparatively costly auxiliary equipment and were not readily adaptable to mass production techniques.

One general object of this invention, therefore, is to provide a new and improved method and apparatus for electrostatically coating the surfaces of articles with divided substances.

More specifically, it is an object of this invention to provide such a method and apparatus which enables the application of a coating to the articles of substantially any desired thickness.

Another object of the invention is to provide an electrostatic precipitation process and apparatus which is of particular utility in the coating of a large number of articles in a rapid and straightforward manner.

A further object of the invention is to provide an electrostatic coating process for applying a smooth and uniform coating to the various articles.

Still another object of the invention is to provide a

novel electrostatic precipitation apparatus which is economical and thoroughly reliable in operation.

In accordance with the invention, in certain particularly advantageous embodiments, the article to be coated is provided with a plurality of layers of charged particles of a divided coating material in successive electrostatic precipitation steps. Subsequent to the first such step, the particles are electrically charged to a D.C. potential of a polarity which is opposite to that of the charge appearing on the article at the start of the subsequent step. The particles applied during the subsequent step are attracted by the oppositely charged article such that any tendency toward the establishment of a counter-field repelling further particles is ineffective to adversely affect the thickness of the applied coating. The coating is thus built up to a combined depth far exceeding the depths heretofore attainable.

In accordance with several good embodiments of the invention, a first layer of particles is applied to the article by means such as a first electrostatic spray gun which is connected to the negative terminal, for example, of a high voltage D.C. source. Thereafter, a second layer of particles is deposited on the article by means such as a second electrostatic spray gun connected to the positive terminal of either the same or a different source. The negative particles applied by the first spray gun effectively neutralize any tendency toward the establishment of a counter-field opposing the positive particles from the second spray gun. The resulting coating is thus of substantially increased thickness.

In accordance with another advantageous arrangement, all of the coating particles applied to the article are charged to a D.C. potential of the same polarity. Intermediate each successive application of particles, the article is subjected to an ionizing field which serves to reverse the polarity of the charge appearing thereon. At the time the article reaches a succeeding coating station, the layer of particles thereon is of a polarity opposite to that of the charge on the particles to be applied at the succeeding station. With this arrangement, all of the spray guns or other particle applying means may be connected to a voltage source having a single output polarity.

The foregoing and other objects and advantages of the invention will appear more clearly and fully from the following detailed description of various preferred embodiments, when read in conjunction with the accompanying drawings, in which:

FIGURE 1 is a diagrammatic representation of one illustrative embodiment of a coating apparatus for the execution of the improved method in accordance with the invention;

FIGURE 2 is a diagrammatic representation in general similar to FIGURE 1 but showing another illustrative embodiment of the invention; and

FIGURE 3 is a diagrammatic representation of the type shown in FIGURES 1 and 2 but depicting a further illustrative embodiment of the invention.

In the embodiment shown in FIGURE 1, an article A to be coated is advanced along a feed path indicated schematically by the arrow *f* past a pair of electrostatic precipitation stations **6** and **7** and a subsequent bonding station **8**. As the article A reaches the first station **6**, it is subjected to a series of charged particles of a finely divided coating substance from an electrostatic spray gun

4 of conventional construction. The gun 4 is supplied with the particles from a suitable container 3 through a conduit 9, as more fully described in the French patents referred to above. The particles are charged by the gun to a high D.C. potential of negative polarity which is derived from an electrostatic generator 1. The negative terminal of this generator is electrically connected to the gun by a conductor 25, while the opposite generator terminal is connected to ground.

The spray gun 4 mixes the finely divided coating particles with air or other carrier gas which is fed to the gun 4 through a line 10 connected to a suitable source (not shown). The carrier gas illustratively is at a pressure of about 1.5 p.s.i.g. The particles are discharged through the output nozzle of the gun in the form of a cloud of negatively charged particles within the carrier gas which is applied to the surface of the article A thereadjacent. This article is maintained at a potential different from that of the applied particles and illustratively is at ground potential. Because of the negative charges on the particles, an electrostatic field is established which causes the particles to adhere to the article surface and form a coating layer thereon.

As the negatively charged particles begin to build up on the surface of the article A at the coating station 6, the surface acquires a negative potential of gradually increasing strength which establishes a counter-field tending to repel further negatively charged particles from the spray gun 4. The rate of movement of the article along the feed path *f* is such that, by the time the repulsion of additional particles from the gun 4 becomes of significance, the article has moved past the station 6 toward the immediately succeeding station 7. At the time the article reaches station 7, the charge appearing on its surface is of negative polarity.

The precipitation station 7 includes an electrostatic spray gun 5 which is connected to the positive terminal of a high-voltage D.C. generator 2 by a conductor 26. In the embodiment illustrated in FIGURE 1, the opposite or negative terminal of the generator 2 is connected to ground, although in other good arrangements the negative terminal may be used to furnish the negative voltage to the spray gun 4 at the station 6. The spray gun 5 is supplied with particles of the coating substance through a conduit 9 connected to the container 3. These particles are charged to a high positive potential and are then mixed with carrier gas from a line 10. The particles are discharged from the nozzle of the gun 5 in the form of a cloud of positively charged particles within the carrier gas and are directed toward the article A thereadjacent.

The positively charged particles from the spray gun 5 are attracted by the negative charge appearing on the article A at the precipitation station 7 and settle over the layer of coating particles applied at the immediately preceding station 6. The positive charge on the particles first neutralizes the negative charge on the article surface and then begins to charge the surface positively. As the article leaves the station 7 and approaches the succeeding station 8, the coating thereon is of positive polarity and has a thickness which is approximately twice the thickness of the coating applied at the first station 6.

The arrangement is such that the negatively charged coating layer on the article A as it reaches the precipitation station 7 substantially reduces any tendency toward the establishment of an inverse electrostatic field of sufficient strength to repel the positively charged particles from the spray gun 5. Upon leaving the station 7, the coating has a considerably greater thickness and is highly uniform even on articles having irregular or complex shapes.

In the embodiment of FIGURE 1, as each coated article A leaves the precipitation station 7 and continues along the feed path *f*, the coating retains its positive charge for a length of time sufficient to hold the particles in place on the article surface until the article reaches the bonding station 8. The article is subjected to a conventional heat treatment at the station 8 by passing it through a suitable oven (not shown in FIGURE 1) which is effective to fuse the deposited particles and make the coating permanent.

In cases in which a coating of even greater thickness is desired on the articles A, each article is moved through a further electrostatic coating station, of a type similar to the station 6, for example, prior to the time it is advanced to the bonding station 8. At the further coating station, the article is exposed to the action of a negatively poled electrostatic spray gun to provide an additional layer of coating particles on the article surface. In a similar manner, the coating may be built up by advancing the article past successive alternately poled coating stations to substantially any desired thickness.

As indicated heretofore, the particles at the coating station 7 are charged with a positive D.C. potential and are thereafter mixed with the carrier gas from the line 10 prior to their discharge from the spray gun 5. With this arrangement, any tendency of the gun 5 to ionize the carrier gas molecules while positively charging the particles of coating material carried thereby is substantially reduced. Because of the absence of positively charged gaseous ions on the article at the station 7, the possibility of any counter-field being established between the ions and the coating particles is eliminated, thus enabling the realization of even thicker coatings on the finished article.

In the modified system shown in FIGURE 2, the articles A to be coated are led along the feed path *f* from an initial station 16, through three successive electrostatic precipitation stations 17, 18 and 19 and then to a subsequent station 20 at which the articles are subjected to heat or other bonding treatment. The electrostatic precipitation stations 17 and 19 are each provided with one of the spray guns 4. Each of these spray guns is connected by a conduit 9 to the container 3 containing particles of the divided coating substance and is also supplied with air or other carrier gas through the lines 10. The spray gun at the coating station 17 is electrically connected by the conductor 25 to the negative terminal of the high voltage D.C. generator 1, while the spray gun at the coating station 19 also is connected to the negative terminal of the generator by a conductor 27. The opposite or positive terminal of the generator is at ground potential.

The intermediate precipitation station 18 is provided with a set of ionizing electrodes 15, illustratively two in number, which are connected in parallel to the positive terminal of the high voltage D.C. source 2, the opposite terminal of which is grounded. The electrodes 15 are arranged to ionize the gas molecules of the ambient air thereadjacent to provide a plurality of positively charged ions in the vicinity of the article feed path *f*.

As a particular article A reaches the first precipitation station 17, the spray gun 4 thereat applies a group of negatively charged coating particles to the article surface in a manner similar to that described heretofore. As the particles begin to build up on the surface, a counter-field of gradually increasing strength is established, and the layer of particles on the surface exhibits a negative charge which is retained by the particles as the article moves from the station 17 to the succeeding station 18.

The negative charge appearing on the surface of the article being coated as it approaches the precipitation station 18 establishes an electrostatic field with the positively charged ions produced by the ionizing electrodes 15. These ions are electrostatically precipitated on the article surface at the station 18 and are effective to reverse the polarity of the charge on the article. As a result, the article carries a positive charge as it is advanced from the station 18 to the subsequent coating station 19.

The electrostatic spray gun 4 at the station 19 again applies a group of negatively charged coating particles to the surface of the article. These negatively charged particles are attracted by the positive charge applied at

the ionizing station **18** and settle on the article surface to provide a second layer of coating particles thereon. The particles from the spray gun at the station **19** first neutralize the positive charge on the article surface and then apply a negative charge which is retained until the article reaches the station **20** and is subjected to a bonding treatment to form the final finished coating. With this arrangement, an exceedingly smooth and uniform coating is applied to the article of substantially any desired thickness, and the equipment needed to perform the process is further simplified.

In cases in which an even thicker coating is desired, the articles may be advanced past an additional ionizing station, such as the station **18**, and then to a further negatively poled coating station prior to the final bonding treatment. The process is repeated a sufficient number of times to provide the desired coating thickness.

In the automatic installation schematically shown in FIGURE 3, a series of articles A' to be coated are advanced along a feed path *f'* by an overhead conveyor indicated generally at **12**. The overhead conveyor **12** is at ground potential and includes a plurality of electrically conductive hangers **12'** from which the articles A' are suspended. The articles are advanced by the conveyor toward a spray booth **13** at a first electrostatic coating station. The spray booth **13** includes an electrostatic spray gun (not visible in FIGURE 3) of a type similar to the spray gun **4** of FIGURE 1. This spray gun is connected by the conductor **25** to the negative terminal of the high voltage D.C. source **1** and is arranged to apply a layer of negatively charged coating particles to each article as it moves through the booth **13**.

The conveyor **12** then carries each of the articles A' through a second spray booth **14** at a subsequent coating station. The booth **14** is arranged to apply a layer of positively charged coating particles thereto from a spray gun (not visible in FIGURE 3) of the type shown at **5** in FIGURE 1. As the article leaves the booth **14**, its surface is provided with a coating of particles of substantially increased thickness. The coated article is then led by the conveyor **12** through a heat treating or fusing oven **11**, or other desired physical or chemical treating apparatus for permanently bonding the applied coating to the article.

The particles applied to the article in accordance with the various illustrated embodiments of the invention may be in either solid or liquid form. In certain arrangements, particularly good results are obtained with particles having either electrically insulating or low conductivity characteristics. As a result, the possibility of substantial current flow between the charged particles and an article being coated is maintained at a minimum, and the electrostatic adhesion between the article and the particles serves to affirmatively maintain the particles on the surface of the article as it moves between the successive precipitation stations.

Representative materials that have exhibited particular utility as coating particles include a wide variety of organic resins, such as pulverulent varnish, polyethylene, polypropylene, nylon, vinyl chloride, the cellulosics, acrylics, etc., the epoxies, several phenolic type resins, the silicones, and various inorganic materials. Examples of suitable materials of this latter class include talc, vitreous substances, metallic oxides, and phosphors.

Of course, it will be understood that the foregoing particle materials are but illustrative, and numerous other materials may be employed without departing from the spirit or scope of the invention as defined by the appended claims.

It will be apparent that various modifications other than those specifically referred to heretofore may be made in the improved coating process and apparatus. As an illustration, the various polarities applied to the particles during the successive precipitation steps may be reversed, if desired. It may be noted that the procedures of each of the illustrated embodiments include a plurality of successive electrostatic precipitation steps. Thus, with respect to the FIGURE 2 embodiment, for example, the articles to be coated are first subjected to an electrostatic precipitation of coating particles charged with one polarity, then to an electrostatic precipitation of gaseous particles charged with the opposite polarity, then with another electrostatic precipitation of coating particles of the first polarity, and so on. A further modification of this latter procedure includes the step of first precipitating gaseous ions on the article by means of ionizing electrodes such as the electrodes **15**, then precipitating a group of coating particles of a polarity opposite to that of the ions by one of the spray guns **4**, then again depositing ions of the first polarity on the article, then applying another group of coating particles charged with the same polarity as the first layer, etc.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What I claimed is:

1. In a method for electrostatically coating a surface with a divided substance, in combination, applying particles of the divided substance to said surface during an electrostatic precipitation step, thereafter applying particles of said substance to said surface during a subsequent electrostatic precipitation step, and electrically charging the particles applied to said surface during each of said steps to a D.C. potential, the polarity of the charge applied to the particles during said subsequent step being opposite to that of the charge appearing on said surface at the start of said subsequent step.

2. In a method for electrostatically coating a surface with a divided substance, in combination, subjecting the surface with particles of the divided substance during a first electrostatic coating step, thereafter subjecting said surface with particles of said substance during a subsequent electrostatic coating step, and applying a high D.C. charging potential to the particles during each of said steps, the polarity of the charge applied during said subsequent step being opposite to that of the charge appearing on said surface at the start of said subsequent step.

3. In a method for electrostatically coating a surface with a divided substance, in combination, subjecting the surface with particles of the divided substance during a first electrostatic coating step, thereafter subjecting said surface with further particles of said substance during a subsequent electrostatic coating step, and applying a high D.C. charging potential to the particles during each of said steps, the polarity of the charge applied during said subsequent step being opposite to that of the charge applied during said first step and appearing on said surface at the start of said subsequent step.

4. A method for electrostatically coating a surface with a divided substance, which comprises subjecting the surface to a plurality of successive electrostatic precipitation steps, establishing a D.C. charging potential between a charging member and said surface during each of said steps, the polarity of the charge established during a given step being opposite to that of the charge established during the immediately preceding step, and subjecting said surface with charged particles of the divided substance during at least two of said steps.

5. A method for electrostatically coating articles while advancing the same along a feed path, which comprises conveying a series of articles to be coated past a plurality of successive electrostatic precipitation stations disposed along said feed path, establishing a high D.C. charging potential between a charging member and said articles at each of said stations, the polarity of the charge estab-

lished at each station but the first being opposite to that of the charge established at the immediately preceding station, and subjecting each of said articles with charged particles of a divided coating substance at at least two of said stations.

6. In a method for electrostatically coating a surface with a divided substance, in combination, charging a first group of particles of the divided substance to a D.C. potential during an electrostatic precipitation step, applying said first group of charged particles to the surface to be coated during said precipitation step, thereafter charging a second group of particles of said substance to a D.C. potential during a subsequent electrostatic precipitation step, and applying said second group of charged particles to said surface during said subsequent step, the polarity of the charge on the particles applied during said subsequent precipitation step being opposite to that of the charge appearing on said surface at the start of said subsequent step.

7. A method for electrostatically coating a surface with a divided substance, in combination, charging a first group of particles of the divided substance to a D.C. potential of one polarity during a first electrostatic precipitation step, applying said first group of charged particles to said surface during said first step to provide a first coating layer charged to said one polarity, thereafter charging a second group of particles of said substance to a D.C. potential of the opposite polarity during a subsequent electrostatic precipitation step, and applying said second group of charged particles to said surface during said subsequent step to provide a second coating layer charged to said opposite polarity, whereby the polarity of the charge on the particles applied during said subsequent step is opposite to that of the charge appearing on said surface at the start of said subsequent step.

8. A method for electrostatically coating articles while advancing the same along a feed path, with a divided substance, which comprises continuously conveying a series of articles to be coated past a plurality of successive electrostatic precipitation stations disposed along said feed path; establishing a high D.C. charging potential between a first group of particles of the divided substance and the articles to be coated, mixing said first group of particles with a carrier gas and applying said first group of particles within said gas to the articles to be coated at a first of said precipitation stations; thereafter establishing a high D.C. charging potential between a second group of particles of said substance and said articles, mixing said second group of particles with a carrier gas and applying said second group of particles within the gas to said articles at a subsequent of said precipitation stations; the polarity of the charge established at each of said stations but the first being opposite to that of the charge established at the immediately preceding station; and heating the particles applied to said articles as they continue their movement along said feed path to a temperature sufficient to bond the particles to the articles.

9. In a method for electrostatically coating an article with particles of a divided substance, in combination, subjecting a selected surface of said article to electrostatically charged particles of the divided substance during a first electrostatic coating step to form a coating of given thickness on said surface, the particles forming said coating producing an electrostatic charge on said surface, and applying additional electrostatically charged particles of said substance to said selected surface during a subsequent electrostatic coating step to increase the thickness of said coating, the polarity of the charge on the particles applied to said surface during said subsequent step being opposite to that of the charge appearing on said surface at the start of said subsequent step, to thereby neutralize a tendency of the charge on said surface to repel said additional particles therefrom.

10. In an apparatus for electrostatically coating a surface with a divided substance, in combination, a plurality of electrostatic precipitation stations, spraying means at each of said stations for applying particles of the divided substance to said surface, first charging means operatively associated with the spraying means at one of said stations for subjecting the particles applied at said one station to a D.C. charging potential, and second charging means operatively associated with the spraying means at a subsequent of said stations for subjecting the particles applied at said subsequent station to a D.C. charging potential, the polarity of the charge on the particles applied at said subsequent station being opposite to the charge appearing on said surface as it is advanced to said subsequent station.

11. In an apparatus for electrostatically coating the surface of an article with a divided substance while advancing the article along a feed path, in combination, a plurality of coating stations disposed along said feed path, electrostatic spray means at each of said stations for applying particles of the divided substance to said surface, first charging means connected to the spray means at one of said stations for subjecting the particles applied at said one station to a D.C. charging potential, and second charging means connected to the spray means at a subsequent of said stations for subjecting the particles applied at said subsequent station to a D.C. charging potential, the polarity of the charge on the particles applied at said subsequent station being opposite to the charge appearing on said surface as it is advanced to said subsequent station.

12. In an apparatus for electrostatically coating articles with a divided substance while advancing the articles along a feed path, in combination, a plurality of coating stations disposed along said feed path, electrostatic spray means at each of said stations for applying particles of the divided substance to said articles, first charging means connected to the spray means at one of said stations for establishing a D.C. charging potential of one polarity between the particles applied at said one station and said articles, and second charging means connected to the spray means at the immediately succeeding station for establishing a D.C. charging potential of the opposite polarity between the particles applied at said succeeding station and said articles, whereby the polarity of the charge on the said particles applied at said succeeding station is opposite to the charge appearing on each of said articles as it is advanced to said succeeding station.

13. In an apparatus for electrostatically coating articles with a divided substance while advancing the same along a feed path, in combination, a conveyor for transporting a series of articles to be coated past a plurality of coating stations disposed along said feed path, means including an electrostatic spray gun at each of said stations for applying particles of the divided substance to a selected surface of each of said articles, first charging means operatively associated with the spray gun at one of said stations for subjecting the particles applied at said one station to a D.C. charging potential, and second charging means operatively associated with the spray gun at a subsequent of said stations for subjecting the particles applied at said subsequent station to a D.C. charging potential, the polarity of the charge on the particles applied at said subsequent station being opposite to the charge appearing on the selected surface of each of said articles as it is advanced to said subsequent station by said conveyor.

14. In an apparatus for electrostatically coating articles with a divided substance while advancing the same along a feed path, in combination, a conveyor for continuously transporting a series of articles to be coated past a plurality of coating stations disposed along said feed path, means including an electrostatic spray gun at each of said stations for mixing particles of the divided substance with a carrier gas and for applying the mixed particles to a selected surface of each of said articles, first charging means electrically connected to the spray gun at one of

said coating stations for subjecting the particles applied at said one station to a high D.C. charging potential, second charging means electrically connected to the spray gun at a subsequent of said stations for subjecting the particles applied at said subsequent station to a high D.C. charging potential, the polarity of the charge on the particles applied at said subsequent station being opposite to the charge appearing on the selected surface of each of said articles as it is advanced to said subsequent station by said conveyor, and means positioned along said feed path for heating the particles applied to said articles to a temperature sufficient to bond the particles to the articles.

References Cited

UNITED STATES PATENTS

2,152,077	3/1939	Meston et al.	117—17
2,287,837	6/1942	Smyser	117—17
2,328,577	9/1943	Oglesby	118—638 X
2,466,906	4/1949	Miller	117—17 X
2,867,542	1/1959	De Keyser et al.	117—34
2,952,559	9/1960	Nadeau	118—638 X
3,130,066	4/1964	Brady	117—93.43

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