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VACUUM COATING APPARATUS

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Fig. 1

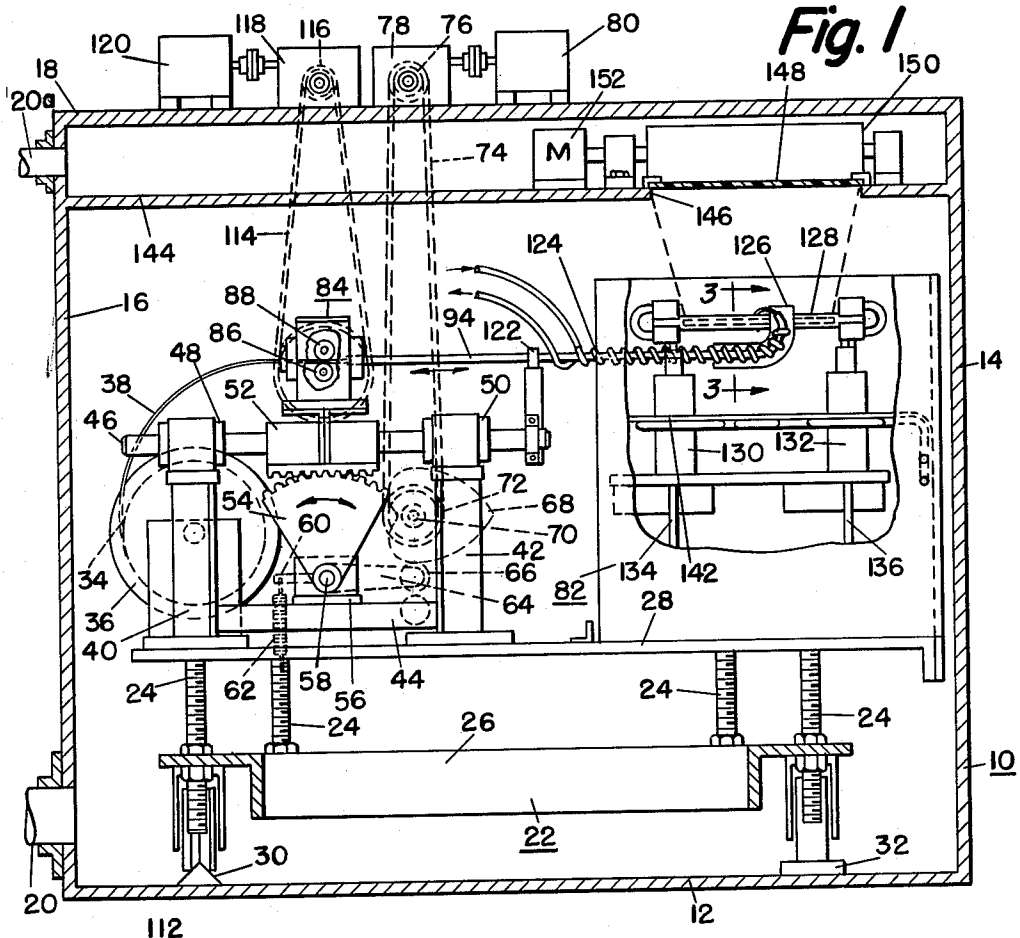


Fig. 2

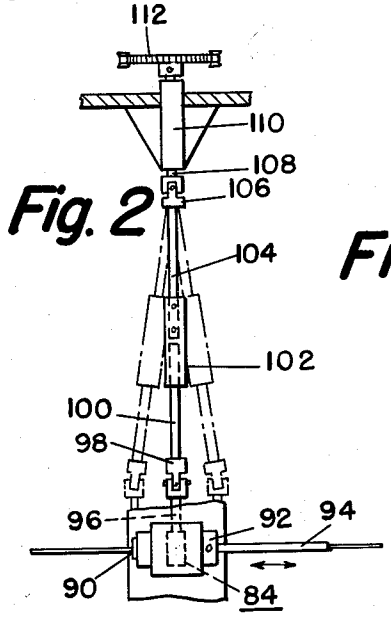


Fig. 3

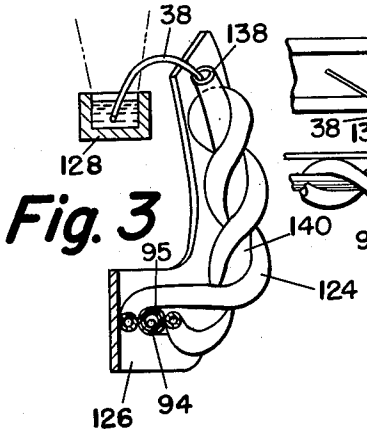
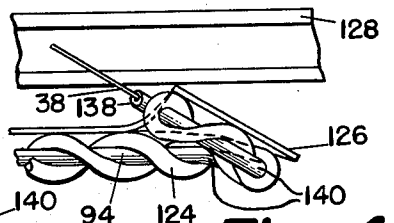


Fig. 4



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VACUUM COATING APPARATUS

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The present invention is directed to vacuum coating apparatus, and more particularly to apparatus for coating articles, such as a web of material, with a metal or the like which has been vaporized in a vacuum.

In the vacuum coating of articles by contact with vaporized material from a boat or reservoir of molten material, severe difficulties have been encountered due to the diffusion of the material being vaporized to the feed source. For example, in the vaporization of aluminum or zinc, where the same is introduced as a wire into a boat, deposition of the vaporized aluminum or zinc on the means for introducing the wire to the boat has caused clogging and jamming of such means and resultant failure of the apparatus. Since satisfactory commercial production requires the continuous adding of material to be vaporized to the boat, the diffusion of such material to the feed source and clogging of the introduction of the feed has prevented efficient commercial utilization of vacuum coating techniques where vacuum coating for protracted periods of time is desired.

The present invention has an object the provision of a novel vacuum coating apparatus.

The present invention has as another object the provision of vacuum coating apparatus in which the supply of the material to be vaporized may be constantly replenished so that the vacuum coating apparatus may be on-stream for protracted periods of time.

The invention has as another object the provision of vacuum coating apparatus in which the loss of vaporized coating material on the feed source is minimized.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a schematic elevational view of a presently preferred embodiment of the vacuum coating apparatus of the present invention.

FIGURE 2 is a fragmentary plan view revealing the operation of the wire feed.

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 1.

FIGURE 4 is a fragmentary plan view of the discharge portion of the wire feed viewed from above.

Referring to the drawings, wherein like reference characters refer to like parts, the vacuum coating apparatus of the present invention comprises an outer vessel 10 having a base 12, sides 14 and 16, and a ceiling 18. The entire interior of the outer vessel 10 may be evacuated to a high vacuum through the conduits 20 and 20*a* in the side 16. Thus, the conduits 20 and 20*a* may be connected to a vacuum system (not shown) whereby the interior of the outer vessel 10 may be evacuated.

A wide variety of outer vessels may be utilized, as will be readily understood by one having skill in the art, and accordingly, the detailed construction of the outer vessel 10 will not be set forth herein. It is, of course, to be understood that the outer vessel 10 includes means for obtaining access to its interior, so as to permit repairs and replacement, while at the same time permitting a vacuum-tight seal to be obtained when the interior of the outer vessel 10 is evacuated.

The understructure designated generally as 22 may be

movably supported on the base 12. A wide variety of understructures may be utilized, and no claim is made as to any specific understructure construction. Preferably the understructures 22 should comprise a plurality of threaded standards 24, each of which should be threadably received within nuts carried by the bed plate 26. In this manner, the height of the support plate 28 in respect to the base 12 may be selectively regulated.

The base 12 may be provided with guide ways 30 and 32 for permitting the transfer of the understructure 22 and the material carried thereon along the surface of the base 12.

The support plate 28 carries the means for feeding the material to be vaporized as well as the processing chamber.

The material to be vaporized is preferably in the form of a wire coil, such as the wire coil 34 carried on the spool 36. For the purposes of illustration, in the example set forth herein, the wire coil 34 will be referred to as a coil of aluminum wire 38.

The spool 36 is rotatably mounted, as on trunnions, intermediate the standards 40. The standards 40 are carried on the support plate 28, and are rigidly connected to spaced standards 42 by the connecting arm 44.

A shaft 46 is supported in bushings 48 and 50 above the standards 40 and 42. The rack 52 having an internal bore is clamped on the shaft 46 which extends through its bore. The rack 52 and shaft 46 are reciprocated in bushings 48 and 50, as will be explained below.

The segment gear 54 is pivotably carried in respect to its gear-support 56 on the pivot 58. Thus, the segment gear 54 is provided with a collar which rotates about the pivot 58. The gear support 56 is carried on the connnecting arm 44. A lever 60 is rigidly secured to the collar of the segment gear 54 which embraces the pivot 58. The free end of the lever 60 is coupled to the compression coil spring 62. The collar of the segment gear 54 also carries the link 64 on which is mounted outside of vessel 10 the cam follower 66. The action of the compression coil spring 62 urges the cam follower 66 against the heart shaped cam 68.

The heart shaped cam 68 is rotatably mounted on the outside of vessel 10 on the shaft 70 which carries the sprocket 72. The sprocket 72 is driven by the chain drive 74 which is coupled to the sprocket 76 of the gear box 78 which is rotated by the motor 80. The engagement between the cam follower 66 and the rotating heart shaped cam 68 will give a uniform oscillating motion to the segment gear 54, which will result in the uniform movement of the rack member 52 on the shaft 46.

The aluminum wire 38 is urged towards the processing chamber 82 by means of the feeder 84. The feeder 84 includes a pair of vertically spaced rotating members, between which the wire 38 is passed, namely the driver 86 and the idler 88. Preferably, the driver 86 is provided with a knurled outer surface, and the idler 88 is formed with a smooth surface. The inlet 90 to the feeder 84 comprises a relatively large bore guide tube, while the outlet 92 of the feeder 84 is coupled to the feed duct 94. The feed duct 94 comprises a metal tube of relatively small inside diameter. Preferably, the feed duct 94 is lined with a self-lubricating material 95 such as the plastic Teflon, a tetrafluoroethylene polymer, to facilitate the movement of the wire 38 therethrough.

Since the feeder 84 is fixedly secured to the rack member 52 it is reciprocated therewith upon the movement of the segment gear 54.

The rotation of the knurled driver 86 by which the aluminum wire 38 is urged through the feeder 84 is accomplished notwithstanding the movement of the feeder 84 in the manner set forth below.

The knurled driver 86 is carried at the end of the rod 96 on which is carried one member of the universal joint

98. The other member of the universal joint 98 is fixedly secured to the coupling rod 100 of the spline coupling 102. The spline coupling 102 also receives the coupling rod 104 which carries at its opposite end one member of the universal joint 106. The other member of the universal joint 106 is secured to the shaft 108 which is carried in the bearing 110 and which has on its end the sprocket 112. The sprocket 112 is driven by the chain drive 114 which is coupled to the sprocket 116 of the gear box 118 which is driven by the motor 120.

The pair of universal joints 98 and 106 and the relatively telescoping motion of the coupling rods 100 and 104 in the spline coupling 102 enables the feeder 84 to be reciprocated, as shown in phantom line in FIGURE 2, while the knurled driver 86 is being rotated due to the action of the chain drive 114 on the sprocket 112.

The feed duct 94 is supported by the guide 122 which is carried on the free end of the shaft 46. The front portion of the feed duct 94 is provided with the cooling coil 124 through which liquid coolant may be introduced. The cooling coil 124 prevents the feeding portion of the feed duct 94 which is disposed within the processing chamber 82 from becoming overheated. This is necessary as melting of the aluminum wire 38 within the feed duct 94 must be avoided for the satisfactory operation of the apparatus of the present invention. A shield 126 formed of high melting metal may be provided on the feeding portion of the feed duct 94 at the side thereof adjacent the boat or crucible 128 in which the molten aluminum obtained from the melting of the aluminum wire 38 discharged from the feeding portion of the feed duct 94 is carried. Shield 126 will protect the feed duct 94 from overheating, and therefore assist the action of the cooling coil 124, since the shield will serve to reflect heat radiated from the boat 128.

The boat 128, which may comprise one or more boats in series or other disposition, is of conventional construction, and may be formed from boron nitride, or other refractory, provided with conducting material, so that the boat 128 may be heated to a temperature sufficient to effect the boiling of the aluminum introduced to it from the aluminum wire 38. Thus, the boat 128 may be carried on standards 130 and 132 within the processing chamber 82. The standards 130 and 132 are provided with electrical conduits 134 and 136 for effecting heating of the boat 128.

As will be seen from FIGURES 1, 3 and 4 the discharge end 138 is spaced to the side of the boat 128. The discharge end 138 may be somewhat above the uppermost surface of the boat 128, or it may be below the uppermost surface of the boat 128, depending on its lateral spacing from the boat 128. Thus, it can be roughly assumed that the vaporized aluminum from within the boat 128 leaves the boat 128 in a conical path for any given vertical plan taken cross-wise of the boat 128, with the apex of such conical path lying on the center line of the floor of the boat 128 and with the inside edges of the top surfaces of the boat 128 defining other points on the conical path. As long as the discharge end 138 lies out of this conical path, generally shown in phantom line in FIGURE 3, excessive condensation of vaporized aluminum on the discharge end 138 of the feed duct 94 will be avoided.

In order to guide the aluminum wire 38 into the boat 128 the feed duct 94 is provided with a compound or multiple bend 140. This compound bend 140 not only includes the reverse bend by which the aluminum wire 38 is doubled back over itself, but moreover as can best be seen from FIGURE 4 includes a bend in which the feed duct 94 is bent laterally away from the boat 128, so that the feed duct 94 extends on both sides of itself in its terminal portion, namely closer to the boat 128 at its discharge end portion 138 than its major length portion, and further away from the boat 128 for a limited

portion of the compound bend that is the remainder of its length.

The compound bend 140 therefore not only reverses the aluminum wire 38, putting a curve therein so that the same may be looped over and into the boat 128 as shown in FIGURES 1, 3 and 4, but moreover urges the aluminum wire 38 against the inside wall of the feed duct 94. This provides frictional engagement between the aluminum wire 38 and the inside wall surface of the feed duct 94 notwithstanding that the inside diameter of the feed duct 94 is appreciably greater than the outside diameter of the aluminum wire 38. While engagement between the inside wall surface of the feed duct 94 and the aluminum wire 38 could be effected by reducing the inside diameter of the feed duct 94, or by providing a relatively small lappage at the discharge end 138, these expedients are normally not desirable because they are prone to lead to jamming, particularly when a minor amount of vaporized aluminum condenses within the feed duct 94. Such jamming of the aluminum wire 38 within the feed duct 94 will lead to failure of the vacuum coating apparatus, and is therefore to be avoided.

A coolant tray 142 is carried on the standards 130 and 132 at a spaced distance beneath the boat 128 to protect the mechanical and electrical parts therebelow from thermal radiation and haphazard diffusion of vaporized aluminum about the bottom portion of the processing chamber 82.

By moving the discharge end 138 of the feed duct 94 along the length of the boat 128, engagement of the aluminum with the boat is along the length of the boat rather than in a localized area. This both facilitates in the vaporization of the aluminum and also increases the life of the boat, since the wear at the region of the engagement of the boat with the aluminum wire 38 is dispersed over a wide area rather than localized.

The outer vessel 10 is provided with a shelf 144 having a slot 146 disposed above the boat 128. As seen in FIGURE 1, the slot 146 may have a width somewhat larger than the boat 128, since the metal being vaporized will leave the boat 128 along a path which will diverge from the ends of the boat as well as include the region directly above the boat (see phantom lines in the right portion of FIGURE 1).

The material to be coated, which may be paper, foil, plastic, etc. shown in the illustrated embodiment as comprising a web 148, such as a web of plastic like Mylar.

A wide variety of means may be used to feed the web 148 over the slot 146, and no claim of invention is made in the present application for any particular means to do so. In the illustrated embodiment, the web 148 is carried between two rollers, one roller 150 being shown, with one of the rollers, namely the roller 150 being rotated by the motor 152.

The apparatus of the present invention enables prolonged runs to be made. Thus, the metal to be vaporized may be continuously fed into the boat 128 at the same rate at which such metal is being vaporized, so that a constant inventory of molten metal may be maintained within the boat 128. Since the apparatus of the present invention provides for both long life of the boat 128 and avoidance of clogging of the discharge end 138 of the feed duct 94, the apparatus may function for extended periods of time without the necessity for ceasing production to replace either the boat 128 or the feed duct 94 (the two most common causes of failure in prior vacuum coating equipment being the failure of the boat which was largely due to the localized introduction of the aluminum wires, or the clogging of the discharge end of the feed duct due to deposition of vaporized metal thereon and condensation of such vaporized metal on the cooled feed duct).

The present invention may be embodied in other specific forms without departing from the spirit or essen-

tial attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. Vacuum coating apparatus for coating a metal onto an article including a vacuum chamber containing an open heated boat for vaporizing the coating metal, and feeding means for feeding coating metal to said open boat, said feeding means including a feed duct through which a wire of the coating metal is fed to the boat, the discharge end portion of said feed duct being substantially parallel to the longitudinal axis of said boat, with the discharge end portion of said duct being laterally spaced from the longitudinal axis of said boat and below the upper edge of said boat so as to be out of the direct path of the vaporized metal emitted from said boat, the discharge end of said feed duct being curved, with said feed duct including means for urging the wire of metal against the inner surface of the mouth of the discharge end as the wire is discharged from said feed duct so that a curved wire of coating metal may be delivered from the discharge end of the feed duct into the boat.

2. Vacuum coating apparatus in accordance with claim 1 in which the discharge end of the duct is directed upwardly so that the curved wire of coating metal is delivered upwardly from the discharge end of the feed duct and then downwardly into the boat.

3. Vacuum coating apparatus in accordance with claim 1 in which the means for urging the wire of metal against the inner surface of the mouth of the discharge end comprises a compound bend in the curved portion of the feed duct adjacent the discharge end.

4. Vacuum coating apparatus in accordance with claim 1, which includes a shield secured to the feed duct and spaced intermediate the portion of the feed duct adjacent its discharge end and the boat for shielding such portion of the feed duct, whereby the curved wire of coating metal extends over a portion of said shield.

5. Vacuum coating apparatus in accordance with claim 1 which includes means for continuously reciprocating the feeding means so that the discharge end of the feed duct traverses a portion of the length of the boat.

6. Vacuum coating apparatus in accordance with claim 5 wherein said means for continuously reciprocating the feeding means includes a reciprocating mount supporting said feeding means, and telescoping coupling rods within said vacuum chamber operatively connected to said feeding means for delivering power to said feeding means as said feeding means reciprocates.

7. Vacuum coating apparatus in accordance with claim 6 including an oscillating segment gear meshingly engaged with a rack on said reciprocating mount for reciprocating said mount.

8. Vacuum coating apparatus in accordance with claim 1 which includes means for cooling by heat-exchange the portion of the feed duct adjacent its discharge end.

9. Vacuum coating apparatus in accordance with claim 1 in which the feed duct is lined with a self-lubricating material.

10. Vacuum coating apparatus for coating a metal onto a moving web of material including a vacuum chamber for containing an open heated boat for vaporizing the coating metal, feeding means for feeding coating metal to said open boat, said feeding means including a feed duct below the upper edge of said boat and through which a strand of the coating metal is fed to the boat, said duct being laterally spaced from the longitudinal axis of said boat out of the direct path of the vaporized metal emitted from said boat, the portion of said feed duct adjacent the discharge end being curved upwardly, a heat reflective shield supported by said duct and disposed between said duct and said boat, with said feed duct including means for urging the wire of metal against the inner surface of the mouth of the discharge end as the wire is discharged from said feed duct so that a curved wire of coating metal may be delivered from the discharge end of the feed duct into the boat, mechanical elements within said vacuum chamber operatively engaged with said feeding means for reciprocating said feeding means and duct in a direction substantially parallel to the longitudinal axis of said boat, and means for supporting the moving web of material spaced above said feeding means, with said supporting means exposing a moving surface of said material in juxtaposition to the top of the open boat.

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