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VAPORIZATION OF METALS

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Fig.1

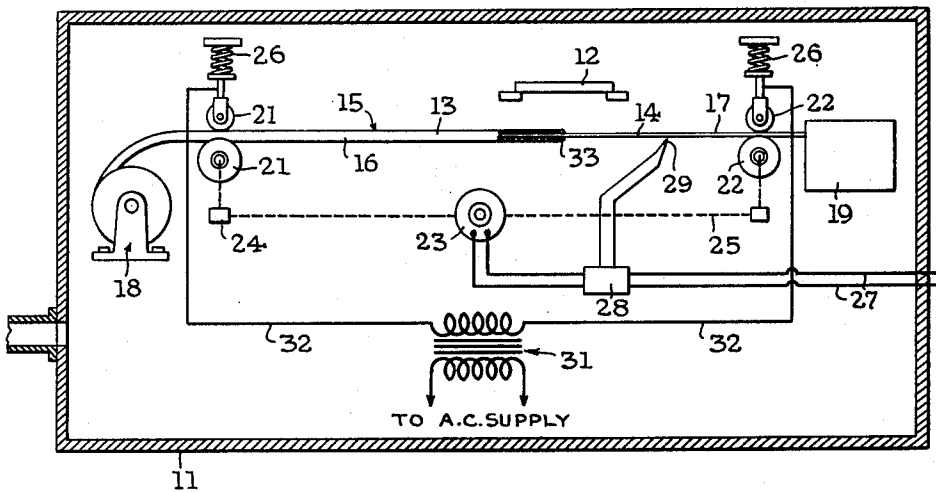


FIG. 2

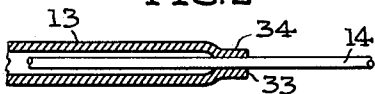
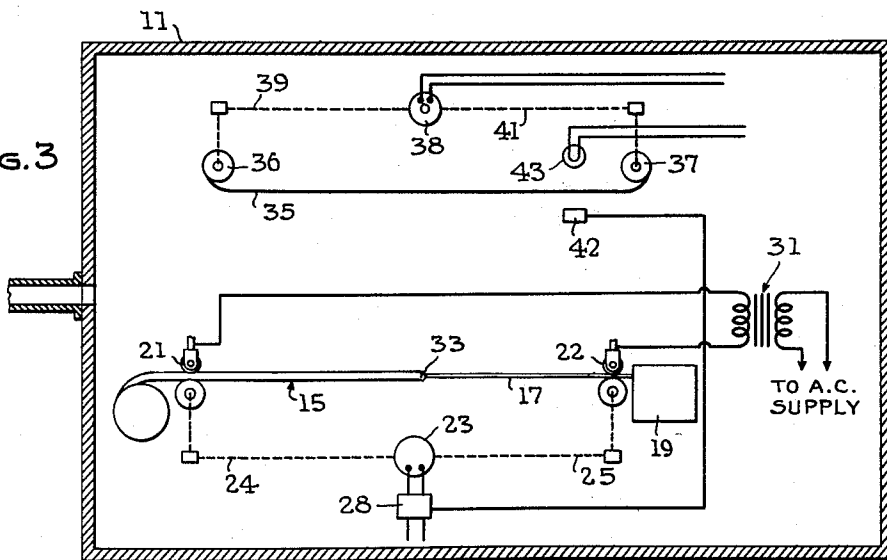


FIG. 3



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This invention relates to coating and more particularly to the vacuum deposition of vaporized metals.

The process of coating bases in a vacuum by the deposition of vaporized metals is used extensively today in the manufacture of mirrors, coated lenses, etc. In these processes, the metal is usually vaporized in one of two ways. In the first, small staples of coating wire are suspended from a straight or helically coated filament and evaporated from the filament by the application of an electric current. In the other method, the coating metal is placed in and vaporized by a small electrically heated crucible. It is apparent that since only a limited amount of coating metal can be placed on the filament or in the crucible, these devices cannot operate for extended periods of time. When it is remembered that the vaporizers operate in a vacuum, it will be realized that this limitation is a serious disadvantage because time and energy are required to re-establish the operating vacuum each time the vaporizer is recharged.

The performance of these vaporizers has been improved somewhat by the inclusion of automatic feeders which continuously transmit coating metal, usually in the form of a wire, to the filament or the crucible as the vaporization process proceeds. However, the automatic feeder is not a panacea. In the filament vaporizer, the continuous application of heat and coating metal weakens the filament and frequently causes it to break, thus interrupting the process. While the crucible vaporizer overcomes this difficulty, it does so at the expense of efficiency because considerable energy is required to maintain the relatively large amount of coating metal at the vaporization temperature. Furthermore, since the crucible represents a rather large heat source, some difficulty has been encountered in using it in processes for coating flexible bases, such as cellophane.

The object of the present invention is to provide an improved way of continuously vaporizing metals by means of an electrically heated filament. According to the invention, the filament and the metal to be vaporized are combined to form a conductor having a compound section in which the filament is a core and the metal to be vaporized is a surrounding sheath, and another section consisting solely of the exposed filament. The conductor is connected with a source of electrical energy so that the current passes through at least a portion of the length of both sections. The heat generated in the exposed portion of the filament will effect a progressive melting and vaporization of the metal in the sheath beginning at the end adjacent the exposed filament. By feeding the conductor lengthwise in the direction of the exposed filament at a rate commensurate with the rate of vaporization, it is possible to achieve continuous vaporization of the sheath at a point fixed in space. Since the heating filament in this invention is continuously fed to the vaporizing point, it is not subject to the deterioration encountered in the prior art. Further, since only the coating metal at the point of vaporization is heated to the vaporization temperature, the invention is eco-

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nomical and can be used in processes for coating flexible bases.

The preferred embodiment of the invention will now be described in relation to the accompanying drawing, in which:

Fig. 1 is a diagrammatic showing of apparatus for coating a stationary base.

Fig. 2 is a partial sectional view of the conductor.

Fig. 3 is a diagrammatic showing of apparatus for coating a movable base.

As shown in Fig. 1, apparatus for practicing the invention is located within a vacuum chamber 11 for coating a stationary base 12. The coating metal 13 and heating filament 14 are combined into a conductor 15 having a compound section 16 comprising a core consisting of the filament 14 and a surrounding sheath formed from a tube of the coating metal 13, and a section 17 consisting solely of the exposed filament 14. The metal 13 can be any one of many which are capable of being vaporized, aluminum being an example. The filament can be made of tungsten. The conductor 15 is wound on a storage reel 18 and is fed by two pairs of copper feed rollers 21 and 22 to a filament collector 19, which, if the filament remains pliable after heating, could be a take-up reel. One roll of each pair is driven by an electric motor 23 through suitable transmissions, indicated at 24 and 25. Springs 26 react against the other roll of each pair to supply the necessary driving friction. Power is supplied to motor 23 by transmission lines 27 and the speed of the motor is controlled by a device 28 which automatically varies the current in accordance with the output of thermocouple 29 located adjacent the exposed filament section 17. Electrical energy is transmitted to conductor 15 from power transformer 31 via lines 32 and copper feed rollers 21 and 22. The transformer is connected with a source of alternating current, not shown.

In preparing the apparatus for operation, it is first necessary to advance conductor 15 through the feed rollers 21 and 22 so that the exposed filament can be inserted into collector 19 and the end 33 of sheath 13 can be located midway between the ends of base 12. In order to provide good electrical contact between the end 33 and filament 14, the tube 13 is swaged onto the filament as shown at 34 in Fig. 2. This procedure insures that vaporization will begin at this point.

When the required vacuum has been established in chamber 11, the transformer 31 will be energized and current will flow through line 32, rollers 21 and 22, and a portion of each section of conductor 15. In the compound section of this conductor, both the sheath 13 and the filament 14 will carry the current, whereas in the other section all of the current will be carried by the filament. Consequently, the exposed filament section will become hotter than the compound section and vaporization will begin at the end 33 adjacent the exposed section and proceed progressively along the length of sheath 13. As soon as the process commences, the motor 23 will be started and conductor 15 will be fed through the apparatus at a rate equal to the rate of vaporization. Since the rate of vaporization is a function of the temperature of the exposed filament and since the speed of motor 23 is varied in accordance with the output of thermocouple 29 which measures this temperature, it can be seen that this equality between the rates of feed and vaporization will be maintained throughout the process. As a result, the point of vaporization (end 33) will remain fixed in space and the length of exposed filament between this end and rollers 22 will be constant. In this way, the process will be continuous and a uniform coating will be deposited on base 12. Furthermore, if it is desired to change the rate of vaporization,

it is only necessary to vary the current supplied to conductor 15 since the temperature control will automatically adjust the rate of feed.

In Fig. 3, the vaporizing apparatus is employed to coat a continuous sheet of flexible material 35, such as cellophane, which is stored on a reel 36 and fed to a take-up reel 37 by a constant speed electric motor 38 and suitable transmissions 39 and 41. In this embodiment, the speed of feed motor 23 is varied in accordance with the output of photoelectric cell 42 which measures the amount of light transmitted from a source 43 through the coated base. The output of the cell 42 is proportional to the thickness of the deposited coat and since this thickness is a function of the rate of vaporization, it will be seen that, as in the Fig. 1 embodiment, the rates of feed and vaporization will be maintained equal, and the point of vaporization will remain fixed in space.

As stated previously, the drawing and description relate only to preferred embodiments of the invention. Since many changes can be made in their embodiment without departing from the inventive idea, the following claims should provide the sole measure of the scope of the invention.

What is claimed is:

1. Apparatus for coating a base in a vacuum by the process of depositing a vaporized metal, comprising a conductor having a compound section consisting of an electrically conducting heater filament and a contiguous layer of the coating metal, and another section consisting only of the filament; a source of electrical energy; an electrical circuit including the source and at least a portion of the length of both conductor sections and means for feeding the conductor lengthwise in the direction of the filament section.

2. The apparatus defined in claim 1 including means for controlling the length of the filament section included in the electrical circuit.

3. The apparatus defined in claim 1 in which the contiguous layer of the metal in the compound section is in the form of a tube surrounding the filament.

4. The apparatus defined in claim 3 including control means for maintaining constant the length of the filament section included in the electrical circuit.

5. A process for vaporizing a metal at a point in a vacuum comprising the steps of feeding an electrical heater filament through said point; feeding an elongated body of the metal to be vaporized to said point; and passing an electrical current through a portion of the length of the filament which includes the point of vaporization; said current being sufficient to cause progressive vaporization of the elongated metal body as it is fed to said point.

6. A process for vaporizing a metal at a point in a vacuum comprising the steps of feeding to said point an elongated conductor having a compound section consisting of an electrical heater filament and a surround-

ing sheath of the metal to be vaporized, and another section consisting only of the filament, and passing an electrical current in series through a portion of the length of each section and through the junction of the two sections, the current being sufficient to cause progressive vaporization of the metal sheath beginning at said junction.

7. The process defined in claim 6 including the step of so correlating the rates of feed and vaporization that the point at which vaporization occurs remains fixed in space.

8. A process for vaporizing a metal in a vacuum which comprises the steps of forming an elongated conductor having a compound section consisting of an electrical heater filament and a contiguous layer of the metal to be vaporized, and another section consisting only of the filament; establishing an electrical circuit including in series a portion of the length of the filament section, the junction of the two conductor sections, and a portion of the length of the metal layer; and passing an electrical current through said circuit of sufficient magnitude to cause progressive vaporization of the metal layer beginning at the junction of the two conductor sections.

9. A process for vaporizing a metal in a vacuum which comprises the steps of forming an elongated conductor having a compound section consisting of an electrical heater filament and a contiguous layer of the metal to be vaporized, and another section consisting only of the filament; establishing an electrical circuit including a portion of the length of each section and the junction of the two sections; passing an electrical current through said circuit of sufficient magnitude to cause progressive vaporization of the metal layer beginning at said junction; and feeding the conductor lengthwise in the direction of the filament section as vaporization proceeds.

10. The process defined in claim 9 including the step of correlating the rates of feed and vaporization so as to control the location of the point at which vaporization occurs.

11. The process defined in claim 10 in which the rates of feed and vaporization are so correlated that the point at which vaporization occurs is maintained fixed in space.

12. The process defined in claim 9 in which the contiguous metal layer in the compound section is in the form of a tube surrounding the filament.

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