April 21, 1964 D. S. THOMSON 3,130,343

ELECTRON BEAM EVAPORATING DEVICE

Filed June 9, 1960 2 Sheets-Sheet 1

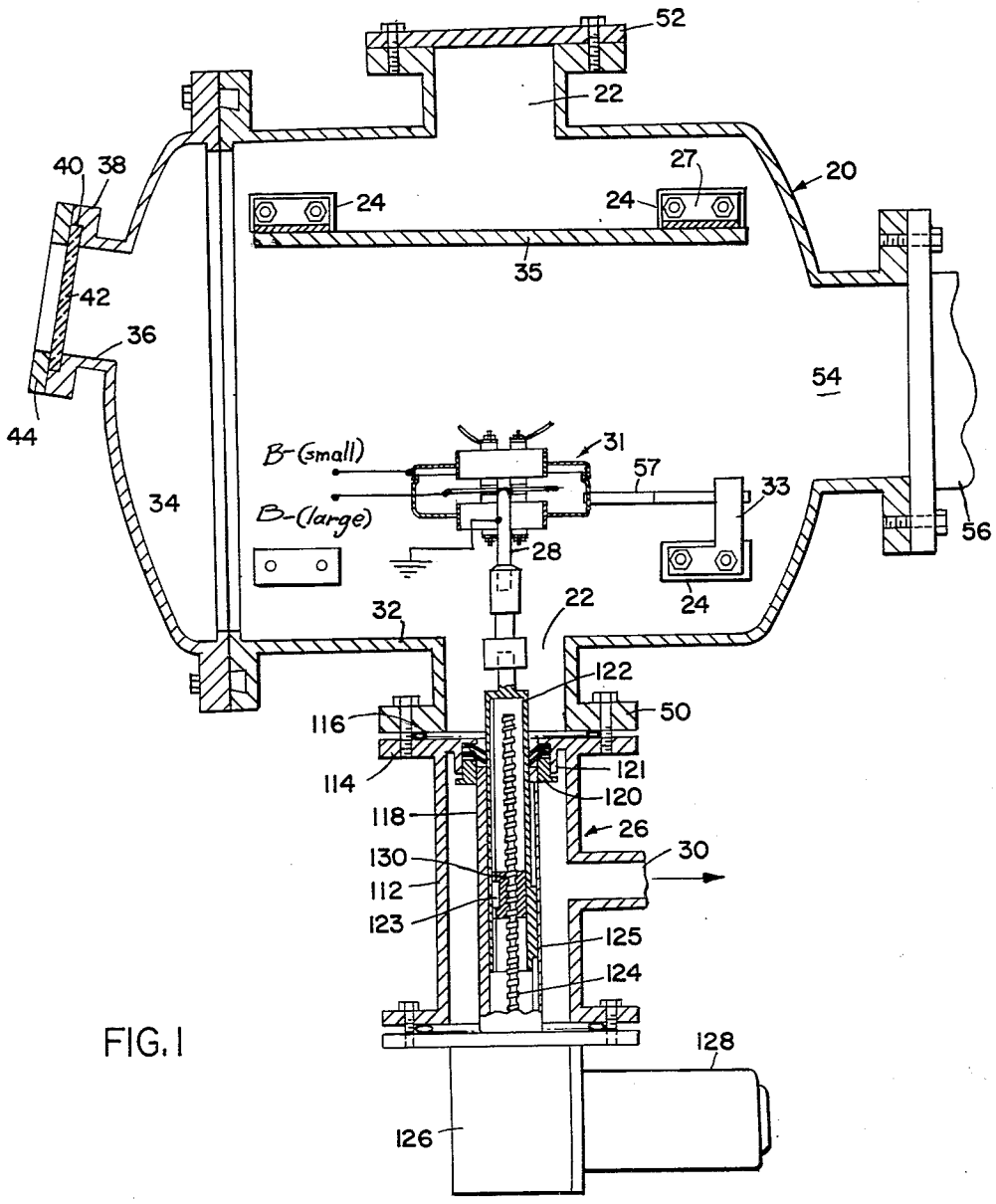


FIG. 1

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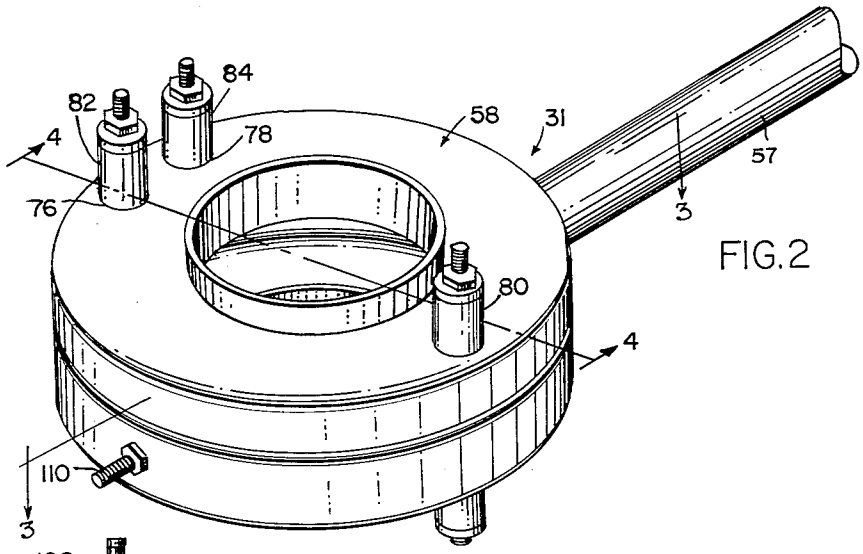


FIG. 2

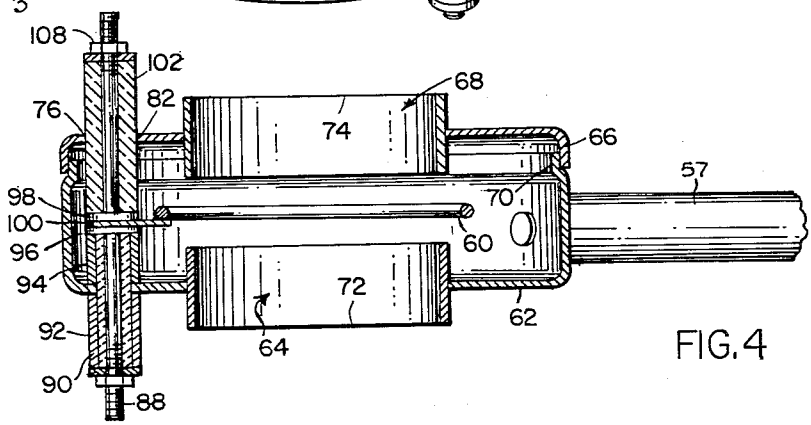


FIG. 4

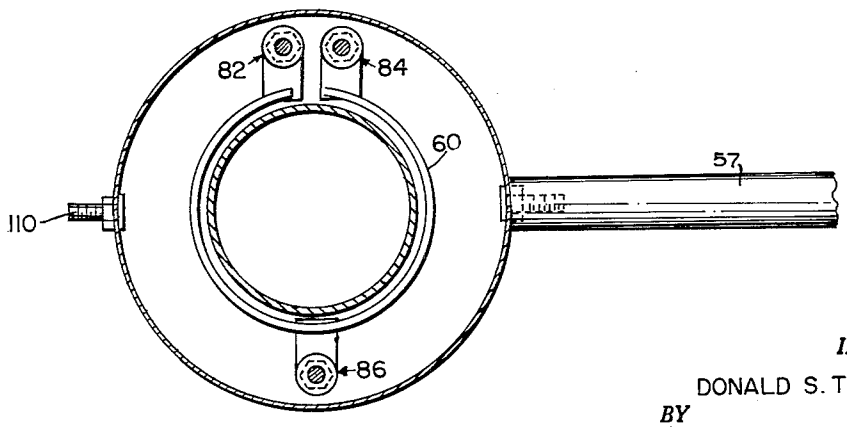


FIG. 3

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3,130,343

ELECTRON BEAM EVAPORATING DEVICE

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5 Claims. (Cl. 313—146)

The present invention relates to the vacuum deposition of evaporated material and, more particularly, to a versatile device for ececting evaporation of a coating material by electron bombardment and deposition on a substrate in a vacuum. Such vacuum deposition possesses advantages over conventional deposition techniques in permitting the rate of evaporation to be precisely and readily controlled by electrically determining the electron beam energy transmitted. Generally, such a device comprises a hermetic enclosure that is continuously evacuated to low pressure, a source from which electrons are emitted, a holder for positioning a coating material for the reception of the electrons and a holder for positioning the substrate for reception of resulting vapor from the coating material.

The primary object of the present invention is to provide, in a system of the foregoing type, an electron gun of simple but efficacious construction particularly adapted to cause evaporation of a coating material. The construction includes a toroidal casing having an inner peripheral gap and an annular cathode for emitting electrons through the gap toward an axis at which a rod of material to be evaporated is located. The toroidal casing may be disassembled in such a way as to permit the annular cathode to be replaced readily.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

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

FIG. 1 is a cross-sectional view of a system embodying the present invention;

FIG. 2 is a perspective view of an electron gun for effecting evaporation in accordance with the present invention;

FIG. 3 is a cross-sectional view of the electron gun of FIG. 2, the section being taken substantially along the lines 3—3 of FIG. 2; and

FIG. 4 is a cross-sectional view of the electron gun of FIG. 2, the section being taken substantially along the line 4—4 of FIG. 2.

Generally, the system illustrated in FIG. 1 comprises a hermetic enclosure 20 providing a plurality of ports 22 through and a plurality of mounts 24 in the enclosure, an associated positioning module 26 for advancing a rod 28 of material to be evaporated, a pump 30 for maintaining the interior of the enclosure at a predeterminedly low pressure (preferably less than 0.01 micron of mercury) and an electron gun 31 embodying the present invention.

Enclosure 20 is provided by a generally cylindrical casing 32, at the forward end of which is an outwardly convex closure 34. Closure 34 has a port 36 the outward edge of which is provided with a flange 38. Flange 38 is disposed in a plane perpendicular to the axis of port 36. The axis of port 36 is disposed at an angle to the axis of cylindrical casing 32. Flange 38 is provided with a depression 40 that receives a sight glass 42. Sight glass 42, which is clamped in position by a ring 44, for example, is composed of an X-ray opaque but light transparent lead glass that shields the operator from any X-radiation. Closure 34 is pivotally connected to casing 32 by a suitable hinge (not shown).

Ports 22 are disposed at 90° intervals around the circumference of casing 32. All of these ports have flanges 50 that present coupling areas of like conformation and provide bores of like diameter and relative location. These flanges are intended to be mated with reciprocal flanges of positioning module 26 to be described below. Alternatively, these flanges are mated with reciprocal caps 52 that present coupling areas of like conformation and that provide bores of like diameter and relative location. Any flange of the ports and any flange selected from either the reciprocal flange of module 26 or corresponding areas of reciprocal caps 52 may be coupled, with an O-ring therebetween, by suitable threaded nuts and bolts. The O-ring, which is composed of a suitable elastomer, for example, a rubber-like material, renders the interconnection hermetic. Communicating with chamber 20 through a port 54 are a mechanical force pump and a mercury diffusion pump, shown in part at 56. These pumps cooperate continuously to maintain chamber 20 at an extremely low pressure when the device is in operation.

Electron gun 31 is located in enclosure 20 by a handle 57 carried by a bracket 33 that is supported by one of mounts 24. A substrate 35 to be coated is located in enclosure 20 by a pair of brackets 27 that are supported by a pair of mounts 24. As shown in FIGS. 2, 3 and 4, electron gun 31 includes a toroidal casing 58 that is open at its inner periphery and that contains an annular electrode 60. Casing 58 includes: a lower dish shaped portion 62 having a transverse base provided with a central aperture 64 and an upwardly flanged outer rim; and an upper dish shaped portion 66 having a transverse base provided with a central aperture 68 and a downwardly flanged outer rim. The upwardly flanged outer rim at its extremity is of reduced diameter to provide a lip 70 which may be seated in the lower extremity of the downwardly flanged outer rim. Within apertures 64 and 68, which are of substantially the same diameter, are welded a pair of tubular stub sections 72 and 74, which serve to control the path of vapor emitted from within the gun. Mounted on lower casing portion 62 and extending through openings 76, 78 and 80 in upper casing portion 66 are three connectors 82, 84 and 86. Each of these connectors includes a threaded rod 88 within a ceramic sleeve 90, extending through an opening of like diameter in the base of lower casing portion 62. A pair of collars 92 and 94 abut against portions of the base of casing portion 62 in order to position the connector. In sequence upwardly from collar 94 are: a pair of ceramic insulating washers 96 and 98 between which is a tab 100 that communicates electrically with rod 88; and a ceramic spacer 102. The entire assembly of parts associated with rod 88 is secured together by lock nuts 106 and 108 at the opposite extremities of the rod. As shown in FIG. 4, tabs 100 are provided with lugs to catch portions of electrode 60. A terminal 110, affixed to casing 58, determines the potential of casing 58.

As shown, rod 28 is mounted for vertical reciprocal movement into or from the center of electron gun 31. Module 26 includes a sleeve 112 that is aligned with a port 22 and that is provided with a flange 114. Flange 114 is mated with flange 50 by suitable bolts extending through openings in flanges 114 and 50. A suitable O-ring 116 is provided between flanges 114 and 50 for the purpose of hermetically sealing sleeve 112 to port 22. Extending upwardly through sleeve 112 is a hollow shaft 118, the upper end of which is sealed at 120 to inwardly projecting flanges 121 of sleeve 112. Extending through inwardly projecting flanges of sleeve 112 is a hollow shaft 122. Extending through hollow shaft 122 is a helical screw 124, the lower end of which is driven through a suitable gear box 126 by a motor 128. An internally threaded rider 130, moves along screws 124 as

it rotates. Rider **130** is operatively keyed to hollow shaft **122** as at **123** and hollow shaft **122** is operatively keyed as at **125** to hollow shaft **116** so that as motor **128** rotates, rod **28** advances into or retracts from electron gun **31**.

In operation, rod **28** of material to be evaporated may be advanced within the electron beam region at a predeterminally slow rate in such a way that vapor therefrom may be emitted from within electron gun **31** in a cone of predetermined extent and deposited on a substrate **35** to be coated. Annular electrode **60** is maintained at a large negative potential, casing **58** is maintained at a small negative potential and rod **28** is grounded. In practice, annular electrode **60** may be replaced readily, simply by removing electron gun **31** from within chamber **20**, separating casing portion **66** from casing portion **62** and re-assembling the casing portions with a new electrode therewithin.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. An electron gun comprising a generally toroidal casing defining a toroidal region therewithin and having an open inner periphery, said region being developed about an axis, said casing including a first part having a centrally apertured base portion and a first peripheral portion and a second part having a centrally apertured base portion and a second peripheral portion, said first peripheral portion and said second peripheral portion being detachably mated, a pair of insulated connectors secured to one of said parts and projecting freely through openings in the other of said parts, an annular electrode connected between said connectors, a first tubular stub secured within the aperture of said first part, and a second tubular stub secured within the aperture of said second part.

2. An electron gun comprising a generally toroidal casing defining a generally toroidal region therewithin and having an open inner periphery, said region being developed about an axis, said casing including a first part having a base portion provided with a central opening and a first peripheral portion and a second part having a base portion provided with a central opening and a second peripheral portion, said first peripheral portion and said second peripheral portion being detachably mated, a pair of insulated connectors secured to one of said parts, an annular electrode connected between connectors, said annular electrode extending about said axis, a first tubular flange positioned in said central opening of said base portion of said first part, a second tubular flange positioned in said central opening of said base portion of said second part, one of the central openings being adapted to receive a rod of material to be evaporated and the other of the central openings being adapted to emit vapor of said material from said rod.

3. An electron beam heating device comprising a hermetic housing, a generally toroidal casing mounted in said housing, defining a generally toroidal region therewithin and having an open inner periphery, said region being developed about an axis, said casing including a first part having a centrally apertured base portion and a first peripheral portion and a second part having a centrally apertured base portion and a second peripheral portion, said first peripheral portion and said second peripheral portion being detachably mated, a pair of insulated connectors secured to one of said parts, an annular electrode connected between said connectors about said axis, reciprocal means on one side of said casing for advancing an elongated workpiece along said axis into said toroidal region, means for supporting a stratum to be coated on the other side of said casing a first tubular flange on said centrally apertured base of said first part about said axis and a second tubular flange on said centrally apertured base of said second part about said axis.

4. An electron beam heating device comprising a hermetic housing, a generally toroidal casing mounted in said housing defining a generally toroidal region therewithin and having an open inner periphery, said region being developed about an axis, said casing including a first part having a centrally apertured base portion and a first peripheral portion and second part having a centrally apertured base portion and a second peripheral portion, said first peripheral portion and said second peripheral portion being detachably mated, a pair of insulated connectors secured to one of said parts, an annular electrode connected between said connectors about said axis, reciprocal means on one side of said casing for advancing an elongated workpiece along said axis into said toroidal region, and means for supporting a stratum to be coated on the other side of said casing, said pair of connectors secured within apertures in one of said parts.

5. The electron gun of claim 4, including means for applying a potential between said casing and said electrode.

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