

Aug. 6, 1968

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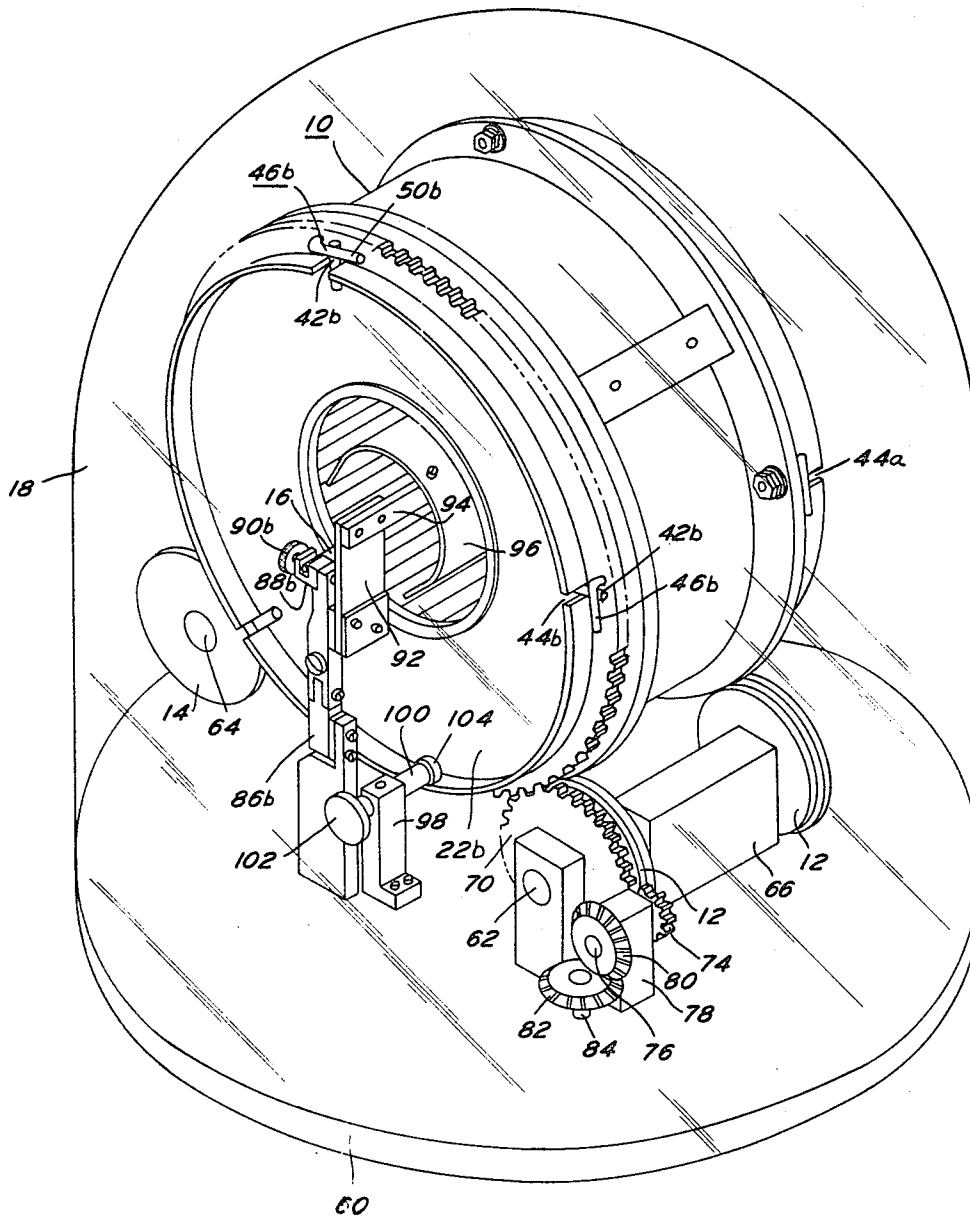
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APPARATUS FOR VAPOR COATING TUMBLING SUBSTRATES

Filed Sept. 23, 1963

4 Sheets-Sheet 1

FIG. 1



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4 Sheets-Sheet 2

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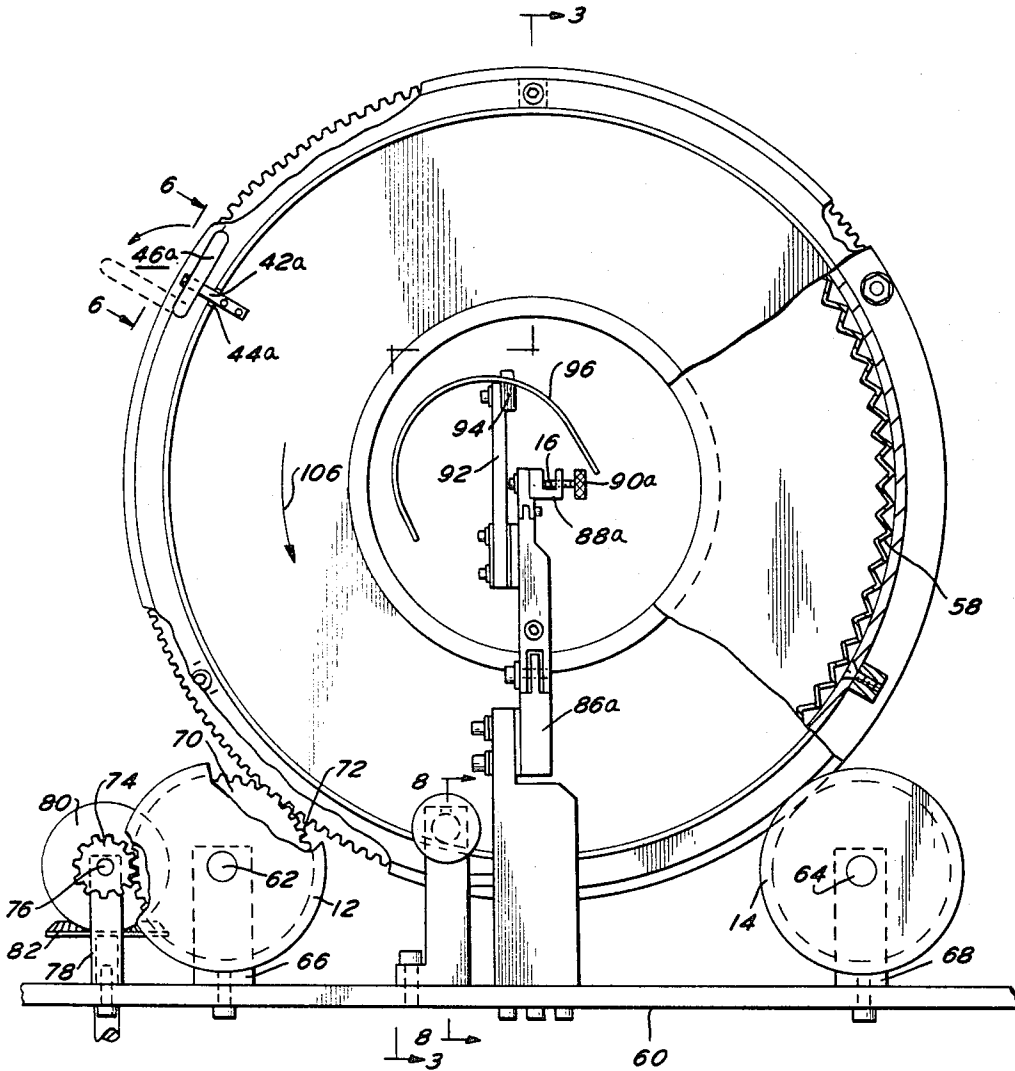


FIG. 2

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4 Sheets-Sheet 3

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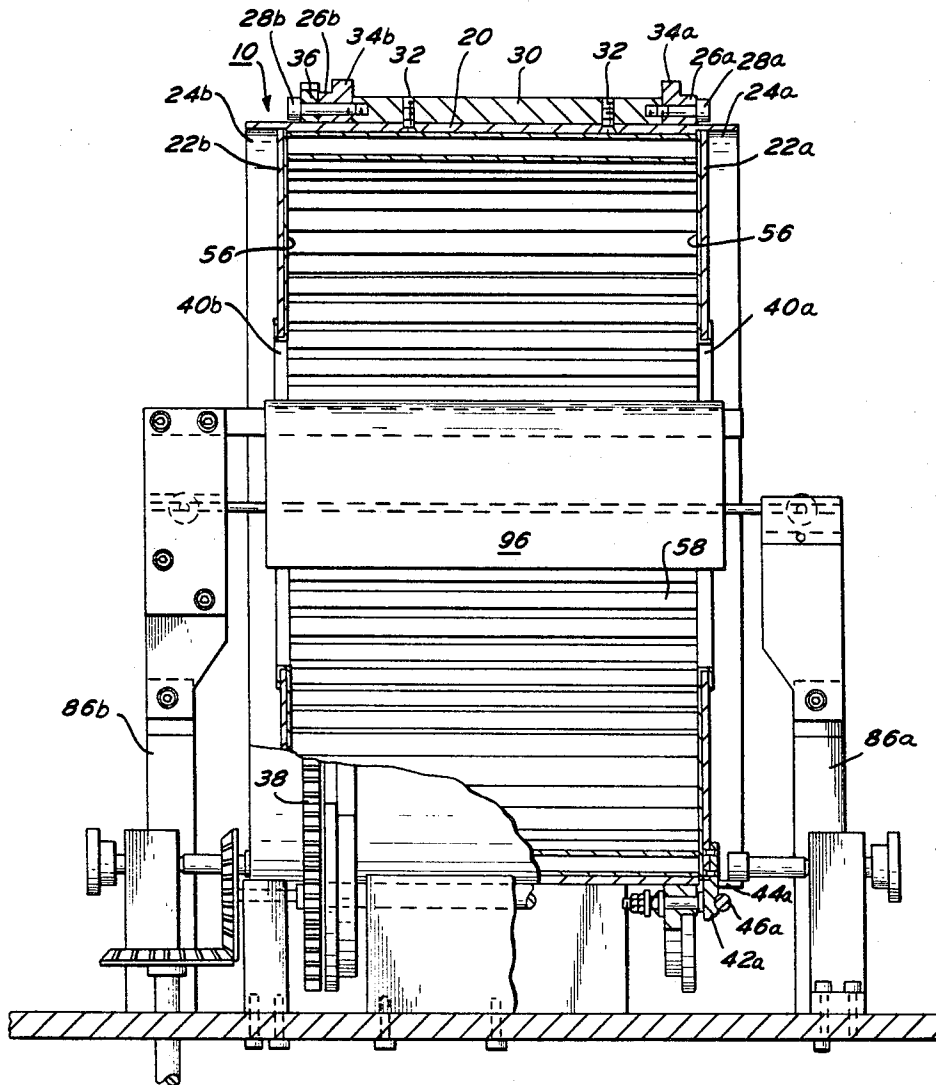


FIG. 3

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4 Sheets-Sheet 4

FIG. 4

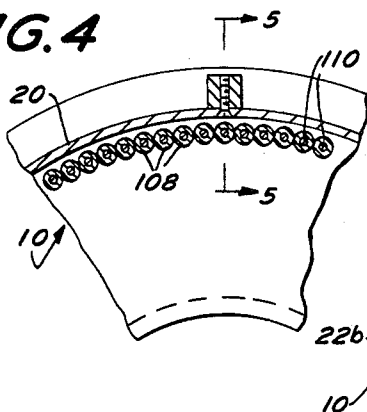


FIG. 5

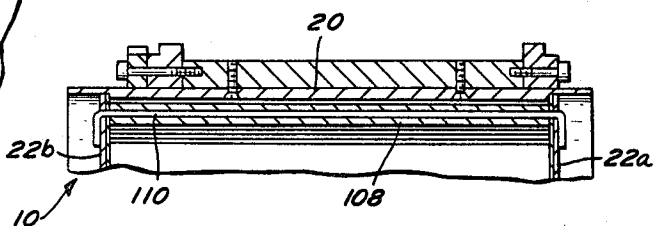


FIG. 6

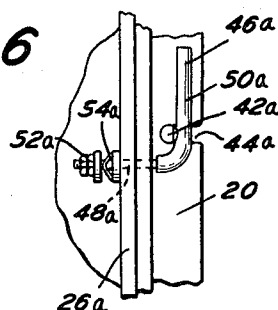


FIG. 7

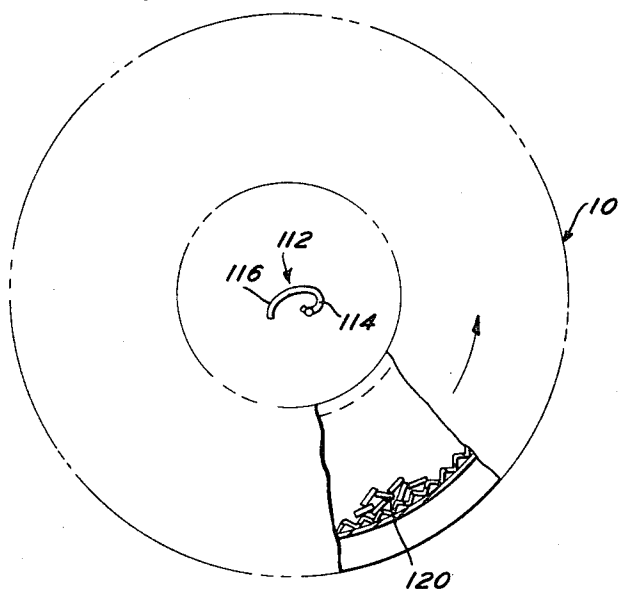
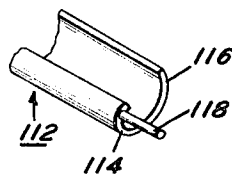


FIG. 8



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APPARATUS FOR VAPOR COATING TUMBLING SUBSTRATES

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9 Claims. (Cl. 118—49.1)

The present invention relates to a method and apparatus for coating articles, and more particularly to a method and apparatus for making electrical resistors.

It has been previously proposed to make metal film electrical resistors by coating a base member of an insulating material with a metal by evaporating the metal in a vacuum, and condensing the metal vapors on the base member. For the commercial manufacturer of such resistors, it is desirable to have a coating apparatus in which a large number of base members can be coated at one time. Also, the apparatus should provide a uniform coating on all the base members so that all the resistors in each batch made will have substantially the same resistance value.

Heretofore, apparatus such as shown and described in U.S. Patent No. 2,522,272 to S. A. Johnson et al., issued Sept. 12, 1950, entitled "Apparatus for Forming Metallic Films on Tubular Carriers" and in U.S. Patent No. 2,847,325 to J. Riseman et al., issued Aug. 12, 1958, entitled "Apparatus and Method for Evaporating Films in Certain Types of Electrical Components" have been used for manufacturing metal film resistors. However, such apparatus have certain disadvantages. In the apparatus of each of these patents, the base members to be coated are mounted on a wire or spindle which is mounted around the periphery of a rotating drum or head. Thus, the number of the base members which can be mounted on the apparatus for a single coating operation is limited by the length of the wires or spindles, and the diameter of the drum or head. Also, the mounting and dismounting of the base members onto and from the apparatus are time consuming operations which add to the expense of the operation.

It is therefore an object of the present invention to provide a novel method and apparatus for coating articles with a metal by evaporation of the metal in a vacuum.

It is another object of the present invention to provide a method and apparatus for coating with a metal, large quantities of cylindrical articles at one time.

It is a further object of the present invention to provide a method and apparatus for coating with a metal, large quantities of cylindrical articles at one time, and obtain substantially uniform coatings on all of the articles.

It is a still further object of the present invention to provide an apparatus for coating articles with a metal wherein the articles can be easily and quickly loaded into and unloaded from the apparatus.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a perspective view of the apparatus of the present invention.

FIGURE 2 is a side plan view, partially broken away, of the apparatus of the present invention.

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 2.

FIGURE 4 is a sectional view of a modification of the drum of the apparatus of the present invention.

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 4.

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FIGURE 6 is a view taken along line 6—6 of FIGURE 2.

FIGURE 7 is a side plan view of a modification of the evaporator of the apparatus of the present invention.

FIGURE 8 is a perspective view of the evaporator of FIGURE 7.

Referring initially to FIGURE 1, the apparatus of the present invention in general includes a hollow, cylindrical drum 10 supported for rotation on two pairs of wheels 12—12 and 14—14. An evaporator 16 extends longitudinally through the drum 10, and is supported substantially along the axis of rotation of the drum. The evaporator is connected to a source of electric current. The drum 10 is provided on its inner surface with a plurality of longitudinally extending projections which will cause the articles to be coated to tumble within the drum when the drum is rotated.

In use, the cylindrical bodies to be coated are poured into the drum 10, and the drum is enclosed in a bell jar 18. The bell jar 18 is evacuated to a pressure suitable for thermal evaporation. The drum 10 is then rotated, and the evaporator 16 heated to the evaporation temperature of the metal contained on the evaporator. The metal vapors flow from the evaporator 16, and upon contacting the colder base members will condense thereon to form a film of the metal. The projections on the inner surface of the drum 10 cause the base members to tumble about within the drum so that the entire surface of the base members are coated with the metal. When a film of the desired thickness is formed on the cylindrical members, the current to the evaporator 16 is turned off. The vacuum in the bell jar 18 is then broken and the cylindrical members are ready for further processing, such as terminating, thereby to be made into completed resistors.

Now referring in detail to FIGURES 1, 2 and 3 of the drawing, the drum 10 comprises an outer cylindrical wall 20, and a pair of flat, circular side walls 22a and 22b. The outer wall 20 is provided on its inner surface with a pair of recesses 24a and 24b at the ends of the outer wall. The side walls 22a and 22b fit within the recesses 24a and 24b respectively, and are seated against the inner ends of the recesses. A pair of annular track rings 26a and 26b are mounted on and around the outer wall 20 adjacent the ends of the outer wall. The track rings 26a and 26b are secured by screws 28a and 29b respectively to three spacer bars 30 which extend longitudinally across the outer surface of the outer wall 20, and are uniformly spaced around the outer wall. Spacer bars 30 are secured to the outer wall 20 by screws 32. Track rings 26a and 26b are provided with flanges 34a and 34b respectively which project radially outwardly from the track rings at the sides thereof adjacent the spacer bars 30. A ring gear 36 having teeth 38 on its outer periphery is mounted on and around the outer wall 20 next to the track ring 26b. The ring gear 36 is secured to the track ring 26b by the screws 28b.

Side walls 22a and 22b have central openings 40a and 40b therethrough respectively. Three clamping rods 42a are secured to the outer surface of the side wall 22a at uniformly spaced points around the side wall 22a, and project radially outwardly beyond the outer periphery of the side wall 22a. Similarly, three clamping rods 42b are secured to the side wall 22b, and project radially outwardly beyond the outer periphery of the side wall 22b. When the side walls 22a and 22b are mounted within the outer wall 20, the clamping rods 42a and 42b project through slots 44a and 44b respectively in the end portions of the outer wall 20. The side walls 22a and 22b are releasably secured to the outer wall 20 by clamping members 46a and 46b respectively which engage the clamping rods 42a and 42b respectively.

As shown in FIGURE 6, each of the clamping members 46a is L-shaped having a shaft portion 48a extending through and rotatably supported on the track rail 26a, and a clamping arm 50a extending over the end portion of the outer wall 20. A nut 52a is threaded on the end of the shaft portion 48a, and a V-shaped spring washer 54a is provided on the shaft portion 48a between the nut 52a and the track rail 26a. Each of the clamping members 46a is mounted on the track rail 26a adjacent to but spaced from a separate one of the slots 44a in the end portion of the outer wall 20. To mount the side wall 22a on the outer wall 20, the clamping members 46a are pivoted to a position in which the clamping arms 50a extend radially outwardly of the outer wall 20 as shown in dotted lines in FIGURE 2. The side wall 22a can then be inserted within the outer wall 20 with the clamping rods 42a projecting through the slots 44a in the outer wall. The clamping members 46a are then pivoted to a position in which the clamping arms 50a extend across and engage the outer surface of the clamping rods 42a as shown in full lines in FIGURE 2. When the clamping members 46a are pivoted so that the clamping arms 50a engage the clamping rods 42a, the spring washers 54a are compressed between the nuts 52a and the track rail 26a. The resiliency of the spring washers 54a thereby pull the clamping arms 50a tightly against the clamping rods 42a, and thereby hold the side wall 22a within the outer wall 20. The clamping members 46b are similar in construction to the clamping members 46a, and are rotatably mounted on the ring gear 36 and track rail 26b in the same manner that the clamping members 46a are mounted on the track rail 26a. Thus, the clamping arms 50b of the clamping members 46b engage the clamping rods 42b of the side wall 22b to secure the side wall 22b within the outer wall 20.

As shown in FIGURE 3, the inner surface of each of the side walls 22a and 22b is lined with a sheet 56 of a metal foil. The inner surface of the outer wall 20 is lined with a corrugated sheet 58 of a metal foil. The metal foil liners 56 and 58 are preferably of aluminum for reasons which will be explained later.

The drum 10 is supported on a base plate 60 by the two pairs of wheels 12—12 and 14—14 mounted in spaced parallel relation on shafts 62 and 64 respectively. The shafts 62 and 64 are rotatably mounted in bearings 66 and 68 respectively which are mounted on the base plate 60. The wheels 12—12 and 14—14 are in registry with the track rings 26a and 26b of the drum 10 so that the track rings rest on the wheels, and thereby support the drum thereon.

A gear 70 is mounted on the shaft 62, and is in registry with the ring gear 36 of the drum so that the teeth 72 of the gear 70 mesh with the teeth 38 of the ring gear. A drive gear 74 meshes with the teeth 72 of gear 70, and is mounted on one end of a shaft 76. Shaft 76 is rotatably supported in a bearing 78 mounted on the base plate 60. A bevelled gear 80 is mounted on the other end of shaft 76 and meshes with a second bevelled gear 82. The second bevelled gear 82 is mounted on a shaft 84 which extends through the base plate 60 and is connected to a suitable drive means, such as a motor (not shown).

The evaporator 16 is mounted between supporting posts 86a and 86b which are mounted on the base plate 60 adjacent opposite sides of the drum 10. The supporting posts 86a and 86b are provided with U-shaped supporting brackets 88a and 88b respectively at the top end thereof. The ends of the evaporator 16 rests in the supporting brackets 88a and 88b, and are secured therein by thumb screws 90a and 90b respectively. The evaporator 16 extends through the holes 40a and 40b in the side walls 22a and 22b of the drum 10, and across the interior of the drum substantially parallel to the outer wall 20 of the drum. As shown in FIGURES 1, 2 and 3, evaporator 16 comprises a heating wire of a high temperature metal, such as tungsten or molybdenum. The

heating wire is coated with the coating metal. The evaporator 16 can be connected across a source of electrical current by any suitable means, such as wires (not shown) connected to the ends of the evaporator and extending through the base plate 60.

A shield supporting post 92 is secured to and electrically insulated from the supporting post 86b and projects upwardly therefrom. A supporting rod 94 is secured to the upper end of the supporting post 92, and extends through the hole 40b in the side wall 22b of the drum and across the interior of the drum substantially parallel to the evaporator 16. A U-shaped metal shield 96 extends over the supporting rod 94, and is secured thereto. The shield 96 is positioned so as to partially encompass the evaporator 16, and so that it opens downwardly and at a 30° to 45° angle with respect to the vertical.

Posts 98 are mounted on the base plate 60 adjacent the evaporator supporting posts 86a and 86b. A separate shaft 100 is supported on each of the posts 98 for slidable movement longitudinally toward and away from the drum 10. A knob 102 is provided on the back end of each of the shafts 100, and a roller 104 is rotatably mounted on the front end of the shafts. The shafts 100 are movable between a position in which the rollers 104 are over the inner surface of the end portion of the outer wall 20 of drum 10, and a position in which the rollers 104 are away from the drum 10. When the rollers 104 are over the outer wall 20 of the drum 10, they act to prevent the drum from slipping or jumping off of the wheels 12—12 and 14—14.

As seen in FIGURE 1, a bell jar 18 or the like is placed over the drum 10 and associated mechanism to form a sealed chamber containing the apparatus. A vacuum pump (not shown) is connected to the sealed chamber in any suitable manner, such as through a hole through the base plate 60, to evacuate the chamber.

To use the apparatus of the present invention the drum 10, while removed from the wheels 12—12 and 14—14, is loaded with the cylindrical objects to be coated. In the manufacture of electrical resistors, the objects are usually cylindrical rods of a ceramic material. The drum 10 is loaded with the cylindrical objects either by pouring the objects into the drum through the center hole in one of the side walls 22a and 22b, or by first removing one of the side walls and then pouring the objects into the drum through the open side thereof. The loaded drum 10 is then placed on the wheels 12—12 and 14—14, with the teeth of the ring gear 36 meshing with the teeth of the gear 70. The shafts 100 are pushed forward to place the rollers 104 over the edge of the outer wall 20 of the drum 10 so as to hold the drum on the wheels 12—12 and 14—14. The evaporator 16 is placed across the interior of the drum 10, and the ends of the evaporator are clamped in the brackets 88a and 88b by the thumb screws 90a and 90b. The shield 96 is also secured in position across the drum 10. A bell jar 18 is then placed over the drum 10 to enclose the apparatus in a sealed chamber, and the chamber is evacuated to a pressure suitable for thermal evacuation, usually about 0.5 micron. The drive means for shaft 84 is turned on to rotate the gear 70, and thereby rotate the drum 10 around the evaporator 16. The current to the evaporator 16 is turned on to heat the evaporator to the evaporation temperature of the coating metal on the evaporator.

As the drum 10 rotates, for example in the direction of arrow 106 in FIGURE 2, the cylindrical objects are carried by the corrugated liner 58 from the bottom of the drum upwardly in the direction of rotation. When the objects have been carried for approximately 45° of travel, the weight of the objects will cause them to drop back to the bottom of the drum. Thus, the objects are tumbled about in the lower quadrant portion of the drum which is in the direction of rotation of the drum. When the coating metal on the evaporator 16 evaporates, the vapors diffuse in all directions from the evaporator. Some of the

vapors flow directly toward the objects tumbling about in the drum 10, and the remaining vapors are deflected by the shield 96 to flow toward the objects. As the vapors contact the cylindrical objects they condense on the objects to form a film. When a film of the desired thickness is coated on the objects, the current to the evaporator is turned off. The rotation of the drum 10 is stopped, and air is admitted to the bell jar 18. The bell jar 18 is removed, and the coated cylindrical objects are unloaded from the drum 10.

Since the cylindrical objects are tumbled about against the walls of the drum 10 as the coating is being applied thereto, it is necessary that the liners 56 and 58, particularly the liner 58 for the outer wall 20 of the drum, be of a material which does not appreciably abrade the coating being applied to the objects, and does not abrade onto the coating being applied to the objects so as to contaminate the coating. It has been found that liners of aluminum foil do not appreciably abrade the coating being applied to the objects, and do not abrade away to contaminate the coating.

Referring to FIGURES 4 and 5, there is shown a modification of the liner for the outer wall 20 of the drum 10. The modified liner comprises a plurality of cylindrical rods 108 of a ceramic material. The rods 108 are arranged in abutting, parallel relation around the interior surface of the outer wall 20, but spaced slightly therefrom. The rods 108 are of a length to extend entirely across the outer wall 20 between the side walls 22a and 22b. A separate mounting wire 110 extends through each rod 108. The ends of the wire 110 extend through the side walls 22a and 22b, and are bent to extend across the outer surfaces of the side walls so as to secure the wires to the drum 10. The rods 108 provide a corrugated, slightly resilient surface which will tumble the objects being coated upon rotation of the drum 10. During the coating operation, the rods 108 are coated with the same material as is applied to the objects being coated. It has been found that the coated rods 108 neither appreciably abrade the coating being applied to the objects, nor contaminate the coating on the objects. Although each of the rods 108 is shown as being a single piece, the rod can be made up of a plurality of shorter pieces mounted on the wire 110.

Referring to FIGURES 7 and 8, there is shown a modification of the evaporator which can be used in the apparatus of the present invention for evaporating a material which is in powdered or granulated form. Evaporator 112 comprises a sheet of a material having a high melting temperature, such as tungsten or molybdenum. The metal sheet is bent to form a C-shaped container portion 114, and an arcuate deflector portion 116 projecting from one end of the container portion. A mounting wire 118 of the same metal as the evaporator 112 is secured to one end of the evaporator to permit the evaporator to be mounted between the evaporator supporting posts. As shown in FIGURE 7, the evaporator 112 is positioned with the deflector portion 116 facing toward the quadrant of the drum 10 in which the cylindrical objects 120 are tumbled about during rotation of the drum. In the use of the evaporator 112, the coating material is placed in the container portion 114 of the evaporator. An electric current is passed through the evaporator 112 to heat it to the evaporation temperature of the coating material. The vapors of the coating material diffuse from the container portion 114 and impinge on the deflector portion 116. Since the deflector portion 116 is also heated, the vapors are deflected toward the cylindrical objects 120 to coat the objects.

Thus, there is provided by the apparatus of the present invention an apparatus whereby a large number of cylindrical objects can be coated at one time since the objects are merely tumbled about in random fashion within the drum. It has been found that even though the objects being

coated are tumbled about in random fashion, the coating achieved on the objects are relatively uniform in thickness from object to object in a batch. Thus, in making electrical resistors, each batch of the coated objects provides a relatively tight range of resistance values. It has been also found that the tumbling action dislodge loose particles of the coating material which might otherwise cause discontinuities in the film and adversely affect the electrical characteristics of the resistor formed therefrom. In addition, the apparatus of the present invention can be easily and quickly loaded and unloaded so as to reduce the time for each coating cycle, and thereby reduce the cost of the resultant product.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

We claim:

1. Apparatus for coating objects by thermal evaporation in a vacuum comprising a base plate; a pair of shafts rotatably supported on the base plate in spaced parallel relation; a pair of wheels mounted on each shaft with the wheels on one shaft being in alignment with the wheels on the other shaft; a cylindrical drum having a cylindrical outer wall, a pair of flat side walls secured in the ends of said outer wall, each of said side walls having a central opening therein, means secured to said drum and mounted around the inner surface of said outer wall providing a plurality of projections for continuously tumbling the objects being coated as the drum rotates, and a pair of annular track rings surrounding and secured to said outer wall, the drum being rotatably supported on said wheels with each track ring resting on a pair of aligned wheels; a pair of evaporator supporting posts mounted on said base plate one adjacent each side of the drum; an evaporator containing the coating material, said evaporator extending through the openings in the side walls of the drum and across the interior of the drum with the ends of the evaporator supported on the supporting posts; means for heating the evaporator to evaporate the coating material; and means for rotating the drum.

2. Apparatus for coating objects by thermal evaporation in a vacuum comprising a cylindrical drum having a cylindrical outer wall and a pair of flat circular side walls secured to and extending across the ends of the outer wall, each of said side walls having a central opening therein, means for rotating said drum about its longitudinal axis, means secured to said drum and mounted around the inner surface of said outer wall providing a plurality of projections for continuously tumbling the objects being coated as the drum rotates, an evaporator containing the coating material, means mounting said evaporator across the interior of said drum, and means for heating said evaporator.

3. Apparatus in accordance with claim 2 in which the side walls of the drum are removably secured within the ends of the outer wall of the drum.

4. Apparatus in accordance with claim 2 in which the means within the drum for tumbling the objects being coated comprises a corrugated liner covering the inner surface of the outer wall of the drum.

5. Apparatus in accordance with claim 4 in which the corrugated liner is of a ceramic material.

6. Apparatus in accordance with claim 4 in which the corrugated liner is a sheet of aluminum.

7. Apparatus in accordance with claim 6 including a separate sheet of aluminum covering the inner surface of each side wall of the drum.

8. Apparatus in accordance with claim 4 in which the corrugated liner comprises a plurality of ceramic rods secured to the drum and arranged in parallel contacting relation around the inner surface of the outer wall of the drum.

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9. Apparatus in accordance with claim 8 in which the ceramic rods are mounted on wires extending between and secured to the side walls of the drum with the rods being spaced slightly from the outer wall of the drum.

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10

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,395,674

August 6, 1968

Francis P. Burham et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 5 and 6, "International Resistance Company, Philadelphia, Pa." should read ---TRW Inc., a corporation of Ohio ---.

Signed and sealed this 3rd day of March 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents