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ELECTRIC INCANDESCENT LAMP AND METHOD OF MANUFACTURE

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FIG. 1.

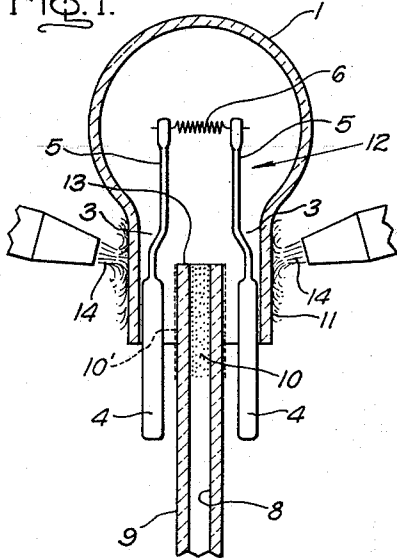


FIG. 2.

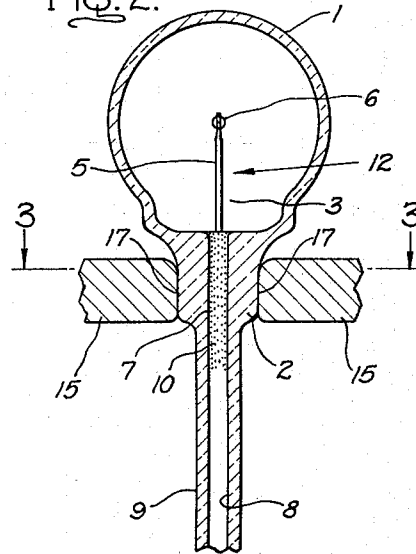


FIG. 4.

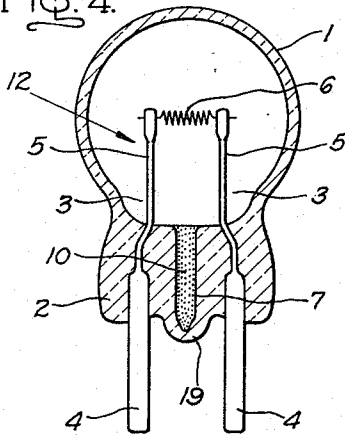
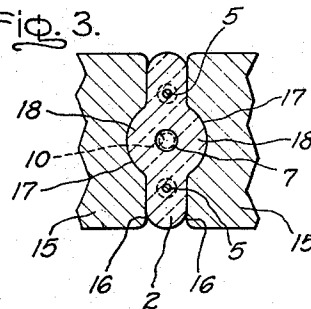


FIG. 3.



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ELECTRIC INCANDESCENT LAMP AND METHOD OF MANUFACTURE

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Application November 28, 1955, Serial No. 549,424

8 Claims. (Cl. 313—318)

Our invention relates to electric lamps or similar devices and to a method of manufacture thereof. The invention is of particular utility in connection with the manufacture of electric lamps of the type having an external stem press through which the lead-in wires of the lamp are sealed.

Electric lamps and other similar type devices commonly consist of an enclosing envelope or bulb having a glass stem press portion through which the lead-in wires of the lamp extend and are sealed. These glass stem press portions are usually provided with an exhaust passageway extending therethrough which communicates with the interior of the envelope and through which the envelope is subsequently exhausted and, if desired, filled with a suitable inert gas at a suitable pressure.

The glass press portions are generally formed by the fusion of a glass exhaust tube to a surrounding tubular glass body such as a stem tube or the tubular neck portion of a lamp bulb. The lead-in wires are positioned and held in place between the two glass tubes, during the interfusion thereof, and the heated and softened glass is compressed by the closure of opposed jaws thereagainst to form a press portion through which the lead-in wires extend and are hermetically sealed. This compression of the softened glass tubes, however, to form the stem press normally results in the closure of the passageway through the exhaust tube, a condition which of course would prevent subsequent evacuation of the lamp envelope or bulb. For such reason it is necessary, during the press-forming operation, to adopt additional procedures or steps which will insure the provision of an exhaust passageway through the completed stem press. In the usual case where the stem press is located internally of the lamp envelope or bulb, the exhaust passageway through the stem press is customarily produced by blowing a hole through the side of the pressed portion while the glass thereof is still in a heated and plastic state, the blow-out being accomplished by the force of a blast of compressed air introduced into the open outer end of the exhaust tube. This is the method which is disclosed in Mitchell and White Patent 1,423,956 and is the standard procedure employed in the manufacture of conventional type incandescent lamps having internal stem presses. However, such a procedure cannot be employed where the stem press is located externally of the bulb as, for example, in the case of the miniature bi-pin incandescent lamp recently introduced on the market by applicants' assignee and commercially designated as their No. 10 lamp. In such case, a side-opening exhaust passageway through the stem press would open to the outside atmosphere only, instead of into the interior of the lamp envelope or bulb. As a result, there would be no exhaust passageway through the stem press leading into the interior of the envelope through which the envelope could then be exhausted.

For such reason, other procedures have been proposed and followed, in the case of lamps having external stem presses, to insure the provision of an exhaust passageway

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through the stem press communicating with the interior of the lamp envelope. Heretofore, such procedures have generally involved either the insertion of metal sleeves, helical springs or other similar liners in the exhaust tube, or the temporary introduction of a mandrel into the exhaust tube during the press-forming operation, for the purpose of maintaining the opening through the exhaust tube. However, these prior procedures for various reasons have not been entirely satisfactory. The use of metal sleeves or bushings, for instance, in the exhaust tube, besides being rather expensive, also introduces strains into the glass stem press which frequently result in the cracking of the press, thus causing an undesirably high percentage of manufacturing rejects or so-called shrinkage. Likewise, the temporary insertion of a mandrel into the exhaust tube during the press-forming operation frequently results in the sticking of the plastic glass to the mandrel and consequent breakage of the glass press when the mandrel is subsequently withdrawn from the exhaust tube. It has also been proposed, in the manufacture of vacuum or radio tubes, to employ a liner for the inner wall of the exhaust tube in the form of a graphite coating thereon. Such a material, however, is wholly unsuitable for use in tungsten filament incandescent lamps because of its deleterious effect on the lamp, the graphite reacting with the tungsten of the filament at the incandescent operating temperature thereof and causing embrittlement of the tungsten filament such as results in greatly foreshortened lamp life.

It is one object of our invention, therefore, to provide an electric incandescent lamp of novel and simple construction and which is relatively easy and inexpensive to manufacture.

Another object of our invention is to provide an electric incandescent lamp or similar device of the type having a stem press provided with an exhaust tube sealed therein and affording an exhaust passageway therethrough, and which can be readily manufactured with a commercially acceptable minimum percentage of production rejects due to cracked stem presses.

Still another object of our invention is to provide an electric incandescent lamp or similar device having an exhaust tube passageway therethrough maintained open, during the formation of the press, by means in said passageway which will not introduce internal strains into the stem press and which will not deleteriously affect the operation of the lamp.

A further object of our invention is to provide an electric lamp or similar device having a stem press provided with an exhaust tube which is sealed therein and which is provided with an internal coating of a material which not only will maintain the exhaust tube passageway open during the formation of the stem press but which also will produce a bright and distinctive colored glow within the lamp envelope under high-frequency glow testing of the lamp.

Another object of our invention is to provide an electric incandescent lamp or similar device having an external stem press protruding from the lamp envelope and provided with an exhaust tube sealed therein and provided with means for maintaining the passageway through the exhaust tube open during the formation of the stem press, the said means being chemically inert with respect to the lamp filament at the operating temperature thereof and being of a character which will not produce internal strains in the glass stem press such as to cause the cracking thereof.

A still further object of our invention is to provide a novel and inexpensive method of manufacturing an electric incandescent lamp.

Briefly stated, in accordance with one aspect of our invention, an electric incandescent lamp or similar device

is constructed with a glass stem press having an exhaust passageway extending therethrough and maintained open, during the press-forming operation, by a coating on the wall of the exhaust passageway of a material having a melting point above that of the glass and chemically inert with respect to the filament at the incandescent operating temperature thereof. According to a further aspect of the invention, the coating material employed for the above mentioned purpose is one which, under the conventional high-frequency glow test to which vacuum type electric incandescent lamps or similar devices are subjected in order to indicate the degree of vacuum in the device, will produce a bright and highly concentrated glow or spot of light such as enables the ready and easy detection thereof and determination of the character of the vacuum in the device by the test operator.

Further objects and advantages of our invention will appear from the following detailed description of species thereof and from the accompanying drawing.

In the drawing, Fig. 1 is an elevational view partly in section showing the component parts employed in the manufacture of an electric incandescent lamp according to the invention, the component parts being shown in assembled position in readiness for sealing the lamp mount into the lamp bulb and forming the glass stem press portion thereof.

Fig. 2 is a sectional view similar to Fig. 1 and showing the compression of the bulb neck to form the stem press of the lamp;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2, and

Fig. 4 is an elevation, partly in section, of a completed electric incandescent lamp comprising our invention.

Referring to the drawing, the invention is there shown as embodied in an electric incandescent lamp of the type having an external stem press, such as the miniature bipin lamp recently introduced on the market by applicants' assignee and known as their No. 10 lamp. It should be understood, however, that the invention is applicable as well to other types of electric incandescent lamps and similar devices such as those having re-entrant stems provided with stem press portions located within the envelope of the device.

As shown in Fig. 4, the particular electric incandescent lamp there illustrated comprises a sealed glass bulb or envelope 1 provided with an outwardly protruding pinched seal or press portion 2 through which a plurality (two in the particular case shown) of lead-in conductors 3, 3 are sealed so as to extend parallel to each other in side-by-side relation. The lead-in conductors 3, 3 are of the multi-section pin type such as are commonly employed in miniature radio tubes and comprising rigid metal outer pin portions 4 and inner lead portions 5 which are hermetically sealed in the envelope press 2, the two sections 4 and 5 of each conductor being butt-welded together in end-to-end relation. The outer pin portions 4 may be made, for example, of nickel wire having a diameter for instance of $\frac{1}{32}$ inch. The inner lead portions 5 may be made of conventional "Dumet" wire commonly employed in the lamp making art for sealing into glass. The metal outer pins 4 serve as terminal contacts for the lamp and for such purpose are embedded at their inner ends in the glass of the press 2 in order to firmly anchor or support the pins in place from the press. The inner leads 5 are connected to an electrical energy translation element such as a filament 6 comprised, for example, of a wire of tungsten or other suitable refractory metal in coiled or coiled-coil or any other suitable form. The envelope 1 is evacuated to the degree customary for conventional vacuum type incandescent lamps. The press portion 2 of the lamp envelope 1 is provided with an exhaust passageway 7 which extends through the press 2 at a point between the two conductors 3, 3 and which serves as a means for evacuating the lamp envelope 1.

In accordance with the invention, the exhaust passageway 7 is constituted by the bore 8 of a glass exhaust tube

9 which is sealed in the stem press 2 and the bore of which is maintained open during the press-forming operation. To this end, the end portion of the exhaust tube which is fusion-sealed into the stem press 2 is provided with a firmly adherent coating 10 of a suitable inorganic material which has a melting point above that of the glass of which the stem press is constituted and which is chemically inert with respect to the lamp filament 6 at the incandescent operating temperature thereof, the said material acting to raise the melting point of the glass underlying the coating during the press-forming operation. Alternatively, the coating 10 may be of a material which, when subjected to the heat attending the press-forming operation, will be transformed into an inorganic material having the above-stated properties. Since the glass lamp parts (i.e., the exhaust tube and the bulb or stem tube) from which the stem presses of electric lamps are fabricated, are customarily made of so-called "soft" type glasses having a melting point of around 650° C., the coating material 10 in such case should be one having a melting point above 650° C. The coating material 10 should also be one which is both physically and chemically stable at temperatures up to at least the temperature (for example at least 700° C.) which the glass exhaust tube 9 will attain during the tipping-off thereof, otherwise contamination of lamps will occur from the gases or other contaminating impurities introduced in the lamp envelope by unstable coating materials. While the coating 10 is preferably applied on the internal wall of the exhaust tube 9 as shown, it may be applied instead on the external wall thereof as shown in dotted lines at 10' in Fig. 1 or it may be applied on both the inside and outside walls of the exhaust tube. The coating 10 or 10' is applied to the exhaust tube 9 prior to the press-forming operation. During the heating and interfusion of the end of the exhaust tube 9 and the surrounding neck 11 of the lamp bulb 1 to form the stem press 2, the coating 10 on the exhaust tube acts to maintain the bore of the exhaust tube open so as to leave an exhaust passageway 7 through the stem press. While the exact manner in which the coating 10 acts to accomplish this object is not known, it is believed that the coating acts either to raise the melting point of the glass of the exhaust tube so that it is at a temperature below that at which it is appreciably plastic, or to raise the surface tension of the glass so that the coated surfaces of the exhaust tube do not "wet" together and close off the bore of the exhaust tube.

There are a number of materials which may be satisfactorily employed as coating materials 10 for the purposes of the invention. Thus, the coating 10 on the exhaust tube 9 may consist of aluminum or silver, or the oxides of aluminum, silver, zirconium, magnesium, titanium, zinc, tin, calcium, barium and strontium, or refractory materials such as silicates, double silicates and titanates. It is preferable to employ coating materials 10 such as those specified above which are light or white in color not only because of their better appearance and the ease of discerning whether lamp-contaminating impurities are present in the coating 10 but primarily because of the greater heat-reflectivity characteristic of such light-colored coatings 10 which therefore minimizes or lessens the softening and likelihood of closing of the glass exhaust tube during the press-forming operation. As a result, considerably greater latitude in the degree of heating of the glass parts, during the press-forming operation, is afforded by the use of such light or white-colored coatings 10, as compared to dark colored coatings, without encountering closure of the exhaust tube. This means that considerably greater freedom is permitted in the setting of the gas fires which are ordinarily used to melt and fuse the glass parts. This comparatively wide range of permissible gas fire settings therefore renders the stem press making process according to the

invention commercially practical for high speed production manufacture since it results in a very low percentage (2% or less) of production rejects due to closed exhaust tubes.

Of the various coating materials 10 which have been found satisfactory for the purposes of the invention, the oxide and silicates (both single and double) of zirconium are preferred for the reason that they perform the additional function of producing a bright and distinctive colored glow within the lamp envelope 1 during the customary high-frequency glow testing of the lamp for the determination of the degree of vacuum in the lamp envelope. This glow of light, which appears as a green column of light within the exhaust passageway 7, is of particular utility in the case of lamps having envelopes or bulbs 1 of low light transmissivity such as where the bulbs are provided with enamel or other coatings. In such case, the color of the glow discharge ordinarily is not discernible in the absence of zirconium oxide or zirconium silicate coating material within the exhaust passageway 7. However, because of its brightness, the green glow of light produced by a zirconium oxide or zirconium silicate coating 10 within the exhaust passageway 7, during the high-frequency glow testing of the lamp still can be observed through a lamp bulb of low light transmissivity. Moreover, even in the case of devices having bulbs which are completely opaque except for a protruding external stem press, the bright green glow of light produced within the exhaust passageway 7 of the stem press by a zirconium oxide or silicate coating 10 therein, during high-frequency glow testing of the device, nevertheless is still readily observable through the protruding stem press. Of the zirconium-containing glow-producing materials which are suitable as coating materials 10, however, zirconium oxide is preferred because it produces the brightest light glow on high-frequency glow testing of the lamp.

From the standpoint of their relative effectiveness in maintaining the exhaust tube open during the press-forming operation, magnesium oxide and the oxide and silicates of zirconium have been found to be the most effective for such purpose. Thus, the use of such materials as the coating 10 on the exhaust tube 9 in the production manufacture of incandescent lamps has been found to produce less than 1/2 percent of production rejects due to closed exhaust tubes 9.

Where the coating 10 on the exhaust tube 9 consists of an oxide or a refractory material, it is preferably applied thereto as a powder coating. The powdered material is suspended in a suitable vehicle to form a slurry of suitable viscosity which, for the application of a coating to the inside wall of the exhaust tube, is drawn into the exhaust tube the desired distance from the end thereof and then allowed to flow out of the exhaust tube so as to deposit a coating of the slurry on the inside wall of the exhaust tube. The vehicle employed for suspending the powdered coating material may be of any suitable character. For example, where the coating material consists of magnesium oxide, the suspending vehicle may consist of a suitable denatured alcohol such as that commercially known as Synosol. The proportion of magnesium oxide to alcohol is not critical. Thus, 100 to 250 grams of magnesium oxide per 1000 ml. of alcohol will give satisfactory coatings. To reduce and delay the thickening of this slurry, a small amount of acetic acid may be added to the suspension in the range of, for example, a few drops to one or two ml. per 100 ml. of suspension. Further improvement in this respect is obtained by the addition of a small amount of a suitable sequestering agent such as ethylene diamine tetraacetic acid (commonly known as EDTA) for sequestering the free ions present in the suspension and rendering them inactive. Thus, an addition of from 1/2 to 1 ml. of a 5% solution of ammonium salt of EDTA to 100 ml. of the suspension has been found satisfactory for this purpose. To improve the

adherence of the powdered magnesium oxide coating to the wall of the exhaust tube, and at the same time improve the uniformity of the coatings on the exhaust tubes, a small amount of a suitable binding agent such as ethyl borate may also be added to the suspension. Thus, from 1 to 5 ml. of ethyl borate per 100 ml. of the magnesium oxide suspension will afford the above mentioned improvement.

Where the coating material 10 consists of zirconium oxide, the suspending vehicle used to form the zirconium oxide coating suspension preferably comprises water and a small addition of a suitable binder such as polymerized (i.e., a copolymer of) vinyl methyl ether and maleic anhydride, commonly known as PVM/MA. While other vehicles may be used for suspending powdered zirconium oxide, water is advantageous for such purpose because of its non-explosive and non-toxic character and its relative inexpensiveness. The polymerized vinyl methyl ether and maleic anhydride is used to increase the viscosity of the zirconium oxide slurry, to improve the suspension of the zirconium oxide particles (it acts partially as a dispersing agent), and to give good and consistent coatings on the exhaust tubes. Preferably, in addition, small amounts of ammonium hydroxide and boric oxide are also incorporated in the zirconium oxide slurry. The ammonium hydroxide addition is employed to control the pH of the slurry and thus control its viscosity. The boric oxide addition to the suspension is employed as a fusing or sintering agent to obtain improved adherence of the zirconium oxide powder particles to the wall of the exhaust tube after the binder is burned off. Without boric oxide in the zirconium oxide coating slurry, the zirconium oxide tends to flake off the wall of the exhaust passageway 7 in the press 2 of the finished lamp. While loose zirconium oxide powder in the lamp envelope 1 is not detrimental to lamp quality, nevertheless the presence of such loose powder within the lamp envelope is more or less undesirable from an appearance standpoint.

The application of the coating of slurry to the wall of the exhaust tube 9 is preferably accomplished by positioning the end of the exhaust tube to be coated so as to touch the surface of a supply of the coating slurry. Capillary action then draws the slurry up into the exhaust tube. The height to which the column of slurry rises in the exhaust tube ordinarily is quite variable. However, by adding a small amount of ethyl borate to the slurry, for example, 10 ml. of ethyl borate per 300 grams of slurry, the height of the slurry rise in the exhaust tubes becomes much more uniform.

As a specific example, a suitable zirconium oxide slurry for application to the walls of exhaust tubes 9 may be prepared by milling for an extended period, preferably from 24 to 48 hours or so, a mixture of the following general composition:

Zirconium oxide	grams	1200
Water	ml.	800
Polymerized vinyl methyl ether and maleic anhydride (10%)	ml.	40
Ammonium hydroxide	ml.	40
Boric oxide	ml.	18

After milling of the above ingredients, the milled suspension is washed out of the milling container with 400 ml. of water containing 4 ml. of a suitable wetting agent such as that commercially known as IGEPA 530, which is a polyoxyethylated nonylphenol of such ethylene oxide to nonylphenol balance as to give medium hydrophobic qualities. It is a surface-modifying agent used to give coatings free of pin holes and other coating defects, and it is manufactured by the Antara Chemical Division of the General Aniline and Film Corporation. The resulting milled zirconium oxide slurry has excellent keeping properties. For example, even after an extended period of three months or so it does not exhibit any deterioration or gelling. Shortly before use of this zirconium

oxide slurry to coat exhaust tubes (preferably not more than 12 hours or so before use), 10 ml. of ethyl borate is added to each 300 grams of the slurry. This ethyl borate addition improves the coating characteristics of the slurry when applied to the exhaust tubes. Inasmuch as the keeping quality of the coating slurry after the addition of ethyl borate is relatively poor, the slurry with the ethyl borate addition should be used within a relatively short period of not more than 24 hours or so.

After the application of the slurry coating to the wall of the exhaust tube 9, the latter is then heated to a temperature sufficiently high, and for a period of time long enough to dry, and burn out the binder in the coating on the exhaust tube and to partially sinter or bind the powder particles of the coating onto the wall of the exhaust tube. To this end, the exhaust tube is heated to a temperature just below the point at which it will soften and distort. For example, in the case of the soft lead or lime glasses which are ordinarily used for exhaust tubes and having a melting point of around 650° C., the exhaust tube should be heated to a temperature of the order of 600 to 650° C. at which temperature the binder will be burned out of the slurry coating on the exhaust tube and the powder particles of the coating will be set onto the wall of the tube. A uniform and firmly adherent powder coating is thereby produced on the wall of the exhaust tube which will not flake off during the handling of the exhaust tube and during the formation of the stem press and after the lamp has been completed.

In the manufacture of the lamp or other device according to the invention, a glass exhaust tube 9 having a coating 10 thereon, a mount structure 12 and a glass envelope or bulb 1 are first positioned in proper sealing relation to each other (as illustrated in Fig. 1) in one of the sealing heads (not shown) of a conventional type lamp sealing-in machine such as commonly employed in the lamp-making art. As shown, the mount 12 comprises a pair of lead-in conductors 3 and the filament 6 which is connected at its ends across the tips of the inner lead portions 5 of the lead-in conductors 3. The bulb 1 is supported with its neck end 11 down, and the mount 12 is supported in a vertical position with the heavy end or pin portions 4 of the conductors 3 down and extending part way into the bulb neck 11 and with the filament 6 located within the bulbous portion of the bulb. The glass exhaust tube 9 is supported in a vertically extending position with its coated end 13 uppermost and located within the bulb neck 11 in a position between the two conductors 3.

With the exhaust tube 9, mount 12 and bulb 1 thus supported in place in the sealing head of the sealing machine in position for sealing, the neck 11 of the bulb is suitably heated as by gas fires 14 directed against opposite sides of the bulb neck, as shown in Fig. 1. Upon softening of the glass of the bulb neck, it gathers together and contracts against the upper coated end 13 of the exhaust tube 9 which is therefore heated and softened by radiation and conduction of heat from the hot glass of the bulb neck. The heating of the bulb neck 11 by the gas fires is so controlled as to maintain the temperature of the coated end of the exhaust tube below the temperature at which it becomes appreciably plastic, the coating 10 on the exhaust tube assisting in maintaining this temperature control. The heating is continued until the softened glass of the bulb neck 11 and exhaust tube 9 becomes thoroughly interfused, whereupon the gas fires 14 are removed and, as shown in Figs. 2 and 3, the molten glass of the bulb neck then pinched, as by means of pinching jaws 15 to press the glass completely around the inner lead portions 5 of the conductors 3 as well as around the inner or upper end portions of the pin ends 4 of the conductors 3 and into intimate contact with the glass of the exhaust tube so as to form a solid mass of glass embedding the conductors 3 and constituting a press 2.

During the fusion operation, as well as the subsequent pinching operation, the coating 10 on the wall of the exhaust tube 9 effectively prevents collapsing of the exhaust tube within the press 2 and resultant closing of the bore 8 of the exhaust tube. However, to fully insure against closure of the bore 8 through the exhaust tube 9 by the pressure of the pinching jaws 15 during the pinching operation, the pinching faces 16 of the said jaws are suitably relieved as by being provided with vertically extending semi-cylindrical shaped recesses 17 which, when the jaws are in their fully closed position, are more or less concentric with the exhaust tube 9, as shown in Fig. 3, and leave corresponding semi-cylindrical shaped enlargements 18 in the completed press 2 on each of its opposite sides.

After the pinching of the molten glass of the bulb neck 11 and exhaust tube 9 to form the press 2 of the lamp, the pinching jaws 15 are removed or opened and gas fires then directed once more against the pressed glass 2 first to further interfuse and work the glass thereof and then to anneal the glass so as to remove any strains developed therein during the pinching operation, the coating 10 on the wall of the exhaust passageway 7 meanwhile continuing to perform its function of maintaining the exhaust passageway open through the stem press 2.

Upon completion of the sealing operation as above described, the lamp envelope 1 is evacuated to the desired degree of vacuum through the exhaust tube 9 and through the exhaust passageway 7 in the stem press 2, after which the projecting exhaust tube is then tipped off as closely as possible to, and preferably at the very junction with the press 2, as shown at 19 in Fig. 4, to thereby hermetically seal the lamp envelope. The tipping-off of the exhaust tube 9 may be accomplished in the conventional manner by directing sharp gas fires against opposite sides of the exhaust tube at a point immediately adjacent the stem press 2, the glass wall of the exhaust tube collapsing upon softening and forming a tip 19 closing off the exhaust passageway 7. Because of the physically and chemically stable character of the coating material 10 within the exhaust tube at the temperature to which it is subjected during this tipping-off operation, no contaminating impurities are formed by the coating material and introduced into the lamp envelope 1 during the tipping-off operation such as to cause contamination of the lamp and adversely affect the operation thereof.

Although a preferred embodiment of our invention has been disclosed it will be understood that the invention is not to be limited to the specific construction and arrangement of parts shown, but that they may be widely modified within the spirit and scope of our invention as defined by the appended claims.

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

1. An electrical device comprising a sealed glass envelope having a press portion, an incandescible tungsten filament within said envelope, lead-in conductors sealed through said press portion and connected to said filament, an exhaust passageway extending through said press portion and communicating with the interior of said envelope, said press portion having a tipped-off residue of a glass exhaust tube hermetically closing off said exhaust passageway at its outer end, and a partially sintered powder coating on the entire length of the wall of said exhaust passageway and firmly adherent thereto, said powder coating consisting essentially of an inorganic material having a melting point above that of the glass wall of said exhaust passageway and chemically inert with respect to the said filament when at its incandescent operating temperature.
2. An electrical device as specified in claim 1 wherein the said coating on the wall of the exhaust passageway comprises a material of the group consisting of the oxides of zirconium, magnesium, titanium, zinc, tin, aluminum, calcium, strontium and barium, and silicates, double silicates, and titanates.

3. An electrical device comprising a sealed glass envelope having a press portion, lead-in conductors sealed through said press portion, an exhaust passageway extending through said press portion and communicating with the interior of said envelope, said press portion having a tipped-off residue of a glass exhaust tube hermetically closing off said exhaust passageway at its outer end, and a partially sintered powder coating on the entire length of the wall of said exhaust passageway and firmly adherent thereto, said powder coating consisting essentially of a material of the group consisting of the oxide, silicates and double silicates of zirconium.

4. An electrical device comprising a sealed glass envelope having a press portion, lead-in conductors sealed through said press portion, an exhaust passageway extending through said press portion and communicating with the interior of said envelope, said press portion having a tipped-off residue of a glass exhaust tube hermetically closing off said exhaust passageway at its outer end, and a powder coating on the entire length of and firmly adherent to the wall of said exhaust passageway and consisting essentially of zirconium oxide.

5. An electrical device comprising a sealed glass envelope having a press portion, lead-in conductors sealed through said press portion, an exhaust passageway extending through said press portion and communicating with the interior of said envelope, said press portion having a tipped-off residue of a glass exhaust tube hermetically closing off said exhaust passageway at its outer end, and a powder coating on the entire length of and firmly adherent to the wall of said exhaust passageway and consisting essentially of magnesium oxide.

6. An electrical device comprising a sealed glass en-

velope having an external stem press protruding therefrom, an incandescible tungsten filament within said envelope, lead-in conductors sealed through said press portion and connected to said filament, an exhaust passageway extending through said press portion and communicating with the interior of said envelope, said press portion having a tipped-off residue of a glass exhaust tube hermetically closing off said exhaust passageway at its outer end, and a partially sintered powder coating on the entire length of the wall of said exhaust passageway and firmly adherent thereto, said powder coating consisting essentially of an inorganic light-colored material having a melting point above that of the glass wall of said exhaust passageway and chemically inert with respect to the said filament at its incandescent operating temperature.

7. An electrical device as specified in claim 6 wherein the said coating on the wall of the exhaust passageway consists essentially of a material of the group consisting of the oxide, silicates and double silicates of zirconium.

8. An electrical device as specified in claim 6 wherein the said coating on the wall of the exhaust passageway consists essentially of zirconium oxide.

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