

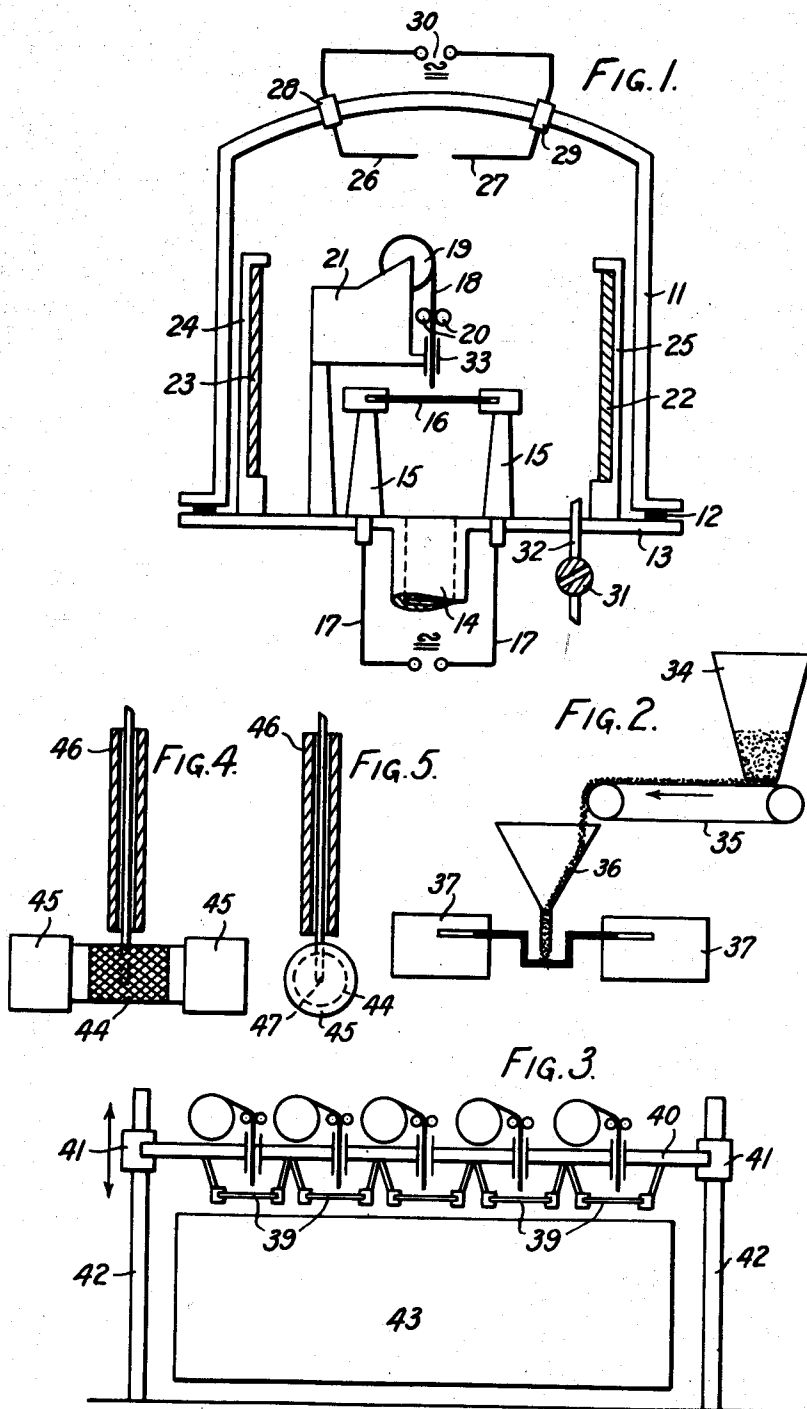
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PROCESS AND APPARATUS FOR THERMAL DEPOSITION OF METALS

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PROCESS AND APPARATUS FOR THERMAL
DEPOSITION OF METALSPaul Alexander and Andor de Dáni, Huyton, Eng-
land; said de Dáni assignor to said AlexanderApplication July 14, 1937, Serial No. 153,548
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9 Claims. (Cl. 91—12.2)

This invention relates to a process and apparatus for depositing a film of metal or other material on a support by its evaporation in a vacuum.

A Process and apparatus hitherto employed have certain disadvantages. In one process, the metal to be evaporated is contained in a vessel of a metal of high melting point. The heat capacity of the vessel causes serious delay in operation, and the occluded and absorbed gases in the metal of the vessel are given off and make the maintenance of the necessary vacuum difficult. Also the metal to be evaporated is liable to combine with the metal of the vessel to form an alloy. In another process, the use of a vessel has been avoided by coating a spiral or a wire or a strip of tungsten or molybdenum with the metal to be evaporated, and heating the spiral or the like electrically. The coating of metal is first melted and then evaporated. While the large heat capacity of the vessel is, by this means, avoided, the spiral or the like has only a short life, owing to formation of alloys, and the need for coating it at each operation causes loss of time. Both these processes have a serious disadvantage of requiring a high vacuum of 10^{-4} mm. Hg or less, in order to obtain a film of good quality. In such processes, it has been found that the vacuum must be such that the free path of the metal atoms is at least of the order of the distance between the point of evaporation and the support. If the free path is less, the metal atoms collide with one another and with the cold molecules of the residual gas. As a result of colliding with the cold gas molecules, the metal atoms lose kinetic energy and then, in colliding with other metal atoms, build up particles which form an imperfect film.

According to the invention, the material to be evaporated is fed towards a heater at a rate so low, while the temperature of the heater is so much above the evaporation temperature of the material at the vacuum employed, that the material is evaporated substantially as soon as it comes into contact with the heater. When the material is in the form of a wire or strip, it is fed so that its end contacts with the heater, the area in contact being so small having regard to the mass and size of the heater, that the material is evaporated substantially as soon as it comes into contact with the heater. Preferably the heater is brought to a temperature above the evaporation temperature of the material at the vacuum employed before the material is brought into contact with the heater. The residual gas in

the chamber is preferably inert to the material to be evaporated and is preferably ionised.

In the accompanying drawing:—

Figure 1 is a diagrammatic section of an apparatus for evaporating metal from a wire or strip;

Figure 2 shows a device for evaporating metal in granular form;

Figure 3 shows a device for depositing a film on a large surface, and

Figures 4 and 5 are side and end views respectively of a heating device.

Referring to Figure 1, the vacuum chamber with upper part 11 sealed to the base 13 by the packing 12, is evacuated through the pipe 14. The heater 16, held in supports 15, is a strip of refractory metal such as tungsten or molybdenum which can be heated by current through the conductors 17. The metal to be evaporated is in the form of a wire or strip 18 contained on a spool 19 and fed downwards by rolls 20 on to the heater 16. Both wire and strip are to be deemed to be included in the term "wire of any convenient form of cross-section" used in the appended claims. Any convenient feeding device, indicated by the casing 21, such as a clockwork, may be employed, means being provided operable from outside the chamber, for starting and stopping it. The supports on which films are to be deposited are shown at 22 and 23, held in frames 25 and 24 respectively. Two electrodes 26 and 27 are connected with a source 30 of high potential, and serve to ionise the residual gas in the chamber. These electrodes are not essential, but are of advantage when the vacuum is low. The pipe 32 with valve 31 serves to introduce gas into the chamber when it is desired that the residual gas should be other than air. The gas is introduced before or during evacuation and is then evacuated to the desired vacuum.

The heater 16 is heated to a temperature substantially above the vaporisation temperature of the metal 18 at the vacuum employed. For example, if the metal to be evaporated is aluminium, and the vacuum 10^{-3} mm. Hg the heater is heated to about 1500° C. The rolls 20 are started to feed the wire 18 against the heater 16, and, as soon as the wire touches the heater, its point is immediately vaporised and the vapour is deposited on the supports 22 and 23. The rate of feed should be adjustable so that, for any metal, it is as fast as possible without exceeding the rate at which the metal can be evaporated on contact with the heater.

When long flexible supports, such as paper

strips, are to be covered with a deposited film, these may be contained on rolls, adapted to feed the strip to expose it to the evaporated metal. For such purposes, or when many supports are to be covered, the device described, in which the metal to be evaporated is contained on a spool, is convenient, but, when only a small quantity of metal has to be evaporated, a straight wire or strip may be placed in the guide 33, so as to rest on the heater 16. The wire or strip is then fed down as it is evaporated by its own weight.

Where the material which is to be evaporated is more conveniently obtained in granular form, as for instance, in the case of quartz, the device may be employed which is shown in Figure 2, wherein only the material feeding device and the heater 38 in supports 37 are shown. The granular material is fed from the container 34 by the conveyor 35 to the funnel 36, by which it is directed on to the heater 38. This is preferably in U-form, so that grains shot off on contact with the bottom of the heater may strike the legs of the U.

Figure 3 shows a device for depositing a thin film on a large surface, to form, for instance, a mirror (the vacuum chamber and other accessories being omitted). A plurality of wire feeding devices, with heaters 39, are mounted on a bar 40 attached to sleeves 41 which are adapted to be moved up and down the guides 42, whereby the evaporating points are passed close to all points of the support 43.

Figures 4 and 5 show an alternative form of heater, composed of a cylinder 44 of gauze of wire of a refractory metal, provided with terminal blocks 45. The wire or strip 47 of metal to be evaporated supported in the guide 46, is passed through a hole or slit in the gauze cylinder 44, and is evaporated within the cylinder. This form of heater has the advantage that the metal atoms are distributed over a large area without becoming cooled, because they are heated in passing outwards through the meshes of the gauze. Equivalents to a gauze may be used, such as a wire cage, or a perforated metal cylinder.

By the above described process, only a very small quantity of metal is evaporated at a time, and the evaporation takes place at a high temperature, so that the vapour is superheated and its density small. Further, the evaporation takes place at a point (or along a line if a strip is used) and the atoms travel outwardly in all directions away from the heater, so that the further they are from the evaporation point (or line) the further they are away from each other, and the less likely they are to collide. If, then, an atom collides with a gas molecule, it tends to remain with fairly high kinetic energy by reason of its very high initial kinetic energy, and the chance of two atoms of low kinetic energy colliding and coalescing together is very small. On this account, the vacuum may be substantially less than is necessary with processes hitherto used to produce a film of good quality.

In the case where a plurality of evaporation points are used, it is important that their distance apart should be such that the size of each evaporation point is negligible in comparison, so that a very small vapour density is ensured.

A further advantage of the process is that, if the metal to be evaporated is brought into contact with the heater only after this has been raised to a temperature above the evaporation point of the metal, no alloy is formed, and the heater therefore has a long life.

It is preferable to replace the residual air in the chamber by an inert gas, such as hydrogen, and a still lower vacuum may be employed if the gas is ionised by means of the electrodes 26, 27.

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

1. Apparatus for the deposition of a film on a support by evaporation in a vacuum in a chamber comprising means for supporting wire of any convenient form of cross-section of the material to be evaporated, a heater, means for heating the heater to a temperature above the evaporation point of the material at the vacuum employed, and means for feeding the wire towards the heater so that its end contacts with the heater.

2. Apparatus for the deposition of a film on a support by evaporation in a vacuum in a chamber comprising a container for granular material to be evaporated, a heater, means for heating the heater to a temperature above the evaporation point of the material at the vacuum employed, and means for dropping the granular material gradually on to the heater at a predetermined rate.

3. Apparatus for the deposition of a film on a support by evaporation in a vacuum in a chamber, comprising a heater in the form of a hollow perforated body, means for heating the heater to a temperature above the evaporation temperature of the material to be evaporated, an opening in the heater body, and means for feeding the material to be evaporated at a predetermined rate through the opening into the interior of the heater body.

4. Process for the deposition of a film on a support by thermal evaporation in a vacuum, characterised by the material to be evaporated being fed towards a heater at a rate so low, while the temperature of the heater is so much above the evaporation temperature of the material at the vacuum employed, that the material is evaporated substantially as soon as it comes into contact with the heater.

5. Process for the deposition of a film on a support by evaporation in a vacuum of material in the form of wire of any convenient form of cross section, in which the material is fed endwise towards the heater so that only its end contacts with the heater, the rate of feed being so low, while the temperature of the heater is so much above the evaporation temperature of the material at the vacuum employed, that the material is evaporated substantially as soon as it comes into contact with the heater.

6. Process for the deposition of a film on a support by thermal evaporation in a vacuum of granular material, in which the material is fed gradually and continuously on to the heater at the rate of feed so low, while the temperature of the heater is so much above the evaporation temperature of the material at the vacuum employed, that the material is evaporated substantially as soon as it comes into contact with the heater.

7. Process as in claim 4, in which the residual gas in the chamber is ionized.

8. Apparatus for the deposition of a film on a support by evaporation in a vacuum in a chamber, comprising a heater having a substantially horizontal heating surface, a straight wire of the material to be evaporated of any convenient form of cross section, and a guide adapted to retain the wire in a substantially vertical position so that its lower end rests on the heater while

leaving it free to feed itself onto the heater by its own weight.

9. Apparatus for the deposition of a film on a support by evaporation in a vacuum comprising
5 guides parallel to one dimension of the support, a frame slidably mounted on said guides, and a plurality of evaporating devices mounted on the

frame close to the support so as to extend linearly across the other dimension of the support, each evaporating device consisting of a heater and a means for feeding the material to be evaporated towards the heater.

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