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APPARATUS FOR VACUUM COATING

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2 Sheets-Sheet 1

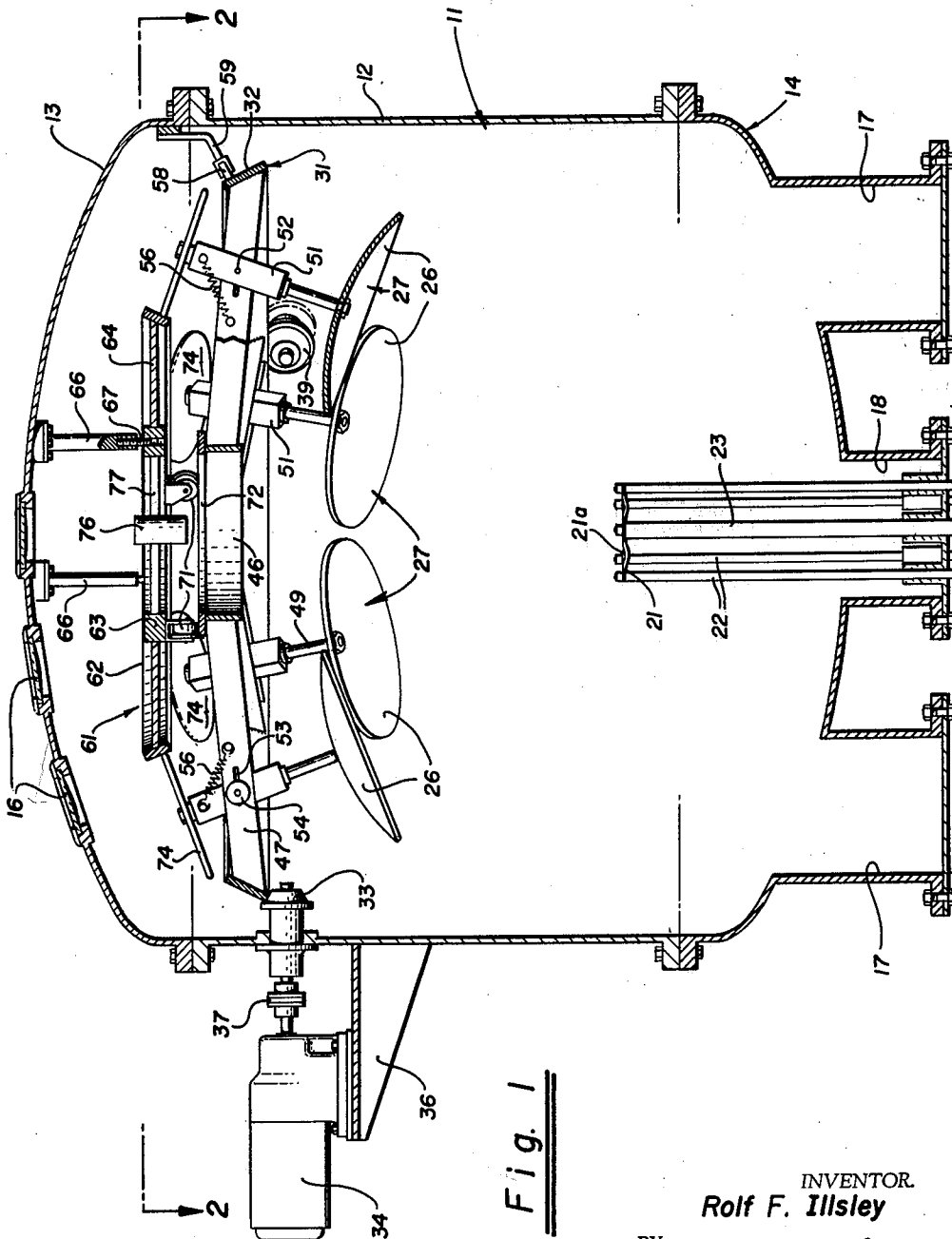


Fig. 1

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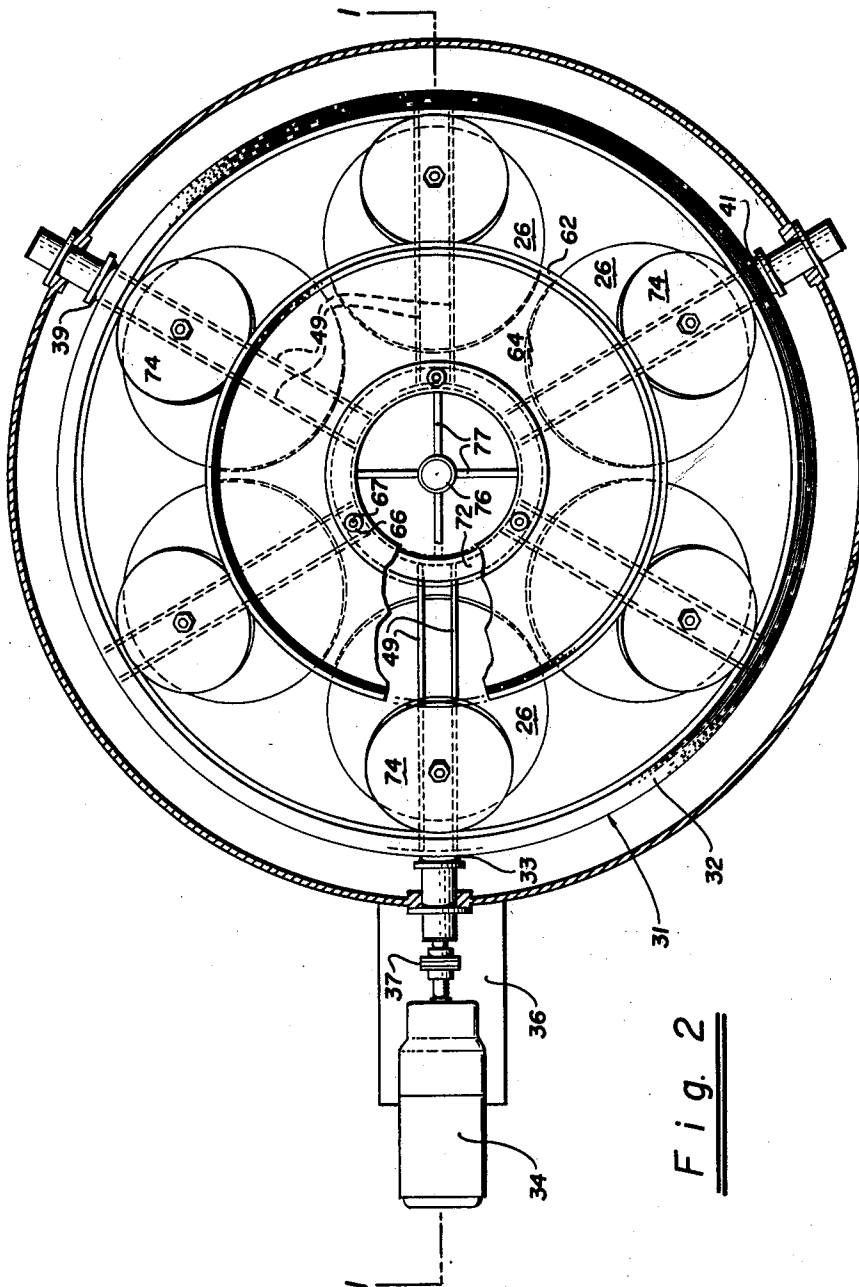


Fig. 2

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1

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APPARATUS FOR VACUUM COATING

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4 Claims. (Cl. 118—49)

This invention relates to an apparatus for vacuum coating and more particularly to an apparatus for vacuum coating having high capacity.

In vacuum apparatus heretofore provided for thermal evaporation, it has been a common practice to place the evaporating boat containing the material to be evaporated at a particular location in the vacuum chamber and then to place the substrates which are to be coated in stationary parabolic racks overlying the source material so that as the source material is heated in a suitable manner such as by resistance heating, induction heating or electron bombardment, the evaporating material passes in straight lines from the source to the stationary parabolic racks to apply a uniform coating to the substrates contained in the racks. Such apparatus has severe limitations. For example, if it is desired to use several evaporating boats so that different materials can be utilized for the coatings, it is impossible to place all these sources in the same position so as to obtain uniformity in the coating as the material is evaporated. For that reason, there has been developed vacuum apparatus for vacuum coating in which the evaporating boats containing the source material are mounted on one side of the vacuum chamber in the form of a ring of evaporating boats or in a ring extending around the chamber. Means is then provided in the chamber for rotating the parabolic rack to obtain uniformity in the coating. However, such an arrangement also has disadvantages in that only a very small amount of the material being evaporated is actually used for deposition upon the substrates carried by the parabolic rack. A much larger proportion is wasted on the wall of the vacuum chamber. Also, in such apparatus, there is a tendency for the boats or sources to become distorted during heating. This distortion of the sources may vary the ratio of the coating on the substrates on the rack to the coating on a monitor plate disposed within the vacuum chamber. If the source should for any reason tip towards or away from the rack, the substrates carried by the rack will be coated too lightly or too heavily for a given coating on the monitor plate. In addition, such apparatus has the disadvantage of limited production. There is, therefore, a need for a new and improved apparatus and method for the vacuum deposition of coatings on substrates.

In general, it is an object of the present invention to provide an apparatus for vacuum coating which overcomes the above named disadvantages.

Another object of the invention is to provide an apparatus for vacuum coating in which a substantial portion of the source material being evaporated is deposited on the substrates being coated.

Another object of the invention is to provide an apparatus for vacuum coating in which tipping of the boats carrying the source material or distortion of the boats does not appreciably effect the ratio of the coating on the substrates with respect to the coating on the monitor plate.

Another object of the invention is to provide an apparatus for vacuum coating of the above character in which the evaporating boats are centrally located within the vacuum chamber.

Another object of the invention is to provide an apparatus for vacuum coating of the above character in which several racks are provided and are rotated about

2

their own axes while they are rotated around the centrally located sources.

Another object of the invention is to provide an apparatus of the above character which provides a very large number of coated parts in comparison to the vacuum area required.

Another object of the invention is to provide an apparatus of the above character in which it is possible to obtain a very high degree of uniformity for many pieces of substrate.

Another object of the invention is to provide an apparatus of the above character in which a relatively short coating distance is provided for a large area and for many pieces of substrate.

Another object of the invention is to provide an apparatus of the above character in which there are no high angles of incidence for the vapor stream.

Another object of the invention is to provide an apparatus of the above character in which it is possible to provide an excellent position for the thickness control without interfering with the substrate arrangement.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment is set forth in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is a side elevational view in cross-section taken along the line 1—1 of FIGURE 2 of an apparatus for vacuum coating incorporating my invention.

FIGURE 2 is a top plan view in cross-section taken along the line 2—2 of FIGURE 1.

In general, my apparatus for applying a coating of a thermally evaporable material to a substrate consists of a vacuum chamber in which is mounted in a fixed predetermined position at least one source of evaporable material. It also includes a plurality of racks which are provided for carrying the substrates. Means is provided for rotating the racks about the source, while at the same time rotating the individual racks. The racks are positioned in such a manner that the surfaces of the substrates to be coated face towards the fixed predetermined position of the source from which the material is being evaporated.

As shown in the drawing, my apparatus for vacuum coating consists of a vacuum chamber 11 of conventional design. It consists of an intermediate cylindrical portion 12, a top cover or lid 13, and a bottom cover or lid 14. The top lid 13 is provided with a plurality of viewing apertures 16 and the bottom lid 14 is provided with a plurality of outlets 17 disposed adjacent the outer wall of the chamber and a centrally positioned outlet 18.

Means (not shown) is provided for placing the chamber under a vacuum and can take the conventional form of mechanical and diffusion pumps connected through the outlets (not shown) to pump air from the chamber 11. Outlets 17 are provided for additional electrical feed through connections. For example, they can be used for installing terminals for substrate heaters and high voltage glow discharge circuits.

Means is provided within the chamber for mounting a plurality of sources of thermally evaporable material and consists of a plurality of elongate boats or holders 21 which have their ends mounted between a plurality of circumferentially spaced conducting rods 22 and a central conducting rod 23. The holders 21 can be formed of any suitable conducting material and are each provided with a cavity or recess 21a which is adapted to receive the evaporable material. Means (not shown) is provided for supplying electrical current to the rods 22 and 23 selectively and independently so that the boats can be heated in any desired order for the purpose of initially fusing the

material carried by the boat and then subsequent vaporization of the material.

As will be noted, the sources are mounted in a predetermined position within the vacuum chamber 11 and, as shown, are generally centrally positioned in alignment with the vertical axis of the cylindrical section 12 of the vacuum chamber and lie in a plane generally perpendicular to the vertical axis of the section 12 in the lower portion of the section 12.

A plurality of dish-shaped racks 26 are provided within the chamber. The dish-shaped racks are of a conventional construction and are adapted to carry a plurality of the objects to be coated which normally are called substrates. As is well known to those skilled in the art, such racks are normally dish-shaped or, in other words, parabolic or spherical in form to obtain optimum and uniform coating of the exposed surfaces of the substrates carried by the racks.

Means is mounted within the vacuum chamber for rotating the racks about the centrally disposed sources, while at the same time rotating the individual racks about their own axes. Such means consists of a large circular horizontal wheel 31 disposed in a plane which is generally perpendicular to the vertical axis of the chamber. Wheel 31 is provided with an outer rim 32 which inclines outwardly and downwardly and which rests upon a beveled friction drive member 33. The friction drive member 33 is rotatably mounted in the side wall of the vacuum chamber 11 in sealed relation with respect thereto and is driven by a gear motor 34 carried by a bracket 36 fixed to the side wall of the chamber. A coupling 37 connects the gear motor to the tapered drive member 33. Two additional tapered support rollers 39 and 41 are rotatably mounted within the vacuum chamber and serve in conjunction with the drive member 33 to provide a three-point support for the rim 32 of the wheel 31.

The wheel 31 also includes a central hub 46 which is connected to the rim 32 by spaced pairs of radially extending ribs 47. The racks 26 are fixed to spindles 49 which are rotatably mounted in spindle housings 51. The spindle housings 51 are provided with pivot pins 52 which are mounted in slots 53 in the ribs 47 and which extend longitudinally of the ribs. The outer ends of the pins are threaded and are provided with knobs 54 so that the pins can be fixed in a predetermined position in the slots 53. Springs 56 connecting the upper ends of the housing to the ribs 47 are provided for a purpose hereinafter described. From the construction so far described, it is apparent that as the gear motor 34 is operated, the wheel 32 carrying the racks 26 will be rotated about the centrally located sources.

Means is also provided for rotating the racks about their own axes while they are being rotated about the sources and consists of a second horizontal wheel 61 which is provided with a rim 62 which tapers downwardly and inwardly. This rim is fixed to a centrally located hub 63 by a radially extending web 64. The wheel 61 is held in fixed position by a plurality of posts 66 which are fixed to the top lid 13 of the vacuum chamber and which are fixed to the hub 63 by pins 67.

Means is provided for maintaining a predetermined spaced relationship between the first and second wheels and consists of a plurality of casters 71 which are fixed to the hub 63 of the wheel 61 and which ride upon a flange 72 provided on the hub 46 of the wheel 31.

Means is provided for driving the spindle 49 from the second wheel and consists of a plurality of discs 74 which are fixed to the spindles 49 and which frictionally engage the outer surface of the rim 62 of the wheel 61. The springs 56 are provided for the purpose of yieldably maintaining the disc 74 in continuous frictional engagement with the wheel 61.

Guide rollers 58 are provided for engaging the outer surface of the rim 32 provided for the purpose of retaining the rim in the proper relationship with respect to the

vacuum chamber and also with respect to the driving member 33. The guide rollers are held in the desired position by brackets 59 fixed to the side wall of the chamber.

A control plate changer 76 of conventional construction is mounted upon the wheel 61 and is supported upon the hub 63 by framework 77. Alternatively the changer 76 can be fixed to the lid 13. The changer is positioned in such a manner that it is in alignment with the vertical axis of the chamber and so that it generally overlies the sources. As is well known to those skilled in the art, this control changer is of a type which can be controlled externally and which can be utilized for measuring the thickness of the layers being deposited upon the substrates.

Operation and use of the apparatus for vacuum coating may now be briefly described as follows: Let it be assumed that the substrates 27 have been loaded into the racks 26 in the conventional manner and that the racks have been mounted on the spindles 49. Let it also be assumed that the chamber has been drawn down to the desired vacuum and that the gear motor 34 has been placed in operation. Operation of the gear motor 34 causes rotation of the drive member 33 which, in turn, causes rotation of the wheel 31 about the vertical axis in a clockwise or counter-clockwise direction depending upon the direction of rotation of the drive member 33 to carry the racks 26 in a circular path around the centrally disposed sources of evaporable material. At the same time this is occurring, the discs 74 engage the stationary wheel 61 to cause rotation of the individual racks in a clockwise or counter-clockwise direction depending upon the direction of rotation of the wheel 31. If the wheel 31 is rotating in clockwise direction, the racks 26 will be individually rotated in the same direction about their own axes.

The first layer of the coating to be applied to the substrates can then be applied by applying heat to one of the holders 21 to evaporate the material therein so that it forms a vapor stream which travels upwardly into uniform contact with the substrates carried by the racks 26. At the same time the vapor stream will pass onto the lowermost plate carried by the control plate changer 76. During the time that the evaporation is occurring, the racks are being rotated about the centrally located source and at the same time are being individually rotated so as to maintain a high degree of uniformity of deposition of the material on the substrates. The material from the boat can travel in a straight path upwardly towards the substrates in all directions with no high angles of incidence so that very little of the material is wasted.

As is well known to those skilled in the art, there are two basic laws of physics which govern the thickness of a coating layer on any portion of a substrate. The first law is called the "inverse square" law which states that the thickness of the coating deposited is inversely proportional to the square of the distance from the source to the substrate. The second law is called the "cosine" law which states that the thickness of the coating deposited is proportional to the cosine of the angle of which the matter impinges on the surface.

The arrangement shown in particularly advantageous in that it permits the coating of a large number of substrates, while at the same time retaining a relatively short coating distance. As is well known to those skilled in the art, the coating distance is a very important factor in evaporation. If the coating distance is too great, a soft coating is obtained. By utilizing this manner of rotation, the same angle of incidence is retained as with a single rack being rotated within a vacuum chamber. In addition, the number of parts in relation to the total area evacuated is very favorable because the chamber itself is relatively flat, that is, has a relatively large diameter in comparison to its height so that it can accommodate a large number of racks as, for example, eight racks shown

having relatively large diameters. The arrangement also has an advantage in that it is possible to place the control plate changer at an optimum position so that it is possible to obtain a very accurate and precise control over the coating being deposited on the substrates in the racks. There are no high incidence angles for the vapor stream. The position of the thickness control 76 in no way interferes with the arrangement of the racks or the substrates in the racks.

In addition to the foregoing reasons, the double rotation of the rack explained above is advantageous in that if the source should distort slightly during heating or if the source should tip towards or away from the rack, the substrates will not be coated too heavily in one place and too lightly in another place because of the double rotation. It is true that such distortion or tipping of the sources can cause too heavy a coating or too light a coating, however, this will occur for only a very short period of time on any one of the substrates because of the double rotation of the substrates so that the net result is an averaging of the too heavy coating and too light coating so that the end result is very close to the end coating which is received by the monitor plate. Because of this fact the ratio of the coating on the substrates relative to the coating on the monitor plate does not vary appreciably. Because of this averaging out of the coatings, I have found it possible to achieve coating thicknesses with much greater accuracy than has heretofore been possible. Also because of this averaging-out feature, it is possible to position the boats slightly off center in the machine and still achieve the same highly accurate results as if the boats were exactly in the center. This makes it possible to rigidly position several sources in a ring around the center as shown in the drawings and still achieve optimum results. This eliminates the necessity of moving the sources into the exact center of the vacuum chamber and providing movable electrical contacts for these sources.

With the arrangement shown, I have found that it is possible to continually expose the substrates and the racks to a vapor stream from the sources. As is well known to those skilled in the art this makes it possible to achieve better packing of the coating which in turn gives greater durability to the coating. Also, I found that it is possible to more precisely control the thickness of the individual layers of the coatings because with my method and apparatus, the ratio of the monitor plate thickness to the substrate layer thickness is substantially 1:1.

The spindle housings 51 are mounted in the ribs 47 in such a manner that the spindles can be tilted so as to position the individual racks in the chamber so as to obtain optimum uniformity in the coating.

A friction drive has been utilized to minimize the use of bearings and to reduce the motion in the vacuum chamber to the minimum required.

It is apparent from the foregoing that I have provided a new and improved apparatus for vacuum coating. In fact, I have provided a planetary type of arrangement in which the racks carrying the substrates are rotated about the source and also are rotated individually about their own axes. The construction of the apparatus is such that it is simple and economical to manufacture and is relatively trouble-free.

I claim:

1. In apparatus for applying a coating of thermally evaporable material to a plurality of substrates, a vacu-

um chamber, means for mounting a plurality of sources in a fixed predetermined position within the chamber so that the sources are substantially coincident with the vertical axis of the chamber, a wheel structure rotatably mounted in the chamber and having its axis of rotation in substantial alignment with the vertical axis of the chamber, a plurality of spindles, means for mounting said spindles on said wheel structure so that said spindles are spaced from the center of the wheel structure and so that the spindles can be rotated on their axes and pivoted at right angles to their axes, a rack mounted on each of the spindles, each of the racks carrying a plurality of substrates, a stationary member mounted in the chamber, means mounted on the spindles and engaging the stationary member independent of the angular positions of the spindles for rotating the spindles about their axes as the wheel structure is rotated, and means for rotating the wheel structure to rotate the racks about the sources.

2. In apparatus for applying a coating of thermally evaporable material to a plurality of substrates, a vacuum chamber, means for mounting a plurality of sources in a fixed predetermined position within the chamber so that the sources are substantially coincident with the vertical axis of the chamber, a wheel structure rotatably mounted in the chamber and having its axis of rotation in substantial alignment with the vertical axis of the chamber, a plurality of spindle housings, means for mounting the spindle housings on the wheel structure so that they are spaced from the axis of rotation of the wheel structure and are pivotally mounted about horizontal axes, a spindle rotatably mounted in each of the spindle housings and having an axis of rotation at right angles to the axis of pivotal movement for the spindle housing, a dish-shaped rack mounted on each of the spindles, a plurality of substrates carried by the rack, a stationary wheel-like member mounted in the chamber, a disc-like member mounted on each of the spindles, means connected between the spindle housings and the wheel structure and yieldably urging the spindle housings in a direction so that disc-like members are urged into frictional engagement with the wheel-like member and means for rotating the wheel structure whereby said reels are rotated about said sources and are simultaneously rotated about their own axes.

3. Apparatus as in claim 2 wherein said wheel-like member has a rim which is inclined from the horizontal and wherein said disc-like members frictionally engage said rim.

4. Apparatus as in claim 2 wherein the wheel structure is provided with radially extending ribs, said ribs having slots therein extending substantially longitudinally of the ribs and wherein the means for mounting the spindle housings on the wheel structures includes pins secured to the spindle housings and extending through the slots in the ribs and means for securing the pins in a predetermined position in the slots.

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