March 17, 1959 R. C. JUVINALL **2,878,143**

ELECTROSTATIC COATING SYSTEM WITH A CURVED ARTICLE PATH INCLINED TO PRODUCE A CONSTANT RATE VERTICAL MOVEMENT OF THE ARTICLE

Filed Oct. 12, 1953 3 Sheets-Sheet 1

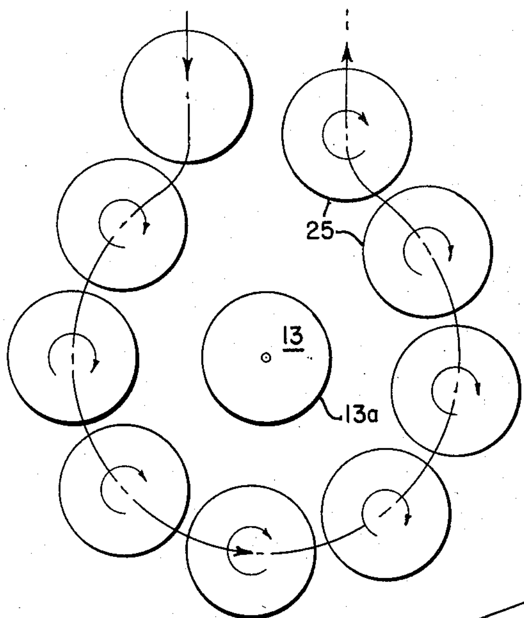

Fig. 1

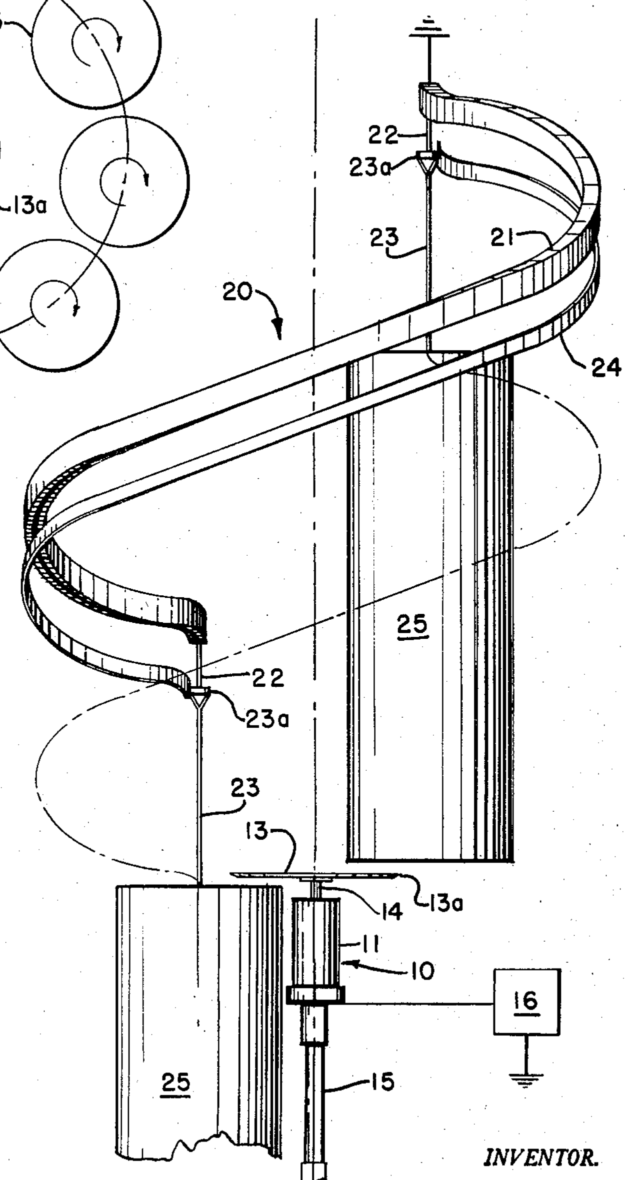

Fig. 2

INVENTOR.
ROBERT C. JUVINALL
BY Harry E. Downer
[signature]
Attorneys

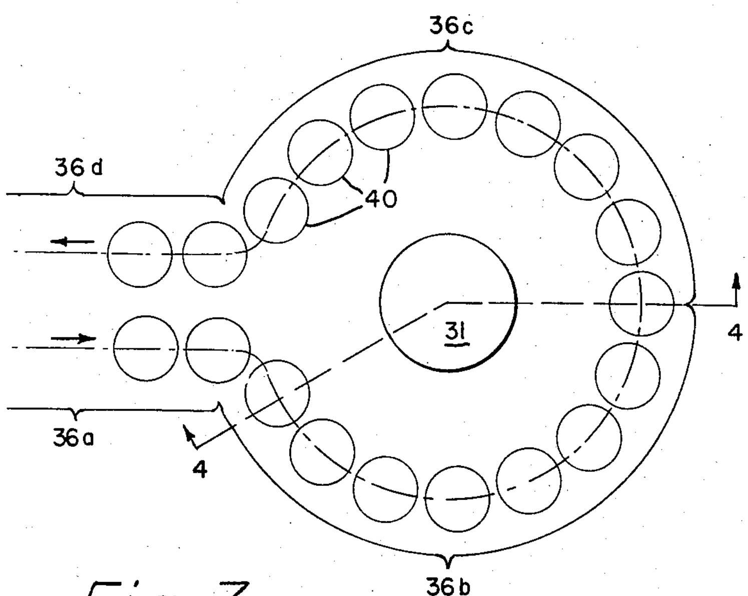

Fig. 3

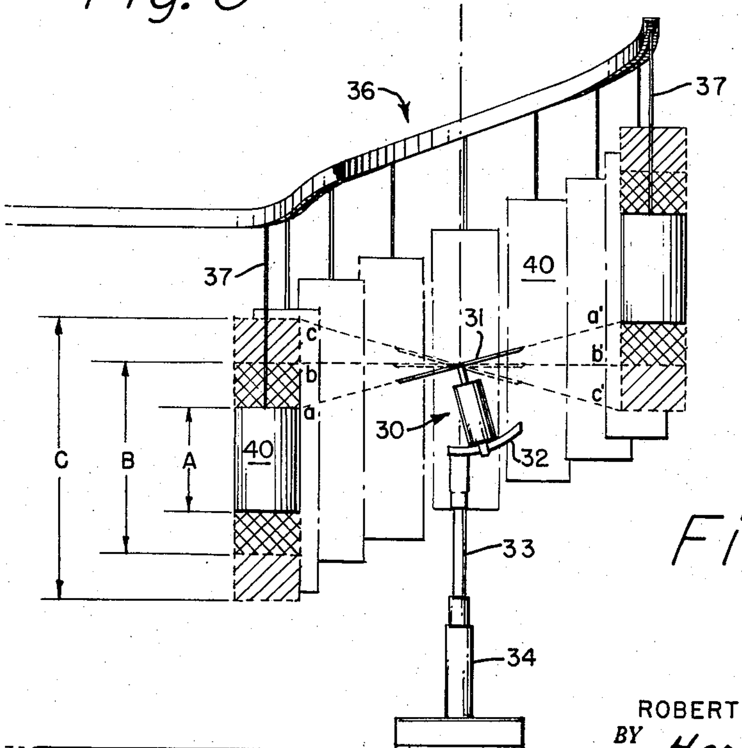

Fig. 4

INVENTOR.
ROBERT C. JUVINALL
BY Harry E. Downer
[signature]
Attorneys

March 17, 1959 R. C. JUVINALL 2,878,143

ELECTROSTATIC COATING SYSTEM WITH A CURVED ARTICLE PATH INCLINED TO PRODUCE A CONSTANT RATE VERTICAL MOVEMENT OF THE ARTICLE

Filed Oct. 12, 1953 3 Sheets-Sheet 3

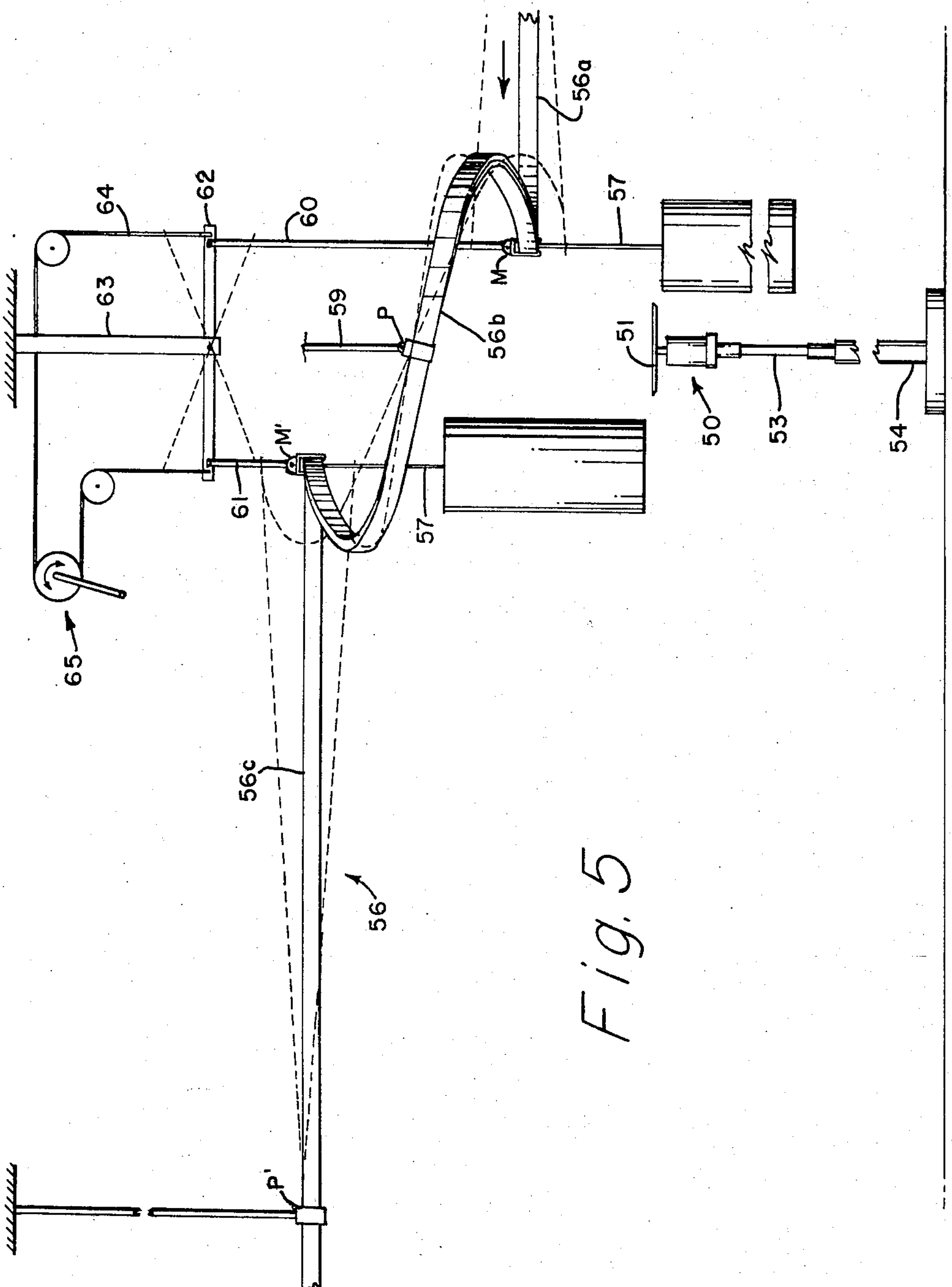

Fig. 5

INVENTOR.
ROBERT C. JUVINALL
BY Harry E Downer
Williams&Johnson
Attorneys

United States Patent Office

2,878,143

Patented Mar. 17, 1959

2,878,143

ELECTROSTATIC COATING SYSTEM WITH A CURVED ARTICLE PATH INCLINED TO PRODUCE A CONSTANT RATE VERTICAL MOVEMENT OF THE ARTICLE

Robert C. Juvinall, Indianapolis, Ind., assignor to Ransburg Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

Application October 12, 1953, Serial No. 385,379

5 Claims. (Cl. 117—93)

This invention relates to methods and apparatus for coating articles and particularly to a system readily adaptable for spray coating articles of different size.

The spray coating of articles of manufacture is a well known industrial art. In recent years electrostatic forces have been used in spray coating systems to efficiently effect deposition of spray particles on the articles and also to eliminate such objectionable features as turbulence and overspray resulting from the compressed air utilized in older systems for atomizing and moving the spray particles. Electrostatic coating systems are now in use which produce a spray of coating material particles which moves through a quiescent atmosphere radially outward from a relatively flat arcuate or more commonly an annular (i e. circular) atomizing zone. The term "quiescent atmosphere" does not mean absolute stillness of the atmosphere in the coating zone since possibly movement of the atomizer itself, the electric wind or other factors may result in some air movement. However, the coating zone is free of turbulent air blasts in the order of those associated with conventional air atomizing guns.

Methods and apparatus for taking advantage of the natural pattern of an annular spray (that is, a spray from a circular or annular atomizing zone) by running articles through the spray on a flat circular loop conveyor have been described in the copending application of C. C. Simmons, Serial No. 274,909, filed March 5, 1952, now Patent No. 2,808,343. Such systems have been very successfully used in the spray painting of a myriad of small articles such as door knobs, cans, ammunition and radio tubes.

A feature of the present invention provides a coating system producing a generally horizontal arcuate or annular spray as previously described for coating articles relatively lengthy in their vertical dimension. This is done by moving the articles by means of a conveyor having a helical track portion through the spray along a generally helical path concentric with the atomizing zone and at a pitch so coordinated with the length of the article that as the article moves through the coating zone its entire length passes through the spray and is coated. The axis of the helical portion of the conveyor is normally vertical and the articles may move through the coating zone guided by the conveyor along either an upward or a downward helical path. When the articles are generally cylindrical they are preferably rotated about their own axes a number of times during the coating operation to obtain a more uniform coverage of all surfaces of the articles.

A further feature of the invention provides a system using a single atomizing device producing an arcuate or annular spray which is adaptable for coating articles of different size in a simple and economical manner. One type of apparatus which embodies this feature includes an annular-edged atomizer whose edge is normally horizontal but which can be adjustably tilted or inclined so that the edge lies in a plane somewhat at an angle to the horizontal. This apparatus also includes a conveyor

having a first portion for moving articles in an upward (or downward) helical path about a vertical axis halfway about the atomizer and through approximately half the annular spray. The conveyor may also have a second portion for moving the articles the balance of the way around the atomizer and through the balance of the annular spray in a downwardly (or upwardly) inclined helical path. By changing the angle of inclination of the annular edge of the atomizer this system is readily adaptable to coating articles whose vertical dimensions vary to a considerable degree.

Another type of apparatus used for coating articles of different size includes a helical conveyor whose pitch or helix angle is flexible or adjustable. By providing means for conveniently changing its pitch, the helical conveyor may be easily adjusted to accommodate groups of articles having a wide variety of vertical dimensions.

The foregoing and other features of the invention are particularly described and shown in the following specification and attached drawings, wherein:

Fig. 1 is a diagrammatic plan view of one form of apparatus embodying the invention;

Fig. 2 is an elevational view of the apparatus shown in Fig. 1;

Fig. 3 is a diagrammatic plan view of a modified form of the invention;

Fig. 4 is a side elevational view taken along line 4—4 of Fig. 3 illustrating its adjustable features; and

Fig. 5 is a somewhat diagrammatic elevational view of a further form of the invention.

The invention is capable of many different forms. There have been shown in the drawings and will now be fully described three specific embodiments which it should be understood are illustrative of the principles of the invention without limiting the invention to the embodiments shown and described. The full scope of the invention is set forth in the appended claims.

Figs. 1 and 2 show an electrostatic coating system which utilizes a substantially flat disc type of atomizer shown generally as **10**. Atomizer **10** comprises a motor assembly in a housing **11**, and a substantially flat rotatable disc **13** mounted for axial rotation on a hollow shaft **14**. Housing **11** is supported on a hollow column **15** of insulating material such as polyester bonded fiberglass. Liquid coating material is fed through hollow shaft **14** and thence through a hole in the center of disc **13** to the upper surface of the disc. The entire atomizer **10** is maintained at a high electrical potential by electrical connection to the high voltage terminal of a voltage source **16**.

Disposed concentric with the axis of disc **13** is a helical conveyor **20** shown as of the overhead type. The conveyor **20** comprises a helical track **21** illustrated as an enclosed box-type channel conveyor track housing a continuous flexible linkage (not shown) which is moved at a controlled rate by power means (not shown) through the track. Depending at regular spaced intervals from the linkage within track **21** is a plurality of supports **22** from each of which is suspended a rotatable hanger **23**. Each hanger **23** includes a rotator ring **23***a* whose outer surface rests against the helical inner surface of rotator bar **24** which lies generally beneath and parallel to track **21**. Articles to be coated, shown as cylindrical ammunition canisters **25**, are hung axially from hangers **23**.

Track **21** makes an arc of approximatetly 300° about and concentric with atomizer **10**. At both the entrance and exit end of this arc the conveyor track is curved outwardly and joined to a conventional straight line conveyor system. The length of articles which the system can coat will be increased and also the smoothness of transfer of moving articles to and from the entrance and exit ends of helical track 21 will be facilitated by continuing the angle of inclination of the helix along the outwardly curved entrance and exit portions of the track and perhaps for a short distance along the otherwise conventional straight portions of the track leading up to and away from helical track 21. The extent of the arc which track 21 makes about atomizer 10 is controlled to some extent by the diameter of articles to be coated since provision must be made to prevent bumping or other interference between articles moving onto and from the helical track 21. It is apparent that the smaller the diameter of the articles the greater the arc which may be covered by track 21 without interference between articles passing into and out of the helical loop. However, it has been found that where the helix covers an arc of approximately 300°, and especially where the angle of inclination of the helix is continued along the outwardly curved entrance and exit portions of the track, a wide range of articles can be coated without interference between passing articles.

In the operation of the coating system just described activation of the conveyor will move canisters 25 beneath track 21 preferably beneath its lower end so that the canisters will move along an ascending path. As supports 22, hangers 23 and articles 25 are moved in a generally helical path about atomizer 10 contact between rotator ring 23*a* and the face of rotator bar 24 will cause the articles to be rotated about their axes many times as shown in Fig. 1 during their travel around atomizer 10 beneath track 21.

At the same time activation of the motor within the housing 11 will cause the rotation of shaft 14 and disc 13. Liquid coating material of the desired type is fed at a controlled rate through hollow shaft 14 to the upper surface of disc 13. Atomizer 10 is maintained at high potential while canisters 25 are grounded through hangers 23, supports 20 and track 21 and thus an electrostatic field with a high voltage drop is established between edge 13*a* of disc 13 and the adjacent surfaces of canisters 25, which field preferably has an average gradient in the order of 5000 volts per inch. The electrostatic field might also be established by maintaining the articles at high voltage and grounding the atomizer.

Liquid coating material fed to the surface of rotating disc 13 will flow as a thin film over the upper surface to disc edge 13*a*. The liquid material at or adjacent edge 13*a* will be atomized into the electrostatic field existing about disc 13 as a spray of finely divided charged liquid particles in an annular pattern generally in the plane of disc 13. These particles will tend to disperse one from the other and at the same time move generally along the lines of force of the electrostatic field to be deposited on the adjacent surfaces of canisters 25.

Conveyor 20 is normally maintained in a fixed position. The position of atomizer 10, which is adjustable, depends on the length of pendants 23. It is to be understood that the annular spray from atomizer 10 is diverging in the sense that the individual spray particles disperse one from another into a generally continuously widening band during movement of the spray from the atomizer toward articles to be coated. The greater the distance of travel between the edge of the atomizer and the articles, the wider the band of coating material deposited on articles. The distance between disc edge 13*a* and the surface of canisters 25 will, therefore, influence the width of the spray band deposited on canisters 25.

Disc 13 of atomizer 10 should be located in a substantially horizontal plane slightly below the upper edge of canister 25 as the canister enters the coating zone. The vertical distance between disc 13 and the upper edge of canister 25 in this position may be about one half the width of the spray band which will be deposited on the surface of the canister. The angle of inclination of track 21 should be such that canister 25 leaves the coating zone with the lower edge of the canister a distance of about one half the deposited spray band width above the plane of disc 13. In the embodiment shown in Figs. 1 and 2 the helical angle of inclination of track 21 is approximately 20°. As articles move upwardly beneath track 21 and are rotated many times about their axes the entire surface of each article will be brought in coating relation with edge 13*a* of disc 13 and each article thereby receives a uniform coating over its entire surface.

The system just described is especially adapted to the spray coating of identical articles or of articles having approximately like vertical dimensions substantially greater than that of an annular spray. The system is most effective for coating articles having a vertical dimension approximately equal to the vertical rise given articles by track 21 less the vertical width of the spray band from atomizer 10 deposited on the articles.

Figs. 3 and 4 illustrate one flexible coating system embodying features of the invention which may be used to spray coat groups of articles in which the vertical dimensions of the articles vary between groups. There is shown an atomizer 30 having a motor assembly, shaft and disc 31 substantially as previously described. Atomizer 30 is, however, arranged on an adjustably tiltable support 32 so that the center of the upper face of the disc remains at all times fixed, that is, atomizer 30 is tiltable about a point corresponding with the center of the upper surface of disc 31. Support 32 rests on an insulating column 33 whose height is adjustable within a stand 34. Atomizer 30 is maintained during coating operations at a high electrical potential in relation to the articles by a voltage source (not shown).

Above atomizer 30 is a grounded conveyor track 36 having four track portions. Track portion 36*a* is a substantially straight horizontal segment by which articles to be coated are moved toward and into the coating zone. Track portions 36*b* and 36*c* guide the articles through the coating zone. Portion 36*b* extends in an arc of approximately 160° about a vertical axis passing through the center of disc 31 and this track portion follows an upwardly inclined substantially helical path at an angle which is shown as 20° to the horizontal. The lower end of portion 36*b* joins portion 36*a* and its upper end joins portion 36*c* and at these ends track portions 36*a* and 36*b* depart somewhat from a truly helical path to provide a smooth transfer of articles from the one track portion to the other. While track portion 36*a* is generally straight and horizontal along most of its length, the smoothness of transfer of articles to helical track portion 36*b* is facilitated by curving the entrance part of the track leading up to portion 36*b* and by continuing the angle of inclination of the helix, i. e., 20° to the horizontal in the embodiment shown, along the curved part and for a short distance along the straight part of track portion 36*a*.

Track portion 36*c* extends in an arc of approximately 160° about a vertical axis passing through the center of disc 31 and follows a downwardly inclined substantially helical path at an angle shown as 20° to the horizontal. Portion 36*d* is a substantially straight horizontal segment which may lie parallel to track portion 36*a* by which articles are moved out of the coating zone. As is apparent, articles having been propelled along portions 36*a* and 36*b* reach the point between track portions 36*b* and 36*c* and then follow a path which is a mirrored reflection of their previous path since track portions 36*c* and 36*d* are the opposite numbers of portions 36*b* and 36*a* respectively. Suspended from article hangers 37, articles 40 moving in seriatim beneath track portion 36*b* will rise at a substantially uniform rate and then descend at the same rate as they move beneath portion 36*c*. At the same time the articles will be axially rotated many times during their travel through the coating zone by suitable apparatus (not shown) so that all portions of the vertical article surface are presented toward atomizer 30 during passage of the articles through the coating zone.

With disc 31 positioned in a horizontal plane (whose distance below horizontal track portions 36*a* and 36*d* will depend upon and be approximately equal to the vertical dimension of article hangers 37), the system will be adapted to spray coat articles whose vertical dimension is approximately equal to the rise given the articles by track portion 36*b*. In Fig. 4 this dimension is shown as B and it is noted that with disc 31 horizontal the disc will lie in the same plane as the top edge *b* of an article of height B as the article enters track portion 36*b*. The disc will also lie in the same plane as the bottom edge *b'* of the article as the article leaves track portion 36*b*.

When it is desired to spray coat a group of articles having a somewhat smaller vertical dimension such as dimension A shown in Fig. 4, the length of hangers 37 may be increased so the centers of the articles lie in the same horizontal plane as that of articles of the size previously described. Thus the hanger length will be increased over its previously required length a distance equal to one half the difference between dimensions B and A (or alternatively disc 31 may be raised this distance as by increasing the length of column 33). At the same time disc 31 may be tilted about its center by adjustment of support 32 at such angle that disc 31 lies in an inclined plane which passes through the nearest point to the disc edge of the article's upper edge as the article enters the coating zone, that is, as the article passes from track portion 36*a* to 36*b*. This arrangement will automatically position disc 31 so that its plane will also pass through the nearest point of the article's lower edge *a'* when the article is at its highest elevation, that is, passing from track portion 36*b* to 36*c*.

Likewise, when it is desired to coat a group of articles having a somewhat greater vertical dimension such as dimension C shown in Fig. 4, the length of hangers 37 may be decreased so that the center of the articles will remain in the same horizontal plane as that of articles of the two previous sizes described (or alternatively column 33 shortened a distance of one half C minus B if it is desired to use the same hangers). Atomizer 30 may be tilted so that disc 31 will lie in an inclined plane passing through the nearest point to the disc of the article's upper edge *c* as the article enters the coating zone. This arrangement will position the disc so its plane will also include the nearest point on lower edge *c'* of the article when it is at its highest elevation. It is apparent that similar adjustments to those above described will readily adapt atomizer 30 to the coating of groups of articles with vertical dimensions varying within a substantial range.

It has been found that the uniformity of coating tends to decrease as the disc is tilted. In many instances when the angle of tilt is more than 30° to the horizontal objectionable non-uniformities result, although for certain types of spray coating tilting the disc at an angle of greater than 30° may produce satisfactory results. While the angle of inclination of track 21 has been shown as 20° to the horizontal and such angle permits the system to spray coat articles with widely varying vertical dimensions, it will be apparent that maximum flexibility or adaptability of the system will be achieved when the angle of inclination of track 21 equals or is greater than the maximum angle to which disc 31 may be tipped and still obtain commercially acceptable coatings. Under many industrial conditions maximum flexibility is obtained by a conveyor track having an angle of inclination of approximately 30° to the horizontal since, under such conditions, 30° represents about the maximum permissible angle of tilt of disc 31.

Fig. 5 illustrates another flexible coating system embodying further features of the invention, which system may be used to spray coat groups of articles whose vertical dimensions vary between groups. There is shown an atomizer 50 having a motor assembly, a shaft and an atomizing disc 51 generally as already shown and described. Atomizer 50 is supported on an insulating column 53 whose height is adjustable within a stand 54. As previously described the atomizer is maintained during coating operations at high potential in relation to the articles to be coated.

Somewhat above atomizer 50 is a grounded conveyor track 56 with two substantially straight segments 56*a* and 56*c* along which articles are moved respectively into and out of the coating zone. Between track portions 56*a* and 56*c* lies helical track portion 56*b* forming a helical loop encompassing an arc of approximately 330° about a vertical axis coincident with the axis of atomizer 50 and disc 51. The articles to be coated move along track portion 56*b* as shown following an upwardly inclined substantially helical path. The lower entrance and upper exit ends of track 56*b* depart somewhat from a true helical path to provide a smooth transfer of articles from track portion 56*a* to 56*b* and from 56*b* to 56*c* respectively.

In any given position, such as the position shown in the unbroken lines in Fig. 5, helical track portion 56*b* serves to move articles of given vertical dimension into coating relation with atomizer 50 so as to achieve a complete coating of the entire vertical length of the article. Thus in any predetermined position a coating system using conveyor 56 will operate substantially as with conveyor 21 previously described.

However, conveyor 56 is flexible and is provided with means for readily changing the pitch of its helical track portion 56*b*. By adjusting the angle of incline of the helical article path the system can be made to accommodate groups of articles of varying vertical dimension. Various means may be employed to flex or adjust the conveyor track. Relatively small forces have been found sufficient to effect a substantial adjustment in the pitch of a helical conveyor track. For example, a seven foot diameter helical track was constructed of standard four inch I beam (weighing 7.7 pounds per foot) by forming the beam into a flat circular loop and then flexing the beam to any desired pitch. A force of 100 pounds exerted on opposite ends of this flat loop was found to produce a pitch of approximately five feet; this force is materially less than that produced by the weight of the track itself. If the track is constructed to operate as a true helical spring, as the pitch is changed by vertically depressing or extending the track the helix angle will change uniformly along the entire length of the track.

It has been found desirable to fix the helical portion of the conveyor track at one point and to flex or adjust the balance of the track about this fixed point. The fixed point may be located anywhere along the helical track. However, it will be found advantageous in commercial practice to pivot the track about a point which will permit all groups of articles, regardless of their vertical dimensions, to be coated without changing the position of the atomizer. The selection of the fixed point depends in large measure on the desired positioning of the articles on the conveyor. For example, if it is required to use the same length of hanger, such as hanger 57 as shown, for all articles regardless of their length the helical track may be made to flex about a fixed lower end. If it is desired to suspend the articles so that their lower extremities are at the same elevation regardless of the article's vertical dimension, the helical track may be made to flex about a fixed upper end. It has been found in many commercial installations that various sizes of article hangers are used to maintain a relatively constant elevation of the approximate centers of all sizes of articles. In such installations the atomizer can be held at a fixed position if the helical track is pivoted about a fixed midpoint as shown in Fig. 5.

In Fig. 5 the midpoint of helical track portion 56*b* is rigidly attached to a collar which is pivotable about a closely adjacent point P by means of a conventional pin and bearing. Point P is held in fixed position by means of a suitable support such as member 59 which is rigidly attached to a suitable supporting surface (not shown). Track 56 is constructed so that without a force being exerted to depress or extend the pitch of helical portion **56b** the track will have a normal helix angle of approximately 13°. In this "unflexed" position track **56** is supported at fixed point P (previously described) and two fixed points P', only one being shown at the left hand extremity of track portion **56c**. A similar fixed point P' is not shown but is located at the right hand extremity of track portion **56a**. In addition to these three fixed points track **56** is also supported at two movable points M and M' shown as located adjacent the entrance and exit ends respectively of track portion **56b**. Pivotable members **60** and **61** connect to track **56** at movable points M and M' respectively to support the track in its predetermined position.

Members **60** and **61** are also connected at their ends opposite to their connection to track **56** to a pivot bar **62** which is pivotably mounted at its center about a fixed member **63** rigidly attached to a suitable supporting surface as shown. A cable **64** may be employed to maintain the ends of pivot bar **62** in any given position which position, however, may be altered as by a suitable drum and crank mechanism shown diagrammatically at **65**. As the drum and crank are turned in a clockwise direction the end of pivot bar **62** attached to support member **61** will be moved upwardly and the end of pivot bar **62** attached to support member **60** will move downwardly a like distance, thus increasing the pitch of helical track **56b**, raising track portion **56c**, and depressing track portion **56a**. With the increased pitch or helix angle conveyor **56** is now adjusted to accommodate articles with a greater vertical dimension than could be accommodated with the conveyor in its normal or unflexed position. In a similar manner, if articles of lesser vertical dimension are to be accommodated the helix angle may be decreased by simply turning the crank of mechanism **65** in a counter-clockwise direction.

Since movable points M and M' lie at all times exactly the same distance from fixed point P it is seen that the helix angle will be always changed uniformly along the entire extent of track portion **56b**. However, in one embodiment which has been successfully used it was found desirable to provide two movable points of support for helical track **56b** on each side of its fixed midpoint in order to provide more points of support for the conveyor and to insure a uniform helix angle through the entire length of portion **56b**. The desired number of points of support is dependent on the relative rigidity of the track and on the accuracy required in retaining the conveyor's true helical form. In one helical conveyor with an enclosed box-type channel as illustrated in Fig. 5 which was constructed and supported at one fixed and four movable points it was found that in flexing the track it retained a uniform helix angle throughout its extent within limits of one degree.

I claim:

1. Apparatus for coating an article comprising an atomizing device having a substantially planar extended curved atomizing edge, means for supplying liquid coating material to said atomizing edge at a controlled rate for atomization therefrom as a spray of finely divided liquid particles, means including a source of high voltage for charging the spray particles in relation to an article to be coated, means including a conveyor track having a helical track portion extending at an angle to the horizontal for moving the article in coating relation to the atomizing device and for changing the elevation of the article relative to the device during the coating operation at a substantially constant rate, and means for inclining the plane of said atomizing edge in relation to the axis of said helical track portion.

2. A method for electrostatically coating a plurality of articles from exteriorly thereof, comprising projecting spray particles from a source radially in a pattern expanding generally in a single plane, carrying articles to be coated in a path extending a substantial distance around said source, said path being inclined to the horizontal and to the plane of the spray pattern and having a configuration to produce vertical movement of the articles through said pattern at a substantially constant rate, and creating an electrostatic charge differential between the spray particles and the articles electrostatically to deposit the particles on the articles.

3. A method for electrostatically coating a plurality of particles from exteriorly thereof, comprising projecting spray particles from a source radially in an expanding disc-like pattern, carrying articles to be coated in a path extending a substantial distance around said source, said path being inclined to the horizontal and to the plane of the spray pattern and being helical in shape to produce vertical movement of the articles through said pattern at a substantially constant rate and creating an electrostatic charge differential between the spray particles and the articles electrostatically to deposit the particles on the articles.

4. A method for electrostatically coating a plurality of articles from exteriorly thereof, comprising projecting spray particles from a source radially in an expanding disc-like pattern, carrying articles to be coated in a path extending substantially entirely around said source, said path being inclined to the horizontal and to the plane of the spray pattern and being helical in shape to produce vertical movement of the articles through said pattern at a substantially constant rate and creating an electrostatic charge differential between the spray particles and the articles electrostatically to deposit the particles on the articles.

5. In a method of electrostatically coating a plurality of articles from exteriorly thereof wherein the articles are moved successively around an atomizing device projecting spray particles from a source radially in a pattern expanding generally in a single plane and an electrostatic charge differential is created between the projected spray particles and the articles to be coated electrostatically to deposit the particles on the articles, the step of changing the elevation of the article relative to the atomizing device at a substantially constant rate during the spraying operation while maintaining the atomizing device at a fixed elevation.

References Cited in the file of this patent

UNITED STATES PATENTS

1,855,869	Pugh	Apr. 26, 1932
2,168,917	Perkins	Aug. 8, 1939
2,373,638	Perkins	Apr. 10, 1945
2,378,025	Melton et al.	June 12, 1945
2,408,143	Huebner	Sept. 24, 1946
2,442,986	Ransburg	June 8, 1948
2,456,853	Arbron	Dec. 21, 1948
2,602,415	Hall	July 8, 1952
2,658,472	Ransburg	Nov. 10, 1953
2,685,536	Starkey	Aug. 3, 1954