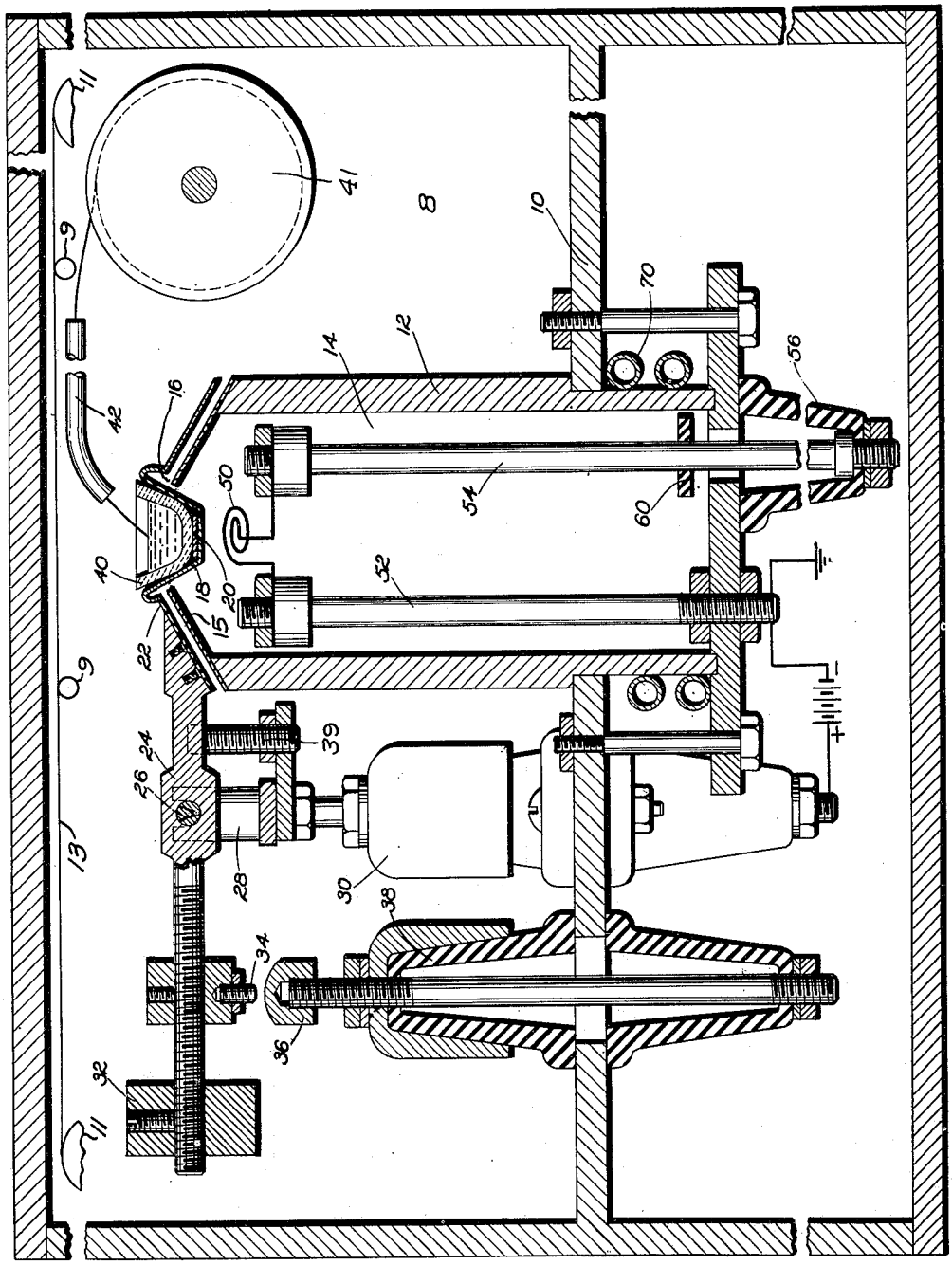
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VAPOR COATING DEVICE

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VAPOR COATING DEVICE

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This invention relates to the deposition of materials by thermal evaporation thereof at attenuated pressures and is concerned particularly with improved apparatus and methods for thermally evaporating such materials as metals for deposition thereof as coatings upon objects, particularly upon heat-sensitive materials without subjecting the materials to the destructive effects of form-changing temperature.

In a preferred form, this invention contemplates the utilization of electron bombardment energies for inducing the thermal evaporation of the material to be deposited. Electron bombardment has heretofore been proposed as an energy source for causing metal evaporation in deposition processes, but presently known methods have had severe limitations, particularly with respect to speed and quality of coating, thermal efficiency, and encounters with intolerable electrical discharges destructive at pressures exceeding about 0.01 micron. The operations have required long outgassing periods and large capacity outgassing equipment to attain and maintain such low pressures and production has been small for each evacuation.

Among the objects of this invention is the provision of new and improved methods for evaporating materials for deposition upon heat-sensitive or other materials, permitting operation, at considerably higher pressures—as high as 0.1 microns—than those heretofore permissible with consequent coating at higher speeds and shortened and simplified outgassing; hence with higher production rates.

It is a further object of the invention to provide apparatus wherein such coating may be accomplished, and one which operates with good thermal efficiency and without destructive discharges.

It is a further object of the invention to provide a method and apparatus for increasing the overall output of the apparatus with each evacuation.

In accordance with this invention, markedly improved coatings at rapid rates of deposition with good thermal efficiency have been secured in an electron bombardment furnace wherein the parts are so arranged that the paths of the energy transmitting electrons are remote from the paths of the evaporated metal atoms and wherein stray electrons emanating from the source of bombardment electrons are kept away from the vapor area, particularly the area immediately adjacent the vaporizing surface of the molten metal, so that they will not ionize the evaporated metal, or residual gases in this area.

By such arrangement, general discharges, which otherwise might develop through gaseous ionization starting in the metal vapor in the region just above the metal melt, where local pressures may go as high as several millimeters of pressure

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depending upon the evaporation rate, do not develop since the electrons are prevented from entering this region of relatively high pressure just above the melt. Ionization of the vapor in this region being precluded, voltage and current transients responsible for destructive arcing in the power supply no matter how carefully insulated, and resulting from general ionization throughout the chamber following upon initial ionization in the region just above the melt, are avoided.

By removing the cause of destructive arcing, one need no longer rely upon low pressure to prevent the arcing and accordingly, operation may be safely conducted at pressures of the order of 0.1 micron, heretofore impossible.

The reduction in amount of ionization accompanying operation in accordance with this invention increases thermal efficiency by converting energy heretofore consumed in unproductive and unwanted ionization to productive work in the deposition process—energy losses are less.

Production runs involving deposition of large quantities of metal, with good thermal efficiency, are insured by limiting the body of molten material from the surface of which vaporization takes place, to a small amount, and providing, in the evacuated portion of the apparatus, a source of the material in solid form, which replenishes, by manual or automatic feed, continuously or periodically, the molten body as needed, without breaking the vacuum.

Apparatus in accordance with this invention and of the type wherein the methods of this invention may be practised is shown in the accompanying drawing, being a cross-sectional view through the apparatus which is broken away to show extent.

The apparatus comprises a vacuum chamber, 8 supplied with suitable outgassing equipment (not shown) and containing, or having associated therewith, suitable rolls 9 for supporting and power feeding an object to be coated, for example, a roll 11 of heat-sensitive sheet material 13 such as a thermoplastic cellulosic derivative film.

In the bottom of the chamber supported on a cross-frame 10 is a cylindrical wall 12 defining a furnace chamber 14. The top of the furnace chamber comprises a conical wall 15 having a central circular opening 16 communicating with the vacuum chamber 8. Suspended in this circular opening and spaced from the conical wall 15 to provide a heat insulation gap is an electron bombardment target illustrated as a drawn tantalum cup 18 reinforced by a bottom lining in the form of a tungsten plate 20 resting on the bottom of the cup. The cup is supported by a conical element 22 affixed to a balance lever 24 supported on a knife edge bar 26 mounted in

blocks 28 carried by shielded insulators 30. A counterweight 32 adjustable longitudinally of the balance lever 24 acts to depress an electrical contact 34 under certain conditions as hereinafter described to make electrical connection with a cooperating contact 36 carried by insulator 38. A stop 39 limits the downward movement of cup 18 so that it never touches wall 15. The tantalum cup 18 supports a refractory crucible 40 adapted to contain a material to be evaporated. A source of such material, for example, a reel of metallic wire 41 is mounted in the chamber and is adapted to be fed into the melt in crucible 40 through a guide tube 42 which directs the wire towards the surface of the melt.

An electron emitter in the form of a filament 50 is mounted in the furnace chamber 14 between two posts, 52 and 54, post 52 being at ground potential. Post 54 is electrically insulated from the wall by insulator 56, and shielded by a shield 60 so that metal vapors will not reach the inside of the insulator.

The cup 18 is maintained at a high voltage from a constant power supply, while the filament is heated with a low voltage current carried by the posts 52 and 54. The walls 12 and 15 of the furnace are at ground potential.

Water coils 70 are shown surrounding the lower portion of the furnace wall 12 for cooling purposes.

As thus constructed, and assuming the refractory cup 40 to contain a metal to be vaporized for deposition on the sheet material, electrons emitted by the emitter 50 bombard the electron bombardment target or cup 18 which heats the crucible 40 and its contents to vaporizing temperature by a combination of radiation and conduction. The counterweight is so adjusted that when the weight of molten metal in the crucible 40 reaches a predetermined low limit the contactors 34 and 36 make a circuit which, as through a relay, gives either a visual indication or automatically starts the wire feeding mechanism controlling reel 41 to feed more metal into the cup. The circuit is broken by the increased weight of the crucible contents rocking the lever arm 24 to a position to break the contact and the feed mechanism may be either manually or, through well-known electronic timing devices, automatically stopped after a desired amount of metal has been fed.

The wall of the furnace 12 serves to confine electrons to the furnace chamber and it collects heat radiated from the cup and filament which can thus be carried away by water flowing in the coils 70.

Because the top conical partition 15 of the furnace chamber is at ground potential and connected to the furnace wall and because of the close clearance at 16 between this conical partition and the tantalum cup 18 at high potential, there is a high electric field strength across this gap which diverts any electrons which attempt to pass through the opening into the coating chamber to the tantalum cup 18 as a collector, before they can reach the chamber 8. Furthermore, the general arrangement of the parts is such as to minimize access of the vapors, which tend to rise from the receptacle, to the furnace area through the gap at 16. For both reasons, destructive gaseous discharges which would otherwise be initiated are eliminated with the resulting advantage of permissible operation at correspondingly higher pressure.

I claim:

1. A coating device including an electron bombardment furnace for the thermal evaporation of materials, said device comprising walls defining a vacuum-tight chamber including a vaporization area and a furnace area, wall means separating said two areas, means defining a restricted opening through said wall means, a support in said vaporization area for an object to be coated, a thermionic electron emitter in said furnace area, an electron target suspended across, but spaced from, the means defining said restricted opening, means for maintaining said target at a potential higher than that of both said emitter and the means defining said restricted opening, whereby a field of voltage gradient is created across the space between said target and the means defining said opening for diverting to said target and intercepting any electrons entering said space to prevent them from reaching said vaporization area, and a receptacle in said vaporization area adapted to be heated by said target for holding material to be evaporated, said receptacle being positioned with respect to said support so that vapors generated in said receptacle travel to said object and condense thereon.

2. A coating device including an electron bombardment furnace for the thermal evaporation of materials, said device comprising walls defining a vacuum-tight chamber, one portion of said chamber walls defining a vaporization area and another portion of said chamber walls defining a furnace area, a support in said vaporization area for an object to be coated, part of said furnace-defining wall comprising an electron bombardment target separating said areas, a thermionic electron emitter within said furnace area, means for maintaining said target at a high potential relative to said emitter, said target being spaced from, and mounted for movement with respect to, other portions of said furnace-defining wall, means for maintaining a steep voltage gradient across the spacing between said target and said other portions of said furnace-defining wall to prevent said electrons from passing through said spacing and reaching said vaporization area, and a receptacle in said vaporization area, but adjacent said target, for holding material to be evaporated, said receptacle being positioned with respect to said support so that vapors generated in said receptacle travel to said object and condense thereon.

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