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METHOD OF APPLYING MIRROR SURFACES TO THE INTERIOR OF LAMP BULBS

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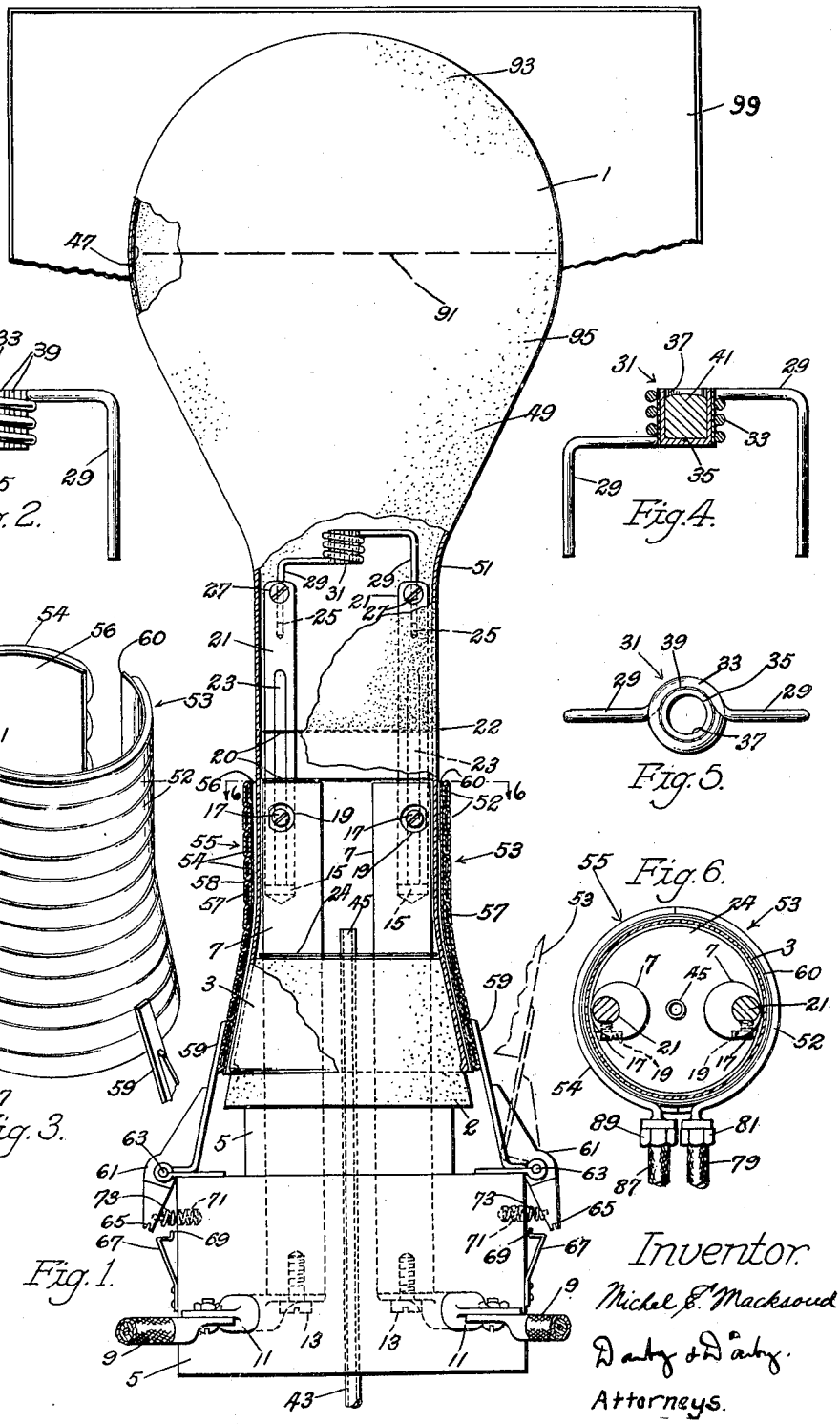


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

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METHOD OF APPLYING MIRROR SURFACES TO THE INTERIOR OF LAMP BULBS

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This invention relates to improvements in methods and apparatus by means of which metallic mirror surfaces may be applied to glass surfaces and particularly to the interior surfaces of lamp bulbs.

An object of this invention is to provide an improved method and simplified apparatus by means of which a thin metallic reflecting film of uniform thickness may be easily and simply applied to the interior of lamp bulbs.

A further object of this invention is to provide a method by which reflecting metallic films may be directly applied to the interior of lamp bulbs to provide a highly reflective mirror surface which requires no buffing or polishing.

A still further object in the invention is to provide an improved method for this purpose by means of which the metal to form the film is vaporized and deposited directly on to the glass surface.

The invention also concerns a novel and ingenious device for limiting the area in which the metal film is deposited, thus obviating the need of further treatment to remove surplus metal and obtain a sharp line of demarcation between the reflecting and the transparent areas. It will be obvious that such a device prevents waste of metal.

A novel cooling system is also employed by which the neck of the glass vessel and the support therefor are protected from the effects of the high temperatures generated in the process.

Briefly speaking, the invention utilizes a high frequency induction coil in which is placed an insulated crucible containing the charge of metal to be vaporized. The high frequency process is to be preferred over the process using resistances for the generation of heat to vaporize the metal.

These and other objects and advantages of the invention will be more readily understood and appreciated from the following description of a preferred embodiment thereof, as illustrated in the accompanying drawing, in which:

Figure 1 is a view in side elevation partly in perspective with some parts broken away and some parts in cross-section;

Figure 2 is an enlarged view in side elevation of the vaporizing unit;

Figure 3 is a view in perspective of the cooling unit;

Figure 4 is a view in vertical central cross-section through the vaporizing unit;

Figure 5 is a plan view; and

Figure 6 is a cross-section taken on the line 6—6 of Figure 1.

A detailed description of the apparatus will be given first, followed by an explanation of the process and the advantages thereof. It may be noted at the outset that the unit of Figure 1, capable of treating one bulb at a time, may, as will be apparent to those skilled in the art, be incorporated into an automatic machine having a plurality of these units so that the bulbs are delivered thereinto at one point ready for treatment and removed therefrom at another point in finished form.

In the unit illustrated there is a suitable base 5 of insulating material, on the upper surface of which is secured a sealing stopper 2 made of rubber or other suitable material. The glass envelope to be treated is shown comprising a bulbous portion 1, a neck portion and a terminal portion at the end of the neck which flares outwardly as shown at 3. The stopper 2 is of correct size and proportions to receive the flared end 3 of the envelope and to form an air-tight seal therewith.

Mounted in the base 5 and extending upwardly through the stopper 2 are a pair of heavy electrodes or metal standards 7—7 which are provided at the upper ends with bores 15 in which are mounted smaller metal electrodes 21. The electrodes 21 are provided with slots 23 and may be locked in adjusted vertical positions by means of the set screws 17. These set screws are preferably recessed into the electrodes 7 as shown at 19. Current conducting leads 9 are removably secured to the connectors 11 which in turn are attached to the electrodes 7 by means of the screws 13. The leads 9 which are suitably insulated as illustrated extend to any suitable form of high frequency current source. At 20 are a pair of discs of mica, alundum, or other suitable electrical and heat insulating material. The lower disc 20 through which the electrodes 21 project rests on top of the electrodes 7. The upper disc 20 through which the electrodes 21 project frictionally engages them so that it may be positioned vertically as desired. Its purpose will be described later. The disc 24 through which the electrodes 7 project rests upon the stopper 2 and protects it against charring under the heat developed in the process.

In the upper ends of the electrodes 21 are drilled the holes 25 to receive the arms of legs 29 of the vaporizing unit. The unit is held in place by means of the set screws 27. The form of vaporizing unit which is generally illustrated at 31 is shown as comprising a small coil of closely wrapped turns 33, the terminal ends of which form legs 29. The material of this coil may be

of any metal having a sufficiently high melting point to prevent its deterioration under the heat generated in the process. For example, the coil may be made of tungsten or molybdenum wire or alloys thereof. Other materials are suitable for the purposes, depending upon the particular material to be vaporized to form the film. In addition to the requirement that the melting temperature of the metal of the coil be sufficiently high, it is desirable to use a metal on which there is no dissolving action on the part of the metal vaporized under the temperatures employed. Disposed within the coil is a crucible 35 of material which will not melt, soften or vaporize under the temperatures of the process. Here again molybdenum and tungsten are suitable. In some cases the crucible may be made of carbon, graphite, pure fused magnesia, alumina, or sintered and fused thorium oxide. The crucible is made by boring out or otherwise removing the center of a suitable body of the material to provide the cup or recess 37 in which the material to be vaporized is placed, as indicated at 41 in Figure 4. Interposed between the coil and the crucible is a series of strips 39 of mica which hold the two out of electrical contact (Figure 2). It may be noted that in the temperatures encountered in the process the mica has a tendency to fuse but this is a helpful rather than a harmful occurrence. Of course, other suitable insulating materials may be used for this purpose.

Extending upwardly through the support 5 and the stopper 2 is a tube, the upper end 45 of which opens into the glass envelope and the lower end 43 of which provides a means for connection to a suitable vacuum source.

At 53 and 55 are indicated the two sections of a cooling unit which when they hug the neck of the envelope substantially completely encircle it. These sections include substantially semi-circular plates 56 and 60 (Figure 3) of a suitable metal such as copper, to the outer surface of which are secured the flat tubes 52 and 54. The tube 52 is provided with a suitable cooling medium supply pipe 75 which is attached thereto by a fitting 77 and the exhaust connection 79 which is connected thereto by the fitting 81. In a similar way the coil 54 is provided with the cooling medium supply pipe 83 attached thereto by the fitting 85 and the exhaust pipe 87 attached thereto by the fitting 89. The coils are shown in the form of flat thin-walled tubes which closely hug the outer faces of the plates 56 and 60, and the adjacent convolutions are preferably spaced as indicated at 56 to permit circulation of air between them.

Secured to each section near the bottom is a bracket 59 which is pivotally mounted on the support 5 by means of the pivot pins 63. Secured to the arms 59 are the arms 61 which are engaged at the lower ends by the springs 73 which lie in the recesses 71 in the support 5. The lower ends of the arms 61 are notched at 65 to receive the ends 69 of the flat springs 67 secured to the support 5. When the cooling sections 53 and 55 are swung outwardly to the dotted position shown at 51 on the right of Figure 1, the springs 67 engage the arms 61 to hold the sections outspread.

To heat the glass vessel to annealing temperature a conventional oven 99 is employed. This oven 99 is well known in the art and forms no part of the invention.

The process in which this apparatus is employed will now be described.

An envelope such as an electric lamp bulb is first cleaned on the inside so as to remove all foreign matter of any kind whatsoever and particularly to remove any grease film that may be on it. It is highly important that any film such as a fatty acid film that may be on the surface be removed. If the surface is not thoroughly clean the hot metallic vapor depositing thereon may react with the greasy film to form blisters, holes, pimples, or other irregularities in the mirror surface with the undesired effect of increasing the tendency of the film to peel off. Any reaction that may occur between the hot metallic vapor and the foreign material present will tend to fog the coating or give it an uneven appearance. One method of cleaning the bulb is to wash the interior with a detergent such as "Alphasol." This is then rinsed out and the surface washed with potassium hydroxide which is also washed out. The interior is then washed with nitric acid and again rinsed, preferably with distilled water. This order of application of the cleaning agents is the reverse of that used in silvering mirrors because fatty acids adhere to the alkaline glass surface more readily than to the acidified glass surface. The bulbs are then dried by placing them neck down in an oven to increase the speed of drying or merely allowing them to dry by exposure to air at ordinary temperatures. The surface to be coated should be so clean, as it will be by this washing method, that when the breath is blown on it a uniform structureless gray film of moisture will form with no apparent pattern. If a pattern in the moisture film is present, this indicates that the surface is not thoroughly clean and should be recleaned. However, if the above cleaning method is carefully followed the surface will be suitably cleaned for the purposes hereof.

It may be noted that "Alphasol" is one of a class of detergents which are sulphonated organic compounds of high molecular weight and specifically is an alcohol. They have a neutral reaction and their advantage over soap lies in the fact that they may be used in neutral, alkaline, or acid solutions. Unlike soaps they form soluble compounds with the magnesium and calcium solids common in tap water and therefore rinse easily.

A glow discharge may be employed to finally clean the glass bulb after a vacuum has been produced in it, and while it is mounted on the unit, by applying a high frequency current discharge to one of the electrodes.

Another suitable method of washing and cleaning the bulbs is to wash them with agitation in ammonium bifluoride. The bulbs are then rinsed with water and this may be tap water under pressure and rinsed again with hot or boiling water. Just prior to silvering they are again washed in a bath of stannous chloride followed by thorough washing with distilled water and drying.

They may be cleaned also by washing, using a solution of chromic acid which is prepared by mixing 100 cc. of sulphuric acid with about 4 grams of sodium dichromate. They are then washed out, first with tap water and then with distilled water, and dried.

When thoroughly dried the bulb is placed on the stopper 2 and with the vacuum pump connected to the tube running it is drawn tightly thereon to form an air-tight seal. A fairly high vacuum is desirable and this can be secured by using condensation or diffusion pumps cooled by a dry ice trap in combination with the usual mechanical oil pump. Adequate vacuumizing capacity is desirable, not so much to maintain an extremely high vacuum within the bulb since

the degree of vacuum is not critical, but to aid in maintaining a substantial vacuum during the vaporization of the mirror metal. At the beginning of the heating of the crucible and mirror metal there is a substantial "outgassing" and it is desirable that the freed gases be quickly removed from the bulb.

Prior to the application of the bulb to the stopper a suitable quantity of the mirror metal 41 is placed in the crucible. A pellet of pure silver is highly satisfactory for the purpose. However, other metals may be employed, such as aluminum, magnesium, chromium, and alloys thereof.

After a vacuum has been created in the bulb and prior to the vaporization of the mirror metal, it is highly desirable that the glass bulb be heated sufficiently high to "de-gas" it. It has been found that if the bulb is heated to the proper degree prior to the vaporization of the mirror metal and maintained substantially at that temperature during the vaporization of the metal, the resulting mirror is deposited with a high lustre and polish equal to the polish of the glass bulb surface and needs no further polishing, buffing or burnishing. The bulbs should be heated to temperatures at least equal to the annealing temperatures of the glass of which they are made. This drives out substantially all occluded gases and removes considerable moisture and residual impurities from the glass. By maintaining the bulb at or near the annealing temperature of the glass during the vaporization process, the glass is kept dry and any further gases which evolve are removed. The result of this treatment is that the resulting metal coating firmly adheres to the glass with little danger of it later peeling therefrom. In addition, this heating contributes to the high lustre and polish of the metal film because the crystalline structure of the deposited film is kept fine. It is important to note that since the annealing temperatures of different glasses vary it is essential that the glass manufacturers' annealing temperatures be followed in the heating of the bulbs.

The high frequency current is then supplied to the coil 33 which very rapidly heats the mirror metal to the point of vaporization. It is heated until it has a vapor pressure of the order of one-tenth of a millimeter of mercury. The vacuum is sufficiently high to give a long mean free path so that the molecules of the metal travel with substantially no inter-molecular collisions from the crucible to the wall of the envelope. It may be here noted that silver is particularly desirable because of its tendency to clean up any released vapor. That is its "getter" action. Aluminum also displays this characteristic to a high degree. The mirror metal reaches the vaporization point very rapidly and the vapor quickly travels to and condenses upon the inner wall of the envelope to form a thin, clear, uniform film thereon. In accordance with this process and particularly when silver is used, the resulting mirror surface is extremely smooth and highly polished so as to require no further buffing or polishing operation. The film has no blush and is uniformly clear without pattern or blemish.

The coil 33 and crucible 35, of course, become so hot during the vaporizing step that any mirror metal that deposits on them is immediately vaporized, insuring that the diameter of the wire in the coil 33 does not build up and short circuit the turns and further insuring that the wall thickness of the crucible 35 does not increase.

The upper disc 20 is positioned on the electrode 21 at the point at which it is desired to terminate the film. If the disc fits snugly in the neck of the glass bulb the cut-off is sharp, requiring no additional treatment.

During the operation the cooling coils are in the position shown in Figure 1 and any suitable cooling fluid such as air, water, or refrigerating liquid is caused to flow therethrough, protecting the apparatus and particularly the stopper against destruction. The cooling coil also keeps the electrodes and the glass vessel from getting excessively hot during processing. It is important to note that the effectiveness of this process is increased by a rapid condensation of the metal vapor on the glass vessel. For this reason it is, of course, desirable to keep the apparatus itself as cool as possible.

The entire coating has been indicated generally at 49 and is shown more specifically at 47. The reference numeral 22 indicates the line of cut-off of the coating at the edge of the upper disc 20. The region indicated at 51 is a desirable position for the vaporizing unit to insure direct exposure of the inner walls to the vaporized metal and a quick deposit thereof on them. However, the high frequency coil and crucible may be moved to any preferred suitable position to produce the required deposit of the mirror metal vaporized therefrom in any preferred portion of the glass bulb envelope.

The vapor condenses quickly and the cooling coil sections are swung outwardly so that the bulb may be removed from the stopper. The dash line 91 indicates the substantial meridian of the bulbous portion and represents the line of cut-off in forming either a directly reflecting bulb or an indirectly reflecting bulb. If a directly reflecting bulb is desired a suitable acid solution such as a nitric acid solution is placed in the bulb while it is held vertical until its level is about at the line 91. This removes the deposit over the area 93 and the acid solution is then removed with a suitable tube. If an indirectly reflecting bulb is desired it is dipped neck down vertically into a bath of nitric acid until submerged to the line 91. This removes the film indicated by reference numeral 95, leaving only the end coated. The line of cut-off is sharp and requires no further treatment. After such acid solution treatment and metallic film removal, the bulb is washed in an ammonium hydroxide solution to counteract the effects of the acid solution and then rinsed in distilled water.

The thickness of the metal film deposited on the glass may, of course, be controlled by varying the amount of metal placed in the crucible. In some cases it may be desirable to build up the film by the application of successive layers which may easily be done by repeating the vaporization step. In some cases it has been found desirable to apply several layers each of a different metal. For example, because of the fact that chromium adheres closely to the glass, even if it has not been thoroughly cleaned, it is sometimes desirable to first deposit a film of chromium followed by the deposit thereon of a film of silver or aluminum.

In some cases it may be desirable to apply a protecting coating over the metal film which may be done, for example, by placing a small quantity of quartz in the crucible and vaporizing it so that

it is deposited on the metal film. This protects the film against scratching, tarnishing, or other damage without seriously interfering with its light reflecting properties.

For ordinary light reflecting purposes, it is desirable to keep the metal film as thin as possible because a higher lustre and polish results. This arises from the fact that in thicker coatings the crystalline structure becomes coarser forming a duller and less reflective film. A film that is just opaque to sunlight seems most efficient as a reflector. Such a film has a thickness of the order 1000 A.

Those skilled in the art will readily appreciate that the details of the apparatus disclosed and the method of procedure may be readily varied without departure from the novel and true scope of this invention. I do not, therefore, desire to be strictly limited to the disclosure as given for the purposes of illustration, but rather to the scope of the appended claims.

What I seek to secure by Letters Patent is:

1. Method of applying a metallic film of high lustre to a glass surface, which comprises cleaning said surface successively with ammonium bifluoride, and stannous chloride, rinsing said surface after each application of cleaning solution, drying said surface, placing a crucible of a metal selected from the group consisting of silver, aluminum, magnesium, chromium and alloys thereof in proximity to said surface, subjecting said surface and crucible to a substantial vacuum, heating said surface to a temperature equal to the annealing temperature of said glass surface, subjecting the crucible and its contents to a high frequency field to vaporize the metal and deposit the vapor in a film on the adjacent glass surface, and subsequently vaporizing a charge of quartz in said crucible to deposit a protective coating over the metal film.

2. Method of applying a metallic film of high lustre to a glass surface, which comprises cleaning said surface, drying said surface, placing a crucible of metal selected from the group consisting of silver, aluminum, magnesium, chromium and alloys thereof in proximity to said surface, subjecting said surface and said crucible to a substantial vacuum, heating said surface to approximately the annealing temperature of said glass surface, and creating a high frequency field about the crucible to vaporize the metal and deposit the same in a film on the adjacent surface while maintained approximately at its annealing temperature.

3. A method of forming a metal film on a glass bulb, which comprises creating a vacuum within the bulb, heating the bulb to substantially the annealing temperature of the glass, vaporizing the film metal within the bulb whereby it condenses on the wall thereof while so heated, and limiting the area whereon condensation may take place.

4. A method of forming a high lustre metal film on the inner wall of a glass bulb, which comprises thoroughly cleaning the glass bulb to remove dirt and grease therefrom, positioning a quantity of the film metal within the bulb, heating the bulb to substantially the annealing temperature of the glass, and vaporizing the film metal so that it deposits on the inner wall of the bulb while maintaining the bulb heated to its annealing temperature.

5. A method of forming a high lustre metal film on the inner wall of a glass bulb, which comprises thoroughly cleaning the glass bulb to remove dirt and grease therefrom, positioning a quantity of the film metal within the bulb, heating the bulb to substantially the annealing temperature of the glass, evacuating the bulb, and vaporizing the film metal while maintaining the bulb heated to the annealing temperature and maintaining the vacuum in and the annealing temperature of the bulb during vaporization of the film metal.

6. A method of producing a multiple metal film on the inner wall of a glass bulb, which comprises cleaning the inner wall of the bulb, positioning quantities of the metals to form the film within the bulb, creating a vacuum in the bulb, heating the bulb to and maintaining it at substantially annealing temperature and successively vaporizing the film metals so that they are successively deposited on the bulb.

7. A method of applying a metal film to the interior of a lamp bulb mounted on a sealing member with its neck downward comprising maintaining the bulb at approximately its annealing temperature, evacuating the bulb, subjecting a quantity of the film metal to a high frequency field to vaporize it, and cooling the neck of the bulb in the region of the sealing member while vaporizing the metal.

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