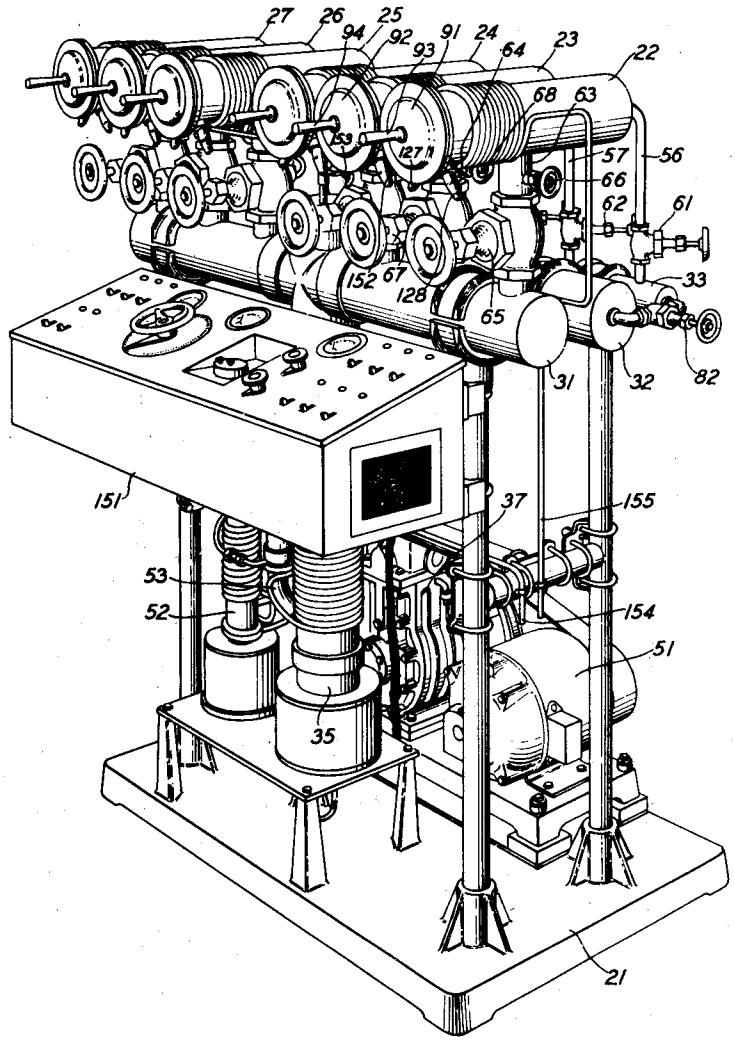
May 6, 1941. H. W. WEINHART 2,241,228

COATING MACHINE

Filed March 3, 1939 3 Sheets-Sheet 1

FIG. 1



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COATING MACHINE

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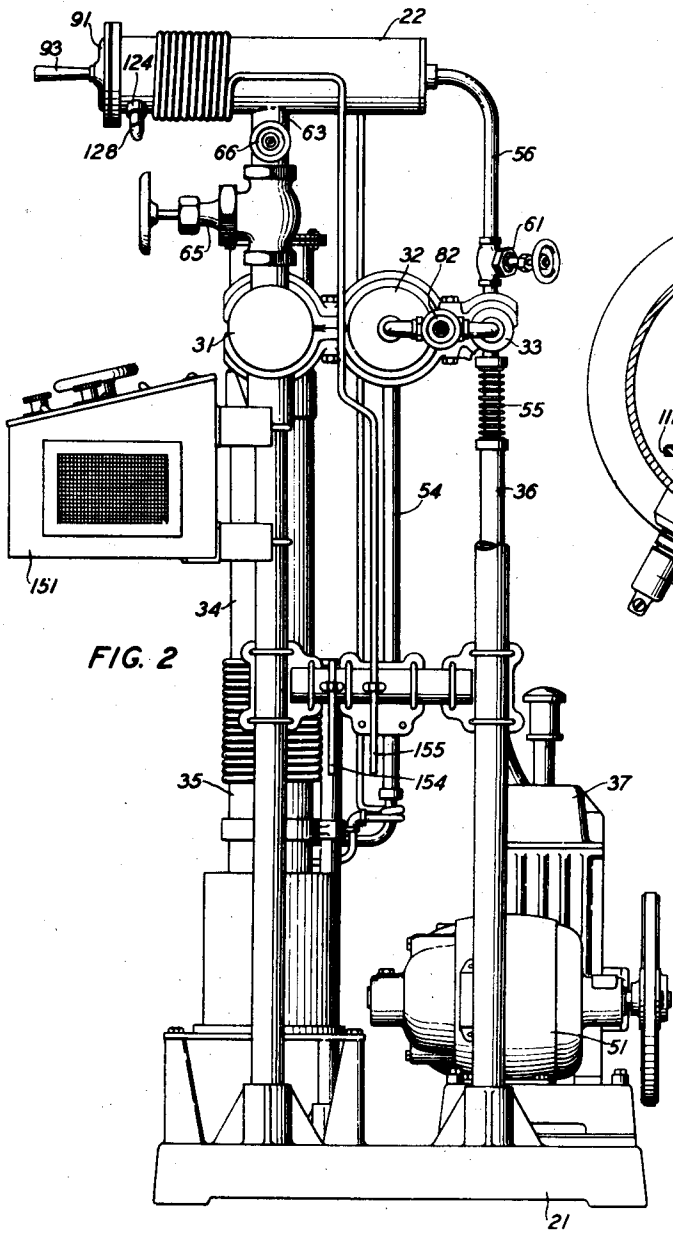


FIG. 2

FIG. 7

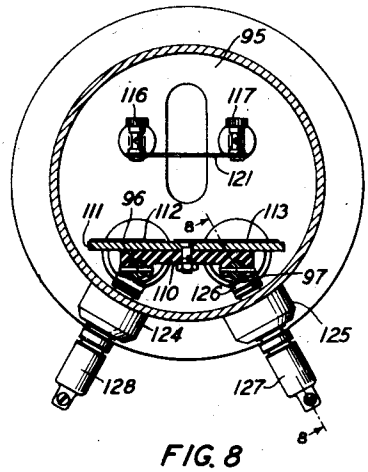
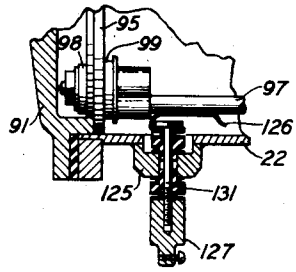


FIG. 8



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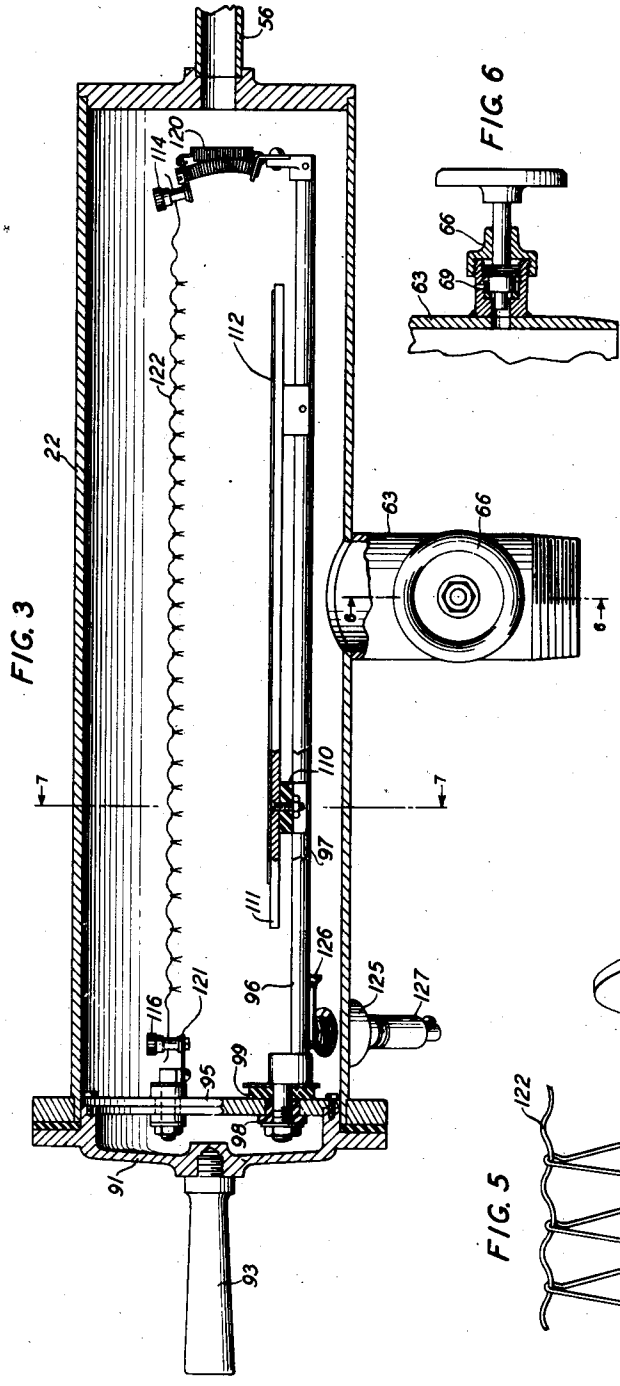

FIG. 3

FIG. 6

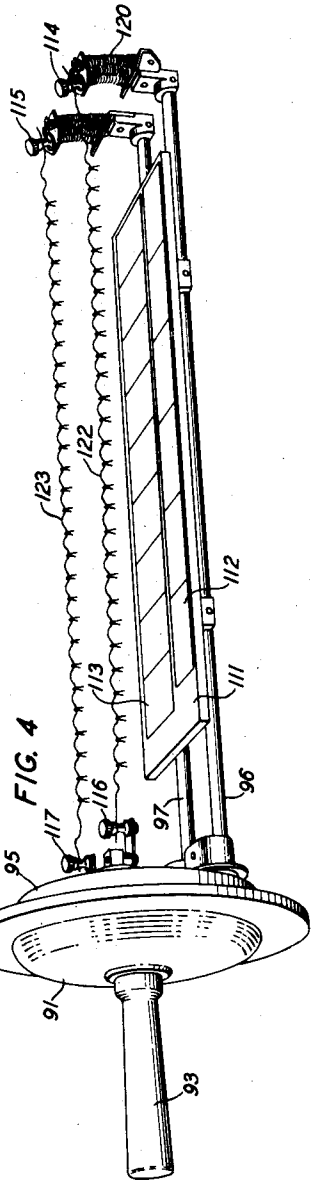

FIG. 4

FIG. 5

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UNITED STATES PATENT OFFICE

2,241,228

COATING MACHINE

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Application March 3, 1939, Serial No. 259,623

9 Claims. (Cl. 91—12.2)

This invention relates to a coating machine and particularly to a machine for applying metallic coatings to objects by the thermal evaporation process.

An object of the invention is to facilitate the application of metallic coatings to objects.

A more specific object of the invention is to facilitate and render more economical the application of metallic electrode coatings to piezoelectric crystal plates.

Piezoelectric crystal plates are, as is well known, commonly used as elements in electrical circuits where a constant frequency is essential and are of increasing importance as elements of electrical filters and other networks. When these plates are used in electrical circuits it is necessary, of course, that some means be provided whereby the plates may be electrically connected to the other elements of the circuit. It is common practice to provide for this purpose metallic electrode coatings, such, for example, as a thin film of aluminum on the surfaces of the crystal plate, these coatings being electrically conductive with respect to the surface to which they are applied. The external conductors of the circuit may then be connected to the proper electrode coatings by suitable means.

The machine of the present invention is particularly adaptable to the application of such coatings to the surfaces of piezoelectric crystal plates.

In accordance with a specific embodiment of the invention, a plurality of evaporation chambers are provided, all of which may be exhausted by a common evacuating means. Each chamber is provided with suitable heating elements for bringing about evaporation of the coating material.

A feature of the invention is separate "high pressure" and "low pressure" exhausting paths for each chamber.

Another feature of the invention is means whereby the high pressure and the low pressure path of each chamber may be operated entirely independently of each other.

A further feature of the invention is means whereby the pressure within any one of the chambers may be raised or lowered without materially affecting the pressure within the other chambers.

A still further feature of the invention is a readily removable unit for each chamber, which unit includes a table for supporting the plates to be coated and the heater filament assembly.

A complete understanding of the arrangement and functioning of the machine contemplated by the present invention as well as appreciation of the various valuable features thereof may be gained from consideration of the subsequent detailed description in connection with the drawings in which:

Fig. 1 is a perspective view of a coating machine embodying features of the present invention;

Fig. 2 is an end view of the machine shown in Fig. 1;

Fig. 3 is a sectional view of one of the evaporation chambers;

Fig. 4 is a perspective view of one of the removable table supporting units;

Fig. 5 is a view of a portion of one of the filaments;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 3 showing the details of the air intake valve;

Fig. 7 is a sectional view taken on line 7—7 of Fig. 3 showing details of the unit within the evaporation chamber; and

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7 showing details of the terminal member and connector spring.

Referring now to the drawings, there is shown in Fig. 1 a coating machine assembly mounted on a suitable base member 21. The assembly illustrated includes six evaporation chambers 22, 23, 24, 25, 26 and 27 and three tubes 31, 32, and 33. Manifold tube 31 (Fig. 2) is connected through pipe 34 directly to unit 35 of an oil diffusion vacuum pump while manifold tube 33 is connected through pipe 36 directly to mechanical oil vacuum pump 37. Pump 37 is driven by motor 51. Unit 52 of the oil diffusion pump assembly is connected in series with unit 35 thereof through pipe 53 (Fig. 1), gas storage reservoir tube 32 being connected through pipe 54 (Fig. 2) directly to unit 52 (Fig. 1) of the diffusion pump.

A resilient portion 55 is provided in pipe 36 in order to prevent the transmission of undesirable vibrations from mechanical pump 37 to the evaporation chambers.

Manifold tube 31 and storage tube 32 which are connected to the oil diffusion vacuum pump (through pipes 34 and 54, respectively) comprise what may be called the "low-pressure" section of the pumping system while manifold tube 33, which is connected to mechanical oil vacuum pump 37 through pipe 36, comprises what may be called the "high-pressure" section of the system.

Each of the evaporation chambers is connected directly to manifold tube 33 by means of a short pipe connected at the rear of each chamber. For

example, pipe 56 connects chamber 22 to manifold tube 33, pipe 57 connects chamber 23 thereto and so on. Each of these six connecting pipes is provided with a shut-off valve. For example, pipe 56 is provided with shut-off valve 61, pipe 57 with shut-off valve 62 and so on.

Each of the evaporation chambers is also connected directly to manifold tube 31 through a short pipe located near the front of each chamber. For example, chamber 22 is connected to manifold tube 31 through pipe 63, chamber 23 through pipe 64 and so on. Each of these short connecting pipes is provided with two valves, one a cut-off valve for effectively closing the connection through the pipe to manifold tube 31 and the second an air intake valve for controlling the admission of air from the outside atmosphere to the evaporation chamber. For example, connecting pipe 63 is provided with cut-off valve 65 and air intake valve 66 while connecting pipe 64 is provided with shut-off valve 67 and air intake valve 68. Each of the air intake valves controls the admission of air through an aperture from the outside atmosphere. For example, as shown in Fig. 6, valve 66 controls the admission of air through aperture 69.

Shut-off valve 32 is provided for effectively separating upon occasion the high pressure section from the low pressure section of the pumping system.

Each of the evaporation chambers is provided with a closure cap, for example, chamber 22 is closed by cap 91, chamber 23 by cap 92 and so on. Each of these caps is provided with a handle, as 93 and 94, for convenient manipulation. Each cap removably supports a unit including a table for supporting the plates to be coated and the heater filament assembly. By way of example, the unit provided in chamber 22 will now be described.

As clearly shown in Figs. 3 and 4, a plate 95 is mounted on the inner edge of cap 91. Two rods, 96 and 97, of conductive material are rigidly supported by plate 95, being electrically insulated therefrom by suitable bushings and washers of insulating material, bushing 98 and washer 99 being shown. A metal table 111 is supported by rods 96 and 97 being electrically insulated therefrom by suitable mounting blocks of insulating material, block 110 being shown in Fig. 3. This table serves as a support for the plates being coated. A number of plates, as 112 and 113, are shown (Fig. 4) in position on table 111. Terminal posts 114 and 115 are provided at one end of rods 96 and 97; terminal posts 116 and 117 are mounted on plate 95. Terminals 114 and 115 are electrically distinct while terminal posts 116 and 117 are electrically connected by conductive strip 121 (Fig. 7).

Filament wire 122 which may be tungsten, for example, is supported between terminal posts 114 and 116 and filament wire 123 is supported between terminal posts 115 and 117. As shown in detail by Fig. 5, a number of "hairpins" of the coating material, for example, aluminum, are suspended on each filament wire being pinched tightly to the filament to prevent shifting.

The filament wires are maintained under a substantially constant tension due to the resilient mountings provided for terminals 114 and 115, each of which mounting is provided with a tensioning spring, such as spring 120 (Fig. 3).

Bushing lugs 124 and 125 are mounted on chamber 22 (Fig. 7) and support terminal members 126 and 127, respectively. Terminal member 127 is electrically connected to spring contact 126 by bolt 131 (Fig. 8); terminal member 128 is similarly connected to a like contact spring, (not shown). When the unit is in position within the chamber, bar 97 is electrically connected to terminal member 127 by spring 126 and bolt 131; bar 96 is electrically connected to terminal member 128 in a similar manner. This connecting means provides a convenient arrangement for connection between the removable unit and the external circuit elements.

The necessary switches, rheostats, meters and other apparatus incidental to the control of the electrical current are mounted in control box 151. The electrical current is supplied to the leading terminals 127, 128, 152, 153, and so on, of the evaporation chambers through suitable flexible conductors, not shown.

The chambers of the oil diffusion vacuum pump and each evaporation chamber are surrounded by coils of tubing; this tubing terminates in sections 154 and 155 to which may be connected the terminals of a suitable pumping system, not shown, for the supply of a cooling fluid which may be water.

In order to further illustrate the invention, the actual operation of the machine contemplated thereby will now be described. Let us assume that all of the evaporation chambers, 22 to 27, have been "loaded" with piezoelectric plates to be coated and that all the closure covers, as 91, are in position.

All air-intake valves, as 66 and 68, are closed, thereby preventing entry of air from the surrounding atmosphere to the evaporation chambers. Shut-off valves 65, 67, and so on, are closed, thereby effectively disconnecting the chambers from the low-pressure section of the pumping system while valves 61, 62, and so on, are opened, thereby connecting the chambers to the high-pressure side of the system. Valve 32 is closed, thereby separating the two systems from each other.

Mechanical oil pump 37 is now set into operation and as much of the air as possible is removed from the chambers through the high-pressure side of the pumping system, pump 37, as pointed out above, being connected, directly to high-pressure manifold tube 33. The air is discharged through a vent provided on the output side of pump 37.

After as much of the air as possible has been removed by use of the mechanical oil pump, valves 61, 62, and so on, are closed, valves 65, 67, and so on, and valve 32 are opened and the oil diffusion vacuum pump is set into operation to remove more of the air through the low-pressure side of the system (manifold tube 31 and storage reservoir 32), the air being discharged through manifold tube 33, pipe 36 and the vent on the output side of mechanical pump 37. The preliminary removal of a large part of the air by means of the mechanical pump prevents an undesirable rush of air through the low-pressure system; provision of the oil diffusion pump permits achievement of a lower pressure than could be obtained by means of the mechanical pump alone.

When a sufficiently low pressure has been attained in the chambers, the electrical current is turned on and the filaments are heated to a temperature that causes the aluminum "hair-pins" supported on the filaments to evaporate; the evaporated material condenses on the surfaces of the crystal plates forming the desired metallic coating thereon.

The electrical heating circuit referred to above may be traced, with reference to chamber 22 (Figs. 3, 4, 7 and 8) as follows: terminal 127, bolt 131, spring 126, rod 97, terminal 115, filament 23, terminal 117, conductive strip 121, terminal 16, filament 122, terminal 114, rod 96, and through a spring and bolt (not shown but similar, respectively, to spring 126 and bolt 131) to terminal member 128. The circuits of the other terminals are completed in a similar manner.

Let us assume now that we wish to open evaporation chamber 22 in order to remove the plates therefrom, without affecting the pressure in the other evaporation chambers. Valve 65 is first closed, thereby shutting off chamber 22 from the low-pressure side of the pumping system. Valve 66 is then opened in order to admit air into chamber 22 so that the chamber may be opened. Cover 91 may now be removed by use of handle 93 and the unit supported thereby withdrawn from the chamber.

After the unit has been replaced in chamber 22 and cover 91 closed, valve 66 is again closed. Valve 82 is closed and valve 61 is opened whereupon most of the air in chamber 22 is removed by mechanical pump 37 through pipe 56, manifold 33 and pipe 36. During this time, i. e., while valve 82 is closed, any air collected in the low pressure side of the system will be temporarily stored in gas storage reservoir tube 32. After as much of the air as possible has been removed by pump 37, valve 61 is closed and valves 82 and 65 are opened, thereby again connecting the chamber to the low pressure side of the system. In view of the fact that most of the air has already been removed from chamber 22, the pressure of the other chambers is not materially changed when chamber 22 is reconnected to the low pressure side. In like manner, of course, any of the other chambers may be opened without affecting the pressure in the other chambers.

While a specific embodiment of the invention has been selected for detailed description, the invention is not, of course, limited in its application to the embodiment disclosed. The embodiment described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, common means for exhausting the air from all of said chambers, means for changing the air pressure in any of the chambers and means for maintaining the pressure in the other chambers unvaried irrespective of the operation of said pressure changing means.

2. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, a manifold, means for producing a low pressure in said manifold, means for individually connecting each of said chambers to said manifold, means for effectively disconnecting each of said chambers from said manifold, and means for controlling admission of the free atmosphere to each of said chambers.

3. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, a manifold, means for producing a low pressure in said manifold, pipes for individually connecting each of said chambers to said manifold, a valve in each of said pipes for effectively disconnecting each of said chambers from said manifold, and a second valve in each of said pipes for controlling admission of the free atmosphere to each of said chambers.

4. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, a manifold, means for producing a low pressure in said manifold, pipes for individually connecting each of said chambers to said manifold, each of said pipes having an aperture therein for admission of the free atmosphere to said chambers, a valve in each of said pipes for closing said apertures, and a second valve in each of said pipes for effectively disconnecting the associated chamber from said manifold whereby admission of air to one of said chambers through one of said apertures does not affect the pressure in said manifold.

5. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, a manifold, means for producing a low pressure in said manifold, pipes for individually connecting each of said chambers to said manifold, a valve in each of said pipes for effectively disconnecting each of said chambers from said manifold, a gas storage tube, means for connecting said manifold through said low pressure producing means to said storage tube, a second manifold, means for producing a low pressure in said second manifold, pipes for individually connecting each of said chambers to said second manifold, a valve in each of said last-mentioned pipes for effectively disconnecting each of said chambers from said second manifold, a pipe for connecting said second manifold and said gas storage tube, and a valve in said last-mentioned pipe for effectively disconnecting said gas storage tube from said second manifold.

6. Apparatus for coating a surface of an object by thermal evaporation comprising a cylindrical open-ended evaporation chamber, removable means for closing the open end of said chamber, a filament adapted to be positioned within said chamber, means for supporting said filament from said closing means, an electrical terminal mounted on the outside of said chamber, and means mounted within said chamber effective to electrically connect said terminal and said filament when said closing means is in position to close said chamber.

7. Apparatus for coating a surface of an object by thermal evaporation comprising a cylindrical open-ended evaporation chamber, removable means for closing the open end of said chamber, a filament adapted to be positioned within said chamber, means for supporting said filament from said closing means, a conductor member supported by said closing means, means for electrically connecting said filament and said conductor member, an electrical terminal mounted on the outside of said chamber, and an electrically conductive spring member electrically connected to said terminal and mounted within said

chamber in a position to engage said conductor member when said closing means is in position to close said chamber, thereby electrically connecting said filament to said terminal.

8. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of cylindrical, open-ended evaporation chambers, a cap for each chamber adapted to close the open end thereof, a plurality of rigid electrical conductor members carried by said cap, a table carried by said conductors adapted to support the objects to be coated, a plurality of filaments carried by said cap and supported above said table, means for conductively connecting each of said filaments to one of said rigid conductor members, a plurality of electrical terminals on the outside of each of said chambers, and a plurality of conductive spring members inside each of said chambers, each of said spring members being electrically connected to one of said terminals, the spring members being so positioned within the chambers that contact is made by each spring member with one of said rigid conductors when said cap is in position to close the associated chamber.

9. Apparatus for coating a surface of an object by thermal evaporation comprising a plurality of evaporation chambers adapted to receive the objects to be coated, a filament in each of said chambers, means for heating said filaments, a manifold connected to said chambers, means for exhausting air from said chambers through said manifold, means associated with each of said chambers for controlling the admission of air thereto from the surrounding atmosphere, means for preventing the entry of such admitted air to said manifold, and means independent of said manifold for exhausting such admitted air from any of said chambers without entry of such air into said manifold.

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