

**June 13, 1944.**

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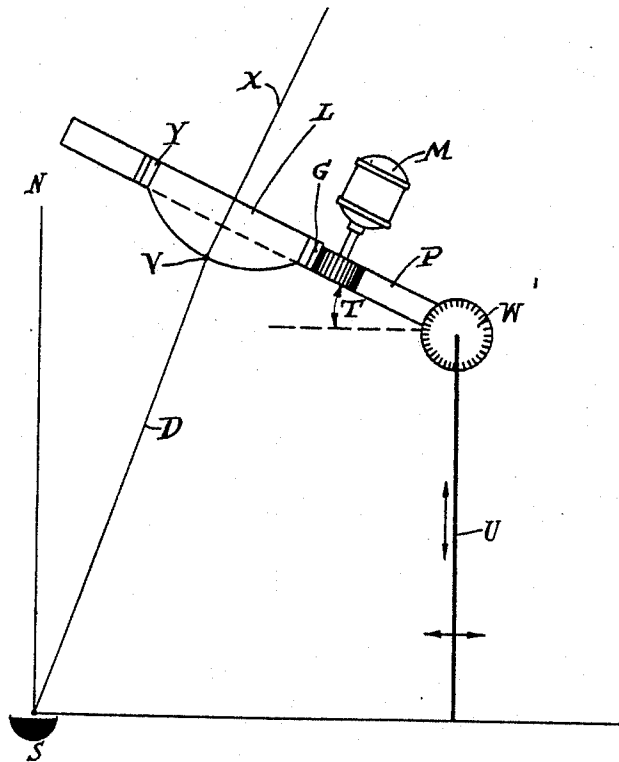
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# APPARATUS FOR TREATING SURFACES

Filed March 5, 1942

**4 Sheets-Sheet 1**

Fig. 1.



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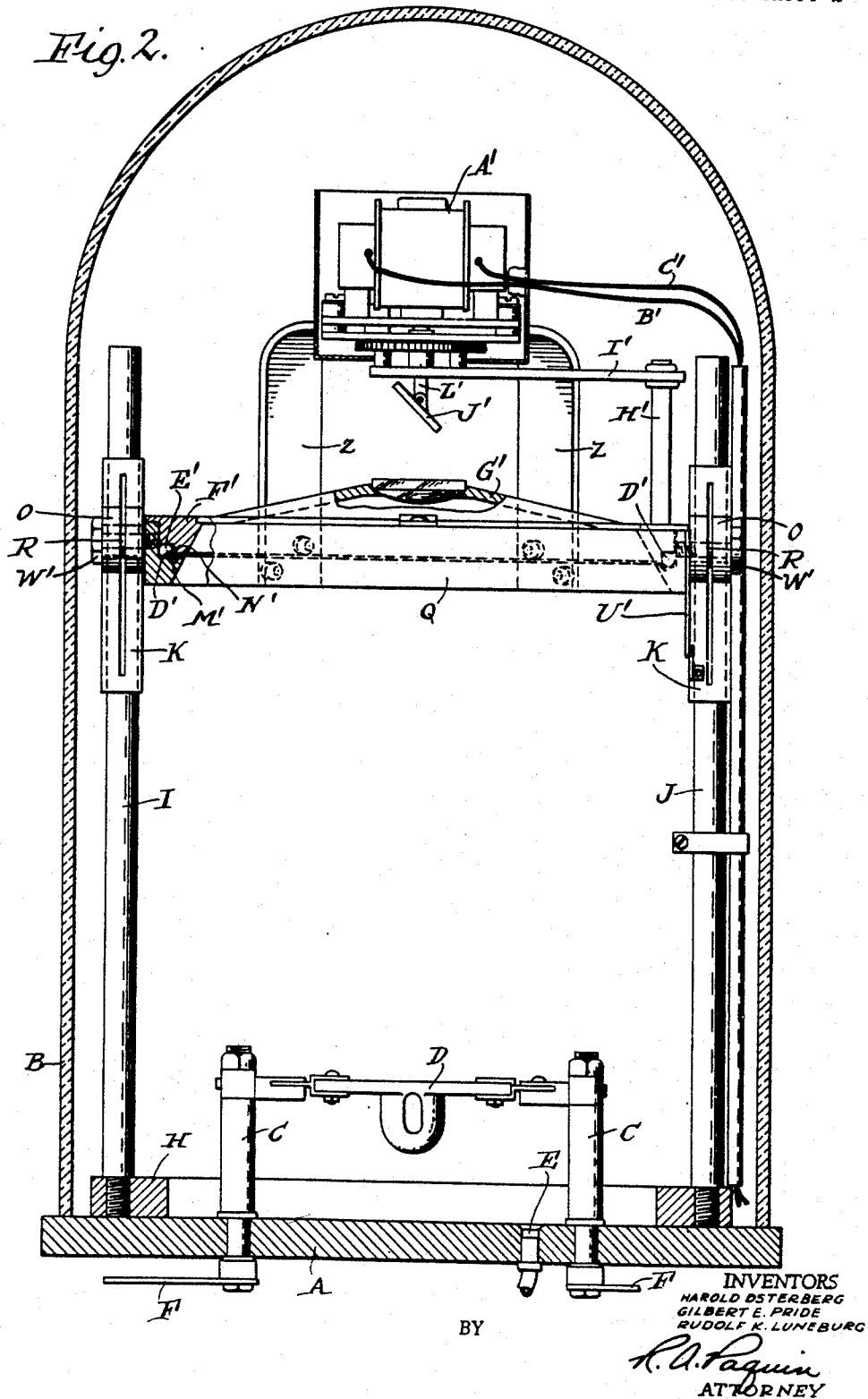
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Fig. 2.



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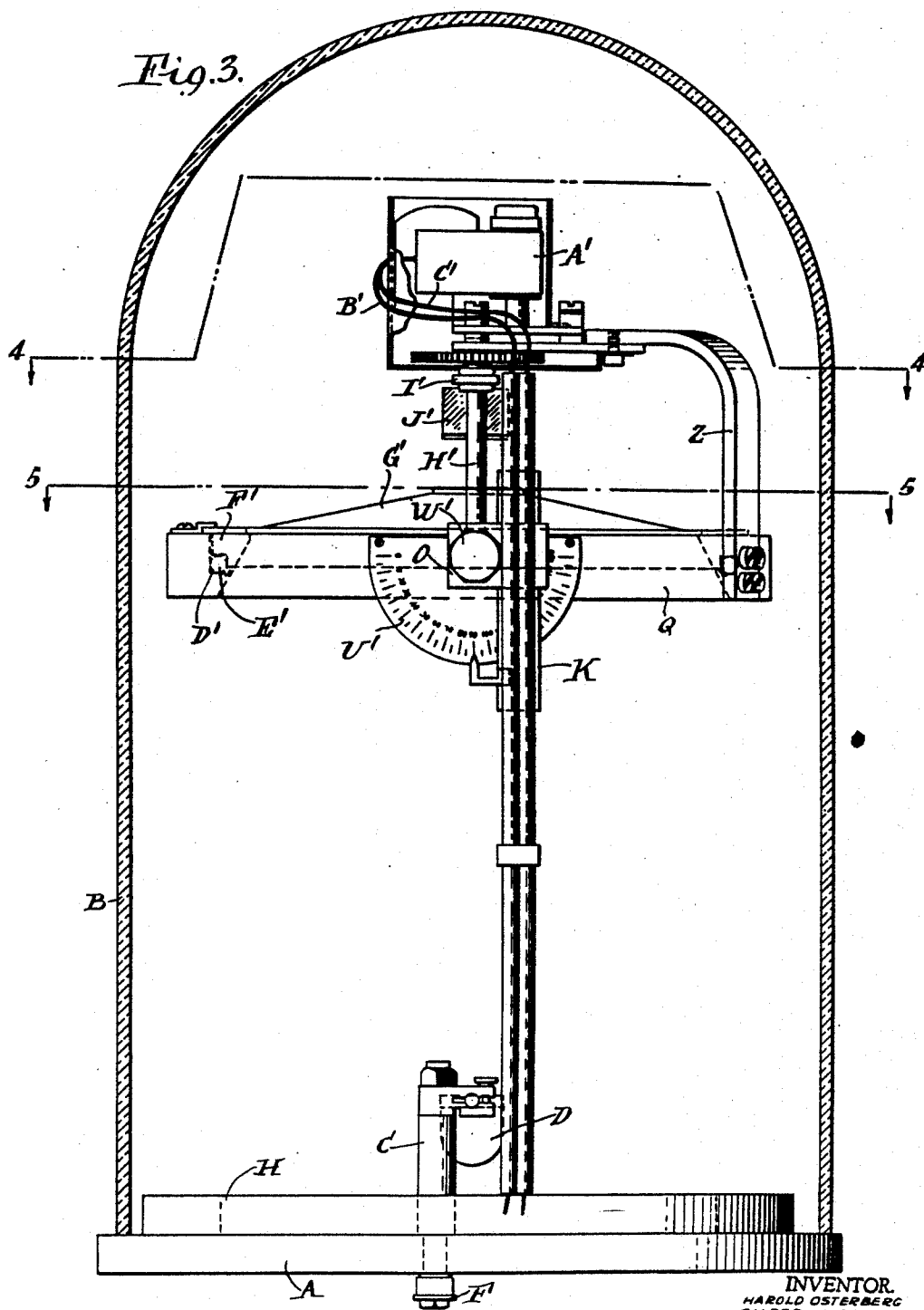
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Filed March 5, 1942

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Fig. 3.



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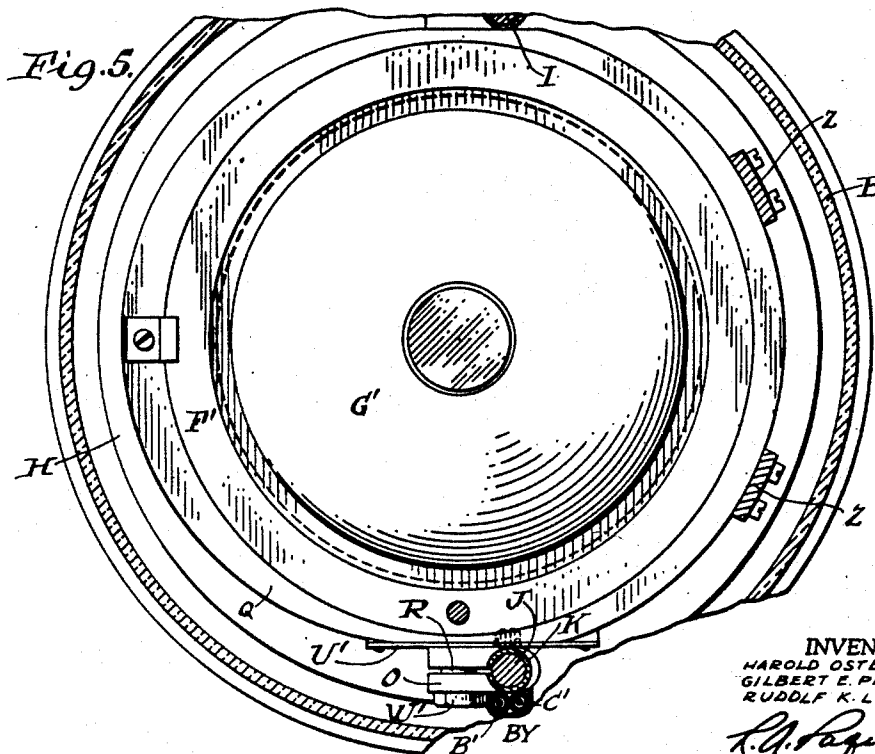
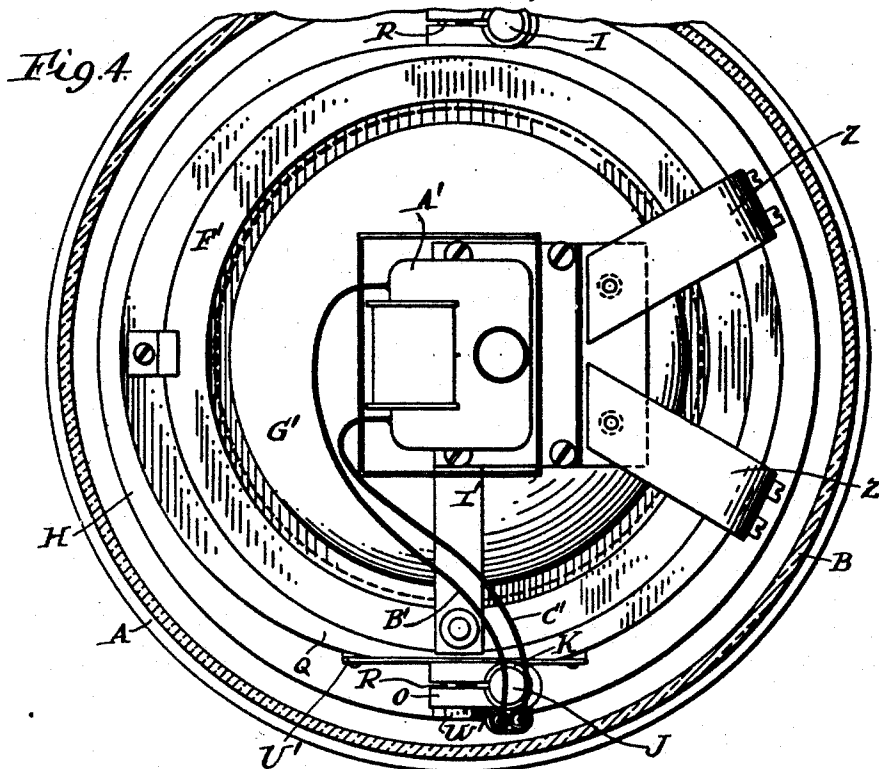
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Filed March 5, 1942

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## UNITED STATES PATENT OFFICE

2,351,537

## APPARATUS FOR TREATING SURFACES

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Application March 5, 1942, Serial No. 433,422

7 Claims. (Cl. 91—12.2)

This invention relates to a new and improved apparatus for treating the surfaces of articles and relates particularly to apparatus for the treating or coating of the surface of a light transmitting article to substantially eliminate the reflection of light from such surface or to change the contour of the surface and thereby alter the light transmitting and/or light refracting properties of the article.

This application is a continuation in part of our application filed April 25, 1941, Serial No. 390,428.

An object of the invention is the provision of an apparatus for treating or coating a surface of an article with which the amount and distribution of the coating may be definitely controlled.

Another object of the invention is to provide a new and improved apparatus for coating the surface of an article whereby the amount and distribution of the coating may be definitely controlled to provide a uniform coating over the entire surface regardless of whether the surface to be coated is flat, plano, spherical, or of other contour.

Another object of the invention is the provision of an apparatus for coating the surface of an article with which there may be obtained a controlled variation in the thickness of the coating at will over the surface.

Another object of the invention is the provision of an apparatus for coating the surface of an article which allows the coating of larger surfaces than has previously been possible.

Another object of the invention is the provision of a new and improved method and apparatus for coating steeply curved surfaces, particularly spherical.

Another object of the invention is to provide an apparatus for coating a surface of an article which apparatus will accommodate a greater variety in the contour of the surfaces to be coated without the employment of any auxiliary apparatus.

Another object of the invention is the provision of a new and improved apparatus for coating a surface of an article whereby the amount and distribution of the coating may be definitely controlled and wherein the coating material used may be such as to alter the contour of the article to vary the light transmitting or refracting properties thereof. For example, transforming a spherical to an aspherical surface.

Another object of the invention is to provide a new and improved apparatus for altering the surface of one or more lens elements of a lens

system to vary the light transmitting or refracting properties of the lens system.

Another object of the invention is to provide an apparatus of the type set forth which is simple, efficient, convenient and economical in construction and operation.

Other objects and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings. It will be understood that many changes may be made in the details of construction and arrangement of parts without departing from the scope of the invention as set forth in the accompanying claims. We therefore, do not wish to be limited to the exact details of construction and arrangement of parts shown and described as the preferred form has been shown by way of illustration only.

Referring to the drawings:

Fig. 1 is a diagrammatic view of an apparatus embodying the invention.

Fig. 2 is a side view partially in section of an apparatus embodying the invention.

Fig. 3 is a view similar to Fig. 2 but looking at a different side of the apparatus.

Fig. 4 is a view taken on line 4—4 of Fig. 3 looking in the direction of the arrows, and:

Fig. 5 is a view taken on line 5—5 of Fig. 3 looking in the direction of the arrows.

The usual method and apparatus for coating a surface of an article by evaporation from a source has consisted in placing the article having the surface to be coated in a vacuum chamber with the article supported above the source with the center of the plate or article on a line normal to the source and with the plane of the article approximately perpendicular to the normal to the source. It is well known that with an apparatus of this type that the center of the article will receive a thicker deposit of the evaporated material than will be received by the outer zones of the article.

In the past attempts have been made to overcome the known non-uniformity of the deposit on the article as set forth above. One of these methods and apparatus involved the use of several sources of material to be evaporated with the sources disposed so as to give approximately uniform deposits. One of the difficulties with this arrangement was that it required many sources of material to be evaporated and also required that the distribution of such sources be varied from one set-up to another. Another arrangement which has been employed has been to interpose rotating sectors between the source of the

material to be evaporated and the surface to be coated in such a manner as to increase the relative deposit at the outer edges of the surface to be coated. While this gave good control for an article having a plane surface, it does not permit the use of one sector for several set-ups where the contours of the surfaces to be coated are different. It involved laborious calculation to determine the proper sector deviation and also slows down the rate of coating and is hardly applicable to convex spherical surfaces of small radii of curvature.

By employing the apparatus of this invention as set forth herein, the amount and distribution of the coating or deposit of the evaporated material may be definitely controlled.

The method and apparatus herein disclosed have varied uses and by employing different coating materials, may be used for many purposes. An example of the use of this apparatus is for coating reflectors or the like with a reflective metallic coating of aluminum or other reflective metals to form a mirror reflector or partial reflector. Another example of the use of this apparatus is where the coating material is a metallic fluoride or the like or other suitable material for forming nonreflective coating on the surface of prisms, lenses, windows or other light transmitting articles.

Another important advantage of this method and apparatus is that it allows lenses or other light transmitting articles to have molecules deposited on the surface thereof so as to change the contour and curvature of the surface of said lens or article. For example, by properly controlling the amount and distribution of this coating or deposit a spherical lens surface may be transformed into an aspheric surface.

The use of the apparatus of this invention also allows the obtaining of a substantially uniform coating over the entire surface to be coated or a coating which is thicker at the edge than at the center or a coating which is thinner at the edge than at the center or other controlled distribution of the coating material and will permit definite control of the distribution from one extreme to the other over any part or of all of the surface to be coated.

The apparatus of this invention allows the coating of surfaces of larger articles than has been possible with prior apparatus and also allows of its adaptation from one set-up to another with only minor adjustments.

Referring more particularly to the drawings wherein similar reference characters designate corresponding parts throughout the several views:

It is well known that in accordance with the cosine law of distribution, that when molecules of the coating substance are evaporated from a source, the greatest intensity of the molecules emitted occurs along the normal to the surface of the source and falls off as a cosine of the angle of emission from said normal.

In our application, Serial Number 390,428, referred to above, we have shown and described arrangements for obtaining a coating of a desired thickness and distribution on the surface of an article. In said prior application we described a method of pivotally mounting the article, the surface of which is to be coated, about an axis which is varied from the normal to the source to obtain the desired control in the coating or deposit on the surface to be coated and also that if this axis is properly chosen that the coating on the surface of the plate may be controlled to give

a coating of desired uniformity of distribution over the surface of the article.

In said prior application we also described a means and formula for determining and computing the best angle at which to place the axis of rotation of the article.

In Fig. 1 there is shown diagrammatically one form of apparatus for carrying out this invention. In this view N is the normal to the source S, U is an upright adapted to support the parts hereinafter described. It will be noted that as shown by the arrows the upright U is adjustable both vertically and horizontally to alter the position of the parts as necessary.

In this view there is further shown at the upper end of the upright U a pivot W having a protractor or angle scale to allow the support P to be set at any desired angular relation T with reference to said upright U such as the angle T as shown in the drawings.

On the support P is mounted the plate holder Y on which is mounted the plate L and the motor M and gear G are provided for rotating said plate holder Y and thereby causing rotation of the plate L during the coating process. The support P is also so connected with the upper end of the upright U as to allow its being tilted or adjusted in two planes at right angles to each other, that is, it is practically a universal connection.

The plate L has been shown and described in connection with Fig. 1 as a single plate but it will be understood that this might instead consist of a plurality of elements secured in a plate holder and that such elements may be spherical or plane or of any desired contour, as described in connection with the forms of the invention shown in the other figures of the drawings.

In the forms of the invention shown in Figs. 2 to 5 inclusive the apparatus is shown enclosed in an evaporated chamber such as a bell jar, but it is pointed out that either the form of the invention shown diagrammatically in Fig. 1 or the embodiment of the invention shown in the other figures may or may not be placed in an evacuated chamber depending on the coating material to be applied, and if the apparatus is placed in an evaporating chamber the adjustable upright U shown in Fig. 1 may assume the form of a bellows or other forms that can be adjusted from within or without the evacuated chamber. Also the motor M may be placed in the vacuum and operated entirely therein or may be magnetically operated by means of auxiliary magnets from without.

Referring again to the embodiment of the invention shown in Figs. 2 to 5 inclusive, the device shown comprises a base A on which is positioned the bell jar or the like B to form an evacuated chamber. Extending through the base A are the electrodes C which may be of any desired number and the crucible D is provided, which is connected at its opposite ends to one of the said electrodes C.

Through the base A is provided the opening E which may be connected with a vacuum pump to provide a vacuum in the vacuum chamber. The leads F are provided from each of the electrodes to its respective current supply.

On the base or support A is provided the annular frame member H to which are supported the uprights I and J, preferably at diametrically opposed points, although this location of said uprights is not essential.

Slidably mounted on each of said uprights I and J are located the sliding members K. These sliding members K are slit for resiliency and each

have the offset portion O for supporting the annular member Q which has the projecting portions R adapted to entering openings through the offset members O and said projecting portions R being adapted to receive the screws or the like W' to retain said parts in assembled relation and by tightening said screw members W' the slit members O are tightened to retain the sliding members K at the desired point on the uprights I and J and also the annular member Q may be pivoted or rotated to position the lenses or the like in desired angular relation with the source of material to be evaporated from the crucible D.

On said annular member Q are secured the two supporting brackets Z adapted to support the motor A' in operative position and current for the motor A' is furnished through the leads B' and C' which may be enclosed in separate glass tubes which are secured to one of the uprights I and J and which are secured at their lower ends to a pair of the electrodes C.

On the annular member Q is the ball race D' containing the ball bearings E' and on which is the rotatably positioned annular member F' which is adapted to support a plate or the like G' which is adapted to contain the lenses or other articles of which the surfaces are to be coated with the surfaces of said articles to be coated facing the crucible D.

The annular member F' which is adapted to rotate on the ball bearings E' has secured thereto adjacent the periphery thereof the member H' which is connected to the lever I' adjacent the outer end of the said lever I' and the said lever I' is secured adjacent its other end to the motor A' whereby rotation of the motor causes rotation of said annular member F' and thereby causes rotation of the plate holder G' and the articles supported thereby.

It is pointed out that said plate holder G' may contain a single large article having a surface to be coated or may have openings therethrough adapted to support a plurality of smaller objects.

If said plate holder G' is to be of the form required to hold a plurality of small objects then it is preferable to place an opening in the center of said plate holder G' in which one of said objects may be placed in order to enable the operator to watch the coating of the surface of said article in said center opening in the reflector J' so that the operator will know when the articles have been properly coated and thereby enable him to discontinue the evaporation when the desired coating has been applied to the surfaces.

In order to set the annular member Q at the proper angular relation with the normal to the source of the coating material the screws W' are loosened and said annular member Q is then pivoted to the desired angular relation as is shown on the protractor or scale U' and then said screws are tightened again to secure said annular member in desired angular relation. This tilting of said annular member Q simultaneously changes the angular relation of the supporting plate G' and motor A' which are secured to said annular member Q so that said parts are always in operative relation regardless of the angle of said annular member Q.

The reflector J' must be secured so that it will not revolve, which would not allow constant observation thereof by the operator and in order to secure said reflector in such a position that it will not interfere with the movement of said lever I', we secure the mirror support L' to that part of the shaft of the motor A' which is not

rotatable so that the reflector J' always remains in fixed relation with the other members and does not interfere with the movement of the rotating concentric member I'.

The annular member Q has in the upper surface thereof an opening M' in which is received a projection N' on the annular member F' which prevents the entrance of the evaporated material into the ball race D'.

The motor A' is of the shaded pole type having oilless bearings and having the laminations cleaned and put together with Glyptal and the coil winding of an enameled wire sealed with Glyptal and the armature coated with Glyptal and then cadmium plated. The Glyptal sealing and the cadmium plating prevents the formation of air pockets and completely seals the parts of the motor.

Also, in the construction of the motor any fiber parts, such as insulators, or reducing gears are eliminated for the same reason.

In operation the supply of the coating material is placed in the crucible D and the article or articles to be coated are placed on the plate or portion G' with the surface thereof to be coated in the direction of the crucible D.

The annular supporting member Q is then pivoted to the proper angle for the desired coating and is locked at such angle by means of the screws W' as described above. This angle is shown on the protractor or scale and pointer.

The angle at which the support Q and articles to be coated is placed is computed according to the formula and method set forth in the prior application referred to above. Current is then applied through the electrodes C to the crucible D and motor A' to cause the coating material to be evaporated and the lever I' to be rotated to rotate said plate support F' to rotate the plate or plates G' and the operator observes the coating operation in the reflector J' until the surfaces have obtained the desired coating when the current is shut-off.

It is pointed out that while the apparatus described has been shown as having a single source of coating material that any desired number of such sources, including sources of desired contour such as ring shaped sources, may be employed. The changing of the number and location of such sources will, of course, require corresponding changes in the angle at which said support Q is positioned.

It is also pointed out that by employing the method and apparatus outlined herein, that plane or spherical surfaces may be transformed into aspherical surfaces and lens systems may be considerably transformed or designed to produce new systems having greatly improved optical properties as regards image definition and speed. The coating material for forming nonreflective films may be magnesium or calcium fluoride or cryolite or other suitable substances or a layer of quartz over a layer of titanium dioxide, beryl, aluminum oxide, or other suitable material.

The coating material for transforming plane or spherical surfaces into aspherical surfaces may be beryl, quartz, magnesium fluoride, or cryolite or other suitable material.

The apparatus and method described above may also be employed where the coating material is metal, such as in the forming of reflectors or reflective surfaces.

It is also pointed out that while we have shown and described the plate or plates to be coated as rotatable and the source of material to be

evaporated fixed relative thereto, that it is possible to maintain the plate or plates in fixed position and moveably mount the source so that said source will move relative to said plate or plates.

From the foregoing it will be seen that we have provided simple, efficient and economical means for obtaining all of the objects and advantages of the invention.

Having described our invention, we claim:

1. In an apparatus for producing a coating of controlled thickness on the surface of an article, means for supporting a coating material, means for supporting the article to be coated with at least a portion of the surface to be coated toward said means for supporting a coating material, means for rotating said article support to rotate said article, means for changing the angular relationship between said means for supporting a coating material and the article to be coated and means for rotating said article about an axis computed to produce a coating on said article of controlled thickness while causing emission of said coating material from said means for supporting a coating material.

2. In a device of the character described, means for supporting a coating material, means for supporting an article a surface of which is to be coated in alignment with said means for supporting a coating material, means for positioning said support in desired angular relation with said means for supporting a coating material, means for changing said angular relation and means directly connected with said article support for rotating said article and said means for supporting a coating material relative to each other while in said angular relation and during the coating of a surface of said article.

3. In a device of the character described, means for supporting a coating material, a support, means on said support to carry an article a surface of which is to be coated and means whereby the distance between said article and said means for supporting a coating material may be varied and means for changing the angular relationship between said means for supporting a coating material and the article to be coated.

4. In a device of the character described, means for supporting a coating material, a support, means on said support to carry an article a sur-

face of which is to be coated and means whereby the distance between said article and said means for supporting a coating material may be varied and means for changing the angular relationship between said means for supporting a coating material and the article to be coated and means directly connected with said article support for rotating said article during the coating thereof.

5. In a device of the character described, an evacuated chamber, means for supporting a coating material and an article support in said evacuated chamber, means for varying the distance between said means for supporting a coating material and said article support, means for varying the angular relationship between said means for supporting a coating material and said article support and means directly connected with said article support for rotating said article support during the coating of an article supported thereby.

6. In a device of the character described, an evacuated chamber, means for supporting a coating material and an article support in said evacuated chamber, means for varying the distance between said means for supporting a coating material and said article support, means for varying the angular relationship between said means for supporting a coating material and said article support and a motor in said evacuated chamber and connected with said article support for rotating the same during the coating of an article supported thereby.

7. In an apparatus for producing a coating of controlled thickness on the surface of an article, means for supporting a coating material, means for supporting the article to be coated with at least a portion of the surface to be coated toward said means for supporting a coating material, means for rotating said article support to rotate said article, means for changing the angular relationship between said means for supporting a coating material and the article to be coated and means directly connected with said article support for rotating said article about an axis computed to produce a coating on said article of controlled thickness while causing emission of said coating material from said means for supporting a coating material.

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