

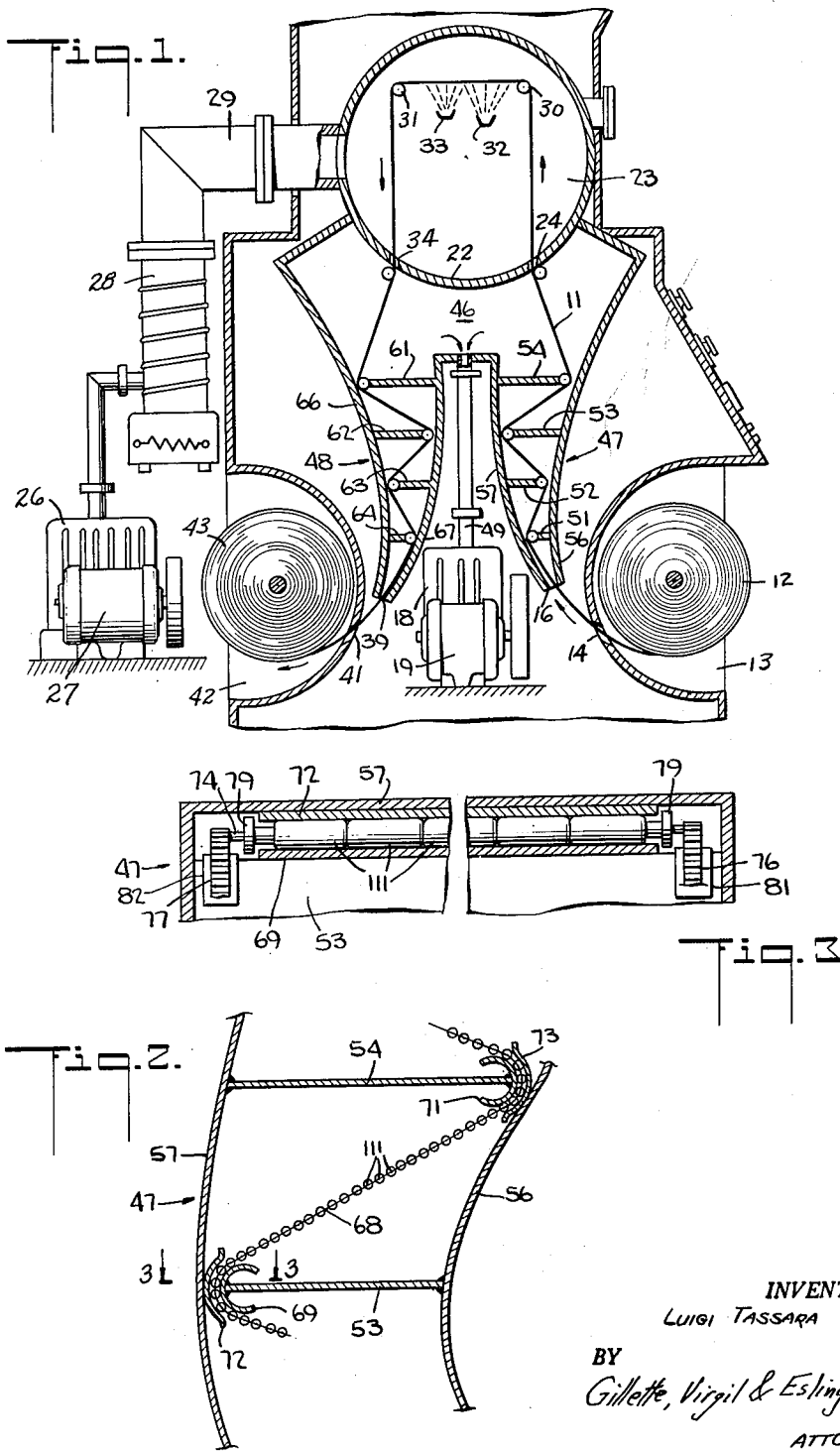
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APPARATUS FOR VACUUM METALLIZING HOLLOW CERAMIC RODS

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APPARATUS FOR VACUUM METALLIZING HOLLOW CERAMIC RODS

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1 Claim. (Cl. 118—49)

This invention relates to apparatus for continuously applying a coating to a moving base structure by means of an evaporation-condensation process carried out in an evacuated chamber.

One of the primary objects of the invention is to provide apparatus for continuously evaporating a coating onto a moving base structure in an evacuated chamber, including moving the base structure into the chamber from the outside and through the chamber and out again in a steady stream. It is a further object to provide means which will deposit a metal coating on a base structure in the form of a moving strip of material, as well as in the form of a chain of individual elements. In accordance with the invention the apparatus for coating a continuously moving base structure consists of an evacuated chamber in which the coating process is carried out and one or more airlock chambers through which the base structure passes before reaching the coating chamber and again directly upon leaving the coating chamber. The atmospheric pressure in the airlock chamber is intermediate between ambient atmospheric pressure and the residual pressure in the coating chamber. If there are several airlock chambers, the pressure in any chamber is intermediate between the pressures on each side, so that, as the material to be coated moves from outside the apparatus toward the evacuated coating chamber, it passes through airlock chambers of successively decreasing pressure, and as the material leaves the coating chamber, it passes through airlock chambers of successively increasing pressure, finally emerging into ambient atmospheric pressure as it leaves the last airlock chamber.

The invention will be more comprehensively described in the following specification, together with the drawings, in which:

FIG. 1 is a schematic representation of one embodiment of apparatus for continuously coating a strip of material, the side wall of the apparatus being broken away to show the interior;

FIG. 2 shows an enlarged cross-sectional view of part of the apparatus in FIG. 1; and

FIG. 3 is a cross-sectional view of the part shown in FIG. 2.

In FIG. 1, the base structure to be coated is in the form of a strip of material 11 wound on a reel 12 within a recess 13 in the front panel, FIG. 1 being essentially a side view of the apparatus. The strip 11 passes through a slot 14 into the interior of the apparatus and then through another slot 16 at the constricted end of one tapered section 47 of an airlock chamber 46.

The airlock chamber 46 is so-called because a low-atmospheric pressure is maintained in it by a vacuum pump 18 operated by a motor 19 and connected to the chamber 46 by a pipe 49. Although, for illustrative purposes, the slot 16 is shown as being relatively large, it actually fits closely about the strip of material 11. This limits the amount of air that can flow through the slot 16, and, as a result, the pump 18 can remove most of it.

The purpose of having the section 47 tapered is to control the air pressure therein. Since air is continuously being removed from the chamber, the pressure inside does not reach an equilibrium condition, and the pressure is greatest near the slot 16.

Section 47 comprises a plurality of baffles 51-54. The baffles 51 and 53 extend from one side wall 56 of the

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section 47 and the alternate baffles 52 and 54 extend from the opposite side wall 57. In each case the baffles 51-54 extend only part of the way to the opposite wall, leaving a slot through which the material 11 passes. Since successive slots are on opposite sides of the chamber section 47, the material 11 is forced to follow a rather complicated zigzag path. However, air molecules are forced to follow the same path, which makes it easier to keep the chamber 46 pumped down to a low pressure. In effect the baffles 51-54 act as barriers dividing the section 47 into separate airlock chambers. Since air can enter only via the entrance slot 14, the chamber between that slot and the first baffle 51 has the highest pressure, and successive chambers between baffles 51 and 52 and above have successively lower pressures.

At the large end of the tapered section 47 is a wall 22 that separates the chamber 46 from a more highly evacuated chamber 23 in which the coating process is carried out. The latter chamber is, for this reason, referred to as the coating chamber. The strip of material 11 passes from the airlock chamber 46 into the coating chamber 23 through a constricted passageway 24 in the wall 22.

The coating chamber 23 is evacuated by a relatively high vacuum system comprising a mechanical pump 26 run by a motor 27 and a mercury vapor vacuum pump 28. The vacuum system is connected to the chamber 23 by a pipe 29.

Within the coating chamber 23 are two rollers 30 and 31 over which the strip of material 11 is looped. Between the rollers and below the strip 11 are two cups 32 and 33, which contain metal to be evaporated. The metal in cup 32 may be zinc or aluminum, for example, and that in cup 33 may be silver. Other metals may be used instead, provided they vaporize and adhere properly and at low enough temperatures. The cups are electrically heated to melt the metal held therein and to raise the temperature of the molten metal sufficient to drive off metallic vapor. Because of the lack of interfering air molecules, the vaporized metal moves in substantially straight lines to strike and to adhere to the under surface of the strip 11. If it is desired to coat both surfaces, the strip 11 can be looped around additional rollers to cause the other surface to pass over a second set of evaporators.

After passing across the last roller, the strip of material 11 passes out of the coating chamber 23 by way of a second constricted passageway 34 in the wall, or barrier, 22 between the coating chamber and the air-lock chamber 46.

The exit, or outlet, section 48 of the airlock chamber 46 is also provided with a series of baffles, or barriers, 61-64 arranged between opposite walls 66 and 67 in a manner similar to the arrangement of the baffles 51-54. The movement of the strip of material in section 48 is downward, but air can only enter via the exit slot 39, and so the material 11 moves through regions of increasingly greater air pressure until it finally moves out of the slot 39 into ambient air pressure.

After passing through the slot 39, the strip 11 passes through another slot 41 into a recess 42 in the rear wall of the device and is wound onto a reel 43.

The proper atmospheric pressure for coating a surface with metal, as shown here, is quite low. This is equivalent to saying that the chamber 23 must be pretty well evacuated. A typical pressure for this purpose would be something like one one-millionth of normal atmospheric pressure. Since normal atmospheric pressure is approximately 760 mm. of mercury, one one-millionth of this is roughly 10^{-4} mm. of mercury. The

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pump 26 should be capable of achieving and holding this kind of pressure in the coating chamber 23.

If the high vacuum system comprising the mechanical fore pump 26 and the mercury pump 28 is capable of removing 99.9% of the air in the chamber 23, that is equivalent to saying that the high vacuum system is capable of reducing the pressure in the coating chamber to one one-thousandth of what the pressure would be without the pump. Without the high vacuum system the pressure in the coating chamber would be the same as that in the airlock chamber 46, since the only openings in the chamber 23 are the slots 24 and 34. Therefore, if the residual pressure in the coating chamber is to be about one one-millionth of atmospheric pressure, the pressure in the upper end of the airlock chamber 46 would need to be about one one-thousandth of the ambient pressure outside of the apparatus.

An alternative way of stating this is to say that the pressure in the airlock chamber 46 should be the geometrical mean, rather than being the arithmetical average, of the pressures in the spaces at each end of these chambers. Of course, it may be that the high vacuum system pumps 26 and 28 would have sufficient capacity to take more of the load so that the pressure in the airlock chambers could be higher than the geometrical mean value. Alternatively, the pump 18 might be capable of reducing the pressure in the airlock chamber 46 to a lower value, in which case the pump 26 could be smaller, but the balanced condition would be for each pump to reduce the atmospheric pressure by the same ratio.

FIG. 2 shows an enlarged view of a portion of section 47 of the chamber 46 in FIG. 1, but with modifications to accommodate a different form of base structure. The base structure in FIG. 2 consists of a number of small, ceramic rods 111, here seen from one end, all linked together by a tape or chain 68. Since such a chain of individual parts could not bend as sharply as a thin ribbon, each of the baffles, of which only baffles 53 and 54 are shown, is provided at its free end with a cylindrical guard section. These are indicated by reference characters 69 and 71 for the guards on the baffles 53 and 54, respectively. The guards 69 and 71 are convex and they cooperate with a pair of concave slot-defining members 72 and 73, respectively, to determine the path actually taken by the chain 68 around the ends of the barriers 53 and 54.

FIG. 3 shows a partial cross sectional view of the tapered section 47, including part of the surface of the baffle 53 together with cross sections of the guard 69, the member 72, and the wall 57. As may be seen in this figure, the base structure to be coated consists of a number of short, ceramic rods 111 mounted on a shaft 74, the ends of which are hooked onto a pair of chains 76 and 77. Two spacers 78 and 79 locate the rods 111 on the shaft 74. The chains 76 and 77 may be supported on a pair of guides 81 and 82, substantially concentric with the guard 69. The guides 81 and 82 may be curved flanges, similar to the guard 69, or they may be wheels supported in the plane of the baffle 53. As a further alternative, the guard 69 may be in the form of a roller, since it is a roller-shaped member.

While this invention has been described in terms of a specific embodiment, modifications thereof will occur to those practicing the art, so that the scope of the invention is to be understood as being determined by the following claim.

What is claimed is:

Apparatus for coating a continuously moving base structure in the form of a series of hollow ceramic rods, said apparatus comprising: a plurality of support shafts, each of said shafts extending through a plurality of said rods; chain means for supporting both ends of said shafts with adjacent shafts parallel to each other; an airlock

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chamber having a first tapered section with a large end and a constricted end, said constricted end having a slit-like opening through which said chain means and said rod-bearing shafts enter said chamber; a plurality of baffles in said chamber to restrict the passage of air therethrough, adjacent ones of said baffles extending from opposite walls of said airlock chamber to form a zigzag path along which said chain means and said rod-bearing shafts pass through said airlock chamber and to divide said airlock chamber into a plurality of sub-chambers; a first vacuum pump connected only to the sub-chamber at the large end of said airlock chamber, the remainder of said sub-chambers communicating only with each other; roller-like members attached to the edges of each of said baffles to permit said rod-bearing shafts to move smoothly over said baffles; chain supporting means attached to each of said baffles, said chain supporting means being substantially concentric with said roller-like members; a coating chamber adjoining the large end of said airlock chamber and sealed thereto by a gas-tight seal and having a constricted, slit-like passageway communicating with the interior of said large end of said airlock chamber to permit said chain means and said rod-bearing shafts to pass from said airlock chamber into said coating chamber; a plurality of rollers in said coating chamber to support said chain means and to define a path along which said chain means and said rod-bearing shafts pass through said coating chamber; metal evaporating means located adjacent said rollers to form a metal vapor through which said rods move; a high vacuum system connected to said coating chamber to reduce the residual atmospheric pressure in said coating chamber to a fraction of that in said airlock chamber; a second tapered airlock chamber having a large end and a constricted end, the large end of said second airlock chamber being sealed by a gas-tight seal to the wall of said coating chamber, whereby a portion of the wall of said coating chamber also forms a part of the wall of said second airlock chambers, and to the sub-chambers at the large end of said first airlock chamber; a second constricted, slit-like passageway in said portion of said wall of said coating chamber to permit said chain means and said rod-bearing shafts to pass out of said coating chamber into said second airlock chamber; a plurality of baffles in said second airlock chamber, adjacent ends of said latter baffles extending from opposite sides of said second tapered airlock chamber to form a second zigzag path along which said chain means and said rod-bearing shafts pass; roller-like members at the edges of each of said latter baffles to restrict the opening between the said edges of said baffles and the opposite side of said second tapered airlock chamber to impede the flow of air through said second airlock chamber and to divide said second airlock chamber into a plurality of sub-chambers of which only the sub-chamber at the large end of said second airlock chamber is directly connected to a vacuum pump and the remaining sub-chambers communicating only with each other; chain supporting means attached to each of said edges of said latter baffles, said chain supporting means being substantially concentric with said roller-like members; and edges at the constricted end of said second airlock chamber forming a constricted exit through which said chain means and said rod-bearing shafts pass out of said apparatus.

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