United States Patent

Tousimis

[15] **3,656,453**

[45] **Apr. 18, 1972**

[54] **SPECIMEN POSITIONING**

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[52] **U.S. Cl.** **118/48,** 118/53, 269/57

[51] **Int. Cl.** **C23c 13/08**

[58] **Field of Search** 118/48–49.5, 500, 118/503, 53, 56; 269/61, 71, 57; 279/5

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Primary Examiner—Morris Kaplan
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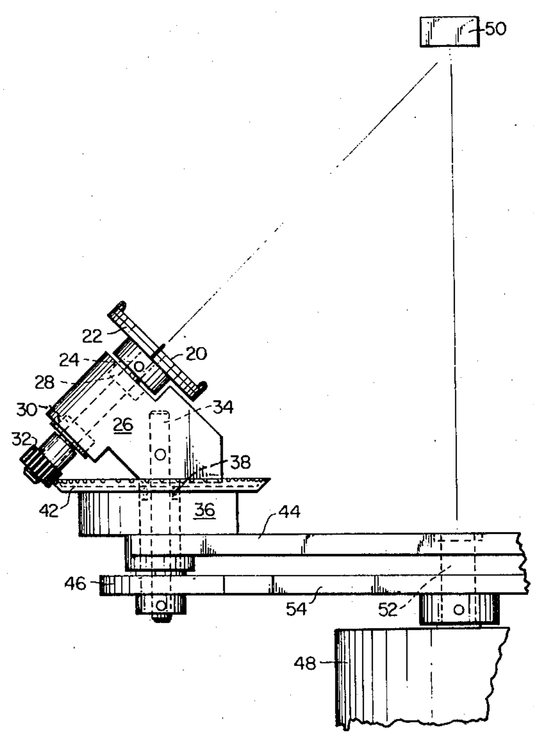
[57] **ABSTRACT**

An individual specimen positioner and a system for vacuum deposition of metal to prepare a specimen for observation by a scanning electron microscope. A number of specimens are held and positioned simultaneously, each positioned by an identical specimen positioner. Each specimen positioner has a grip for the specimen. The grip is mounted to a base through an angled shaft which is mounted on bearings to rotate the grip. The base is integrally connected to a vertical shaft, the axis of which extends through the center of gravity of the specimen. The vertical shaft is mounted on bearings to permit it to rotate the base. The vertical shaft is driven from a single motor which drives all of the several positioners in the same way. Perpendicular to the vertical shaft is a stationary crown gear. The angled shaft is positioned at a 45° angle with the horizontal, which in one position of rotation points that shaft directly at the evaporation source on a path which extends through the center of gravity of the specimen. The end of the angled shaft carries a pinion which meshes with the crown gear and thereby rotates the specimen through the action of the angled shaft as the specimen is also rotated by the vertical shaft. Rotation around the angled shaft is at more than five times the angular velocity of the rotation around the vertical shaft.

21 Claims, 7 Drawing Figures



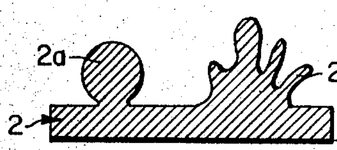


FIG. 1

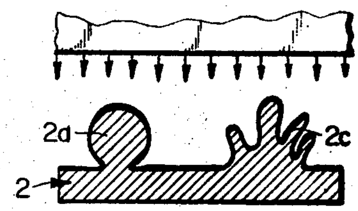


FIG. 2

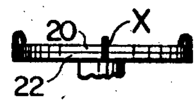


FIG. 4a

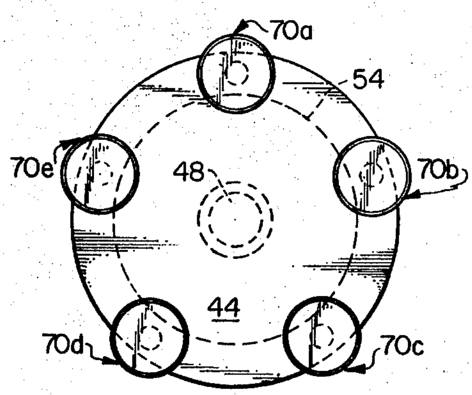


FIG. 5

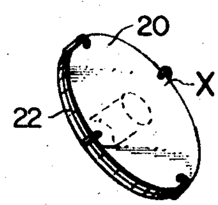


FIG. 4b

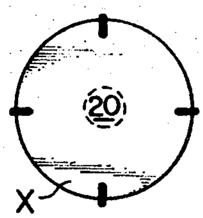


FIG. 4c

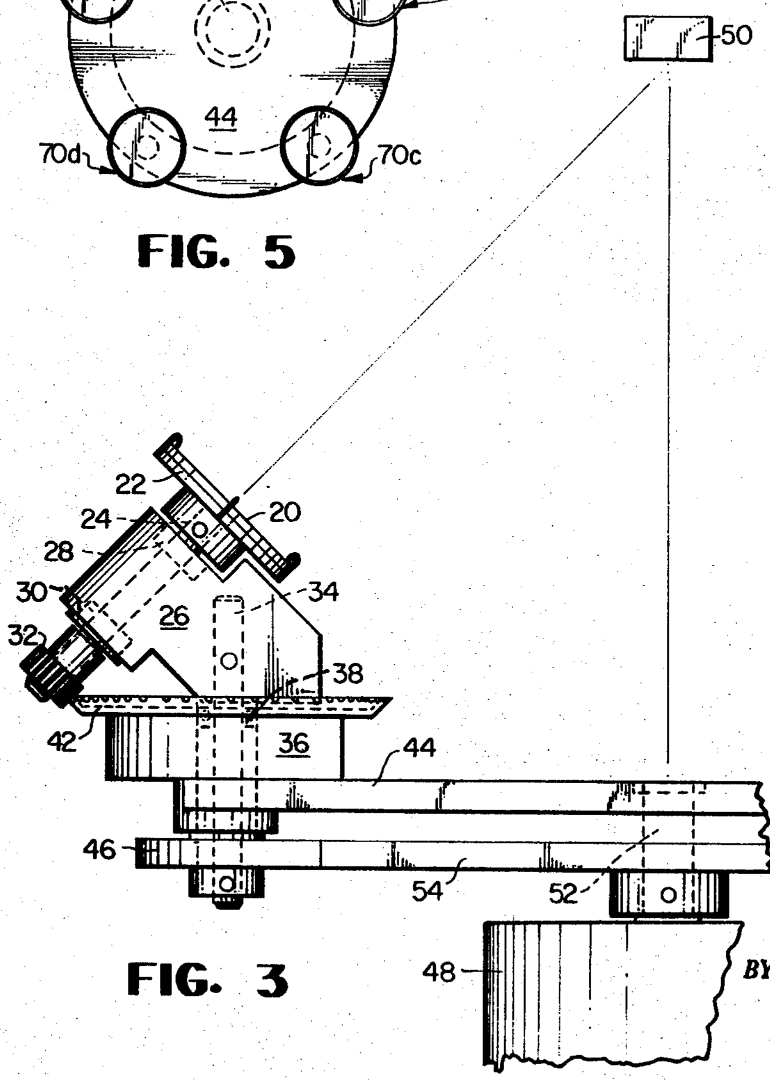


FIG. 3

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SPECIMEN POSITIONING

This invention relates to the positioning of specimens during an operation from a source on the specimens. More specifically, this invention relates to moving the specimens during vacuum deposition of coating to achieve improved coating results, and is useful for many other purposes such as to achieve 360° diffraction of X-rays from a stationary source.

Deposition of evaporable substances by vapor deposition techniques upon items positioned in an evacuated chamber is, of course, an art which is practiced commercially for many purposes. These coatings may, among other uses, serve decorative purposes, inhibit corrosion or wear, provide desirable optical properties, or provide a replication of the surface coated in electrically conductive material.

The item or items to be coated are positioned in an evacuated chamber while deposition is conducted. The item may be moved during the coating operation. In some systems, the item is rotated so as to better coat a larger surface. Also, stepwise or continuous tilting stages are available commercially for rotating the surface on one axis between 0° and 90° to the source. The usual uses for these devices are for intentional shadowing at low angles of incidence to accent surface irregularities.

The prior art does not teach a satisfactory technique to achieve a coating of very uniform thickness on a wide range of surface irregularities. Such a result is particularly important in certain specialized, but highly significant, areas of operation. Of particular importance in this regard is electron microscopy, particularly, scanning electron microscopy.

In electron microscopy technology, a sample surface is coated as uniformly as practical with a thin film which is generally conductive. This layer should be as thin as possible in order to retain the image of the surface contour of the sample. At the same time, the coating should be sufficiently thick to provide a continuous cover for purposes of mechanical integrity and electrical conductivity.

In the microcosmic sense, virtually every item is rough and jagged. When items are to be inspected with an electron microscope, such minute unevenness is often the very point of interest.

Consequently, it is a primary object of this invention to provide means to coat uneven items with conductive material with a coating which is at least approximately even over a large part of the coated surface. It is an object to provide such an evenly coated surface, especially when the surface contains very minute contours and roughness. The mechanisms in accordance with this invention may be used for other important purposes such as for X-ray diffraction studies on specimens held and moved in the same manner as specimens to be coated.

Current practice is generally to evaporate material onto the surface to be coated from a stationary source. The surface is positioned facing the source at any angle 90° to the source. The rough and uneven parts of the surface in such a system shadow parts of the surface and thereby hide those parts from the source of emanations. The resulting coating is not of uniform thickness and may be discontinuous in many areas.

A more satisfactory coating is achieved in accordance with this invention by improved positioning of the specimen while using conventional vacuum coating equipment. The specimen is moved during a conventional vacuum deposition operation so that an approximately even coating is deposited on most of the surfaces being coated.

Consequently, it is a basic object of this invention to provide a specimen positioner for a vapor deposition system which will cause the deposition of an approximately even coating on a large part of the surface coated.

It is a further object of this invention to provide such a specimen positioner which is relatively small and compact.

It is another, more specific object of this invention to provide such a specimen positioner which is economical, small, and compact, and which can operate well with relatively heavy specimens.

It is a more general object of this invention to provide such a specimen positioner which may be used simultaneously with other such positioners in a single vacuum deposition system.

It is another object of this invention to provide a specimen positioner in which during coating operations the distance between evaporant source and specimen is approximately constant, to thereby provide a more even coating from the use of less complex mechanisms.

It is another, more specific object of this invention to provide a specimen positioner which can turn the sample away from the evaporant source, to thereby avoid the need for a shutter in a coating system.

In accordance with broad aspects of this invention, the specimen positioner contains means to impart two different rotative movements to the specimen. One movement tilts the entire specimen being coated to different angles relative to the source of emanations. As part of the operation, the specimen is also rotated in a different plane to present different sides of contours on the surface facing the source. Topographic shadowing is thus circumvented.

Topographic shadowing is minimized by exposing the surface to evaporant from all directions. To approach that, the surface should be rotated in a manner to present the full surface to the source at all angles from and including 0° and 90°. At the same time, this surface should be rotated around an axis perpendicular to the surface. A greater variation in angles presented to the source is obtained as the angular velocity around the perpendicular axis is increased relative to the velocity of the other rotation. Both rotative actions may be continued for any number of cycles, and a greater variation in angles is obtained as the cycles are continued when the two rotative movements are aperiodic, that is, when the angular velocity around the perpendicular axis is not an integral multiple of the other angular velocity.

The above mentioned and other objects, features, and advantages will be made more apparent by the following detailed description of the preferred embodiment of this invention, as illustrated by the accompanying drawings.

FIG. 1 is a drawing which is merely illustrative of major features representative of the type of irregularities typically found on surfaces with which this invention is concerned;

FIG. 2 illustrates the result of coating the surface of FIG. 1 by vacuum deposition with emanations from one, stationary source. The black outlines in FIG. 2 illustrate the coating applied;

FIG. 3 is a detailed illustration of the preferred embodiment of one specimen positioner assembly in accordance with this invention;

FIGS. 4*a*, 4*b*, and 4*c* show the preferred device in outline form in three angular positions to illustrate the different movements involved in the preferred embodiment of this invention;

FIG. 5 is illustrative of a plurality of the preferred specimen holders in a system in which several of them operate simultaneously to coat different specimens.

Reference is made to FIG. 1, which is intended to be merely illustrative of the surface of a typical substrate. FIG. 1 is a sectional view showing the surface of an item 2 to be coated for subsequent examination with use of a scanning electron microscope. FIG. 1 shows the surface of the item 2 with random irregularities which may be somewhat circular as at 2*a* or may be jagged as at 2*c*. It is desired to cover the surface as completely and evenly as possible with a very thin conductive coating.

FIG. 2 illustrates the results of coating the surface by deposition from a vacuum source when the source is simply positioned in a stationary position at 90° in relation to the surface being coated and deposition is continued until much of the surface is covered. Since parts are shaded or partially shaded by irregularities 2*a* and 2*c*, those parts are coated much more slowly or not at all, depending the extent of the shading by surface irregularities. The solid black outline of coating in FIG. 2 illustrates the position and thickness of the coating which results. It is highly uneven and is discontinuous in many places. If deposition were continued, a more continuous coating could be achieved in many cases, but the coating would be much thicker in other areas with a consequent substantial loss in detail of the surface being coated.

STRUCTURE OF SINGLE POSITIONER

FIG. 3 shows the details of one specimen positioner in accordance with this invention. The specimen 20 to be coated is held by a grip 22, which is shown merely illustratively as it may be of any suitable construction, of which a number are presently known. Grip 22 is keyed or otherwise integrally linked to shaft 24. Shaft 24 extends through holder base 26 and is appropriately mounted on bearings 28 and 30 to freely rotate. At the bottom end of shaft 24, pinion gear 32 is keyed or otherwise integrally linked to shaft 24.

In addition to providing support for shaft 24, base 26 extends as a single unit to a position where vertical shaft 34 is received, which is at a position directly under the center of where grip 22 holds specimens. Vertical shaft 34 is keyed or otherwise integrally linked to base 26. Shaft 34 extends through support member 36, and is appropriately mounted for movement on bearings 38. Crown gear 42 is a circular member mounted perpendicular to shaft 34 on top of support member 36.

The entire unit is held by plate 44, upon which member 36 is positioned. Plate 44 supports a number of the positioning units, each as shown in FIG. 3, and also may support or partially support the motor for driving the units as will be described. Plate 44 is firmly mounted to the frame of the vacuum deposition unit. This may be by any convenient device (none shown), many of which are within the state of the art.

Vertical shaft 34 extends freely through plate 44 and holds gear 46 near its end. Gear 46 is integrally connected to shaft 34. Motor 48 is positioned at the center of the coating area, generally under the location of evaporation source 50 and under plate 44 so that it is shielded from evaporant. Shaft 52 is driven by motor 48. Shaft 52 is integral with large, power gear 54. Gear 54 links with gear 46 on the positioning unit to provide the power for movement of the entire assembly. (No fundamental limitation is intended to be implied by the specific location and linkage of motor 48 in this preferred embodiment. It is clear that the motor can be positioned in any number of locations both near and displaced from the coating area. Although the gearing arrangement used is an especially useful one, torque could be supplied directly to either shaft 24 or shaft 34, or motive power could be supplied by means basically different from that used in this preferred embodiment. When the motor is positioned outside of the evacuated chamber used in the deposition process, it may be of a more conventional design rather than of a design suited to operate in and maintain a vacuum).

Evaporation source 50 is positioned above and spaced from the specimen positioner assembly. Shaft 24 is generally perpendicular to the surface of items coated when held by grip 22. The angle of shaft 24 with the horizontal is about 45°, and shaft 24 points directly at evaporation source 50 when grip 22 holds specimen 20 at 90° to source 50.

OPERATION OF SINGLE POSITIONER

During the operation of a single positioner, a specimen 20, which may be a small biological specimen, is inserted so that it is held by grip 22. In the preferred embodiment, specimen 20 is shown as a thin, generally flat circular item. As is conventional, the area is evacuated and the vacuum source 50 is brought to an elevated temperature to allow minute portions of conductive material to be evaporated from source 50 and to move of their own momentum to specimen 20.

Prior to or at an early time in the coating process, motor 48 is started to thereby cause shaft 52 to rotate, which, in turn, causes rotation of large gear 54.

Large gear 54 is geared to vertical shaft 34 through gear 46. Thus, shaft 34 is rotated. Shaft 34 is integrally linked to base 26 and, through shaft 24 to grip 22. Therefore, grip 22, holding specimen 20 is rotated around a vertical axis which is coextensive with shaft 34. This component or rotation moves the entire face of specimen 20 being coated so that the entire face is continually presented to source 50 at different angles. With continuous rotation in this manner, the angle at which emanations from source 50 reach the surface of specimen 20 will vary in a continuum from 0° to 90° and back to 0°, assuming a starting position of 0° and sufficient rotation of shaft 34.

As that rotative motion occurs, pinion gear 32 is forced along stationary, crown gear 42. That interaction imparts a rotation to shaft 24, which is directly translated to grip 22 and thereby to specimen 20. This second rotative movement is on an axis perpendicular to the surface of specimen 20 being coated. That rotative motion tends to present toward source 50 at different times all sides of irregularities on the surface of specimen 20 being coated.

FIG. 4 shows in outline form a single specimen holder in three positions so as to further illustrate the motions obtained and the positions assumed. The structures and angular relationship between source 50 and specimen 20 and grip 22 is the same as that of the system shown in FIG. 3.

FIG. 4*a* is a view from the evaporative source 50 of the specimen at the start of a coating cycle. At this position, which is preferred as the starting position, specimen 20 is entirely turned away from source 50 and is therefore not positioned to receive substantial amounts of material from source 50. It is therefore feasible to start the evaporation process and allow release of low vapor pressure contaminants from the source as those released will not be directed toward the surface of the specimen 20 to be coated. For that reason, a shutter is not a necessary feature to minimize this initial contamination.

A point on the specimen labeled X for convenience is assumed to be at the top of the specimen at this starting position. Almost any point on the surface being coated would be as suitable for study as the one selected since the entire surface of specimen 20 is rotated under the emissive source 50, primarily by the action of shaft 24, and it is rotation of that nature which is of interest in the tracing of point X.

When conditions are suitable for coating the surface, motion is imparted to the gear 46 through the action of gear 54, which is driven by motor 48. Vertical shaft 34 is thereby rotated. FIG. 4*b* shows the position obtained when shaft 34 has rotated clockwise 90°. The rotation of shaft 34 includes a component of rotation which has an axis perpendicular to an imaginery line from source 50 to specimen 20. That rotative motion has tilted the entire surface of specimen 20 toward source 50. Simultaneously shaft 24 has rotated the specimen 20 relatively rapidly around an axis perpendicular to the surface being coated. One full revolution of that nature presents all sides of surface irregularities to source 50.

A ratio of about 5.1 to 1 exists between the diameter of crown gear 42 and that of pinion gear 32. Consequently, shaft 24 is driven by gear 42 at an angular velocity which is 5.1 times that of the angular velocity of shaft 34. That ratio yields a reasonably uniform coverage from all angles, but other ratios would be satisfactory and perhaps even better in certain instances. The non-integral relationship of the two parts of the ratio assures that the motions obtained are aperiodic. In fact, the motions obtained will not produce an exact duplication of a previous position until several revolutions of shaft 34 have occurred.

In FIG. 4*b*, shaft 34 has rotated 90° from the starting position. Shaft 24 has therefore been rotated by gear 42, an amount of 5.1 times 90 or 459°. That component of motion is the one of primary importance and interest in tracing the motion of specimen 20 around the axis perpendicular to its surface.

Shaft 34 is in a vertical position, and shaft 34 therefore inherently imparts a component of motion around the axis which is perpendicular to the surface of specimen 20. As seen by source 50, that component of motion is an oscillation around the vertical axis at an angle which appears to be somewhat larger than 45°. That motion can be traced by considering the high point of specimen 20 observed as shaft 34 is rotated clockwise through the three positions shown in FIGS. 4a, 4b, and 4c. FIG. 4b illustrates the position after a 90° turn of shaft 34. The high point of specimen 20 has moved clockwise to an angle somewhat greater than 45° with the vertical. In FIG. 4c, after a 180° turn of shaft 34, the high point of specimen 20 once again appears at the center.

As mentioned, the component of motion directly imparted by shaft 34 on an axis perpendicular to the surface of specimen 20, is inherent. The rotation around that axis is largely dominated by the much greater motion supplied by shaft 24. The corresponding component of rotation by shaft 34 will be mentioned and described only to a limited extent as is desirable to assure completeness. However, to the extent that it is an incident to the relatively continuous and slow exposure of the specimen obtained in accordance with the more preferred aspects of this invention, that component of rotation should not be considered umimportant.

Movement of the point X between the FIG. 4a position and the FIG. 4b position is a combination of all components of motion.

Rotation directly in response to shaft 24 is 5.1 times the 90° movement of shaft 34, which is 459°. The figure of 459° is representative, of course, of the fact that all points on the surface of specimen 20 have rotated one complete circle and are 99° into the second circle. The corresponding rotative motion imparted directly by shaft 34 is subtractive. The position of point X is therefore at an acute angle on the right above the horizontal, generally as illustrated in FIG. 4b.

FIG. 4c is the same view from source 50, this view being at the point when shaft 34 has rotated 180°. The surface being coated is then presented to source 50 at full face on a plane perpendicular to an imaginary line from source 50 to specimen 20. Shaft 24 has rotated 918° under the action of crown gear 42, and the component of rotation on that axis directly from shaft 34 is zero. Total rotation around the perpendicular axis is therefore also 918°. That is two full circles plus 198°. The position of the point X is at 198° as shown in FIG. 4c.

The total motion of particular significance can be described as being in two parts. One is a component of rotative motion around an axis perpendicular to a line from source 50 to specimen 20, which presents the surface of specimen 20 at all angles of incidence to emanations from source 50. At the same time the other is a rotation around the axis perpendicular to the surface being coated, which tends to present continually all sides of irregularities at all angles to emanations from source 50.

DISCUSSION AND CONCLUSION

It will be noted that grip 22 is positioned and rotated on an angle so that at one point the specimen held is on a plane which approximately passes through the center of evaporation source 50. The specimen positioned on that plane is the starting position as shown and discussed in connection with FIG. 4a. Such a configuration has the advantage of providing positions of the specimen from fully hidden to fully open positions with a minimum of hidden positions. In fact, theoretically, the only hidden position is the starting position. Rotation past that point presents the surface to source 50, and the change in angle of the surface presented is slow relative to the speed of rotation.

Of course, the face of the specimen to be coated may be mounted on structures designed to provide no components of rotation except one component on an axis perpendicular to the surface being coated and one component on an axis perpendicular to a line from source 50 to the specimen 20. In such a system, the rotation around the latter axis would hide the surface about half of the time. However, rarely are the rate of movement of the specimen or the amount of material which is deposited elsewhere than on the specimen, factors of great importance. Often, the specimen can simply be rotated repetitively until coating is complete. Alternatively, the speed of rotation around the parallel axis can be reduced.

It will be noted that shaft 34 and shaft 24, the two shafts imparting rotative motion, are each on an axis which passes through the center of specimens held by grip 22. If the specimen held is symmetrical, each axis will pass through the center of gravity of the specimen, and problems of momentum during operation will be minimized. Should an item be irregular, an alternative method of operation would be to conduct the rotation of shaft 34 intermittently. Rotation of shaft 34 is a relatively slow movement which need not be continuous. Rotation of shaft 24 could still be continuous or, of necessary, that component could be intermittent.

The mechanism can be stopped in any position if coating from a particular angle is desired for a special purpose.

In the preferred embodiment, the face of the specimen is presented at 90° to the source at one point in the coating cycle. At that point the approximate center of the surface being coated is on a plane perpendicular to a line from the source to the surface. Although similar results could be obtained from other configurations, the highest coating rate and more direct surface coverage does occur when that position is presented as part of the coating operation, since it presents the face of the specimen most directly for coating.

However, in accordance with the broader aspects of this invention, the axis around which the described rotations occur need not intersect the specimen being rotated. One or more of the axes can be displaced, and a largely complete coverage of the specimen will occur basically as previously described. However, problems in angular momentum in rotating on wide arcs will be apparent. Furthermore, such rotation tends to vary significantly the distance of the sample from the source, and it is generally important to maintain a nearly constant distance to realize a more uniform coating.

FIG. 5 is illustrative of the system in a preferred form in which a number of positioners identical to that discussed above are positioned in the same vapor deposition unit and operate simultaneously. Motor 48, through power gear 54 drives them all. (As previously mentioned, many alternatives are possible in the supplying of power, and no fundamental limitation is intended by the showing of the specific power mechanisms in the preferred embodiment.)

In an actual device, 6 positioners 70a–70f each capable of holding and positioning a specimen of, for example, one-eighth inch by one-half inch in area have functioned with excellent results in a single vacuum coating operation. All of the holders are supported by plate 44. All are driven simultaneously by motor 48 through large gear 54 (seen in dotted outline under plate 44).

In an exemplary embodiment, each holder is rotated at 5 rotations per second by shaft 34. Copper is deposited from source 50 for the required period ranging from fractions of seconds to seconds depending on thickness desired. Most metals, alloys of metals, and carbon are capable of evaporation by, for example, electron beam evaporation or sputtering techniques. Generally the motor must be capable of operating in a vacuum of at least 10^{-4} torr. Examples of materials coated are: aluminum, copper, silicon, silicon dioxide, uranium, platinum, copper and gold-palladium alloy. Deposition of silicon and silicon dioxide and conductive metals is significant for the manufacture of solid state circuits.

It will be apparent from the nature of the invention and the above teachings that the broader aspects of the invention herein described are not limited by the specifics of the structure shown. Consequently, reference should be made to the following claims, properly interpreted according to law, for the limits of the coverage sought.

What is claimed is:

1. A vapor deposition apparatus comprising in combination:

a vapor source;

a laterally extending, fixed means vertically spaced from, and on an axis common with said source;

at least one specimen support assembly disposed on a peripheral portion of said fixed means and in facing relationship with said source;

said support assembly having a body portion rotatably mounted on a vertically disposed shaft supported on said fixed means;

said rotatable body including means supporting a rotatable shaft extending therethrough at an inclination to said shaft and towards said source;

a specimen holder means fixed at its center, to the upper and inwardly directed end of said inclined shaft and in a plane normal to said inclined shaft;

said shafts, body and holder being so structurally related that the center of said specimen holder and specimen coincides with the extended axis of said vertically disposed shaft;

a stationary gear means concentric with said vertically disposed shaft;

a second gear means fixed to the outer end of said inclined shaft and in operative association with said stationary gear means;

means to rotate said vertical shaft whereby (1) said body is rotated about the vertical shaft; (2) said second gear means is carried about said stationary gear means; (3) said specimen is rotated about its own axis while nutating with respect to said extended axis; and

whereby a uniform deposition is effected upon said nutating specimen as it is carried progressively through positions wherein the specimen surface lies in a plane normal to a vapor stream emanating from said source and in a plane parallel to said stream.

2. The combination of claim 1 comprising a plurality of said specimen support assemblies and drive means therewith disposed at peripheral portions of said laterally extending fixed means.

3. The combination of claim 2 wherein said plurality of specimen support assemblies are driven by the same power source.

4. The combination of claim 1 wherein said means to rotate around said inclined shaft provides a rotation of at least twice the angular velocity of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

5. The combination of claim 4 wherein said means to rotate around said vertical shaft provides a rotation of at least 90°.

6. The combination of claim 5 wherein said means to rotate around said inclined shaft provides a rotation of at least four times the angular velocity of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

7. The combination of claim 6 wherein said means to rotate around said inclined shaft provides a rotation of angular velocity which is a non-integral multiple of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

8. The combination of claim 1 wherein said source comprises an evaporable material for vacuum deposition.

9. The combination of claim 8 wherein said means to rotate around said inclined shaft provides a rotation of at least twice the angular velocity of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

10. The combination of claim 9 wherein said means to rotate around said inclined shaft provides a rotation of angular velocity which is a non-integral multiple of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

11. The combination of claim 9 wherein said means to rotate around said vertical shaft provides a rotation of at least 90°.

12. The combination of claim 11 wherein said means to rotate around said inclined shaft provides a rotation of angular velocity which is a non-integral multiple of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

13. The combination of claim 11 wherein said means to rotate around said inclined shaft provides a rotation of at least four times the angular velocity of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

14. The combination of claim 13 wherein said means to rotate around said inclined shaft provides a rotation of angular velocity which is a non-integral multiple of the angular velocity of the rotation provided by said means to rotate around said vertical shaft.

15. The combination of claim 14 wherein a driving means power said means to rotate said vertical shaft and the changes of position of said support assembly around said vertical shaft are transmitted by a stationary ring gear linked through said second gear means to said inclined shaft to move said specimen around said extended axis.

16. The combination of claim 14 wherein said ring gear is a crown gear.

17. The combination of claim 14 wherein said second gear means is a pinion gear.

18. The combination of claim 2 wherein said vapor source is the common source for the plurality of said specimens.

19. The combination of claim 6 including a plurality of said specimen support assemblies and drive means therewith disposed at peripheral portions of said laterally extending fixed means and said vapor source is the common source for the plurality of said specimens.

20. The combination of claim 8 including a plurality of said specimen support assemblies and drive means therewith disposed at peripheral portions of said laterally extending fixed means and said vapor source is the common source for the plurality of said specimens.

21. The combination of claim 13 including a plurality of said specimen support assemblies and drive means therewith disposed at peripheral portions of said laterally extending fixed means and said vapor source is the common source for the plurality of said specimens.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,656,453 Dated April 18, 1972

Inventor(s) Anastasios J. Tousimis

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

1. On Title Page, Assignee: "Brodynamics" should read --Biodynamics--.

Signed and sealed this 17th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
★ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334