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 APPARATUS FOR AND METHOD OF APPLYING METALLIC
 COATINGS BY THERMAL EVAPORATION
 Filed Aug. 29, 1940

2,363,781

FIG. 1

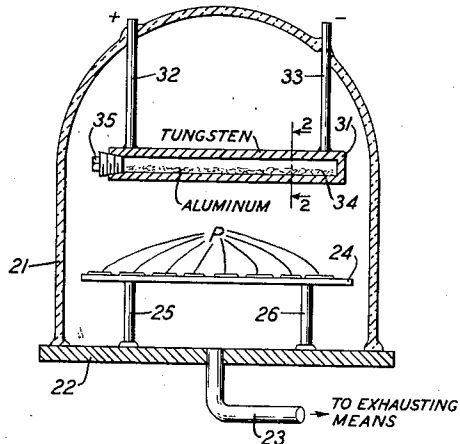


FIG. 2

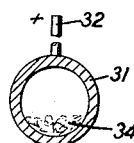


FIG. 4

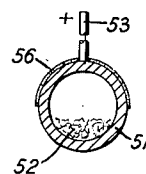


FIG. 3

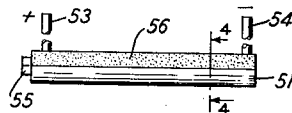


FIG. 5

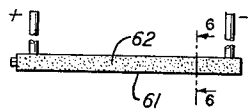


FIG. 6

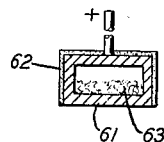


FIG. 7

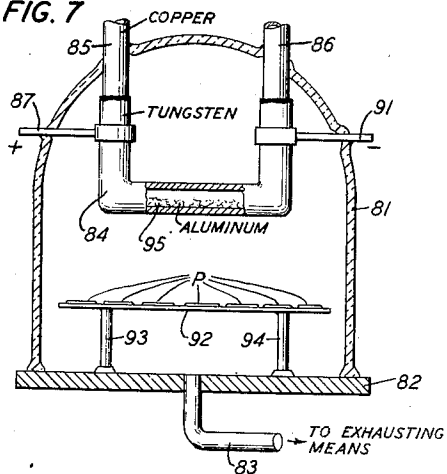


FIG. 9

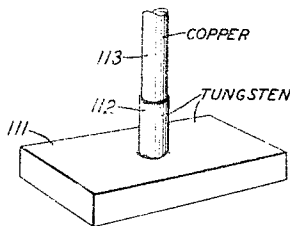
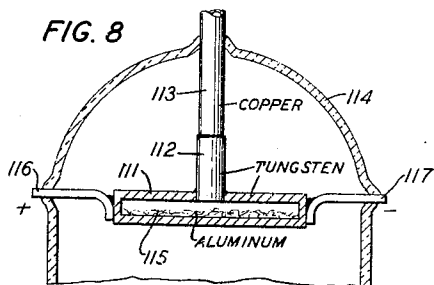


FIG. 8



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APPARATUS FOR AND METHOD OF APPLYING METALLIC COATINGS BY THERMAL EVAPORATION

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Application August 29, 1940, Serial No. 354,711

7 Claims. (Cl. 117-107)

This invention relates to apparatus for and a method of applying metallic coatings to objects by the thermal evaporation process.

An object of the invention is to facilitate the application of metallic coatings to objects.

A more specific object of the invention is to facilitate and render more economical the application of aluminum electrode coatings to piezoelectric crystal plates.

A feature of the invention resides in a heater element of a material through which the coating metal will diffuse rapidly when the temperature of said element is brought to a sufficiently high point.

A further feature of the invention is means for obtaining a directional flow of the evaporated coating metal.

A still further feature of the invention is means for continuously supplying the coating metal from a source outside the vessel to the heater element.

In accordance with a specific embodiment of the invention a tungsten heater rod is positioned within an evacuated vessel, the rod having a hollowed-out chamber therein. The aluminum coating metal is contained within this chamber and, when the rod is heated to a sufficiently high degree, the aluminum diffuses rapidly through the tungsten rod and evaporates from the outer surface thereof.

In accordance with a modification of the above embodiment, predetermined portions of the exterior surface of the heater rod are coated with a material impervious to aluminum whereby a "directed" evaporation of the aluminum results.

In accordance with still another modification of the embodiment referred to above, the heater rod is terminated at each end in copper tubes which are sealed through the wall of the evacuated vessel. The coating metal may then be fed continuously through the tubes into the chamber within the rod from a suitable source outside the vessel.

A complete understanding of the arrangement and operation of the apparatus contemplated by the present invention, as well as appreciation of the valuable features thereof may be gained from consideration of the subsequent detailed description in connection with the drawing, in which:

Fig. 1 is a view partially in section of apparatus for coating piezoelectric plates which embodies features of the present invention;

Fig. 2 is an enlarged end sectional view of the heater rod taken on line 2-2 of Fig. 1;

Fig. 3 shows a modified form of heater rod

adapted to produce a directed evaporation of the coating metal;

Fig. 4 is an enlarged end sectional view of the heater rod taken on line 4-4 of Fig. 3;

Fig. 5 shows a modified heater element in the form of a rectangular strip;

Fig. 6 is an enlarged end sectional view of the heater element taken on line 6-6 of Fig. 5;

Fig. 7 is a view in partial section of coating apparatus arranged to permit a continuous supply of the coating metal in accordance with features of the present invention;

Fig. 8 shows a modified form of heater element for the type of apparatus shown in Fig. 7; and

Fig. 9 is a view in perspective of the heater element illustrated by Fig. 8.

Referring now to the drawing there is illustrated in Fig. 1 an evaporation vessel comprising cover 21 of the bell jar type removably mounted on base 22. Suitable means, such as a gasket, may be provided in order to assure an air-tight junction between the rim of the cover and the base when the vessel is closed. The vessel may be exhausted by suitable means (not shown) through pipe 23.

The objects to be coated, designated P which we will assume for purposes of description are quartz piezoelectric plates, are supported on table 24 which, in turn, is supported from base 22 by uprights 25 and 26.

Heater element 31 is supported from the upper wall of cover 21 by members 32 and 33; these members are of conductive material and serve also as the lead-in conductors for the heating current. As shown in Fig. 1 and also in the enlarged view of Fig. 2, heater element 31 is in the form of a tungsten rod provided with a centrally located chamber. The aluminum coating metal 34 is placed in this chamber and the open end of the heater element is closed by threaded plug 35. The outer surface of rod 31 is substantially continuous, the tungsten being non-porous.

In operation, after the vessel has been evacuated to a sufficient degree, heating current is supplied to heater 31 through members 32 and 33 from a suitable source (not shown). When the temperature of tungsten rod 31 has been raised to a sufficiently high point the aluminum coating metal 34 diffuses rapidly through the tungsten rod and is evaporated from the outer surface thereof. The evaporated aluminum settles on the plates P forming a thin evenly distributed aluminum coating thereon. Upon completion of the process, cover 21 is removed from base 22, plug 35 is removed and the heater rod 31 is recharged with

aluminum. The process may then be repeated for coating the reverse sides of the plates P or for coating a new batch of plates.

The novel combination of a heater element containing the coating metal in a chamber located centrally therein, the element being of material through which the coating metal will diffuse rapidly when the element is heated, results in a simple, economical coating apparatus and leaves behind many problems encountered in the use of previous coating apparatus not the least of which problems was the matter of so positioning and supporting the coating metal with respect to the heating element or elements that the coating metal would be thoroughly vaporized and would be evenly distributed over the objects to be coated. The use of a substantially non-porous heater element results in an even distribution of the diffused metal to be evaporated.

Referring now to Figs. 3 and 4 a modification of the heater element is illustrated whereby a directional evaporation is attained. In this instance, tungsten heater rod 51 is, like heater rod 31, provided with a centrally located chamber which contains the coating metal 52 and is adapted to be supported in the vessel by conductive lead-in members 53 and 54. A plug 55 is provided for closing the open end of the rod. The upper half of the exterior of rod 51 is provided with a coating 56 of a material which is impervious to aluminum so that when the rod is heated, the aluminum will be evaporated only from the lower exterior surface thereof. By this arrangement the flow of the evaporated metal is concentrated in a downward path toward the plates to be coated and a highly efficient distribution of the metal is attained. It will be obvious that the shielding metal may be placed on other portions of the heater element in order to obtain a concentration of the evaporated metal in any desired direction or directions.

Heater rod 61 of Figs. 5 and 6 differs from rod 51 in that it is rectangular in shape. The rod is covered with coating 62 of metal impervious to aluminum on all exterior surfaces except the bottom surface so that evaporation of the coating metal 63 takes place only from the flat under-surface of the rod. This type of heater element provides a broad evaporation surface.

Referring now to Fig. 7 an evaporation vessel is illustrated comprising a bell jar type cover 81 removably mounted on base 82, suitable gaskets being provided to assure an air-tight junction between the cover and base to permit the vessel to be exhausted by suitable pumping means associated with pipe 83. The hollow tungsten heater rod 84 is joined at each end to hollow copper tubes 85 and 86 which are sealed through the top wall of cover 81. Lead-in conductors 87 and 89 are sealed through the side wall of cover 81 and are electrically connected to heater rod 84 a short distance from the ends thereof.

The piezoelectric plates P which are to be coated are placed on table 92 which is supported from base 82 by upright members 93 and 94.

The operation of the apparatus of Fig. 7 is in general the same as that of Fig. 1 which was described above. In this instance, however, the supply of aluminum 95 in heater element 84 may be continuously renewed through tubes 85 and 86 from a suitable source outside of the vessel thereby permitting uninterrupted operation of the apparatus. It will be apparent that, while air may, under some conditions, enter tubes 85

and 86 from the exterior atmosphere, no air can reach the interior of the vessel as both the tungsten and copper tubes are impervious to air under the operating conditions.

The arrangement of Fig. 7 results in a simple way of permitting a continuous supply of metal to be evaporated from the heater unit while interfering in no way with the highly evacuated condition of the vessel.

Figs. 8 and 9 illustrate a modified form of heater element for use with the general type of apparatus of Fig. 7. In this instance the tungsten heater element 111 is in the form of a hollow rectangular block with a short tungsten tube 112 passing through the upper surface thereof and communicating with the centrally located chamber provided in the heater element. Tungsten tube 112 is terminated in copper tube 113. As shown in Fig. 8, copper tube 113 is sealed through the upper wall of cover 114, the supply of aluminum 115 may therefore be continuously renewed through tubes 112 and 113 from a source outside the vessel. Lead-in conductors 116 and 117 are sealed through the side walls of cover 114 and Due to the comparatively low resistance of copper tube 113 and its remote position with respect to lead-in conductors 116 and 117, the temperature of the copper tube remains well below the point at which the tungsten and copper might alloy during operation of the apparatus.

The operation of the apparatus of Fig. 8 is, in general, the same as that of Figs. 1 and 7 described above.

It will be apparent, of course, that the heater elements of the apparatus of Figs. 7 and 8 may, if desired, be provided on predetermined portions of their surfaces with coatings of metal impervious to aluminum in order to attain a directed flow of the evaporated metal.

While certain specific embodiments of the invention have been selected for illustration and detailed description the invention is not, of course, limited in its application to these embodiments. The embodiments described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. Apparatus for coating a surface of an object with aluminum by thermal evaporation comprising an evacuated vessel, a filament having a substantially continuous outer surface of tungsten supported within said vessel, said filament having an inner chamber, a supply of aluminum in said inner chamber and means for heating said filament.

2. Apparatus for coating a surface of an object with aluminum by thermal evaporation comprising an evacuated vessel, a tungsten rod having a substantially continuous outer surface supported within said vessel, said rod having a hollowed-out center chamber, a supply of aluminum in said center chamber, and means for heating said rod.

3. Apparatus for coating a surface of an object with aluminum by thermal evaporation comprising an evacuated vessel, a hollow tungsten rod supported within said vessel, said rod having a substantially continuous outer surface, a supply of aluminum in the hollow portion of said rod, means for heating said rod, and tubes leading into said evacuated vessel and hermetically sealed to each end of said rod whereby said supply of aluminum may be continuously replenished from a source outside of said vessel.

4. Apparatus for coating a surface of an object with aluminum by thermal evaporation compris-

ing a vessel, means for exhausting air from said vessel, a tungsten heater element having a substantially continuous outer surface supported within said vessel, said heater element having an inner chamber, a supply of aluminum in said chamber, means for heating said heater element, means within said vessel for supporting said object to be coated, and means communicating with said inner chamber and the exterior of said vessel whereby said supply of aluminum may be continuously replenished from a source outside of said vessel, said last-mentioned means being impervious to the passage of air into said vessel.

5. Apparatus for coating a surface of an object with aluminum by thermal evaporation comprising a vessel, means for exhausting air from said vessel, a tungsten heater element having a substantially continuous outer surface supported within said vessel, said heater element having an inner chamber, a supply of aluminum in said chamber, means for heating said heater element, means within said vessel for supporting said object to be coated, and a tube sealed through the wall of said vessel and communicating with said inner chamber whereby aluminum may be continuously supplied to said chamber from a source outside of said vessel.

6. The method of coating an object with aluminum which comprises associating within the same evacuated space the body to be coated and a mass of aluminum surrounded by a substantially continuous exterior surface of tungsten and raising the temperature of the tungsten sufficiently to cause the aluminum to diffuse through the tungsten material and to evaporate from the exterior surface thereof whereby aluminum settles on the surface of the body forming an evenly distributed coating thereon.

7. Apparatus for coating a surface of an object with aluminum by thermal evaporation comprising a vessel, means for exhausting air from said vessel, a rectangular tungsten heater element having a substantially continuous outer surface, said heater element having an inner chamber, a supply of aluminum in said inner chamber, means for heating said heater element, a table within said vessel for supporting said object to be coated, and means for supporting said heater element within said vessel above said table with one of the two larger sides of said element substantially parallel to said table with said one side closer thereto than any of the other sides of said heater element.

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