June 22, 1943. P. ALEXANDER 2,322,613

APPARATUS FOR DEPOSITION OF METALS BY THERMAL EVAPORATION IN VACUUM

Filed Feb. 25, 1939

FIG. 1.

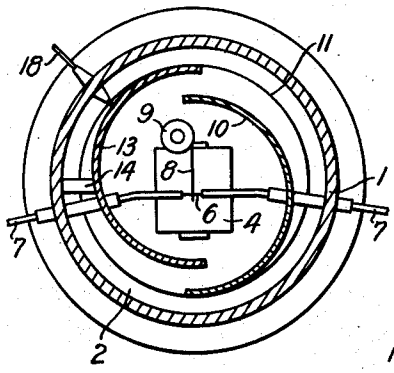


FIG. 2.

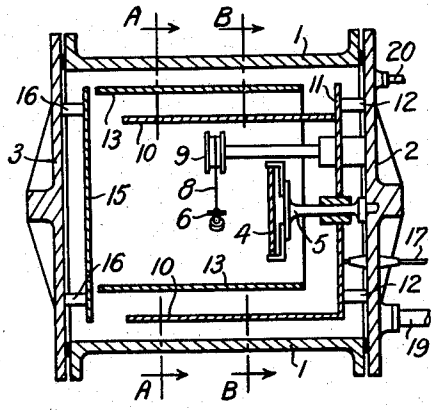


FIG. 3.

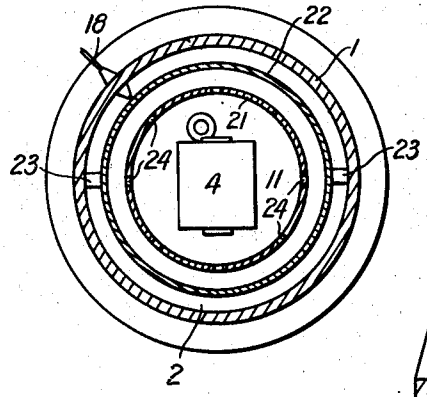


FIG. 4.

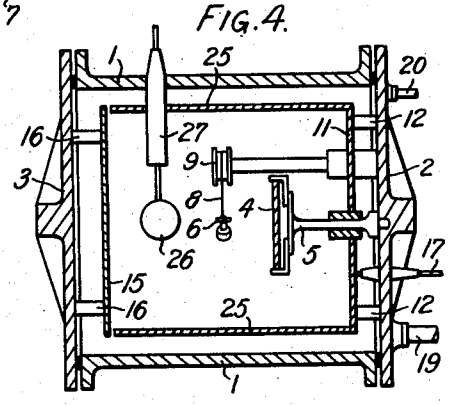
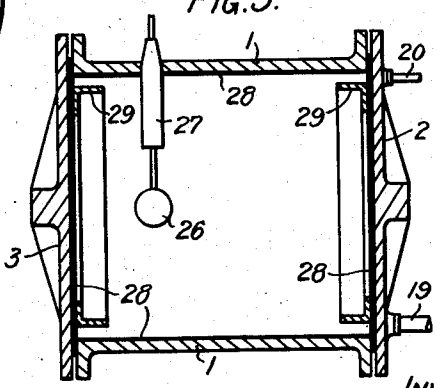


FIG. 5.



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UNITED STATES PATENT OFFICE

2,322,613

APPARATUS FOR DEPOSITION OF METALS BY THERMAL EVAPORATION IN VACUUM

Paul Alexander, Huyton, near Liverpool, England

Application February 25, 1939, Serial No. 258,416
In Great Britain March 2, 1938

5 Claims. (Cl. 91—12.2)

This invention relates to the apparatus for the deposition of metals by thermal evaporation in a vacuum.

Metals are deposited on a support by thermal evaporation, by enclosing the support, the metal to be evaporated and a heater to heat the metal above its vaporisation point, in a chamber connected with continuously operating vacuum pumps, so that a vacuum is maintained in the chamber which is from 0.01 mm. to 0.00001 mm. Hg according to the process used. In the process as ordinarily used a vacuum of 0.0001 to 0.00001 mm. Hg is required in order that a film of good quality may be deposited, but if the metal vapour is heated in its passage from the heater to the support, according to Letters Patent No. 2,100,045, or if the vapour density of the metal vapour is kept very low, by one of the methods set out in Letters Patent No. 2,153,786, a pressure of 0.01 to 0.001 mm. Hg is sufficiently low to obtain a film of good quality.

Now a pumping equipment which is adapted to produce a vacuum of 0.00001 mm. Hg in a chamber of about 15 cubic feet capacity in about four hours, is able to produce a vacuum of 0.001 mm. Hg in about 20 minutes, and the vacuum of 0.001 mm. Hg so produced can be maintained by the pumping equipment during the operation of depositing most metals by thermal evaporation. In the case, however, of aluminium and magnesium, the vacuum cannot be maintained and the pressure in the chamber is found to rise as soon as the Al or Mg begins to evaporate. If deposition be started as soon as the pressure has been reduced to about 0.001 mm. Hg the pressure rises to a value above 0.01 mm. and the film deposited is not of good quality.

In order to maintain the vacuum within the limit required to obtain a film of good quality, without employing a pumping equipment larger than is required for other metals, the vacuum of 0.001 mm. Hg or a higher vacuum must be maintained for a considerable time before deposition is started.

According to the invention, in apparatus for the deposition of aluminium or magnesium, the support and the heating means for the aluminium or magnesium are substantially surrounded, within the vacuum chamber, by a layer of aluminium or magnesium and means are provided for subjecting the layer, as cathode, to an electrical discharge while a vacuum is maintained in the chamber, having as residual gas a gas inert to aluminium or magnesium.

In the accompanying drawing—

Figures 1 and 2 show diagrammatically a vacuum chamber with means for thermal deposition and one form of the invention, Figure 2 being a central vertical section and Figure 1 a section along the line A—A of Figure 2,

Figure 3 shows in a similar chamber another form of the invention, the section as far as the chamber is concerned being along the line B—B of Figure 2, and

Figures 4 and 5 are central vertical sections showing two other forms of the invention.

Referring to Figures 1 and 2, the vacuum chamber 1 has a back 2 and a cover 3. The support 4 on which the deposition is to be made is held in a frame 5 fixed to the back 2. The heater 6 is supplied with current through the leads 7. The aluminium or magnesium to be evaporated is shown in the form of a wire 8 which is fed (by means not shown) from the bobbin 9. A curved sheet 10 of aluminium is fixed to a plate 11 of aluminium, which is supported on the back 2 by insulating pieces 12. Another curved sheet of aluminium 13 is supported in the chamber 1 by insulating pieces 14. A plate 15 of aluminium is attached to the cover 3 by insulating pieces 16, so that, when the cover is closed, the plate 15 contacts with the sheet 13. The two curved sheets 10 and 13 overlap one another, so that, while separated, they substantially surround the heater 6 and support 4. The sheet 10 and plate 11 form one electrode to which a high tension electrical terminal 17 (Figure 2) is connected, and the sheet 13 and plate 15 form the other electrode with terminal 18 (Figure 1). The chamber is evacuated by the pipe 19, and gas can be introduced at 20.

In operation, the chamber is evacuated, hydrogen being introduced to constitute the residual gas. At a suitable pressure in the chamber, a high tension alternating supply is connected to the terminals 17 and 18, to produce a glow discharge between the electrodes 10, 11 and 13, 15. A convenient supply voltage is 2000 and the pressure in the chamber may then be between 0.1 and 0.01 mm. Hg. The evacuation is continued during the discharge and, when the discharge has continued for a few minutes, the discharge is stopped and the chamber is evacuated to the pressure desired for deposition, and the deposition is effected in the ordinary way. It is then found that the vacuum can be maintained within the limits required to obtain a film of aluminium or magnesium of good quality

almost as easily as when other materials are being deposited.

Even when the vacuum used during deposition is 0.0001 to 0.00001 mm. Hg, the above described apparatus is of advantage in maintaining the vacuum within the required liimts, and in reducing the time required to reach the vacuum.

The sheets and plates 10, 11, 13, 15 are most conveniently made of aluminium, but they may be of other metals covered with a layer of aluminium or magnesium, the essential thing being that the heater and support are substantially surrounded by a casing of which the surfaces facing the heater and support are of aluminium or magnesium. The same applies to the parts 22, 25 and 28 mentioned below as being of aluminium.

In the form of the invention shown in Figure 3, an inner cylinder 21 of aluminium is fixed to a plate 11 supported by the back of the chamber, with terminal as in Figure 1. An outer cylinder 22 of aluminium is supported by the chamber by insulating pieces 23 and has a terminal 18. A plate supported by the cover, as the plate 15 of Figure 2, makes contact with the cylinder 22. The inner cylinder 21 is perforated as at 24. The discharge is then effected between the cylinders 21 and 22. The inner cylinder 21 may be made of aluminium or magnesium or of another metal with both inner and outer surfaces coated with a layer of aluminium or magnesium.

In the form of the invention shown in Figure 4, a complete casing is formed round the heater and support, consisting of the cylindrical aluminium body 25 fixed to the plate 11 supported on the back 2, with terminal 17, and the plate 15 supported by the cover 3 as in Figure 2. This casing constitutes one electrode. The other electrode 26 is introduced into the casing through the insulating bush 27. In this form, the discharge must be from a direct current supply, the casing being the cathode.

In the form of the invention shown in Figure 5, from which the support and heater are omitted, the inner wall of the vacuum chamber 1, and the inside of the back 2 and cover 3, are covered with a layer 28 of aluminium or magnesium, as by deposition. An electrode 26 is introduced into the chamber as in Figure 4, and the discharge is made from a direct current supply, with the earthed chamber as cathode. In this case it is preferable to shield the joints between the cover and back and the wall of the chamber by screens 29 of aluminium, in order to protect the jointing material from the ionised gas.

The residual gas in the vacuum during the electrical discharge should be, for the sake of convenience, a gas suited to the subsequent operation of thermal deposition. It is, therefore, preferably, a gas inert to any part of the apparatus and to the metal atoms. Hydrogen is the best gas to use because, for a given vacuum, the mean free path of its molecules is the longest.

Having described my invention, I declare that what I claim and desire to secure by Letters Patent is:

1. Apparatus for the deposition of a metal selected from the group consisting of metals aluminium and magnesium on a support by thermal evaporation in a vacuum, comprising a vacuum chamber containing the said support, said chamber containing as residual gas, a gas inert to the metal to be evaporated, for example hydrogen, electrical means for heating the metal to a temperature above its evaporation point at the vacuum in the chamber, said electrical heating means being located inside the chamber facing the support, means providing a surface facing the heater and support, said surface being of one of the said group of metals, said means being located within said chamber the said surface substantially surrounding the space containing the said support and the said heating means, and means for subjecting the said surface means to an electrical glow discharge, the said means, which provides the surface of one of the said group of metals surrounding the heater and support acting as cathode for at least part of the duration of the discharge, the said discharge being carried out after a vacuum suitable therefor has been produced in said chamber, this vacuum being maintained in the chamber during the discharge, said discharge, after it has continued for a few minutes, being stopped, whereupon the said chamber is evacuated to the pressure desired for the deposition, the deposition being effected when this pressure is obtained.

2. Apparatus for the deposition of a metal selected from the group consisting of metals aluminium and magnesium on a support by thermal evaporation in a vacuum, comprising a vacuum chamber containing the said support, said chamber containing as residual gas, a gas inert to the metal to be evaporated, for example hydrogen, electrical means for heating the metal to a temperature above its evaporation point at the vacuum in the chamber, said heating means being located inside the chamber facing the support, means providing a surface facing the heater and support, said surface being of one of the said group of metals on the inner surface of the vacuum chamber, an anode within the chamber and means for producing an electrical glow discharge between the anode and said surface means as cathode, the said discharge being carried out after a vacuum suitable therefor has been produced in said chamber, this vacuum being maintained in the chamber during the discharge, said discharge, after it has continued for a few minutes, being stopped, whereupon the said chamber is evacuated to the pressure desired for the deposition, the deposition being effected when this pressure is obtained.

3. Apparatus for the deposition of a metal selected from the group consisting of metals aluminium and magnesium on a support by thermal evaporation in a vacuum, comprising a vacuum chamber containing the support, said chamber containing as residual gas, a gas inert to the metal to be evaporated, for example hydrogen, electrical means for heating the metal to a temperature above its evaporation point at the vacuum in the chamber, said heating means being located inside the chamber facing the support, a casing inside the chamber, said casing substantially surrounding the space containing the support and the heating means, at least the inner face of the casing being of one of the said group of metals, an anode within the casing, and means for producing an electrical glow discharge between the anode and the casing as cathode, the said discharge being carried out after a vacuum suitable therefor has been produced in said chamber, this vacuum being maintained in the chamber during the discharge, said discharge, after it has continued for a few minutes, being stopped, whereupon the said chamber is evacuated to the pressure desired for the

deposition, the deposition being effected when this pressure is obtained.

4. Apparatus for the deposition of a metal selected from the group consisting of metals aluminium and magnesium on a support by thermal evaporation in a vacuum, comprising a vacuum chamber containing the support, said chamber containing as residual gas, a gas inert to the metal to be evaporated, for example hydrogen, electrical means for heating the metal to a temperature above its evaporation point at the vacuum in the chamber, said heating means being located inside the chamber facing the support, a casing inside the chamber, said casing consisting of two parts electrically separate, which parts together substantially surround the space containing the support and the heating means, one part being located on one side of the space and the other part being located on the other side of said space, at least the inner face of the two parts of the casing being of one of the metals of the said group, and means for producing an electrical glow discharge between the two parts of the casing, each part serving as cathode for part of the duration of the discharge, the said discharge being carried out after a vacuum suitable therefor has been produced in said chamber, this vacuum being maintained in the chamber during the discharge, said discharge, after it has continued for a few minutes, being stopped, whereupon the said chamber is evacuated to the pressure desired for the deposition, the deposition being effected when this pressure is obtained.

5. Apparatus for the deposition of a metal selected from the group consisting of metals aluminium and magnesium on a support by thermal evaporation in a vacuum, comprising a vacuum chamber containing the support, said chamber containing as residual gas, a gas inert to the metal to be evaporated, for example hydrogen, electrical means for heating the metal to a temperature above its evaporation point at the vacuum in the chamber, said heating means being located inside the chamber, facing the support, a perforated casing inside the chamber, said casing substantially surrounding the space containing the support and the heating means, of which casing at least the surfaces are of one of the metals of the said group, an outer casing inside said chamber, said outer casing surrounding the inner casing, of which outer casing at least the inner surface is of one of the metals of the said group, and means for producing an electrical glow discharge between the two casings, each casing serving as cathode for part of the duration of the discharge, the said discharge being carried out after a vacuum suitable therefor has been produced in said chamber, this vacuum being maintained in the chamber during the discharge, said discharge, after it has continued for a few minutes, being stopped, whereupon the said chamber is evacuated to the pressure desired for the deposition, the deposition being effected when this pressure is obtained.

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