Aug. 15, 1961 A. ENG 2,996,037

VACUUM COATING APPARATUS

Filed Jan. 26, 1959 2 Sheets-Sheet 1

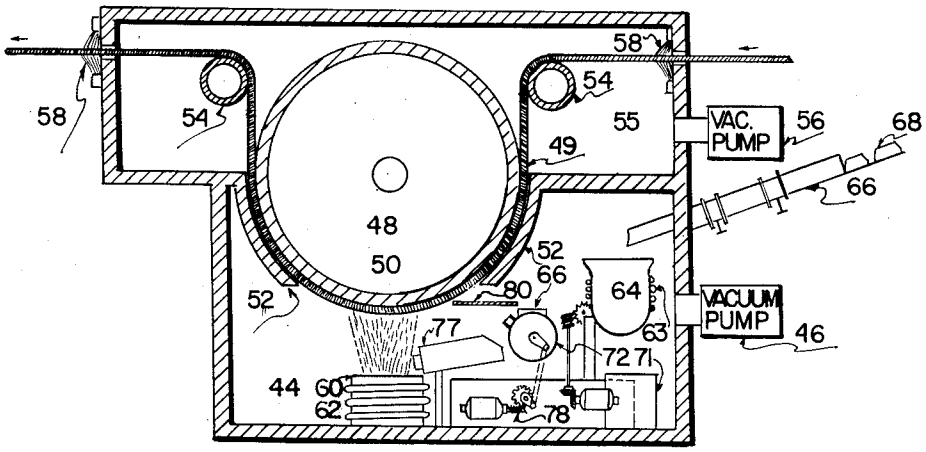


FIGURE 1.

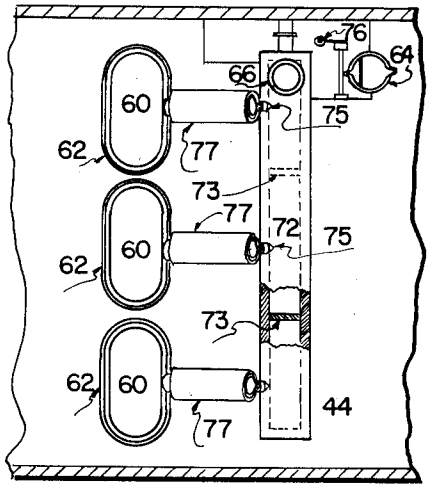


FIGURE 2

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VACUUM COATING APPARATUS

Filed Jan. 26, 1959 2 Sheets-Sheet 2

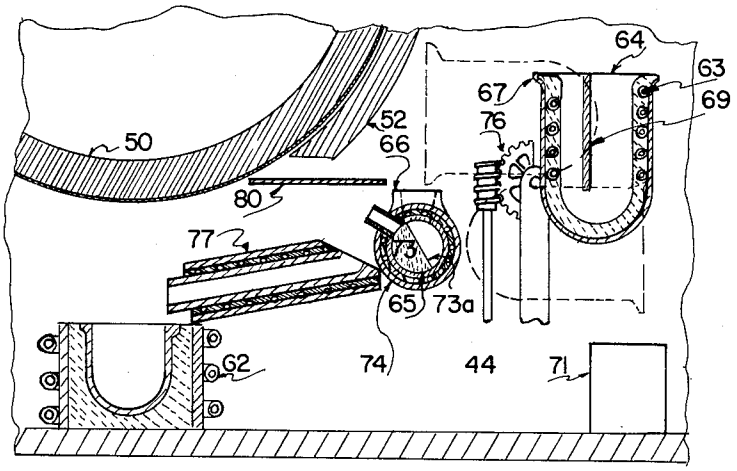


FIGURE 3

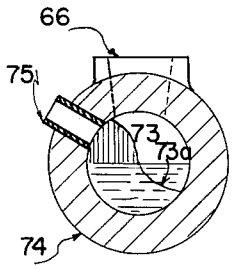


FIGURE 4

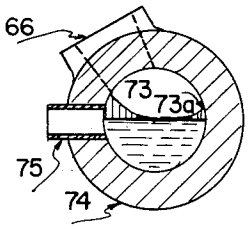


FIGURE 5

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2,996,037

VACUUM COATING APPARATUS

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8 Claims. (Cl. 118—49)

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 objects 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 indicated 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 one embodiment 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 a rotating 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 imperforate 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 through 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 puassing 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 **64**. 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.

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 **73***a*, 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 **73***a*, the molten material levels completely along the length of the launder **72** and the launder is filled to a substantial depth. The launder is then rotated counter-clockwise to a position shown in FIG. 5. The portion of the baffle at **73***a* 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 tipping 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 **73***a* 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 1300° C. by heating means **62** and the crucibles emanate vapors which impinge upon 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 sustaining 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 **60**.

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 with a surface coating of zirconium 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.

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 molten 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 incrementally 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 volumes 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 melt receiving relationship 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 respectively associated crucible whereby melt is delivered to said crucibles 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 therewithin.

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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