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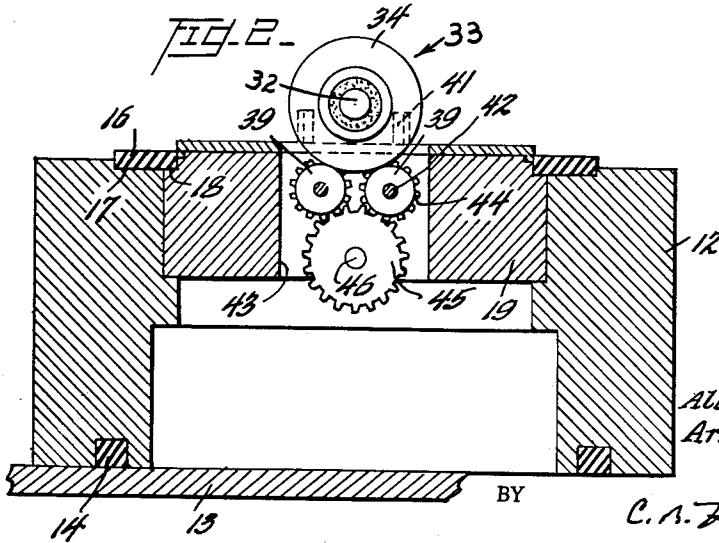
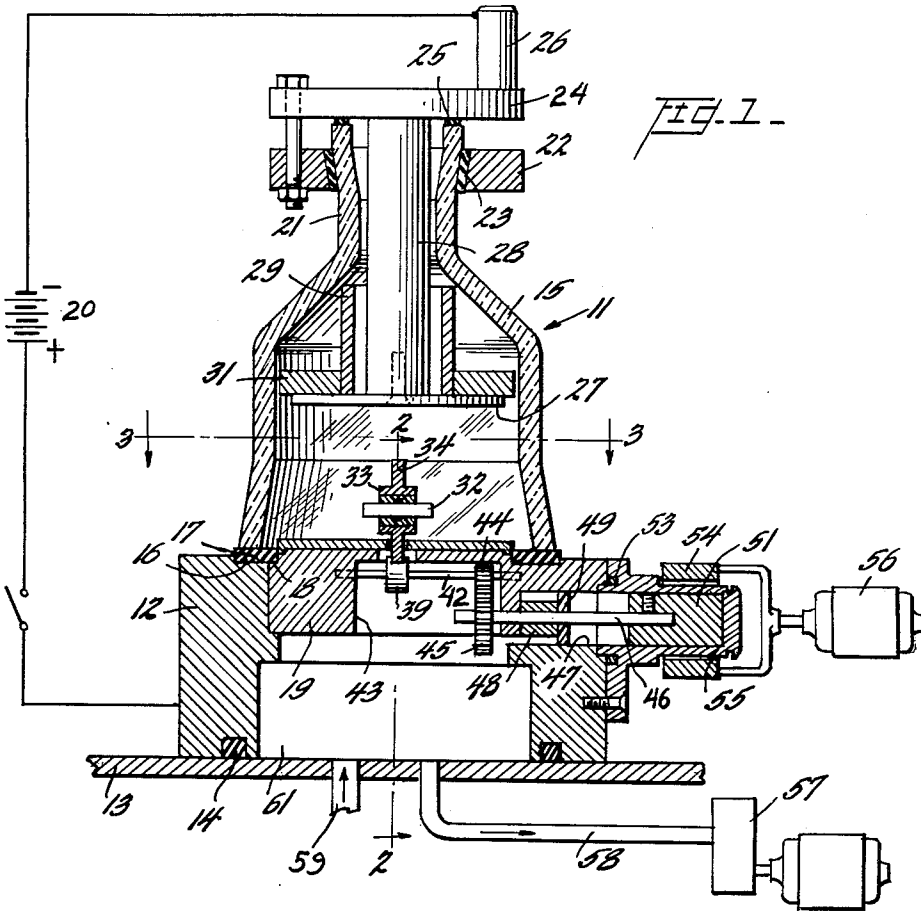
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APPARATUS FOR DEPOSITING FILMS ON ARTICLE SURFACES

Filed March 25, 1959

2 Sheets-Sheet 1



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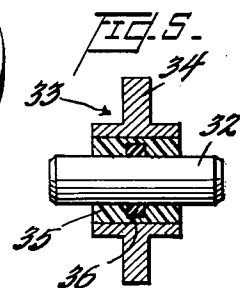
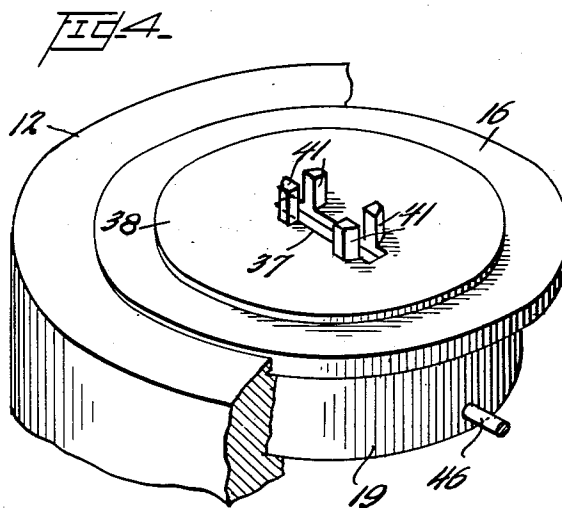
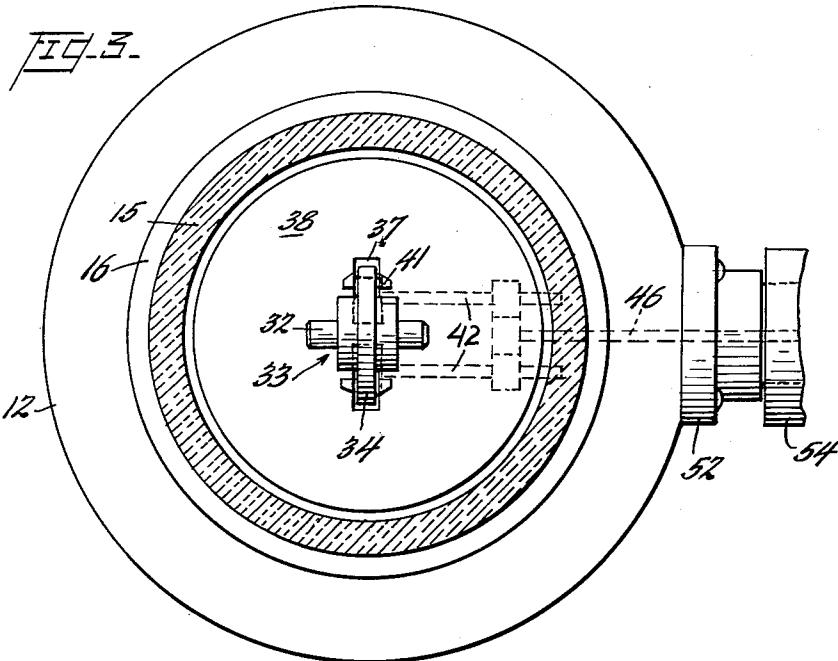
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APPARATUS FOR DEPOSITING FILMS ON ARTICLE SURFACES

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This invention relates to apparatus for depositing films on surfaces of articles, and more particularly to apparatus for depositing uniform electrically conductive terminal coatings on electrical resistor cores.

Uniform deposition of terminal films onto a carbon coated resistor core is necessary for effecting positive electrical contact between the carbon coating of the resistor core and terminal connectors inserted over the ends of the resistor core. Application of terminal films on resistor cores by known techniques and apparatus have not yielded satisfactory results, particularly with respect to uniformity of the conductive film. Consequently, the manufacture of precision resistors by mass production methods is not feasible through the use of the known techniques and apparatus.

It is an object of the present invention to provide an apparatus for the uniform deposition of an electrically conductive terminal film or coating on resistor cores.

A further object is to provide an apparatus for masking a resistor core and rotating the resistor core and the mask as a unit about their common axis so that a uniform exposure of the unmasked portions of the core to a depositing metal is achieved.

An apparatus illustrating certain features of this invention may include a mask for covering a portion of an article and a sputtering cathode. A support for maintaining the masked article is positioned spacially from the sputtering cathode, and means are provided for rotating the masked article about its axis at a fixed location with respect to the cathode to uniformly expose unmasked portions of the article to the material sputtered from the cathode.

A complete understanding of the invention may be had from the following detailed description of a specific embodiment when read in conjunction with the appended drawings, in which:

FIG. 1 is a sectional view of a preferred embodiment of a deposition chamber with a resistor core mounted therein;

FIG. 2 is a vertical section of a lower portion of the deposition chamber taken along line 2-2 of FIG. 1;

FIG. 3 is a sectional view of the deposition chamber taken along line 3-3 of FIG. 1;

FIG. 4 is a fragmentary perspective view of a portion of the deposition chamber; and

FIG. 5 is a sectional view of a resistor core positioned within a mask.

Shown in FIG. 1 is a deposition chamber, designated generally as number 11, having a base 12 mounted on a table 13. A seal-ring 14 seated in the base 12 joins the base to the table 13 to provide a gas-tight seal.

A bell-shaped jar 15 open at both ends is supported upon a gasket 16 which is fitted both into a shoulder 17 in the base 12 and a contiguous shoulder 18 in a hollow roller housing 19 to seal the bottom of the jar 15 to the base 12. The neck 21 of the jar 15 is tapered to receive a clamp 22 which encircles the neck and is separated therefrom by a resilient spacer 23. The clamp 22 is connected by suitable fasteners to a plate 24 of rigid material, such as aluminum. This plate fully closes the top of the jar 15 and forms a vacuum-tight seal with the jar 15 by means of an O-ring 25 of neoprene.

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A terminal connector 26 is secured to the plate 24 and connects a high voltage source 20 to a sputtering cathode 27 supported within the jar 15 by a cathode support rod 28 which is attached to the plate 24. An insulating sleeve 29 and an insulating disk 31 of Pyrex glass confines depositing or sputtering material to the area in the jar 15 located below the cathode 27. The cathode usually consists of a chemically pure form of the material being sputtered, but may also consist of any suitable base, such as copper, plated with the material to be sputtered. In the preferred embodiment of the invention the cathode 27 consists of pure gold.

An important feature of the invention is the provision for masking a central portion of a resistor core 32 and for rotating the masked resistor core about its axis to gradually expose the entire circumferential area of the unmasked ends of the resistor core 32 to the source of the sputtering matter. This feature insures uniform symmetrical electrically conductive terminations to be deposited on the ends of the resistor core 32.

The central portion of the resistor core 32 is covered by a tubular mask, designated generally by numeral 33 (FIG. 5), having a circumferential flange 34. A sleeve 35 of "Teflon" to prevent scuffing of the surfaces of the resistor core 32 during masking and unmasking thereof is fitted within the mask 33. The sleeve 35 contains an O-ring 36 of neoprene to resiliently hold the resistor core 32 within the mask 33.

The mask 33 into which the resistor core 32 is inserted is seated within the jar 16, its flange 34 being received in a slot 37 of the cover plate 38 in frictional engagement with a pair of drive rollers 39. A plurality of projections 41 located in parallel relationship to the slot 37 of the cover plate 38 guide the mask 33 during loading into the chamber 11, and prevent rocking movement of the mask 33 during its rotation, while the slot 37 and the projections limit its axial movement. The cover plate 38 is made of suitable material to permit ready reclamation of scattered deposition matter, and shields the roller housing and parts therein from sputtered matter.

Shafts 42 are spaced in parallel relationship within a recess 43 of the roller housing 19 and carry rollers 39 and pinions 44 which mesh with the drive gear 45. The drive gear 45 is rotated by means of a drive shaft 46 rotatably supported within a horizontal shaft bore 47 of the base 12 by a thrust bearing sleeve 48 and a resilient bearing 49. The shaft 46 is secured to an armature 51 within a hollow cylindrical armature housing 52 which is coaxial with the shaft bore 47 and is attached to the base 12 in a gas-tight seal through an insulating O-ring 53. The armature 51 magnetically couples with a drive ring 54 which has a plurality of magnetic poles and rotatably encircles the cylinder 55 of the armature housing 52. The drive ring 54, when driven by an electrical motor 56 or other suitable means, imparts by magnetic coupling rotary motion to the armature 51 and the drive shaft 46. This shaft rotates the drive gear 45, the pinions 44, the shafts 42, and the drive rollers 39, which impart rotation to the mask 32 and resistor core 33.

The interior of the chamber 11 may be evacuated by means of a suitable vacuum apparatus 57 through an exhaust tube 58 connected to the table 12. An inlet 59 for inert gas or for air to relieve the vacuum is also provided in the table 12 and opens into a hollow 61 within the base 13.

Operation

The central portion of the resistor core 32 is masked by inserting the resistor core 32 into the mask 33. The mask and the core are then placed within the deposition chamber 11, the jar 15 of which is raised to allow access to the interior of the chamber. The mask 33 is seated

between the projections 41 of the cover plate 38, and the flange 34 is received within the slot 37 and frictionally engages the drive rollers 39.

The jar 15 is then lowered into position and the interior of the deposition chamber 11 is evacuated by means of a suitable vacuum apparatus 57, repeatedly flushed with suitable inert gas, such as argon, reevacuated to a certain desired vacuum, in this particular example to 1.5×10^{-2} mm. Hg, and finally refilled with inert gas, such as argon, to a desired working pressure, for example 5×10^{-2} mm. Hg.

A suitable voltage, for example 3,000 volts at 20 to 30 milliamperes, is applied between the cathode 27 and the base 12, which acts as an anode, to ionize a suitable inert gas within the chamber. The positive ions formed are attracted toward the cathode 27, bombarding its surface and dislodging particles of the material desired to be sputtered. The dislodged particles are diffused into the interior of the jar 15 and deposit upon the exposed end portions of the resistor core 33.

Simultaneously, the drive ring 54, rotated by the electric motor 56, imparts rotary motion to the armature 51. This rotary motion is transmitted through the drive shaft 46, the drive gear 45, the pinions 44, the shafts 42, and the drive rollers 39 to the mask 33 and therefore to the resistor core 32 by frictional contact of the flange 34 with the drive rollers 39. When the mask 33 is rotated the resistor core 32 and the mask 33 rotate as a unit about their common axis. Rotation of the resistor core 32 about its axis is necessary to insure uniform, symmetrical deposition of sputtered particles, such as gold, upon the exposed ends of the resistor core 33.

After a predetermined period, which depends upon the amount of deposition of sputtered particles upon the exposed ends of the resistor, the vacuum is broken by admission of air into the interior of the chamber 11, and the jar 15 is removed from the base 12 to expose the cover plate 38 and the mask 33 seated thereon. The mask together with the terminated resistor core 32 is unloaded and the core is ejected from the mask 33.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is only illustrative and that various modifications may be made without departing from the scope and spirit of this invention.

What is claimed is:

1. An apparatus for depositing coatings upon surfaces of articles by cathode sputtering which comprises masking means for covering central portions of an article to be coated, means for engaging the periphery of said masking means to rotate the masking means and the article held within said masking means about their common axis at a fixed location, and means spacially positioned from the location of the rotated masking means for coating uncovered portions of said article.

2. An apparatus for depositing coatings upon surfaces of articles by cathode sputtering which comprises a mask for covering the central portion of an article to be coated at each end, driven means for engaging the periphery of the mask to rotate the mask and the article held within the mask about their common axis at a fixed location such that the end portions of the masked article are completely exposed, magnetically operated means for driving said driven means, and cathode sputtering means spacially positioned from the location of the rotated mask for coating exposed end portions of the article.

3. Apparatus for use in cathode sputtering of metal terminals on electrical resistor cores which comprises a hollow anode base, a roller housing seated within the hollow base, opposed drive rollers mounted for rotation within the housing, a cover plate supported upon the roller housing and having an elongated slot formed therethrough for uncovering a limited portion of the rollers, a gear train drivingly coupled to the rollers and extending later-

ally through the base, a drive motor connected to the gear train, a base closure sealingly engaged to the bottom of the base, vacuuming means, a conduit connected to the vacuuming means and passing through the base closure to open into the hollow base, a chamber mounted in sealing engagement upon the base, a cathode electrode supported within the chamber at a predetermined distance from the base, the electrode being of a material to be sputtered upon an article, a source of electrical current connected to the cathode and to the anode base, and a hollow cylindrical mask having a circumferential flange for receiving a resistor core, the flange being received in the slot of the cover plate such that the cylindrical portion of the mask is disposed within the chamber and the flange is drivingly supported upon the rollers for rotation of the mask.

4. In an article coating apparatus having a coating source, the combination with said coating source of a housing positioned at a fixed distance from said coating source, a pair of spaced rollers journaled in the housing, a plate having an elongated slot formed therethrough mounted on the housing so that the slot extends transversely of the axis of the rollers, pairs of projecting members mounted to the plate on opposite sides of said slot, an article carrier positioned within said slot between the projecting members and in frictional engagement with said rollers for masking and positioning said article at a predetermined distance from said coating source, and a pair of hubs extending from said carrier and between said pairs of projecting members for engaging said members to keep said carrier positioned within the slot.

5. Apparatus for depositing coatings on surfaces of articles which comprises a cylindrical mask having a bore formed centrally therethrough and a circumferential flange formed thereon coaxially with the bore, a tubular sleeve having an annular groove formed therein mounted within the bore, means mounted in said annular groove for holding an article to be coated within the sleeve, driven roller means in frictional engagement with the flange for rotating the mask and the article about their common axes at a fixed location, and means spacially positioned from the location of the mask for coating the exposed portions of the article.

6. Apparatus for use in cathodic sputtering of metal terminals on electrical resistor cores which comprises a hollow elongated mask for receiving the medial portions of a resistor core whereby the core ends are exposed, said mask having an annular flange formed coaxially with the bore, an anode base having a hollow chamber, a jar mounted on the base and overlying said hollow chamber to form a second chamber with said base, means for sealing said jar to the base, a divider plate mounted on said base and over said hollow chamber for separating said hollow chamber from said second chamber, said plate having a slot formed therethrough for receiving said flange, a cathode of material to be sputtered mounted within the jar in said second chamber, driven rollers mounted on said base in said hollow chamber for engaging and rotating the flange received in said slot to rotate the elongated portion of said mask and said resistor core in said second chamber, means for impressing a vacuum condition in said chambers, and an electrical power supply connected to the anode base and the cathode for applying potential between said anode and cathode to sputter metal terminals on the exposed ends of the core.

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