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W. A. STARKEY
METHOD AND APPARATUS FOR
ELECTROSTATIC COATING
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Fig. 1.

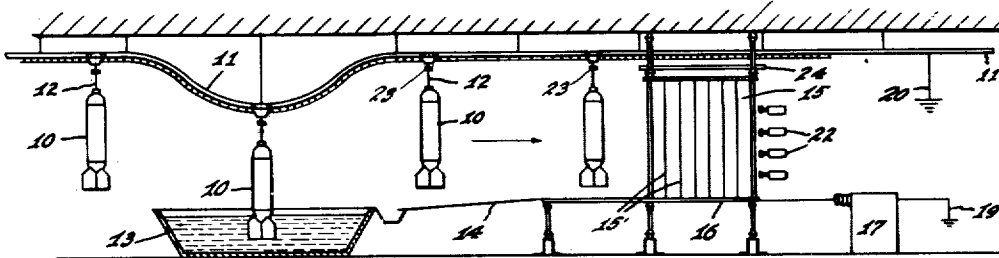


Fig. 3.

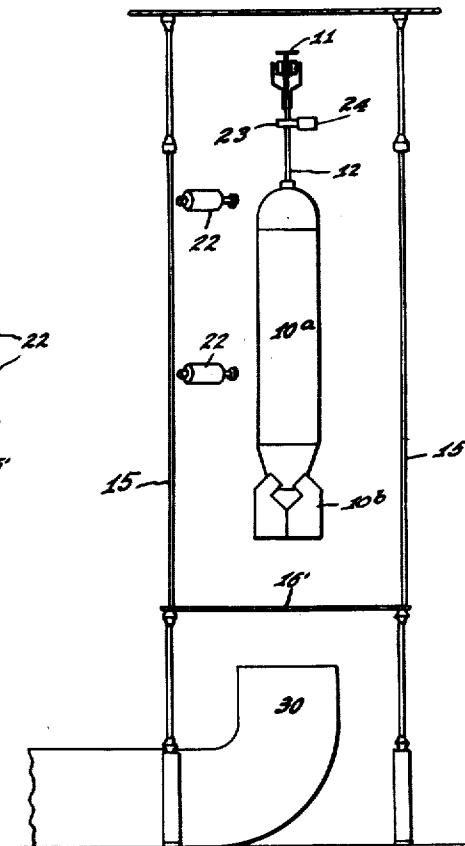
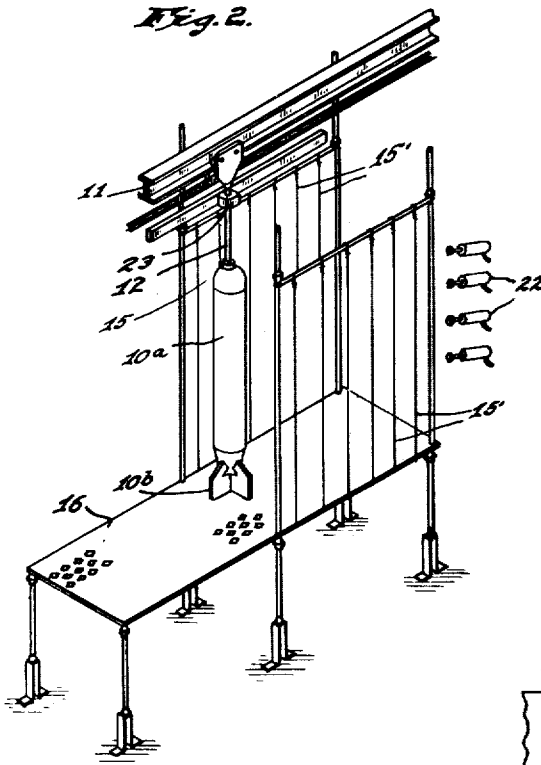


Fig. 2.



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METHOD AND APPARATUS FOR
ELECTROSTATIC COATING

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This invention relates to the coating of articles, and particularly to improvements in the utilization of electrostatic forces in the coating of articles. Generally, there have been two different methods for coating articles with the aid of an electrostatic field. In the first of these methods, exemplified in U. S. Patent No. 2,334,648, an electrostatic field is employed to cause finely divided particles of coating material to move to and become deposited upon the article to be coated; while in the second method, shown in U. S. Patent No. 2,359,476, the article is first treated, as by dipping, with an excess of coating material and the electrostatic field is employed as a "detearing" agent to remove such excess. These two methods differ radically in that in the first method the field acts to cause particles of coating material to move toward the article, while in the second method the field functions to produce particle movement in the diametrically opposite direction, or away from the article.

Determining which of the two methods above mentioned to employ in any given case usually requires a consideration of several factors one of which is frequently the shape of the article to be coated. Generally, it is desired to obtain a coating as uniform in thickness as possible; and some articles are so shaped that the electrostatic deposition of coating material will result in greater uniformity of coating thickness than will the dip-and-detear method, while with articles of other shapes the reverse may be the case. For example, many articles possessing recesses or depressions, may be coated more uniformly by the dip-and-detear method than by the method of electrostatic deposition. On the other hand, as in the case of articles possessing extended surfaces free from recesses or projections, or in the case of articles having relatively sharp edges or corners from which the coating material tends to draw away, it is frequently possible to obtain greater uniformity of coating thickness by electrostatic deposition than by applying an excess of coating material and subsequently detearing electrostatically. In the case of still other articles, it is difficult to obtain a coating of satisfactory uniformity by either method.

My invention is concerned especially with articles of the last type mentioned, it is my primary object to facilitate the coating of such articles

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and to increase the uniformity of coating thickness. More specifically, it is my object to obtain the benefits of the action of an electrostatic field in the coating of articles which, because of their shape, have been coated only with difficulty by the use of an electrostatic field in any manner heretofore proposed. A further object of my invention is to obtain the economy of operation which characterizes the dip-and-detear method while at the same time securing a greater uniformity of coating thickness than has previously been attainable by the method.

In carrying out my invention, I perform electrostatic deposition and electrostatic detearing simultaneously, employing an electrostatic field both to remove coating material over portions of an article coated with an excess of coating material and to propel coating material in finely divided condition towards other portions of the article. More specifically, I apply an excess of coating material to those portions of the article best adapted to coating by the dip-and-detear method, and I then support the article in an electrostatic field into which additional coating material in finely divided condition is introduced. The field acts simultaneously to detear excess coating material from the initially coated portion of the article and to precipitate the finely divided coating material upon the initially bare portions of the article as well as upon any previously coated sharp-edge portions from which the coating tends to draw away in the ordinary detearing operation. Proper construction of the electrode system used in creating the field will facilitate the simultaneous detearing and deposit of coating material. In one embodiment of my invention, I employ liquid coating material deteared from one portion of the article to coat electrostatically another portion of the article.

The accompanying drawing illustrates my invention: Fig. 1 is a diagrammatic side elevation of a complete coating apparatus; Fig. 2 is an isometric view of a suitable form of electrode system; and Fig. 3 is an end elevation of a modified form of apparatus.

The articles illustrated in the drawing as being coated by the apparatus are bombs having an elongated cylindrical body 10a terminating at one end in a rounded nose and provided at the other end with tail fins 10b extending radially

and axially. Such a bomb will serve as an example of articles of the type to which the present invention is especially applicable, as the application to it of a uniform coating by a method involving either electrostatic detearing or electrostatic deposition alone presents difficulty. In coating the bomb by ordinary electrostatic deposition methods there is a tendency for the coating material to be less heavily deposited on the inner or root portions of the fins and on those portions of the body lying adjacent the fin-roots than on other portions of the bomb. If the bomb were completely coated with an excess of coating material and then subjected to an electrostatic detearing operation, a relatively long time would be required for the excess to flow down the elongated body to points at which detearing would occur, and there would be a tendency for the coating material to draw away from the edges of the fins at the upper portions thereof. The bomb, however, is well suited for the application of the present invention.

In employing the present invention, I provide a conveyor 11 from which the bombs 10 are adapted to be hung by hangers 12 of electrical conducting material. The conveyor 11 conveys the bombs over a dip tank 13, and has a depressed portion above such dip tank so that the fins of the bomb will be immersed in and removed from a bath of coating material maintained in the tank. From the dip tank, the conveyor 11 extends over a drain board 14 and into and through a zone in which the bombs are subjected to the action of an electrostatic field maintained between them and an electrode which, in the specific form shown, has three sections—namely, a pair of vertically disposed sections 15 located on opposite sides of the path of bomb travel and a horizontal section 16 disposed beneath the bombs.

A substantial electrical potential difference is maintained between the bombs 10 and the electrode-sections 15 and 16.

Conveniently, the electrode-sections 15 and 16 are electrically interconnected with each other and connected as a unit to one terminal of a high-voltage source 17, the other terminal of which is grounded as indicated at 18. The conveyor 11 is grounded, as indicated at 20, as are also the bombs 10 which are electrically connected to the conveyor through the conducting hangers 12. Desirably, the high-voltage source 17 provides a unidirectional current and serves to maintain between the bombs and the electrode an electrostatic field having an average potential gradient of the order of 10,000 volts per inch.

Mounted in position to discharge between at least one of the vertical electrode sections 15 and the bombs passing in association therewith are one or more spray guns 22 adapted to discharge into the field a supply of liquid coating material in finely divided condition. To promote uniformity in the coating of the body and nose of the bomb, each of the hangers 12 may be rotatably supported from the conveyor 11 and provided with an integral spinner 23 adapted to bear on a stationary spinner rail 24 to rotate the hangers and bombs as they pass through association with the electrode.

In the operation of the apparatus above described, the fins of the bomb are coated with an excess of coating material as a result of their passage through the dip tank 13. As the bombs enter into association with the electrode, the electrostatic field existing over the fins, and especially at the lower edges of the fins, causes excess

coating material thereon to be repelled from the fins and attracted toward the electrode. At the same time, the finely divided coating material discharged into the field from the guns 22 becomes charged and attracted to the cylindrical body and nose portions of the bomb. I have found that the effectiveness of the electrostatic field in producing movement of coating-material particles toward the initially uncoated surface-portion of the bomb and away from the initially coated surface portions can be increased by proper construction of the electrode system. Specifically, if those sections of the electrode opposite the initially uncoated portions of the article—i. e., in this case the electrode-sections 15—embody a limited number of fine wires 15' or are otherwise constructed to present sharply curved surfaces toward the article, the transfer of coating material to the article will be promoted. On the other hand, if the electrode section 16 opposite the initially coated portion of the article is formed to present toward the article relatively extended surfaces, the transfer of excess coating material away from the initially coated portion of the article will be furthered. However, when the detearing section of the electrode is located directly beneath the initially coated surface-portion of the article as is the section 16 in the structure of Figs. 1 and 2, the character of the surface or surfaces it presents toward the article is relatively unimportant.

If the electrode is constructed in the preferred manner just described, the potential gradient in that portion of the field lying between the lower end of the bomb and the detearing electrode-section 16 will be greatest adjacent the lower edges of the fins 10b; while in the field-portions, between the bomb and the electrode-sections 15, the greatest potential gradient will exist adjacent the fine wires 15'. Desirably, the potential gradient of the field adjacent the wires 15' is great enough to produce ionization in the regions surrounding such wires in order that coating-material particles entering such regions will become charged similarly to the electrode and will be repelled therefrom and attracted toward the bomb.

In the modified form of the invention illustrated in Fig. 3, I provide an air duct 30 arranged to discharge upwardly beneath the bottom, or detearing, electrode-section 16'. In this instance, the electrode section 16' disposed beneath the articles, instead of being formed to present relatively extended surfaces toward the article, is preferably constructed, like the sections 15, with a limited number of fine wires around which ionizing zones exist.

The particles of coating material deteared from the lower portion of the article will initially possess charges similar in sign to that of the article, and hence will be repelled therefrom and attracted toward the electrode. However, as they enter the ionizing zones surrounding the wires embodied in the electrode their charges will be reversed, and they will be urged away from the electrode and toward the article. The reionized particles will hence move upwardly under the joint influence of the field and the upward current of air from the duct 30. While some of the upwardly moving particles will be redeposited on the initially coated lower portion of the article, many will be carried past it and deposited on the initially bare upper portion. While the redeposition of some coating material on the lower portion of the article may prolong the operation,

the coating material which is deteared and subsequently deposited in the initially bare upper portion represents a clear saving and makes it possible to reduce the quantity of coating material discharged from the guns 22.

Normally, when articles shaped like the fins of the bombs 10 are dipped or otherwise coated with an excess of coating material and then permitted to drain, the coating material tends to draw away from sharp edges at the upper portion of the article, thus leaving those edges inadequately coated or "blued." To an extent, this is especially true when the article drains in an electrostatic field. But when, with the initially applied coating material still fluid enough to drain, finely divided coating material is introduced into the field for attraction to the article some of such material will become deposited on those edge portions which otherwise would be "blued" and will blend with the previously deposited material to produce a coating of satisfactorily uniform character. Adjacent sharp edges at which the tendency to "blue" is especially pronounced, the potential gradient of the field will ordinarily be relatively steep; and, provided that such potential gradient is not sufficiently steep to create an ionizing zone, the coating material will tend to be deposited mostly heavily on such sharp edges. By thus providing for the deposition of coating material more or less selectively upon sharp edges which tend to "blue" in the practice of the dip-and-deteare process, my invention overcomes the weaknesses of that economical coating method.

Two factors, respectively the adhesion of the coating material to the article-surface and variations in the potential gradient at different points in the field, contribute to the success of simultaneous electrostatic detearing and electrostatic deposition. The tendency of deposited coating material to adhere to the article-surface opposes the electrostatic forces which, because the article and coating material in contact with it are similarly charged, tend to repel the coating from the article. Where the coating material is inordinately thick, as at the bottom portions of a dipped article, the electrostatic forces of repulsion may readily be made great enough to overcome the tendency toward adherence in the surface portions of the coating film, with the result that the excess coating material will be deteared. However, where the coating is not inordinately thick, the forces of adhesion prevail over the electrostatic forces and detearing does not occur. Thus, the finely divided material electrostatically precipitated on the initially bare bomb-body 10a will remain there even though it acquires a charge the same in sign as that of the bomb, while the excess material on the fins 10b will be deteared.

The variation in potential gradient at different points in the field also contributes to the creation of a coating film upon the initially bare bomb-body while excess coating material is simultaneously being deteared from the fins. As set forth above, the preferred electrode system embodies fine wires 15' or other sharply curved surfaces opposite the initially bare, and relatively extended surfaces of the bomb-body. As a result, in that portion of the field between the electrode sections 15 and the bomb the potential gradient adjacent the electrode sections may be made great enough to ionize and repel coating-material particles approaching the electrode while the potential gradient adjacent the surface of the bomb-body will not be sufficient to reionize the

particles until after they have impinged upon and become adhered to the surface. If the detearing electrode-section is provided with relatively extended surfaces, the potential gradient adjacent such surfaces will be relatively slight, and deteared particles of coating material will strike and adhere to the electrode before acquiring a charge similar in sign thereto.

In Figs. 1 and 2 I have shown the detearing electrode-section 16 as being longer than the electrode-sections 15 and as extending closer to the dip-tank 13 than do the sections 15. Such an arrangement is indicated when the time required to detear the initially coated portion of the article exceeds that required to coat the initially uncoated portion. When such a situation exists, it is usually preferable that the electrostatic detearing operation be started before the deposition operations in order that both may be terminated at approximately the same time.

I claim as my invention:

1. In a method of applying a liquid coating to an article, the steps of applying an excess of liquid coating material to the bottom portion only thereof, electrostatically removing excess coating material from the bottom portion of the article by subjecting such bottom portion to the action of an electrostatic field of detearing character creating in such field an upwardly directed air stream carrying finely divided deteared coating material upwardly toward the uncoated portion of the article, and causing such finely divided coating material to be electrostatically deposited on the initially uncoated upper portion of the article by maintaining an electrostatic field of ionizing character thereover.

2. In apparatus for applying a liquid coating to an article, a support for the article, means for applying an excess of liquid coating material to the bottom portion of the article, an electrode disposed in spaced relation to a partially coated article on said support, said electrode having a detearing section disposed below the article and one or more discharge sections disposed at the sides of the article, means including a source of high-voltage electricity for maintaining an electrostatic field between the electrode and article, and means for introducing finely divided particles of coating material in such field between the article and the discharge electrode-sections.

3. The invention set forth in claim 2 with the addition that said discharge electrode-section has narrow, sharply curved surfaces presented toward an article on said support, said detearing electrode-section having relatively large and flat surfaces presented toward such article.

4. In apparatus for applying a liquid coating to an article, means for applying an excess of coating material to the lower portion of the article, an electrode, a conveyor for conveying said article successively through association with said coating means and electrode, means including a source of high-voltage electricity for maintaining an electrostatic field between the electrode and the article passing in association with it, said electrode comprising a detearing section disposed below the path of article travel and a discharge section disposed at one side of such path, and means for introducing finely divided coating material in the electrostatic field between the article and discharge electrode section.

5. In a method of applying a liquid coating to an article, the steps of applying an excess of liquid coating material to a portion only of the article,

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creating over both the coated and uncoated portions of the article an electrostatic field with that portion of the field over the uncoated portion having its greatest potential gradient remote therefrom and that portion of the field over the coating portion having its least potential gradient remote therefrom, and introducing finely divided coating material into those portions of the field adjacent the uncoated portion of the article.

6. Apparatus as set forth in claim 4 with the addition that said detearing electrode-section extends closer to the applying means than does said discharge electrode-section.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,855,869	Pugh -----	Apr. 26, 1932
2,247,963	Ransburg et al. -----	July 1, 1943
2,334,648	Ransburg et al. -----	Nov. 16, 1943
2,359,476	Gravley -----	Oct. 3, 1944