

[54] **TILTING VARIABLE SPEED ROTARY SHADOWER**

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[51] Int. Cl. **C23c 13/02**

[58] Field of Search **118/47-49.5, 500-503, 118/53, 56; 269/53, 57, 61, 71, 56; 117/106-107.2**

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[57] **ABSTRACT**

Method to effect uniform vapor deposition on a specimen by continuously exposing the specimen to a vapor beam while imparting precessional motion to the specimen, including positions wherein the specimen major surface faces said beam at 90° thereto and wherein the specimen edge portions are at 90° to the beam, and while variably shielding the specimen during its precessional motion.

2 Claims, 9 Drawing Figures

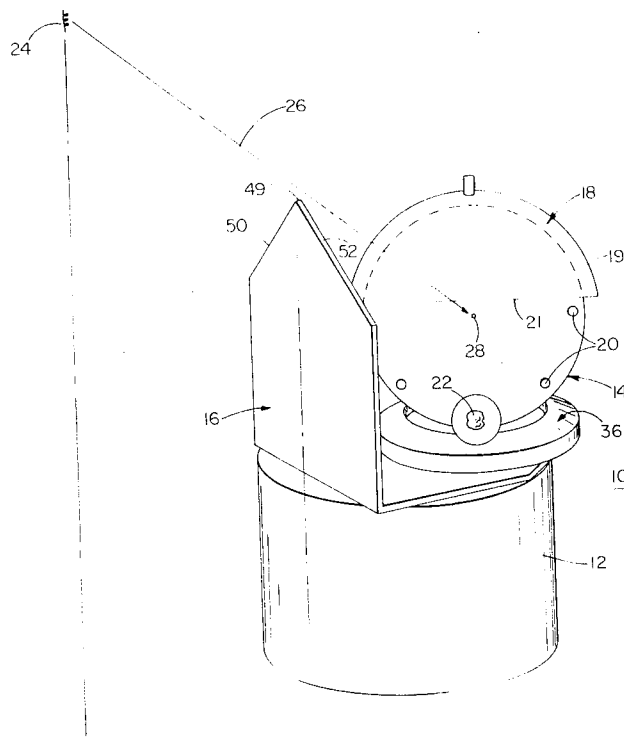


FIG 1

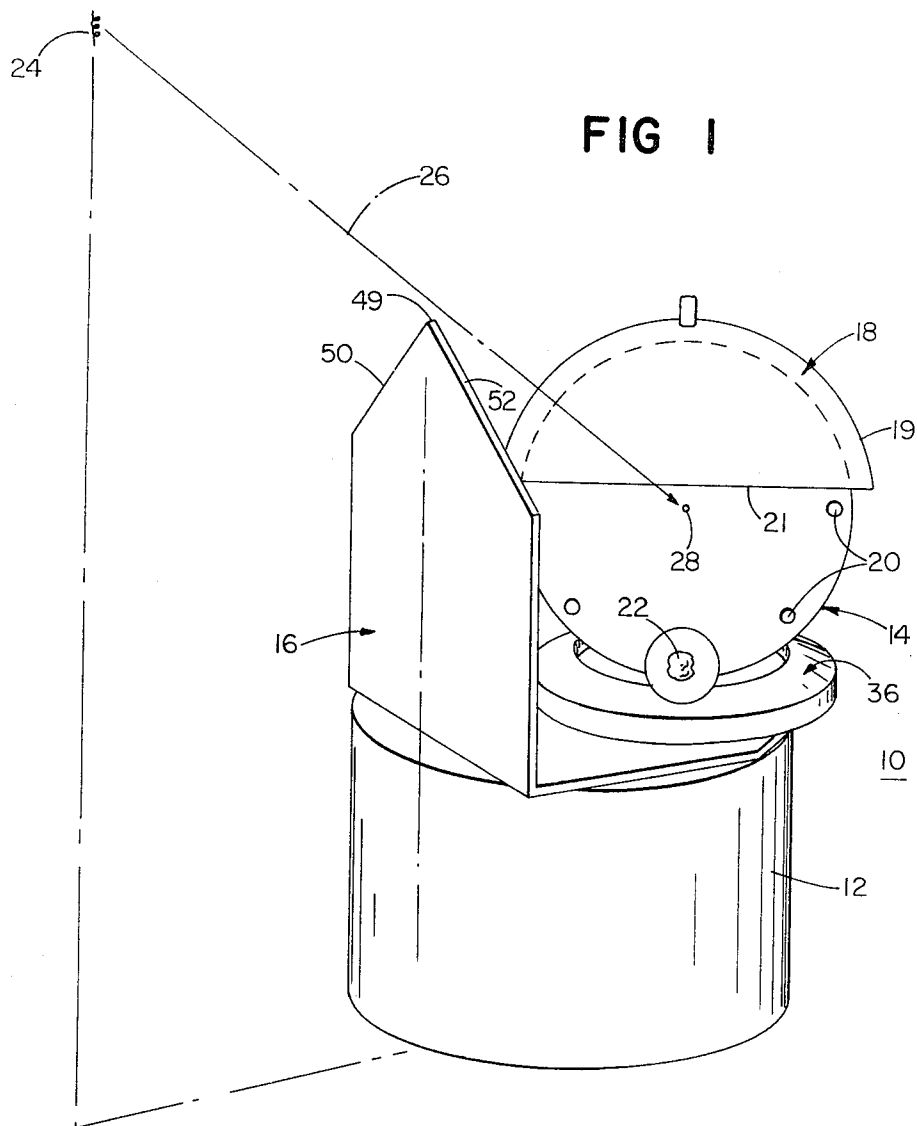


FIG 2

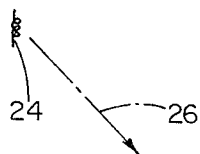


FIG 3

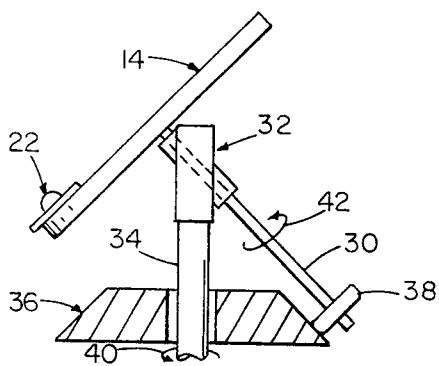
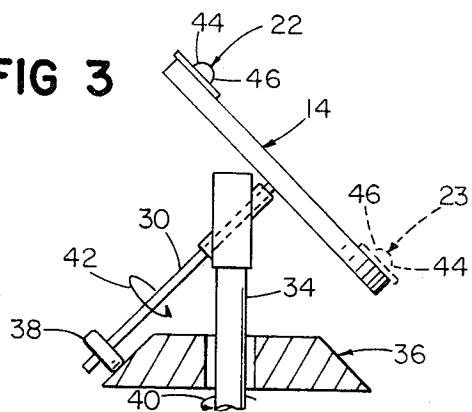


FIG 5

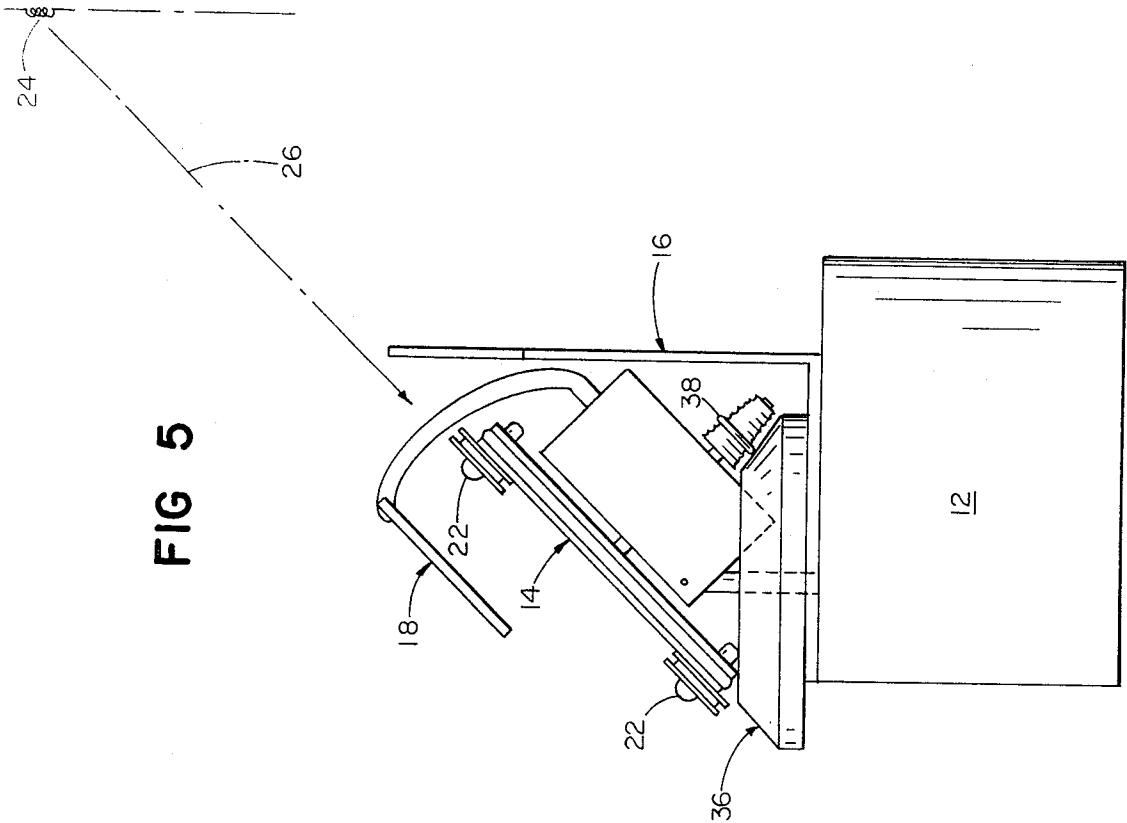
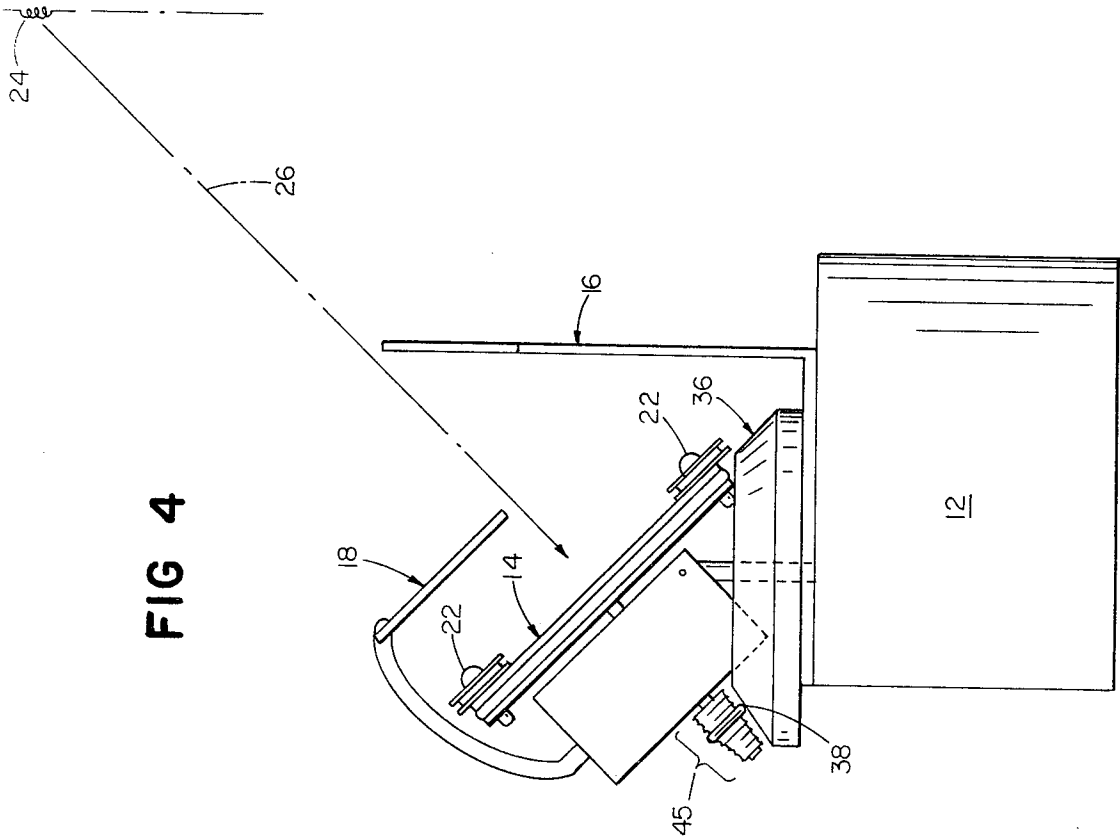


FIG 4



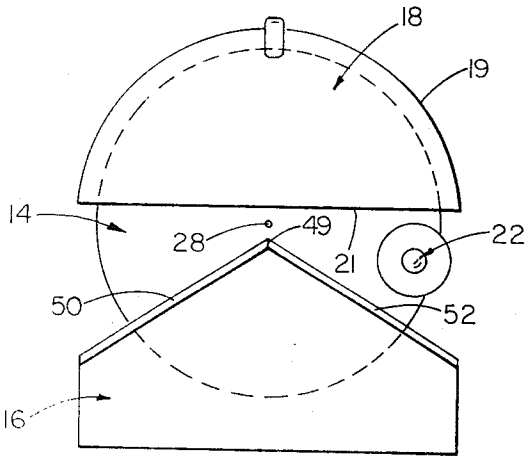


FIG 6

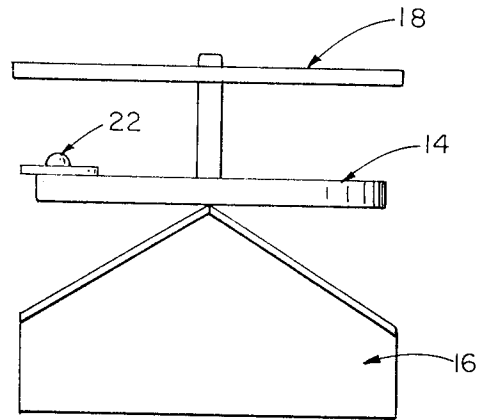


FIG 7

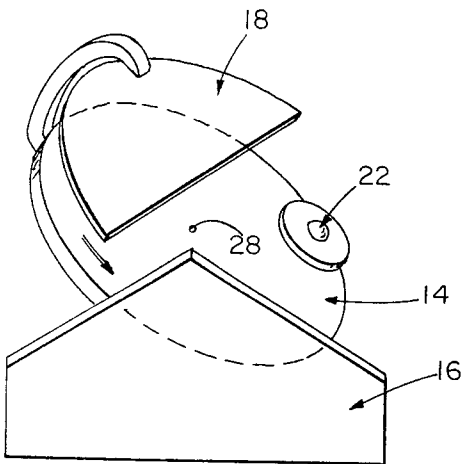


FIG 8

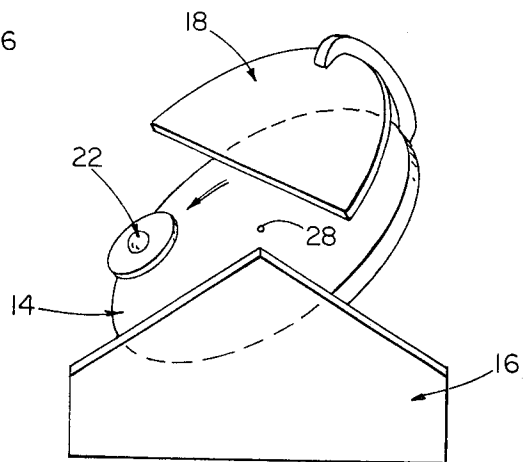


FIG 9

TILTING VARIABLE SPEED ROTARY SHADOWER

This invention relates to the preparation of specimens for examination by an electron microscope.

In scanning electron microscopy, an electron beam scans the specimen being examined. The specimen must not accumulate charge, as this would deflect the beam and prevent the formation of an image. Therefore, a non-conducting specimen must be coated with an electrically conductive material, such as a metal, before being examined in such a microscope. Such coating, also called shadowing, is accomplished by vaporizing a metal (usually a combination of palladium and gold) in a vacuum, and directing the vaporized metal toward the specimen. All portions of the specimen except the bottom are then coated with the metal. It is desirable to provide a coating that completely covers the sample surface and is uniform in thickness.

Previous standard methods of coating a specimen for this purpose have involved rotating or orbiting the specimen at constant speed in one plane, in a chamber under a vacuum, while evaporating a metal in the chamber to coat the sample. This procedure results in a specimen that is coated from a particular angle, the angle of incidence of the metal vapor, but if the specimen surface is not smooth, some areas of it may be missed and hence cannot be scanned.

It is therefore an object of this invention to provide a method that ensure complete coating of all parts of the surface of a specimen. It is a further object to ensure that this coating be of uniform thickness over all areas. It is another object to provide apparatus for such coating that is compact and simple, permitting easy and rapid installation or removal from the vacuum evaporator.

The invention features a method of orbiting a specimen about a first axis, while simultaneously orbiting the first axis about a second axis inclined to the beam direction of the incident metal vapor at about 45°. The first axis intersects the second at about 45° for precessional motion of the first axis and corresponding motion of the specimen between a first position in which, when the first axis is parallel with the beam direction, the top portion of the specimen intersects the beam direction, and a second position in which, when the first axis is normal to the beam direction, the equatorial portions of the specimen intersect the beam direction, with intermediate positions in which remaining upper portions of the specimen intersect the beam axis. The specimen is exposed to the beam during a part of each revolution of the specimen about the first axis; this part decreases from an entire revolution in the second position to approximately one-fourth of a revolution in the first position. This variable exposure of the specimen ensures a uniform coating of all exposed portions of the specimen.

Apparatus to coat a specimen by this method comprises a rotatable support table adapted to hold a specimen at a location spaced from the axis of the table, and a mechanism for moving the table bodily about a second axis inclined to the axis of the table while simultaneously rotating the table about its own axis, for precessional movement of the rotating table between a first position in which a beam is incident normally on the table surface for exposure of the top of the specimen to the beam, and a second position in which the beam is parallel to the table surface for exposure of side portions of the specimen to the beam. Shielding means is provided for shielding the specimen from the beam during a part of each revolution of the specimen about the axis of the table; this part increases from nothing in the second position to about three-fourths of a revolution in the first position. The total exposure of the specimen throughout the precessional motion is thereby made uniform for all areas of the upper portion of the specimen.

In preferred embodiments, the apparatus comprises a specimen support table having peripheral specimen support means, a first shaft supporting the specimen table, a rotatable second shaft, rotatably supporting the first shaft, a drive track concentric with the second shaft, cooperative drive means on

the first shaft engaging the drive track, and power means to rotate the second shaft for precessional motion of the support table and first shaft about the second shaft. The support table is thereby moved between a first position and a second position as previously described. The apparatus further provides shielding means, comprising a first fixed shield and a second shield rotatable about the second shaft. The shields cooperate to shield the specimen during a part of each revolution, increasing from nothing when the beam is incident on the side portions of the specimen to approximately three-fourths of a revolution when the beam is incident normally on the top of the specimen. The total exposure of the specimen throughout the precessional motion is thereby made uniform for all areas of the upper portion of the specimen.

Other objects, features and advantages will appear from the following description of a preferred embodiment of the invention, taken together with the annexed drawings thereof, in which:

FIG. 1 is a perspective view of the apparatus of the invention;

FIGS. 2 and 3 are schematic views of the rotating and precessing portion of the apparatus in two positions;

FIG. 4 is a view of the entire apparatus when the beam is incident on the top or polar area of a specimen;

FIG. 5 is similar to FIG. 4 but shows the beam incident on the equatorial regions of a specimen;

FIGS. 6, 7, 8, and 9 show several positions of a portion of the apparatus as seen from the beam source.

Referring now to the drawings, particularly to FIG. 1, the apparatus of the invention, indicated generally at 10, comprises a housing 12 containing a motor, not shown, a specimen support table 14, a fixed shield 16 and a movable shield 18. The motor is enclosed in a vacuum-tight, lightweight metal housing, thus eliminating pump-down problems associated with the use of DC motors in a vacuum. The unit is operated by a suitable variable voltage DC power supply driven by a 110 v. AC power source. Specimen table 14 provides a number of peripherally located specimen holders 20, in one of which is retained a specimen 22. Apparatus 10 is illuminated by a source 24, which directs a beam of metal vapor along beam axis 26 directed to the center 28 of table 14.

Specimen table 14 is supported on a first shaft 30 (FIGS. 2 and 3) which is rotatably supported in a pivoted sleeve bearing 32 by a second shaft 34. Concentric with shaft 34 is a drive track 36. Shaft 30 provides cooperative drive means comprising a ring 38 of elastomeric material such as rubber encircling shaft 30; ring 38 frictionally engages track 36. Thus when shaft 34 is turned by the motor to rotate in the direction indicated by arrow 40, ring 38 engages track 36 and causes shaft 30 rotate as shown by arrow 42. Shaft 30 may provide a conical portion 45 (FIG. 4) for receiving ring 38, permitting the diameter of ring 38 to be varied, thereby varying the ratio of angular speed of shaft 30 to angular speed of shaft 34. Angular speed of shaft 30 may be varied from 10 to 1,000 r.p.m.

The combination of these two rotations results in a precession of shaft 30 about an axis concentric with shaft 34. Generally shaft 30 rotates several times during a single revolution of shaft 34. All upper portions of a specimen are exposed to the beam at some point in this motion.

When table 14 is in the position shown in FIG. 2, beam axis 26 is incident normally on the table. Since the beam spreads to fill a volume around the beam axis, the top of the polar region of specimen 22 is exposed to source 24. Shaft 30 completes one or more revolutions while in the position of FIG. 2, and the top of specimen 22 is exposed throughout these revolutions. However, in the position of FIG. 3, the equatorial regions of specimen 22 are exposed to source 24. In particular, when specimen 22 is on the side of table 14 nearest to source 24, region 44 is exposed. However, as table 14 rotates about shaft 30, specimen 22 is carried to the position indicated at 23, in which region 46 is exposed but region 44 is not. Thus for revolutions about shaft 30 in the position of FIG. 3, only a portion of the equatorial region of specimen 22 is exposed at any one instant.

In practice it is found that the ratio of total coating of any portion of the equatorial region to total coating of the polar region is about 0.25 to 1.0 if the apparatus and method just described is operated without shielding.

The solution to this problem lies in ensuring the even exposure of all regions of the specimen by selectively shielding the specimen during parts of the precessional motion. In practice it has been found most satisfactory to accomplish this by providing shielding means comprising fixed shield 16 and movable shield 18. While the purpose of the shielding could be accomplished by a movable shield alone, though of different shape and size from shield 18, it is found desirable to provide fixed shield 16 for protection of the rotating and precessing mechanism from beam 26, and this shield may be adapted to provide part of the required shielding of the specimen as well.

In the particular embodiment disclosed here, table 14 has a diameter of 2 3/4 inches. Shield 16 terminates in an apex 49 whose two sides 50 and 52 (FIG. 6) include an angle of about 83°. Apex 49 extends to within not less than one-eighth inch and not more than one-sixteenth inch of beam axis 26.

Movable shield 18 is generally planar and bounded by a curved edge 19 and a straight edge 21 (FIG. 1). Straight edge 21 extends to within about one-eighth inch of center 28 of table 14, and the curved edge overlaps table 14 sufficiently to completely shield specimens passing beneath the shield.

The effect of the combination of shields 16 and 18 appears in FIGS. 6, 7, 8, and 9. Referring to FIG. 6, when table 14 is in the position of FIG. 4, the plane of table 14 is normal to beam axis 26 and therefore appears as a full circle seen from the source 24. Movable shield 18 covers less than a half of table 14, and together with shield 16 obscures about three quarters of the circumference of table 14. Thus during a revolution of specimen 22 about center 28, the specimen is exposed for about one-fourth of the time. When table 14 precesses to the position shown in FIG. 5, the edge of the table is presented to the beam (FIG. 7) and neither shield 18 nor shield 16 obscures specimen 22 during any portion of its motion around the center of table 14. Intermediate positions (FIGS. 8 and 9) result in the specimen's being exposed to the beam during por-

tions of a revolution less than the total but greater than a quarter.

The uniformity of the coating on specimens prepared by this method has been checked by placing Formvar test grids at all angles and positions on the platform and coating them simultaneously. After being coated, they were examined with a Philips electron microscope and the thickness was measured by measuring the intensity of the transmitted beam with a densitometer. The coatings were found to be uniform, to within experimental error.

What is claimed is:

1. Method uniformly vapor depositing by exposing the upper portion of a specimen to an incident beam whose direction of incidence defines a beam axis, comprising the steps of

orbiting said specimen about a first axis, simultaneously orbiting said first axis about a second axis, said second axis inclined to said beam axis at about 45°, said first axis intersecting said second axis at about 45° for precessional motion of said first axis, with corresponding motion of said specimen between a first position in which, when said first axis is parallel with said beam axis, the top portion of said specimen intersects said beam, and a second position in which, when said first axis is inclined at 90° to said beam axis, the equatorial portions of said specimen intersect said beam axis, through intermediate positions in which remaining upper portions of said specimen intersect said beam axis, and exposing said specimen to said beam during a part of each revolution of said specimen about said first axis, said part decreasing from an entire revolution in said second position to approximately one-fourth of a revolution in said first position, whereby the total exposure of the specimen to said beam is uniform for all areas of the upper portion of said specimen.

2. The method of claim 1 wherein said specimen is orbited about said first axis through more than one revolution while said first axis is orbited once about said second axis.

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