This invention relates to vacuum coating. More specifically, this invention relates to apparatus adapted to supply coating vapors such as aluminum in the continuous or semi-continuous coating of substrates such as paper, plastic or metal.

In large scale vacuum deposition coating, it is desirable to have a coating vapor source which is replenished in order to permit coating over extended periods of time. Accordingly, it is an object of the present invention to provide an improved process and apparatus for vacuum coating substrates.

Another object of this invention is to provide a coating apparatus comprising a plurality of coating vapor sources in a vacuum chamber adapted to generate metal vapors such as aluminum at a steady rate over an extended interval.

Another object of this invention is to provide a replenishing system for a coating vapor source having a simple construction and eliminating the requirement of pumps for molten material.

Other objects of this invention will, in part, be obvious and will, in part, appear hereinafter. The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure and the scope of the application of which will be limited in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, wherein:

FIG. 1 is a diagrammatic, schematic, partially sectional side view of the apparatus of the invention:
FIG. 2 is a diagrammatic, schematic, partially sectional top view of a portion of the apparatus of FIG. 1:
FIG. 3 is a magnified sectional side view of a portion of the preferred embodiment of FIG. 2; and FIGS. 4 and 5 are magnified cross-sections of the launder portion of a preferred embodiment of the invention.

In the present invention there is a usual vacuum coating chamber which can be evacuated to pressures in the micron Hg abs. range. An evaporating crucible means is provided with a heating means. Guide rolls are adapted to pass a moving substrate over the crucible means. Above the crucible there is a melting pot adapted to receive solid metal and to melt it and adapted to be poured to supply metal to recharge the crucibles.

In the invention as adapted for aluminum coating, solid aluminum is preferably melted in the vacuum chamber and maintained in molten condition in the melting pot at a low temperature of around 1000° C. Initially, a launder is provided between the melting pot and the crucible means for distributing the molten aluminum from the melting pot to the crucibles. This launder is preferably a longitudinal, substantially enclosed vat maintained at about 1000° C. Heated guides preferably extend from one side of the launder down to the near side of the crucible means. The launder is also preferably provided with guiding means capable of rotating the launder at very slow speeds to feed the molten aluminum to the crucibles.

In preferred embodiments wherein the crucible means comprises a plurality of crucibles, individual guides preferably extend from the launder to each crucible. The launder is preferably segmented by perforate transverse baffles. Upon rotating, fluid tight compartmentation of the launder occurs with volumes defined one from the other whereby fixed portions of melted aluminum are isolated and subsequent incremental tipping of the launder ensures distribution of aluminum to the crucibles equally or according to a preconceived plan. This baffled segmentation is accomplished without hindering the distribution of the melt to each of the various volumes when the launder is filled from a melting pot by a unique arrangement and configuration of the baffles.

Referring now to the drawings wherein like numerals refer to like elements, the details of construction and operation of the invention will be described.

In the preferred embodiment of FIG. 1 there is a vacuum chamber 44 equipped with a vacuum pump 46 adapted to maintain pressures in the micron range, i.e., 1 to 10 micron Hg abs. A means 48 is provided for introducing a substrate 49 into said chamber to expose it to coating vapors and for removing the substrate from the chamber after coating. In the preferred embodiment of FIG. 1 this means comprises a coating drum 50 surrounded by close fitting shrouds 52; guide rolls 54 are provided for guiding the substrate onto and off of the coating drum. In this preferred embodiment the coating drum introduces the substrate from an intermediate chamber 55 which is evacuated by an additional vacuum pump 56. The substrate passes between seals 58 when entering and leaving this intermediate chamber. Immediately below the coating drum there is a crucible means 60, surrounded by heating means 62 adapted to heat metal in the crucible to vaporizing temperatures, producing vapors which impinge upon the substrate passing over the crucible. A melting pot 64 having heating means 63 and a pouring lip is provided in the vacuum chamber 44. A charging means 66 is preferably located so that its discharge end is in the vacuum chamber 44 in an emptying position above the melting pot 46. As schematically illustrated, this charging means passes through the wall of the vacuum chamber 44 in a vacuum-tight manner to permit aluminum pigs 68 to be charged to the pot 64. A preferred embodiment of the melting pot 64 includes a transverse baffle 69 (see FIG. 3) of the type described in the copending application of Clough et al., filed on even date herewith.

Referring now particularly to the embodiment of FIGS. 2 through 5, wherein like numerals refer to like elements in FIG. 1, a baffled launder 72 is located above a series of crucibles 60 but below the melting pot 64. This launder comprises a hollow carbon cylinder 65 having closed carbon ends, and an upper filling opening 66 under the pouring lip of the melting pot 64. The launder 72 is surrounded by electrical heaters and outer insulation 74. An in-line series of short carbon pouring tubes 75 extend from holes in the carbon cylinder through the insulation. Both the melting pot 64 and the launder 72 are rotatably mounted. Tipping means 76 is provided to tilt the melting pot when desired so as to pour liquid from the pot into the launder 72. Slow speed rotating means 78 is provided to gradually rotate the launder 72 permitting liquid in the launder to slowly pour through the pouring tubes 75. A plurality of liquid guides 77, one for each pouring tube 75, are positioned in a liquid receiving position with the pouring tubes, and extend down to a discharge position over edges of the respectively associated crucible. Care is taken that the tubes do not extend over the crucibles to hamper vapor generation. The guides 77 are provided with heating means capable of operating at about 1000° C. to prevent cooling of passing metal.
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Referring now to FIGS. 4 and 5, wherein like numerals refer to like elements in the foregoing figures, there is shown, in greater detail, the unique provision for ensuring that proper amounts of material flow to each crucible. This is achieved by baffles 73 in the launder which isolate proper volumes adjacent the respective pouring tube openings in the launder and prevent communication between adjacent volumes. To ensure that each volume receives an appropriate amount of melt upon filling the launder from the melting pot, as viewed in its upright filling position shown in FIG. 4, each baffle top is not continuously horizontal but rather upper baffle edges on the side of the launder indicated at 73a, opposite from the in-line series of pour tube openings, are substantially lower than the rest. It will be observed that on pouring melt from the melting pot to the launder, the launder is in its filling position as shown in FIG. 4. When the molten material rises above the depressed upper edge of the baffles at 73a, the molten material levels completely along the length of the launder 72 and the launder is filled to a substantially depth. The launder is then rotated counter-clockwise to a position shown in FIG. 5. The portion of the baffle at 73a rises above the level of the molten material and the baffles 73 effectively isolate each volume from the rest. Further rotating causes melt to pour through the thus lowered tubes 75 to the crucible.

In the operation of the preferred embodiment described, the substrate 49 is threaded through a conventional seal, over the rollers 54 and around the coating drum 50. By vacuum pumps 46 and 56 a vacuum in the micron Hg range is attained in chamber 44. Aluminum pigs 68 are introduced into the coating chamber, into the melting pot 64. The melting pot 64 is brought up to a temperature of around 1000° C. and the aluminum is melted. After melting, the melting pot 64 is tilted by means 76 and the molten aluminum flows into the upright launder 72. For equal distribution in the operation of the apparatus of FIGS. 2-5, there must be sufficient molten aluminum poured from the melting pot to bring the level in the launder above point 73a to ensure proper distribution in each of the baffled volumes. Subsequently, the launder is slowly rotated by rotating means 78 and the molten aluminum in the launder flows to each crucible through its pouring tube 75 and guide 73. The crucibles are maintained at 1900° C. by heating means 62 and the crucibles contain passive vapors which impinge on the substrate above. A shield 80 is preferably provided to protect shrouds 52 and the substrate from impinging vapors. As the molten aluminum in each crucible is evaporated, a gentle stream sustains the level of molten material in the crucible is maintained. As the coating progresses, additional solid aluminum is admitted to the melting pot 64 which has been returned to its vertical position, and another batch of aluminum is melted. When most of the molten aluminum in launder 72 has been transferred to the crucible 60, the launder is returned to its initial position and the melting pot is immediately dumped into the launder as above and the launder is then rotated gradually to resume the gentle flow of molten aluminum into the crucibles. Thus continuous operations are permitted with a minimum of interference with the evaporating conditions prevailing in the crucibles 69.

A preferred embodiment of the launder is fabricated with an inner shell of amorphous carbon and an outer shell of alumina and clay and provided with electrical heating coils. The crucibles are preferably of carbonaceous material and have a surface coating of silicon carbide. The crucibles are preferably heated by induction coils powered by a suitable electric source. Guides adapted to preheat or conduct the melted aluminum at or above 1000° C. (as the material flows to the crucibles) are also preferably of carbonaceous material and are likewise insulated with alumina and provided preferably with electrical heating.

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Though this invention has particular utility in continuous operations where the substrate flows continuously from a production line, it is also advantageously used as a semicontinuous coater wherein large amounts of melted aluminum are consumed. The invention has been described relating to aluminum vapor deposition but has utility in other coating applications.

Since many variations on this basic apparatus can be accomplished within the spirit of the invention, it is intended that the description and drawings herein be taken in a descriptive and not limiting sense.

What is claimed is:

1. A vacuum coating apparatus comprising a vacuum-tight chamber, means for evacuating said chamber to a low pressure on the order of a few microns Hg abs. or less, at least one crucible provided with heating means positioned in said chamber, means for passing a substrate above said crucible whereby vapors emanating from said crucible may impinge upon said substrate, a melting pot located above said crucible, means arranged to permit the passage of solid metal to be melted into the melting pot inside the chamber without substantial admission of gases to the chamber, means for tilting said melting pot, a heated launder located between said melting pot and said crucible, said launder being so positioned as to receive the melt from the melting pot when the melting pot is tipped and being in such position so that when the launder is substantially rotated the melt will slowly pour from the launder into said crucible and a rotating means provided on said launder capable of rotating the launder at a slow controlled speed whereby it is possible to maintain the level of melt in the crucible at a substantially constant level over extended periods of time while coating is being performed.

2. The apparatus of claim 1 wherein the launder is spaced apart from said crucible and an insulated and heated guide is positioned to receive melt as it is poured from said launder, said guide being slanted so as to cause the thus received melt to flow to said crucible.

3. A vacuum coating apparatus comprising a vacuum-tight chamber, means for evacuating said chamber to a low pressure on the order of a few microns Hg abs. or less, a multiplicity of in-line crucibles with associated heating means positioned in said chamber, means for passing a substrate above said crucibles whereby vapors emanating from said crucibles may impinge upon said substrate, a longitudinal launder in said vacuum chamber above said crucibles, means for introducing melted material into said launder, outlets on one longitudinal side of said launder arranged to communicate with said crucibles, baffle means separating predetermined areas of the longitudinal launder for each crucible comprising transverse bulkheads in said longitudinal launder having depressed upper edges on the side opposite from said outlets, and launder rotating means adapted to progressively lower said outlets while necessarily relatively raising said depressed portion of said transverse bulkheads whereby volumes of molten material in said launder can be isolated one from another and molten material can be gradually poured into the crucibles as needed.

4. The apparatus of claim 3 wherein a plurality of guides extend from said launder down to the near side of said crucible, each guide being in a line relationships with one outlet of the launder and in a pouring relationship with one crucible, the lower end of each guide being positioned over the near edge of its respective associated crucible whereby melt is delivered to said crucible with minimum interference with vapor emission therefrom.

5. The apparatus of claim 3 wherein a shield is interposed between the substrate to be coated and the launder and its associated equipment.

6. The apparatus of claim 3 wherein the means for introducing melted material into said launder comprises a melting pot located within the vacuum chamber and
means is provided for introducing solid metal into said melting pot.

7. The apparatus of claim 6 wherein the means for introducing solid metal to said melting pot comprises a vacuum lock permitting the passing of solid material into the coating chamber without interrupting the high vacuum therewith.

8. In a vacuum coating apparatus the improvement for replenishing a series of evaporating crucibles comprising means for pouring a quantity of metal into a segmented launder having separate compartments adapted to be emptied into separate crucibles, through a series of outlets on one side of the launder, the segmentation being achieved by transverse baffles having depressed upper edges on the side opposite the series of outlets which are submerged when filled as above, and means for slowly rotating the launder and lowering the outlets relative to said depressed portions of the baffles.

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