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APPARATUS FOR VACUUM COATING

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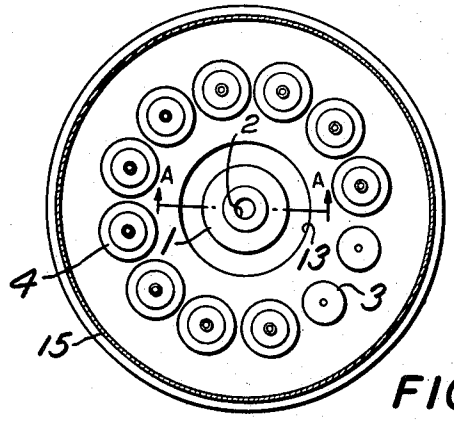


FIG. 1

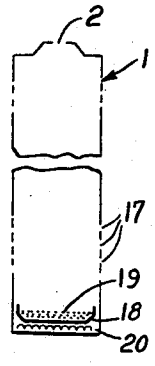


FIG. 3

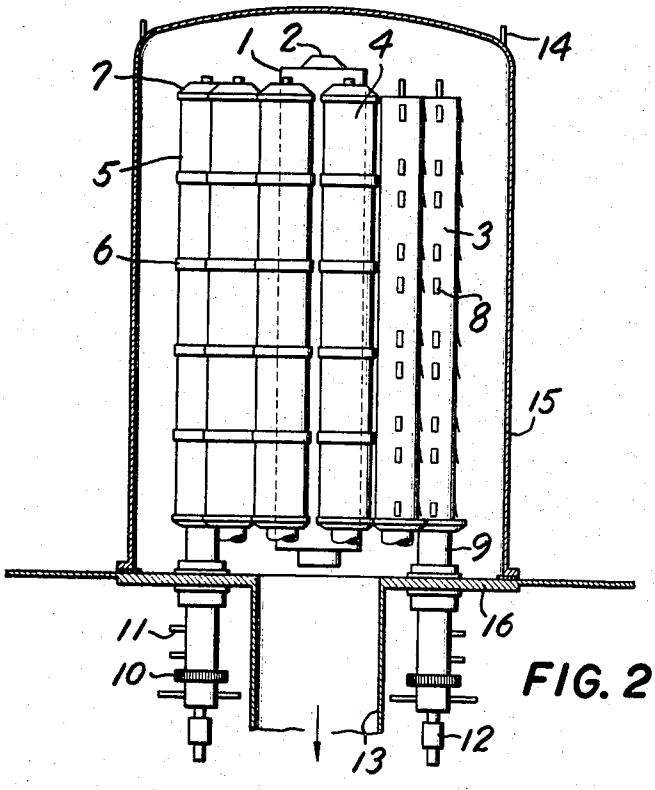


FIG. 2

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APPARATUS FOR VACUUM COATING

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ABSTRACT OF THE DISCLOSURE

Apparatus for vacuum coating articles wherein a vertically disposed evaporation bath disperses coating material in a horizontal direction to the articles being coated.

This invention relates to apparatus for vacuum coating. More particularly, the invention relates to apparatus for vacuum coating by which vacuum coating is carried out in a large amount onto a large number of articles at the same time.

The fields wherein vacuum coating is utilized industrially and in a large amounts are few. For example: there are articles having coatings of the thickness of about the wave length of a visible ray, such as, the reflection preventing coatings for a lens and a translucent mirror; a metallized paper or plastic sheet having metal coatings of the thickness of about 1 micron or thinner used as a capacitor or ornament; metal plating; thin magnetic films; etc.; but the thickness of these coatings is extremely thin. Further, there are rectifiers and photoelectric cells vacuum coated with selenium, germanium, or silicon. The thickness of these vacuum coatings is several microns and is thicker than that of the above-mentioned cases, but the articles to be coated are flat and the areas are not so large. Furthermore, an electro-photosensitive material wherein amorphous selenium is used is also produced by a vacuum coating method but this is also vacuum coating onto a flat article or plate.

The formation over an uniform layer of a comparatively large area having a thickness of above 20 microns by vacuum coating, is conducted on the above-mentioned selenium rectifiers, selenium photoelectric cells, or electrophotosensitive materials using amorphous selenium, but the articles to be vacuum coated in these cases are usually planes. In such cases, the coated film is formed by evaporating a coating material from one or more coating source baths placed horizontally and applying the vapor of the coating material onto the surface of an article to be coated, which is placed above the coating bath or baths with the surface facing the bath. In cases where a large number of articles are vacuum coated, the articles to be vacuum coated are placed around or above a coating bath having opening at the top of the bath and vacuum coating is conducted while revolving the articles around the coating bath. In any case, the evaporation bath in which a coating material is heated and evaporated is almost placed in a horizontal plane and the coating material is evaporated generally upwardly with the vertically directed center portion. This is naturally caused by the fact that the coating material melted at a high temperature is a liquid.

Conventionally adopted evaporation baths will be explained more in detail. For evaporating an extremely small amount of a coating material, a basket of a high-melting point metal is used. In such baskets, at most about 5 g. of the coating material can be charged and

hence it is unsuitable for the present purpose. In order to evaporate a large amount of a coating material in vacuum coating, a high-melting point ceramic crucible of alundum, beryllium, etc., is used. In this case, the large amount of a coating material can be charged at the same time in the crucible, but since the opening of the crucible is always provided at the top thereof, vacuum coating must be conducted only in the space above the crucible. Further, an evaporation bath system is utilized in which a plate of molybdenum or tantalum is fabricated into a boat form and the coating material charged in the boat is evaporated while heating the boat by passing an electric current directly through the boat, but as in the case of using the above-mentioned crucible, the vapor of the coating material is run out only upwardly and hence vacuum coating is conducted in only a space above the evaporation bath.

In order to conduct vacuum coating on a large number of articles by using the afore-mentioned evaporation bath, the purpose is fulfilled to some extent by placing the articles, if they are plane articles, around or above the coating bath and revolving the articles therearound with a vertical axis as the axis of rotation, but there is a defect in efficiency that vacuum coating is conducted only in the space above the coating bath. If the article is not a plane but cylindrical, the cylinder must be rotated in order to be vacuum coated uniformly. Further, in order to carry out vacuum coating on a large number of cylinders at the same time, the rotating cylinders are placed around the coating bath and the cylinders must be revolved therearound since vacuum coating is conducted only in the space above the bath. As the evaporation bath is placed in a horizontal plane, the rotary axes of the cylinder for rotation and revolution are in horizontal planes. This kind of evaporation apparatus has the drawbacks that complicated mechanisms are required for carrying out the rotation and revolution, and that vacuum coating is conducted only in the space above the evaporation bath.

Therefore, an object of this invention is to provide an apparatus suitable for vacuum coating a coating material on the outer surface of a cylindrical article, the thickness of said coating being above 0.5 micron.

Other object of this invention is to provide an apparatus suitable for vacuum coating extremely effectively and at the same time on a large number of articles.

A further object of this invention is to provide an apparatus for vacuum coating while effectively preventing dusts or other matters from sticking on the surface to be vacuum coated or mixing in the vacuum coated layer.

In the present invention, as distinguished from the conventional vacuum coating processes, a vertically disposed cylindrical evaporation bath is located at the center portion, said bath having a cylindrical wall provided with holes throughout the whole area thereof through which vapor coating material can be discharged to the whole space surrounding the coating bath, and a plurality of cylinders to be vacuum coated are located with a certain distance therefrom and vacuum coating is carried out while rotating the cylinders about respective axis thereof. Therefore, since the cylindrical articles to be vacuum coated are placed uniformly around the evaporating bath and the vapor of the coating material is applied onto the articles uniformly and at the same time from the evaporating bath, whole articles can be vacuum coated uniformly and simultaneously without revolving the articles. That is, uniform vacuum coatings are formed on the surfaces of the articles by only rotating the articles. Therefore, since a large number of articles can be vacuum coated uniformly and at the same time without revolving the cylindrical articles and only by rotating the articles,

the apparatus for industrial vacuum coating purpose can be simplified and the coating efficiency can be increased effectively. Moreover, since the evaporation bath and the articles to be vacuum coated are positioned vertically, the contamination of the evaporation bath and the articles to be vacuum coated with dusts and other impurities in the vacuum chamber falling on the surfaces can be effectively prevented. That is, in previous vacuum coating, as the vacuum coating chamber is evacuated, dusts or other impurities in the chamber are adhered on the wall of the vacuum chamber and the surfaces of interior mechanism, and those left or separated from the surfaces fall vertically onto the articles to be vacuum coated in a conventional position, which results in contaminating frequently the surfaces of the articles to be vacuum coated in a conventional vacuum coating case.

Further, in conventional known process wherein an evaporation bath is placed in a horizontal plane, articles to be vacuum coated are placed around the evaporation bath and the vacuum coating is carried out while revolving the articles therearound about a horizontal axis, the surfaces of the articles to be vacuum coated are frequently positioned beneath the evaporation bath or other interior mechanisms, which also results in contaminating the surfaces of the articles with falling dusts or impurities. Whereas, since according to this invention, the articles to be vacuum coated are placed with the surfaces to be vacuum coated being substantially vertically positioned, and a construction can be easily arranged wherein the evaporation bath, a heating system for the articles to be vacuum coated, and a rotation mechanism are not placed above the articles to be vacuum coated, the abovementioned drawbacks can be completely eliminated.

The above explanation referred to cylindrical articles, but the object of this invention is not restricted to only such cylindrical bodies, but the invention may be of course applicable to other shaped articles, such as plane articles.

The invention will be further explained practically referring to the accompanying drawings, wherein:

FIG. 1 is a plan view showing an embodiment of this invention;

FIG. 2 is a side view of the apparatus shown in FIG. 1; and

FIG. 3 is a sectional view of the evaporation bath taken along lines A—A of FIG. 1.

In the drawings, an embodiment of the vacuum coating apparatus of this invention wherein 60 cylinders **5** having the outer diameter of about 20 cm. and the length of 30 cm. are vacuum coated simultaneously is illustrated. That is, a closeable evaporation bath **1** is placed vertically and has an inlet hole **2** for inserting a coating material at the top thereof. The structure of the evaporation bath **1** may be one that the vapor of the coating material charged in the bath can be spurted out of the bath to horizontal directions. For example, a large number of small holes **17** of 1–2 mm. in diameter are formed in the wall of the coating bath **1** and a vessel **18** for the coating material **19** is placed at the bottom of the coating bath, said vessel being able to be heated by means of a suitable heating device **20**. At that, in order to avoid the vapor of the coating material from depositing on the inside surface of the evaporation bath **1**, the wall surface of the evaporation bath must be maintained at a suitable temperature. For the purpose, several heaters may be placed near the inside wall or outside wall of the evaporation bath **1** and a heating coil may be placed along the wall of the evaporation bath. The cylinders **5** to be vacuum coated are mounted on supporting members **3**, which are placed vertically around the evaporation bath, and rotatable by a suitable means. In the figures, the numeral **4** indicates a state that cylindrical articles to be vacuum coated are mounted rotatably on the supporting members. Five cylindrical articles **5** are mounted on a supporting member with intermediate rings **6** between them. The five cylindrical articles **5** are fixed on the supporting member by means of a flange **7**. The supporting member **3** is equipped with spring members **8** at the outside wall, which support the cylindrical articles to be vacuum coated from the inside. Further, the supporting members can be rotated through the rotary axes **9** by means of driving mechanisms **10**. In addition, a system, although it is not shown in the figures, is placed in the supporting member **3**, whereby the supporting member **3** and the cylindrical articles **5** can be maintained at a constant temperature by a circulating liquid maintained at a definite temperature or by an electric heating means. The numeral **11** is an outlet for hot water. The temperatures of the supporting means and the cylindrical articles are withdrawn from rotary rings **12** as an electric signal. All the supporting members may of course have a same structure. The above-mentioned **12** supporting members and the evaporation bath are placed in a vacuum tank **15** and fixed to a base plate **16**, said vacuum tank being evacuated through an exhaust port **13**. The exhaust port **13** is connected to a suitable vacuum pump system.

When the articles are charged or withdrawn from the system, the vacuum tank **15** is raised with hangers **14** by a crane which advances above the vacuum coating apparatus. The articles are dismounted from the supporting member by holding down a dismounting mechanism around the supporting members mounted with the vacuum coated articles and withdrawing the whole articles upwardly by holding the intermediate rings **6** (that is, without holding the coated surfaces of the cylindrical articles). In this case, the articles may be withdrawn partially or at the same time. In the case of mounting, new articles to be vacuum coated are pre-mounted to the dismounting mechanism and then lowered from above and mounted on the supporting members. In this case, the mounting operation is conducted by holding the intermediate rings and hence the surfaces of the articles to be vacuum coated are not contacted with the mechanism. If dusts, cotton dusts, etc., are adhered on the surfaces of the articles to be vacuum coated after the articles have been mounted on the supporting members, the dusts are sprayed off by means of a pressurized air spray equipped on the dismounting mechanism after the mounting procedure is finished and the clamps of the intermediate rings are disengaged. The spraying procedure is carried out by moving the spray gun vertically while rotating the articles mounted on the supporting member. The dismounting mechanism is not shown in the figures since it is not an essential part of this invention, but it may be a combination of a mounting mechanism for the articles to be vacuum coated, a withdrawing mechanism for the articles and a press spraying sweeping mechanism. The mechanism is divided into the "mounting mechanism and sweeping mechanism" and the "withdrawing mechanism," and is operated by means of a crane movable above the vacuum coating apparatus.

An example of the process of this invention wherein electro-photosensitive drums are produced by using the apparatus shown in the drawings is as follows.

Sixty aluminum cylinders **5** of 20 cm. in outside diameter and 30 cm. in length were mounted on the supporting members and about 3 kg. of selenium was charged in a vessel (not shown) in the evaporation bath **1** through the inlet hole **2**, which was then closed. The vacuum tank was then evacuated into about 5×10^{-5} mm. Hg and the selenium was evacuated at about 295° C. while rotating the columns of the cylinders. Thus, sixty electro-photosensitive drums having uniform selenium vacuum coatings was prepared at the same time.

Although the invention was described only with respect to where sixty articles could be mounted on twelve rotary supporting members, it is not limited to this case only. Further, the above-description refers to the case where vacuum coating is applied on the surfaces of cylindrical articles, but the shape of the articles to be vacuum coated

by the invention is not so restricted, but includes articles shaped as planes, square pillars, and the like.

What is claimed is:

1. An apparatus for vacuum coating articles comprising a vertically disposed evaporation bath having outlet holes for spouting coating material in a horizontal direction, mounting means surrounding said evaporation bath and adapted to mount the articles to be vacuum coated, a vacuum vessel containing said bath and said mounting means, and said mounting means being rotatable about vertical axes.

References Cited

UNITED STATES PATENTS

1,965,059	7/1934	Seibt	118—48
2,439,983	4/1948	Morgan et al.	117—106 X
3,128,205	4/1964	Illsley	117—106 X

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U.S. Cl. X.R.

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