

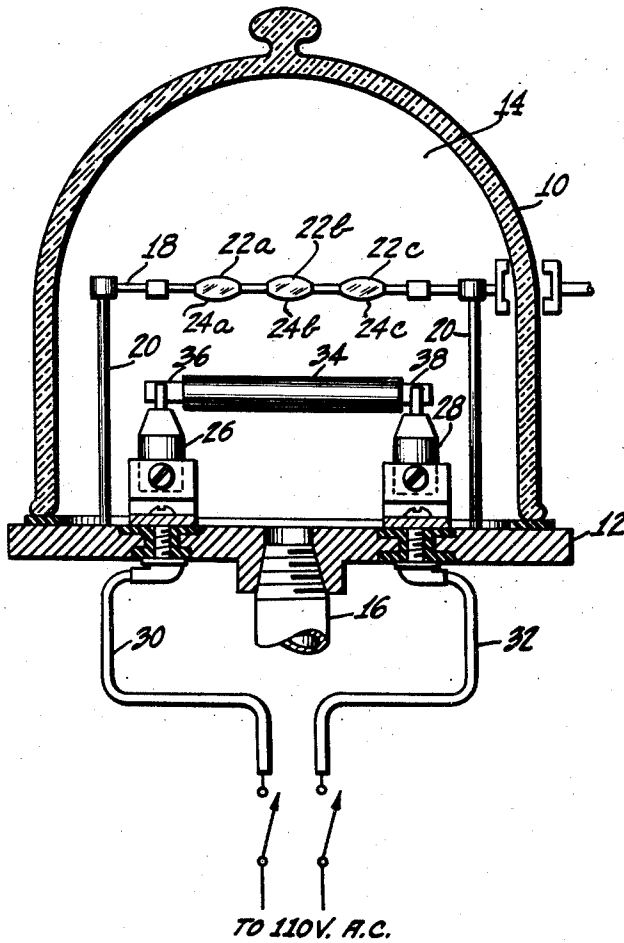
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METHOD OF COATING LENSES

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METHOD OF COATING LENSES

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This invention relates to the application of evaporated coatings to surfaces, particularly the surfaces of optical elements.

It is known that the reflection of light from an optical surface may be controlled by the application to such surface of extremely thin layers of certain appropriate substances. Thus, if a layer of magnesium fluoride having an effective thickness of one-quarter of the wave length of yellow light (14 millionths of a centimeter) is applied to a glass surface, the reflection of incident white light from that surface will be reduced from a normal value of approximately 4 per cent to almost zero. Other coatings of this character may consist of a plurality of superimposed layers, each of which in turn may be composed of a comparatively simple substance such as magnesium fluoride, or of mixtures or compounds of a number of substances. In cases where selective reflection of different components of visible or ultra-visible "light" is desired, the thicknesses of different layers may be related to the wave lengths of different components of such light.

Coatings of the character described are ordinarily applied by evaporation in a vacuum, and in the quantity production of optical elements bearing such coatings, problems arise relating to the control of the thicknesses of such coatings. The time necessary to produce a satisfactory coating using an evaporating boat depends upon a number of variables, including the state of the material to be evaporated, the location of that material in the boat, the relation of the heating coil to the boat, and the power applied to the heating coil.

It is, therefore, an object of the invention to provide an improved method adapted to the quantity production of optical elements bearing thin evaporated coatings.

Another object of the invention is to provide an improved method of and means for controlling the thickness of evaporated coatings.

A further object of the invention is to provide as a new article of manufacture an improved element from which a coating or optically thin film may be evaporated onto a surface.

Another object is to provide as a new article of manufacture an improved coating element suitable for inclusion in or connection to an electrical circuit.

A further object of the invention is the provision of an improved method for the preparation of an element from which material may be evaporated for the deposition of thin films on optical elements.

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These objects are achieved in accordance with the invention by making up rods suitable for inclusion in an electrical circuit, a part of such circuit being contained in the vacuum chamber in which the coating is to be evaporated. The rods are made of compressed powder, which consists of a mixture of a suitable binder with a predetermined quantity of evaporable coating material sufficient to provide a coating of the desired thickness. The binder must be a powder capable of being compressed into a rod or other member of appropriate shape for inclusion in an electrical circuit, and when so compressed and shaped must have resistance to the flow of current to engender sufficient heat for the evaporation of all of the coating material. The binder must further have a volatilizing temperature sufficiently higher than that of the coating material, so that it does not disintegrate at least until all of the coating material has evaporated, and must not combine with the coating material at the operating temperature.

The invention may be better understood from the following description of a preferred embodiment thereof, when read in conjunction with the accompanying drawing, the single figure of which is a view in elevation (but partly in section) of apparatus which may be used for carrying the invention into effect.

A bell jar 10 is mounted upon a base plate 12 of metal or other sturdy material, and forms an air-tight seal therewith. The bell jar and plate define a vacuum chamber 14 adapted to be evacuated through the exhaust outlet 16. A workholder 18 mounted on supports 20 holds the objects to be coated. By way of example, the drawing shows three lenses 22a, 22b, and 22c to whose lower surfaces 24a, 24b and 24c an evaporated coating is to be applied.

Conductive terminals 26, 28 extend through the base plate 12, but are insulated therefrom, and are connected by leads 30, 32 to a source of electrical energy. As shown in the diagram, this may be alternating current of normal commercial frequency or of any other convenient frequency, or, if desired, direct current may be employed. No auxiliary heater is required. The circuit thus constituted is completed by the insertion therein of the rod 34 of the invention, having terminals 36, 38 at either end for connection to the upper ends of the terminals 26, 28.

For the binder, silicon carbide or carbon powder have been found to be satisfactory, although any other material having the characteristics before mentioned (for example, the oxides of thori-

um or zirconium) may be employed, and are intended to be within the scope of the invention. A predetermined quantity of powdered coating material known to be sufficient to produce a coating of desired thickness is thoroughly mixed with the silicon carbide or other inert powder, and the powdered mixture is then compressed by any appropriate means to form a substantially solid rod. In the quantity production of optical or other elements having surfaces coated as here described, any number of the rods may be made up beforehand and stored for use as desired. The rods may contain different quantities or kinds of coating material, in accordance with the thickness and type of coating required.

In practice, the appropriate rod will be inserted between the upper ends of the terminals 26 and 28, and the chamber 14 evacuated. The heating circuit is then closed, and because of the resistance of the rod to the flow of current, heat will be engendered in the rod, and this will cause the coating material to be evaporated onto the lower surfaces of the lenses or other objects to be treated. The heating is continued until all of the coating material has evaporated, but the remainder of the rod will continue to afford resistance to the flow of current, because it has a higher volatilizing temperature than the coating material.

The rate of evaporation depends upon a number of factors, including the size of the particles of silicon carbide or other base material, the temperature and density of the rod, and the proportion of active to inert ingredient. The finer the size of the particles of silicon carbide, the more slowly will the material be evaporated. The temperature of the rod will depend upon its resistance and the voltage applied. The proportion of active to inert material will ordinarily be small. In practice, the rate of evaporation will be so controlled that substantially all the active material will have been evaporated in from 10 to 60 seconds, but this will depend on the type and thickness of the coating desired and the size of the surface to be coated.

To secure proper operating characteristics, it may be desirable to include a certain amount of a powdered substance such as aluminum oxide in the powdered mixture before compressing it into a rod. This serves to dilute the active material further and to control the resistance of the rod. Some of the oxide evaporates with the coating material and produces an improved and more rugged coating. The proportion of such oxide to the inert binder will be small, but large in relation to the active evaporating ingredient.

In some cases it may also be desirable to make up rods having enough coating material to treat a plurality of surfaces and to switch off the heating current at the expiration of a predetermined period known to be sufficient to produce a coating of given thickness. Alternately, shutters may be provided between the source of evaporation and the surface to be coated, together with a time switch for closing the shutters automatically at the end of such period.

Although the member 34 has been shown in the drawing as a rod, and so described throughout the specification, it may be of any shape suitable for inclusion in an electrical circuit, without departing from the bounds of the invention; and, accordingly, wherever the term "rod" has been

used in this specification and in the accompanying claims, it is intended to have a meaning extended as so indicated.

There has thus been described an improved method of evaporating a thin coating of controlled thickness onto a surface by the inclusion in an electrical heating circuit, and in opposed relation to the surface to be coated, of an element which consists of a rod of compressed powder, made by mixing a predetermined quantity of powdered coating material with an inert powdered binder having high electrical resistance and other appropriate characteristics as hereinbefore described. By the use of such a rod, the quantity production of coated optical elements may be simplified and made independent of variables affecting the thickness of the coating.

I claim as my invention:

1. In the method of evaporating a coating of controlled thickness onto the surface of an object in an evacuated chamber, the steps which include (1) mixing a predetermined quantity of powdered vaporizable coating material with a powdered binder which has high electrical resistance and a higher volatilizing temperature than said material and is non-reactive with said material at the volatilizing temperature of said material, (2) compressing said powdered mixture to form a substantially solid rod, (3) arranging said rod in opposed relation to said surface in said chamber, and (4) establishing currents of such magnitude in said rod as to raise the temperature of said rod above the volatilizing temperature of said material but below the volatilizing temperature of said binder, and maintaining said currents for such period as to cause all of said material to be evaporated onto said surface.

2. The method of coating a surface to modify its optical properties which includes the steps of mixing a predetermined quantity of a material known to be sufficient to produce an optical coating of predetermined thickness with an electrically conductive binder which has a higher volatilizing temperature than said material and is non-reactive with said material at the volatilizing temperature of said material, compressing said mixture to form a solid elongated mass, and passing an electrical current therethrough to heat said mass in the presence of a surface to be coated until all of said material is evaporated onto said surface.

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