

May 1, 1951

J. G. OLIVER

2,551,389

APPARATUS FOR THE VAPOR DEPOSITION OF METALS

Filed June 10, 1947

2 Sheets-Sheet 1

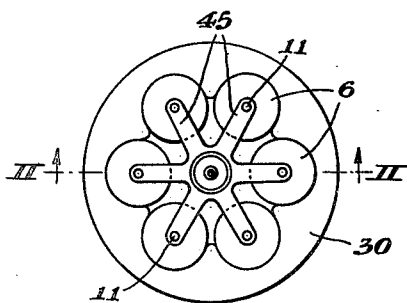


Fig. 1.

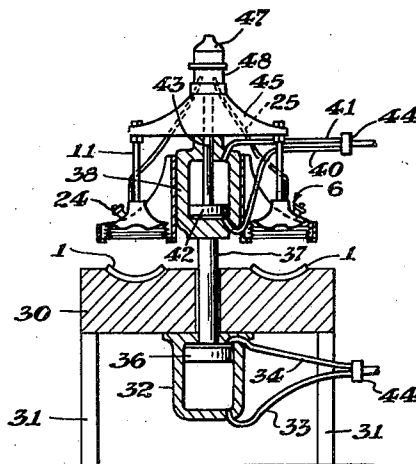


Fig. 2.

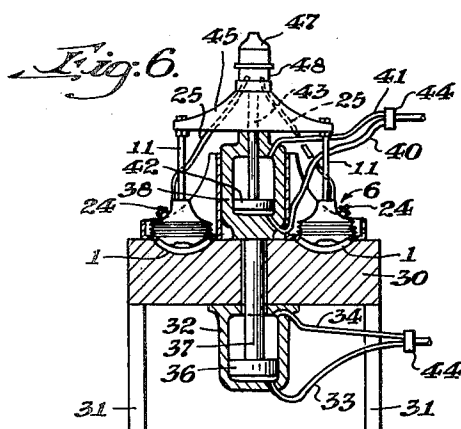


Fig. 6.

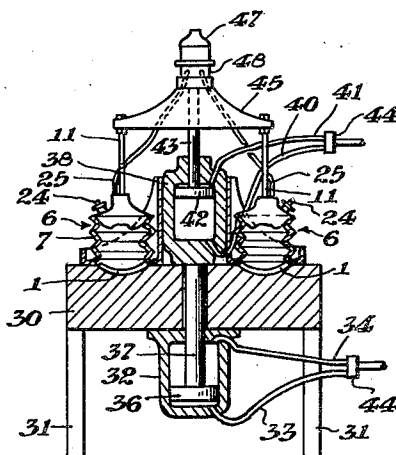


Fig. 7.

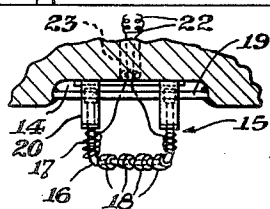


Fig. 5.

Inventor

JAMES G. OLIVER

Olen E. Bee

Attorney

May 1, 1951

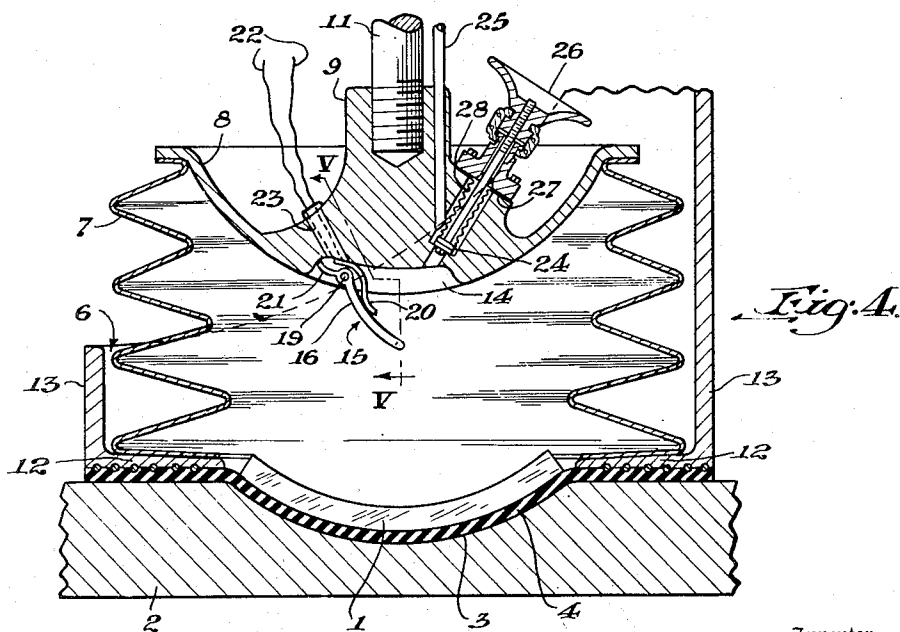
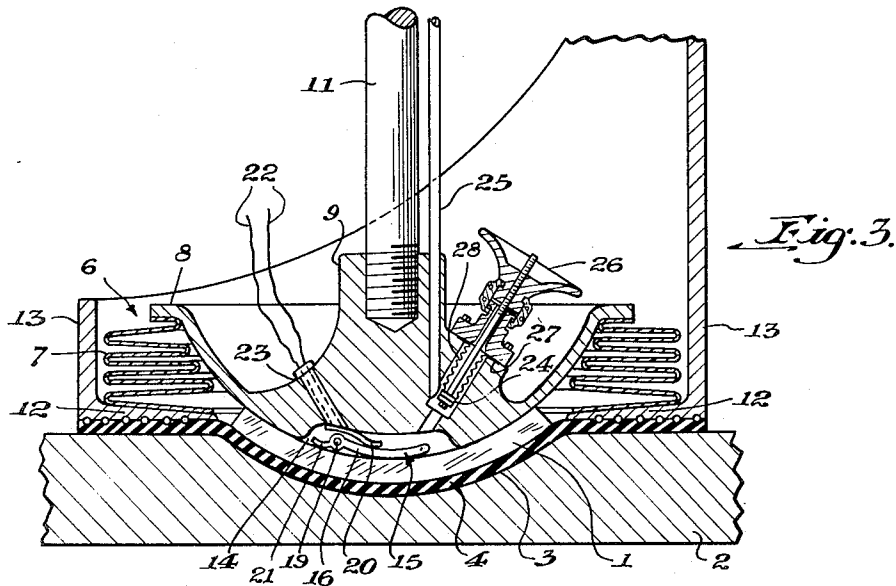
J. G. OLIVER

2,551,389

APPARATUS FOR THE VAPOR DEPOSITION OF METALS

Filed June 10, 1947

2 Sheets-Sheet 2



Inventor
JAMES G. OLIVER

Olen E. Bee
his Attorney

UNITED STATES PATENT OFFICE

2,551,389

APPARATUS FOR THE VAPOR DEPOSITION
OF METALSJames G. Oliver, Rosslyn Farms, Pa., assignor to
Pittsburgh Plate Glass Company, Allegheny
County, Pa., a corporation of Pennsylvania

Application June 10, 1947, Serial No. 753,666

5 Claims. (Cl. 91—12.2)

1

2

This invention relates to apparatus for coating surfaces with a metal by thermally evaporating the metal in a vacuum.

Apparatus of this type presently is used to coat the reflecting surfaces of telescopic mirrors, searchlight reflectors and other reflective surfaces, the optical properties of which must be carefully controlled. The coating is accomplished by supporting the coating material and the object to be coated within a chamber, creating a vacuum therein and evaporating the coating material by electrically heating it.

One objection to prior coating apparatus of this type is that considerable time is required to create the vacuum. This is due to the fact that, in order to obtain a smooth coating of uniform thickness, it is necessary to support the coating material within the chamber at a considerable distance from the object, and consequently the size of the chambers and the volume of the atmosphere to be evacuated from them must be relatively large. A further objection is that the prior apparatus does not provide convenient access into the chamber for quick loading and unloading of the object to be coated. This is due principally to the manner in which the chambers have been sealed by vacuum packing or the like. Due to these and other objections which are known to those in this art, the operations of the prior apparatus have been unnecessarily slow and inefficient.

The object of this invention is to provide an apparatus for depositing metal on an object by thermal evaporation which may be quickly evacuated, which provides convenient access for loading and unloading and which substantially eliminates the necessity for special vacuum packing.

According to the invention the object is coated in a vacuum chamber which includes a rigid end wall which forms a support for the object, another rigid end wall which forms a chamber head and a collapsible and expandable side wall extending between the pair of end walls. An electric circuit enters the chamber through one of the chamber walls and includes within the chamber means for vaporizing the coating material when the chamber is expanded and mechanism is provided for moving one of the rigid end walls away from the other to expand the side wall and thus rarefy the interior of the chamber. With the interior rarefied, the coating material is evaporated to coat the object by energizing the circuit.

Although the vaporizing means may be an arc

between electrodes formed of the desired coating material, preferably it is an electric resistance element about which the coating material is wrapped. The element with the material is mounted in the head of the chamber so that when the side wall is expanded the coating material is positioned centrally of and at a proper distance from the object. Also, most suitably, the head is so shaped that, when the chamber is collapsed, only a small interior space is left in the chamber, and a vacuum pump is connected into this space to quickly evacuate it.

The preferred embodiment of the invention is illustrated somewhat diagrammatically in the accompanying drawings of which Fig. 1 is a plan view of apparatus for simultaneously coating a plurality of objects; Fig. 2 is a vertical section on the line II—II of Fig. 1; Figs. 3 and 4 are vertical sections through a collapsed and an expanded vacuum chamber, respectively; Fig. 5 is an enlarged section along the line V—V of Fig. 4; and Figs. 6 and 7 are sections similar to Fig. 2 showing two different operating positions of the apparatus.

The invention will be described with reference to depositing a coating of metal such as chromium on the concave surface of a glass mirror. However, it should be understood that the invention can be used for coating other objects such as electrical capacitors, resistors, heaters, or even light cells and the like. Also, the coating material used depends upon the characteristics which it is desired to obtain and can include other materials, such as silver, gold, aluminum, mercury, nickel, platinum, quartz, etc.

In the illustrative embodiment of the invention a mirror 1 is supported on a support 2 which is provided with a mirror receiving recess 3 and the top surface of the support is covered with a sheet 4 of impervious and resilient material such as an appropriate chloroprene polymer or other synthetic rubber which is resistant to heat and oils. Referring to Figs. 3 and 4, the mechanism for coating a single mirror includes a vacuum chamber 6 which is adapted to enclose the mirror in an air-tight seal so as to permit a vacuum to be created and the metal to be evaporated. The chamber is formed of a collapsible and expandable metal side wall or bellows 7 and a specially shaped head plate 8 which may be glass or metal as desired. The base of the chamber is formed by support 2. On the central portion of the head plate is formed a vertical lug 9 to which is secured a pull rod 11 which is connected to pressure mechanism

3

adapted both to raise and lower and to collapse and expand the vacuum chamber. The pressure mechanism and its connections will be described later in conjunction with a complete machine for simultaneously coating a plurality of mirrors. To the bottom of bellows 7 is secured, by brazing or the like, an air sealing plate 12 which is carried by a cylindrical frame 13 surrounding the chamber. When the chamber is lowered, plate 12 contacts the resilient cover 4 of the support and pressure mechanism presses the plate into air-tight engagement with it so as to seal the mirror within the chamber. In order to improve the air-tight seal, the lower surface of the plate 12 is provided with circular sealing rings which press into the resilient covering, or, if preferred, annular grooves can be formed thereon.

As shown in the drawings, head plate 8 is provided with a convex inner surface which, when the bellows is collapsed, closely contacts the major portion of the concave surface of the mirror. A recess 14 is formed in this convex surface and an electric heating element 15 is pivotally mounted in the recess. An operative form of such an element is illustrated in Fig. 5. The heating element there shown includes an arm 16 about which is wrapped an electric resistance element in the form of a filament 17 and the coating material 18, which usually is in foil form, is wound about the filament. Arm 16 is pivoted on a pin 19 which is secured to opposite walls of the recess and a leaf spring 20, also secured to a wall of the recess, bears against the arm and normally urges it outwardly of the recess to the position shown in Fig. 4. Arm 16 also is provided with extensions 21 which are adapted to abut the upper wall of the recess and limit the outward movement of the arm. To energize the filament, it is connected by conductors 22 to a source of electrical energy and the openings in the wall of the recess through which the conductors pass are sealed by a glass seal 23. Also connected into the recess is standard type vacuum creating mechanism which includes a valve 24 and a line 25 leading to a vacuum pump. Valve 24 is seated by rotating handle 26 and, in its closed position, Fig. 4, atmosphere is prevented from seeping through the valve mechanism by means of a seal 27 to which one end of a metal bellows 28 is attached, the other end of the bellows being secured to a rubber washer 29 which fits over the valve seat.

In operation, the vacuum chamber and its associated parts are raised from the support a sufficient amount to permit the mirror to be placed in its supporting recess and the chamber then is lowered into air-tight engagement with the support. Assuming the chamber to be expanded, pressure mechanism is operated to collapse it into the position shown in Fig. 3. In such position the chamber's head contacts the mirror and the heating element is pressed into recess 14. With the vacuum valve open the pump is operated to evacuate the small volume of atmosphere which is in the recess and the collapsed bellows. It is to be noted that the time required for such evacuation is considerably shorter than it would be if it were desired to evacuate the atmosphere of the usual chamber or bell jar. Further, no diffusion or auxiliary pump is required to reduce the pressure to the degree necessary for evaporating the metal. When the vacuum has been reduced to about two hundred microns, the vacuum valve is closed

4

and pressure mechanism operated to expand the chamber to the position shown in Fig. 4. The heating element springs out of the recess and places the metal to be vaporized in a position which preferably is radially equidistant from all points on the concave surface of the mirror, so that when vaporized, the metal spreads evenly over the mirror and the coating is of uniform thickness. The heating element's filament then is energized to vaporize the metal and coat the mirror. Preferably, the bellows are not fully expanded in Fig. 4 so that some bellows capacity is available for continuing the stroke during or immediately after the metallic evaporation. Thus, additional bellows capacity may be necessary due to the evolution of gases from the metal being evaporated from other interior surfaces of the chamber.

Figs. 1, 2, 6 and 7 illustrate apparatus for simultaneously coating a plurality of mirrors. In this particular machine, the support for the mirrors is a circular table 30 in which are provided a plurality of recesses 14 arranged in equally spaced radial positions. The table is supported on legs 31 and centrally secured to its bottom surface is a cylinder 32 which is provided with pressure supply and exhaust lines 33 and 34. A piston 36 is reciprocable in the cylinder by air or fluid pressure admitted through one or the other of lines 33 and 34 and a piston rod or arm 37 extends upwardly through the cylinder and projects through a central opening in table 30. The portion of the arm above the table carries another air or fluid pressure cylinder 38 which also has pressure supply and exhaust lines 40 and 41 and a reciprocable piston 42. Secured to this piston is a rod 43 which extends upwardly through cylinder 38 and the upper end of rod 43 carries a plurality of radial spider arms 45 each of which carries at its outer end a pull rod 11 which, as has been described, connect into the head plate of a vacuum chamber. Preferably vacuum motor 47 and pump 48 to which vacuum line 25 connects are mounted centrally on the spider arms. The previously mentioned vacuum chamber's frame 13 is connected rigidly to the outside wall of pressure cylinder 38 so that when arm 37 is reciprocated, the chambers are moved upwardly or downwardly.

The operation of this machine is illustrated in Figs. 2, 6 and 7. The machine shown in Fig. 2 is in its loading and unloading position, the chambers having been raised clear of table 30 by admitting pressure through pressure supply line 33 to raise piston rod or arm 37. It can be noted here that each of the pairs of pressure supply and exhaust lines 33-34 and 40-41 are connected to a four-way valve 44 which is of well-known construction and which is controllable to admit the pressure through either one of the lines of the pairs and simultaneously exhaust the pressure from the other one, and the valves, of course, are connected to a source of hydraulic or pneumatic pressure. After the machine is loaded, the vacuum chambers are lowered into contact with the table by admitting pressure into cylinder 32 through line 34. If the bellows are in an expanded condition they may be collapsed, so as to bring head plate 8 into contact with the mirrors by admitting pressure into cylinder 38 through line 41 to lower only the spindle arms. The atmosphere remaining in the chambers then is evacuated by pump 48 and when the pressure has been reduced the required amount, the chambers are simultane-

5

ously expanded by admitting pressure into cylinder 38 through line 40 to raise the spider arms. In this position, which is illustrated by Fig. 7, the metal is evaporated and the mirrors coated in the manner previously described. The chambers then may be lifted clear of the table and the machine unloaded, reloaded and the cycle quickly repeated.

An important advantage of this invention is that, due to the speed and efficiency with which a plurality of mirrors can be coated, it is well adapted for commercial operations. Such speed results from the short period required for obtaining the necessary vacuum and also from the efficiency of the loading and unloading operations. The quick loading is made possible by the elimination of special vacuum packing, in place of which the machine uses pressure mechanism to create the air seal. Also, in prior similar apparatus, there was a constant danger of contamination from volatiles contained in the chamber and in the numerous mechanical connections through the chamber walls and this danger is substantially reduced by the invention. Also, by using a minimum of mechanical connections, the apparatus insures a better air seal for the chamber.

According to the provisions of the patent statutes, I have explained the principle and construction of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. Apparatus for coating a surface of an object by deposition thereon of a material thermally evaporated in a vacuum, which comprises a bed plate surfaced with a layer of resilient material upon which an object to be coated may be supported, a collapsible and expandable bellows of circular configuration positioned to cover and surround an object when supported in operative position on the resilient material, means for obtaining an air-tight seal between the lower edge of the bellows and the bed plate, a closure secured to the upper portion of the bellows, means for collapsing and expanding the bellows, and means mounted within the bellows for vaporizing a coating material therein.

2. Apparatus for coating a surface of an object by deposition thereon of a material thermally evaporated in a vacuum, which comprises a bed plate surfaced with a layer of resilient material upon which an object to be coated may be supported, a collapsible and expandable bellows of circular configuration positioned to cover and surround an object when supported in operative position on the resilient material, means for obtaining an air-tight seal between the lower edge of the bellows and the bed plate, a closure secured to the upper portion of the bellows, means for collapsing and expanding the bellows, means for evacuating the bellows, and means mounted within the bellows for vaporizing a coating material therein.

3. Apparatus for coating a surface of an object by deposition thereon of a material ther-

6

mally evaporated in a vacuum, which comprises a bed plate surfaced with a layer of resilient material upon which an object to be coated may be supported, a collapsible and expandable bellows of circular configuration positioned to cover and surround an object when supported in operative position on the resilient material, means for obtaining an air-tight seal between the lower edge of the bellows and the bed plate, a head plate secured to and closing the upper end of the bellows, an electric resistance element, for carrying coating material to be vaporized, pivotally mounted upon said head plate within said bellows, means for energizing the electric resistance element to evaporate the coating material, means for evacuating the bellows and means for collapsing and expanding the bellows.

4. Apparatus for coating a surface of an object by deposition thereon of a material thermally evaporated in a vacuum, which comprises a bed plate surfaced with a layer of resilient material upon which an object to be coated may be supported, a sealing plate provided with a central opening of sufficient size to avoid contact with an object supported upon the layer of resilient material, a cylindrical frame supporting said sealing plate and adapted for movement to and from said bed plate, a circular head plate independently supported and adapted for vertically reciprocating movement within the cylindrical frame, a collapsible and expandable bellows of circular configuration extending between said head plate and said sealing plate and secured therebetween, means for evacuating the bellows and means carried upon the inner surface of the head plate for vaporizing a coating material within the bellows.

5. Apparatus for coating a surface of an object by deposition thereon of a material thermally evaporated in a vacuum, which comprises a bed plate surfaced with a layer of resilient material upon which an object to be coated may be supported, a sealing plate provided with a central opening of sufficient size to avoid contact with an object supported upon the layer of resilient material, a cylindrical frame supporting said sealing plate and adapted for movement to and from said bed plate, a circular head plate independently supported and adapted for vertically reciprocating movement within the cylindrical frame, a collapsible and expandable bellows of circular configuration extending between said head plate and said sealing plate and secured therebetween, an electric resistance element, for carrying coating material to be vaporized, pivotally mounted upon said head plate within the bellows, means for energizing the electric resistance element to evaporate the coating material, and means for evacuating the bellows.

JAMES G. OLIVER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,151,457	Williams	May 11, 1939
2,341,603	Dorn, et al.	Feb. 15, 1944