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APPARATUS FOR VACUUM EVAPORATION OF METALS

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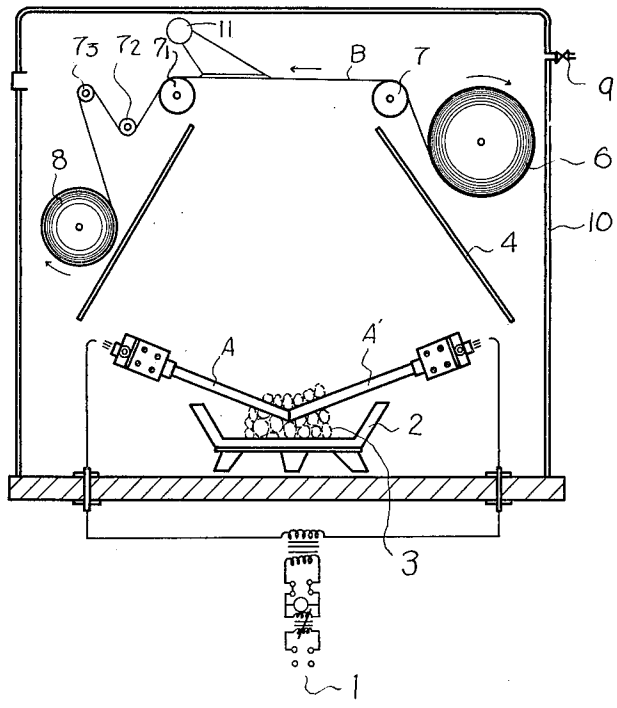

INVENTORS
MINORU IWATA, TATSUO TAKATSUKI
& HARUO KUBOTA
BY
William D. Carothers
THEIR ATTORNEY

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APPARATUS FOR VACUUM EVAPORATION OF METALS

Minoru Iwata, Ikeda-shi, Tatsuo Takatsuki, Omiya-shi, and Haruo Kubota, Nishinimiya-shi, Japan, assignors to Sumitomo Electric Industries, Ltd., Osaka, Japan, a company of Japan

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This invention relates to an improvement in an apparatus for vaporization-coating of material with various metals, especially aluminum, silver, copper, etc., and the method of performing the same, and is characterized in that a plurality of electrodes made of titanium carbide, zirconium boride, chromium boride, silicon carbide or the like which hardly reacts with molten metals at high temperatures are provided in a furnace, and a metal placed in the furnace is heated and vaporized by charging the said electrodes with electric current. Its object is to provide an apparatus and a method to carry out the continuous vaporization coating of material with metals, which is easy and inexpensive, said coating having hitherto been considered very difficult to perform.

As is well known, it is necessary to vaporize the coating metal in a large quantity and continuously, in case where the area to be coated is very large or where the surface to be coated moves on continuously. However, these requirements are not fully satisfied by the hitherto publicly known method of vaporization-coating, for instance the vaporization-coating of reflecting mirrors with aluminum, in which a tungsten coil, tungsten or molybdenum board, and the like are employed as a heater for the vaporization-coating. It has been found extremely difficult to effect vaporization-coating continuously on a long-shaped material to be coated, such as paper tape. This is because it is impossible to effect vaporization in a large quantity in the usual way with such material as a heater, since molten aluminum at a high temperature (about 1,100° C.) reacts actively with almost any material, producing an alloy with almost any metal, reducing oxides and forming a carbide with carbon. Furthermore, molten aluminum at 1,100° C. or higher temperatures is highly mobile liquid, so that it freely wets and flows over the walls of the crucible or may penetrate into invisible pores. This has made the practical application of the method still more difficult, because the provision of protective films proved hardly effective to eliminate such difficulty.

As methods of effecting vaporization in a large quantity, the use of a high frequency furnace, the use of a graphite crucible and the operation made while eliminating the carbide formed, and the use of thick tungsten rods have been proposed. However, all of these methods are far from being satisfactory, because these are quite expensive or are not good for effecting a stabilized vaporization. None of these have come to be practically utilized.

This invention eliminates all of the said defects.

The invention is now explained in detail with reference to the drawing which illustrates an example of the practical applications of the invention.

In the drawing A and A′ represent a plurality of rod-shaped electrodes which are made of titanium carbide or the principal component of which is titanium carbide; **1** their electric power source; **2** a crucible; **3** metal to be vaporized for coating, for instance, aluminum ingots; **4** shield plates. B represents the tape of paper, synthetic resin, etc., to be coated which comes from the feed reel **6** to the guide rollers **7**, 7_1, 7_2 and 7_3 and reeled around the take-up reel **8**. **9** represents a valve on the passage to the vacuum pump (not shown); and **10** represents a vacuum vessel. In making use of such an apparatus of this invention, first, the interior of the vacuum vessel **10** is kept at 10^{-4} mm. Hg or a higher vacuity, and the tape B to be coated is caused to move from the feed reel **6** to the take-up reel **8**, while alternating current is flowed from the power source **1** to the electrodes A and A′, to heat, melt and vaporize the aluminum ingots **3** gradually. When this is done, the vaporized metal continuously and gradually condenses onto the tape B which passes between the shield plates **4**, so that the vaporization-coating of a long-shaped material can be effected in a smooth and easy way.

The electrodes of this invention, which are made of titanium carbide, zirconium boride, chromium boride or silicon carbide, with or without some suitable additives, are not readily affected even by molten aluminum at approximately 1200° C. and have a fairly good electrical conductivity, so that they have favorable properties for use as electrodes. On the other hand, these materials are very hard, are brittle and have little workability, so that they are unsuitable for the electrodes of spiral and other hitherto used types, and have not so far been put to practical use. In the method of this invention, however, these materials are quite satisfactory because the electrodes of a simple shape of rod is used. Especially, since the heating by electric current is effected by contacting the tip parts of the plurality of electrodes A and A′ as shown in the drawing, these tip parts first get red-hot, and then aluminum **3** in the proximity melts and adheres to the electrodes because of its surface tension, and reduces the electrical resistance of that part. In consequence, the parts get red-hot gradually from down to upward, and the molten aluminum, because of its fluidity, gradually adheres from down to upward, on the stem sides, over the surface of the electrodes A and A′. The vaporization of aluminum starts already under this condition; however, as time passes on, all the aluminum in the crucible gets molten and vaporization comes to take place also from the crucible, as temperature gradually rises higher.

According to the method of this invention, the electrodes are made of material which very hardly reacts with molten metals, and such electrodes are so constructed that a plurality of them are combined and the rise of temperature begins at their tip parts. Therefore, the temperature of the walls of the crucible or a similar furnace does not rise so high and the reaction between the molten metals and the material of the furnace walls is suppressed. This makes it possible to use the porcelain crucible of the usual type, and makes the method suitable for industrial applications. As can be seen from the explanation already given, the heat generation takes place in the central part of the furnace and the heating efficiency is high, so that it is very simple to effect thermal insulation of the furnace. Consequently, a step-down transformer like that for a resistance furnace is good enough for the electric power source **1**, so that no expensive high frequency power source is required and the furnace can be made small sized. Furthermore, there is no possibility of the contents of the crucible overflowing because of the high-mobility thereof, said overflowing is difficult to be solved in the case of a resistance furnace. On the contrary, the molten aluminum, because of its high-mobility, climbs up along the surface and gets vaporized after it reaches the part of a high temperature, the high-mobility enhancing the efficiency of electrical current and increasing the vaporization velocity. Of course, it is possible to store a large quantity of metal in the crucible, so that a stabilized vaporization can continuously be effected. Therefore, our method is superior to the method in which a thick tungsten rod or the like is used.

If the tips of the plurality of electrodes A and A′ are strongly brought into contact with each other prior to conducting electric current, they may get broken as a

result of expansion by heat. This possibility, however, can be eliminated if they are first caused to short-circuit through the aluminum ingots 3 placed in the furnace.

For the manufacture of metalized paper or the like, a cooling device is provided in the proximity of the upper surface of the inserted material, namely the surface which is not to be coated, by means of the blower 11 which recirculates the ambient gases against this upper surface for the purpose of preventing the lowering of vacuity or deterioration of the inserted material to be coated, said lowering of vacuity or deterioration being caused by a rise in the temperature of the vacuum chamber.

In the specification and the attached drawing, we have explained the details of this invention by way of examples. It is to be noted, however, that the scope of this invention is by no means restricted to these examples. Needless to say, many changes and modifications can be made without departing from the spirit of this invention.

We claim:

1. An apparatus for vaporization-coating of material with metals consisting of a vacuum vessel having a chamber, means in the chamber to support the material to be coated, furnace means installed in said chamber including a crucible supporting the coating metal and a plurality of electrodes made of a material selected from the group consisting of titanium carbide, zirconium boride, chromium boride and silicon carbide, means to supply said electrodes with electric potential of opposed polarity, and means to support said electrodes of opposed polarity with their ends extending into said crucible in close proximity to each other and engaging the coating metal to form a melted liquid pool of the metal that reduces the electrical resistance between said electrodes increasing their temperature further from the electrode ends to vaporize the liquid coating metal only around said electrodes and above the liquid pool.

2. The vaporizing apparatus of claim 1 characterized in that said means to support said electrodes providing initial direct electric contact between said electrodes.

3. The vaporizing apparatus of claim 1 characterized in that said means to supply said electrodes with an electric potential is a low frequency alternating current.

4. The vaporizing apparatus of claim 1 which also includes cooling means in said chamber above said material being coated to cool the same.

5. The vaporizing apparatus of claim 1 characterized in that said means to support the material to be coated includes moving rollers mounted in said chamber from which the material to be coated is hung.

6. The vaporizing apparatus of claim 5 characterized by a cooling means in said chamber above said rollers for cooling the coated material.

7. The vaporizing apparatus of claim 1 characterized in that said means to support the material to be coated includes reels between which the material is passed through a series of flights from one reel to the other, one flight of the material being coated being horizontal and above and directly exposed to the crucible for receiving the vaporized metal, and shield means between said crucible and said reels and flights other than said horizontal flight to cool the same.

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