March 30, 1948. W. K. KEARSLEY 2,438,561

ELECTROTHERMAL DEPOSITION APPARATUS

Filed April 30, 1942

Fig. 1.

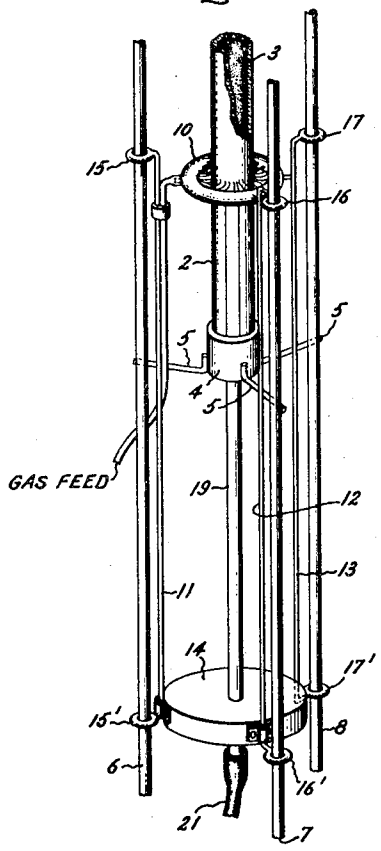


Fig. 2.

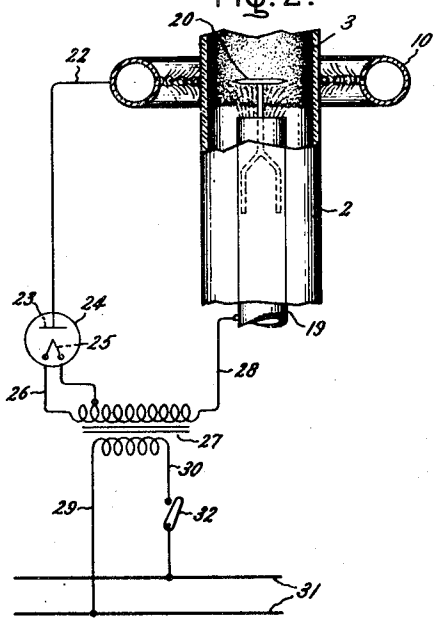


Fig. 3.

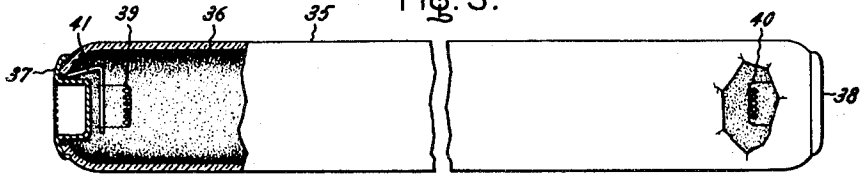
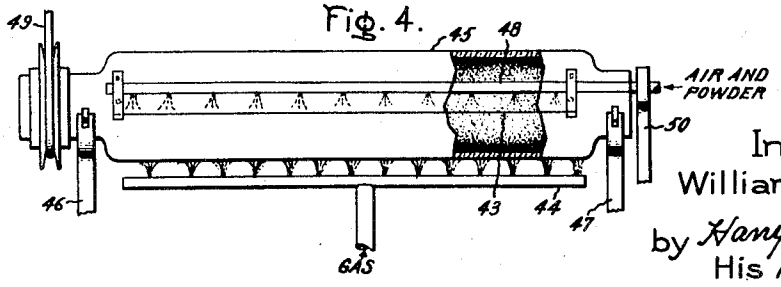


Fig. 4.



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ELECTROTHERMAL DEPOSITION APPARATUS

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4 Claims. (Cl. 91—18)

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The present invention relates to the coating of finely divided material on normally non-conductive surfaces, such, for example, as the interior surfaces of glass tubes and bulbs.

My invention includes an improved apparatus and is particularly applicable to the deposition of powdered phosphor or powdered special glass on the interior of tubes or bulbs in the fabrication of electric lamps.

While it has been suggested heretofore to electrically deposit a powder on the interior of bulbs, I have provided various features of improvement which render such deposition of powder more convenient and better adapted for commercial utilization.

One of the novel features of my invention is the provision of a unidirectional high voltage field in place of high frequency field heretofore suggested; another feature is the provision of means for causing the foundation surface which is to receive the coating to become conductive by heating. Other features of my invention, as for example the feature of deposition on a localized band-like zone and the progressive longitudinal movement of the zone of deposition, will be described hereinafter and pointed out in the appended claims.

In the accompanying drawing Fig. 1 is a side elevation of an apparatus for carrying out my invention; Fig. 2 is a more detailed view including electric connections; Fig. 3 shows a fluorescent lamp as illustrative of devices for the fabrication of which my invention is applicable; and Fig. 4 illustrates a modification in side elevation, the envelope wall being in part broken away.

The apparatus illustrated in Fig. 1 includes a supporting framework on which the work to be coated and the cooperating electrodes are mounted. The work here is shown as a tube 2, which is illustrated as being partly broken away so as to show an internal coating 3. The tube is held vertically in a socket 4 which is mounted on horizontal supports 5. These supports may be attached conveniently to the vertical rods 6, 7 and 8.

Surrounding the tube 2 is a combination heater and electrode constituted by a ring gas burner 10. This heater and electrode member is mounted on a frame consisting of vertical rods 11, 12 and 13 fixedly mounted on a plate 14 as illustrated. The plate 14 may consist of suitable electrically insulating material, such for example as a phenolic resin, hard rubber, etc. As indicated, the ends of the rods 11, 12 and 13 terminate in two sets of rings 15, 16 and 17 and 15', 16' and

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17' which slide on the rods 6, 7 and 8. Passing through, and fixedly connected with the plate 14, is a metal tube 19, the upper end of which enters the tube 2.

As shown in Fig. 2, the orifice of the tube 19 is provided with a deflector plate 20 which has a sharp edge. A stream of air, or other gas, enters the tube 19 at the bottom, to which is connected a flexible conduit link 21. This stream carries with it, as a fine powder or dust, material which it is desired to deposit on the interior surface of the tube 2, for example a powdered fluorescent material.

Any desired source of unidirectional high potential may be employed, a suitable source being illustrated. The burner 10 is connected by a conductor 22 to the anode 23 of a rectifier 24, although the polarity of connections may be reversed. This rectifier may be of the thermionic cathode vacuum type. The cathode 25 is connected to a heating circuit 26 constituted by the end turns of a secondary winding of a step-up transformer 27. The tubular electrode 19 is connected by a conductor 28 to the opposite terminal of the transformer. The primary circuit of the transformer receives energy through conductors 29 and 30 from any convenient source of alternating current, as represented by the mains 31. When the switch 32 is closed, high potential unidirectional current is impressed upon the electrodes 10 and 19.

The ring burner 10 heats the glass or other normally non-conductive material constituting the tube 2 to an elevated temperature at which the material of such tube becomes sufficiently conductive to carry a low wattage, high potential current, thus setting up a corona discharge between the sharp-edged deflector plate 20 and the inner wall of tube 2. The gas flames provide an ionized path of low resistance between the ring burner and the outer wall of the glass tube. The particles of finely divided material become electrically charged upon their egress from the tube 19 and are attracted to the opposite electrode 10 and are deposited as an adhering layer or coating upon the surface of the glass. By moving the cooperating electrodes 10 and 20 longitudinally with respect to the tubular container 2, the deposition may be caused to spread the entire length of the container if so desired.

The temperature to which the glass should be heated for best results and the voltage required to efficiently cause deposition will vary with the kind of glass used, and can readily be determined by observation of the results. Ordinarily a tem-

perature well below the softening point of the glass, for example 300° C., is sufficient to obtain the desired conductivity. The heating of the glass appears to promote the adherence of the deposited particles to the glass. The applied voltage ordinarily may vary within a range of about 5000 to 10,000 volts or more, depending upon the nature of the glass, its temperature, and the diameter of the glass tube.

In Fig. 3 is shown a finished fluorescent lamp, to the fabrication of which my invention is applicable. The interior surface of the tubular envelope 35 of this lamp is provided, as indicated by the stippling, with a coating 36 of desired fluorescent material, such as zinc silicate, zinc-beryllium silicate, calcium tungstate, cadmium borate or the like. The ends of the tube are sealed by plates 37, 38. Thermionic cathodes 39, 40 are mounted at opposite ends upon suitable supports, one of which is indicated at 41. As well known, the gaseous current-carrying medium of such a lamp may consist of a rare gas, such as argon, at a pressure of several millimeters and a small quantity of mercury vapor.

My invention also is applicable to the coating of interior surfaces of glass bulbs with other finely divided, non-conducting material. For example, in the manufacture of sodium lamps it is desired to coat the interior of the glass container with a special glass which is non-reactive with respect to a hot sodium vapor. Such a glass is described in Reynolds United States Patent 2,030,397, patented February 11, 1936. Such a glass in finely divided state may be applied in a layer of desired thickness upon the interior of a tube which is to serve as the sodium-containing envelope of a sodium lamp as shown in said Reynolds patent. In fact, any form of finely divided material thus may be applied, including also for example a powder intended to render a glass container light-diffusing by providing a matte surface.

In the modification shown in Fig. 4, the cooperating electrodes 43 and 44 extend longitudinally, respectively, inside and outside of a container 45 which is rotatably supported on bearings 46 and 47. When the container is rotated on its longitudinal axis, the deposition is circumferentially spaced over the entire inner surface. The electrode 43 consists of a relatively fine metal wire which is supported on a frame 48. This frame may be a hollow tube for supplying the powder to be deposited. The powder may be introduced in suspension in a stream of air as indicated. The electrode 44 is a longitudinally extending gas burner which is provided with a plurality of gas orifices as indicated. The discharge occurs between these electrodes through the flaming gas, the heated wall of the glass container and the air carrying the powder in suspension. A corona discharge readily occurs from a fine wire. Means for rotating the glass container is represented by the pulley 49 although other convenient means may be employed. When the deposition has been completed, the inner electrode 43 is withdrawn from the coated tube by any suitable means here merely indicated by the support 50.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electrodeposition apparatus comprising the combination of a framework for supporting a tubular container, a heater encircling and spaced away from said container, said heater serving also as an electrode, a cooperating electrode within said container, means for supplying finely divided material to the space within said container, and means for impressing upon said electrodes a unidirectional potential of sufficiently high voltage to cause deposition of said material upon the interior wall of said container.

2. Apparatus for depositing finely divided material on the internal surface of an elongated hollow container comprising means for supporting the container, a source of unidirectional high potential, a gas burner for heating a zone of the wall of said container, said burner being connected to one side of said source of potential, a conduit located to be in axial alignment with the container on said supporting means for introducing a cloud of the finely divided material into the interior of the container, said conduit carrying a disc-shaped electrode member located across and spaced from the mouth of said conduit and electrically connected to the opposite side of said source of potential, the container-supporting means and the conduit being arranged for relative longitudinal movement between the container and the conduit to cause progressive deposition of the finely divided material along the length of the container, and means to cause relative movement between the burner and container to heat the entire container.

3. An apparatus for depositing finely divided material on the internal surface of a tubular glass container comprising means for supporting the container, a heater encircling and spaced away from said container, said heater functioning also as an electrode, a cooperating internal electrode comprising a conduit for supplying material to be deposited into the container, means for moving said heater electrode and conduit electrode in cooperative relation longitudinally with respect to said container, and means for impressing upon said electrodes a unidirectional potential of sufficiently high voltage to cause deposition of said material upon the inner wall of said container.

4. An electrodeposition apparatus comprising the combination of means for supporting a tubular container, a heater encircling and spaced away from said container, said heater serving also as an electrode, a cooperating electrode within said container, means mounting said electrodes for movement in cooperative relation longitudinally of said container, means for supplying finely divided material to the space within said container, and means for impressing upon said electrodes a unidirectional potential of sufficiently high voltage to cause deposition of said material upon the inner wall of said container.

WILLIAM K. KEARSLEY.

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