

April 5, 1938.

A. MAVROGENIS

2,112,968

PROCESS AND DEVICE FOR MAKING CATHODES

Filed Oct. 11, 1926

2 Sheets-Sheet 1

*Fig. 1*

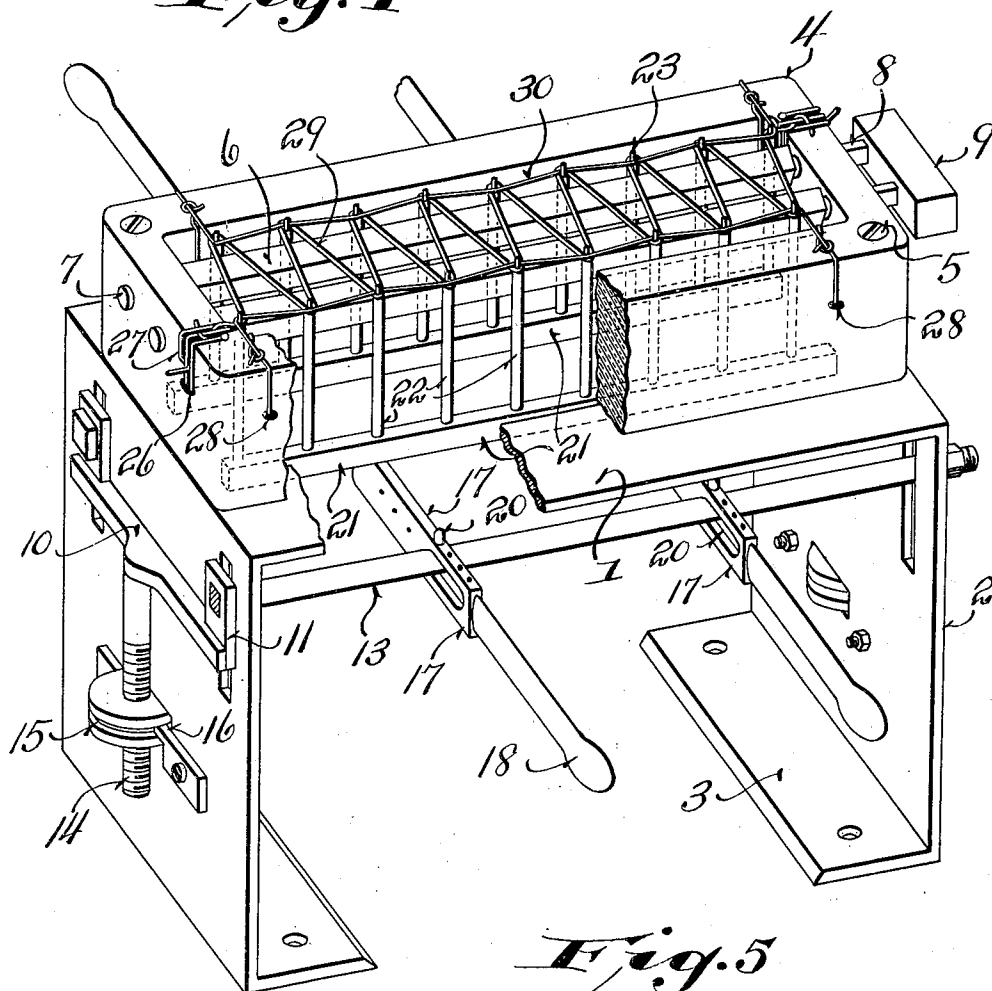


*Fig. 5*

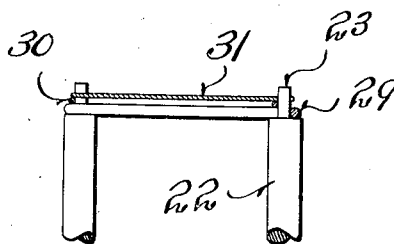
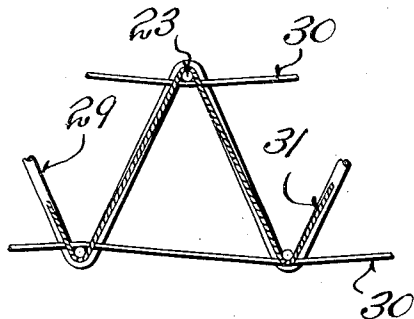


*Fig. 4*



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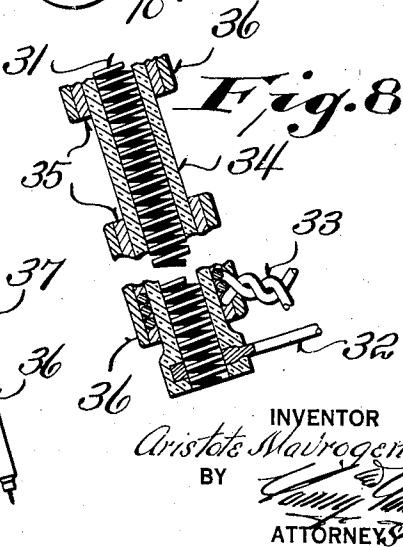
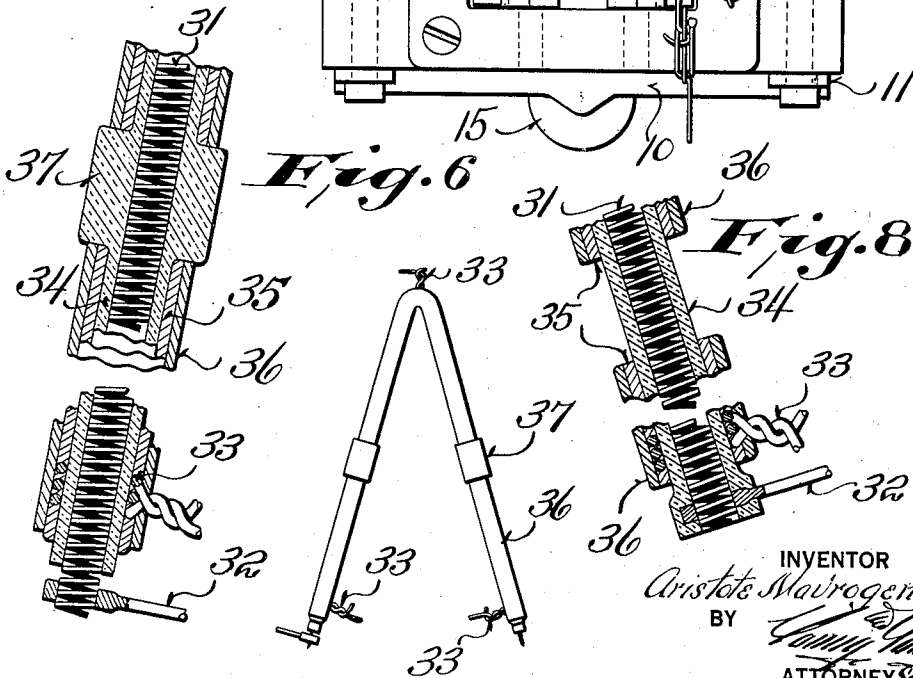
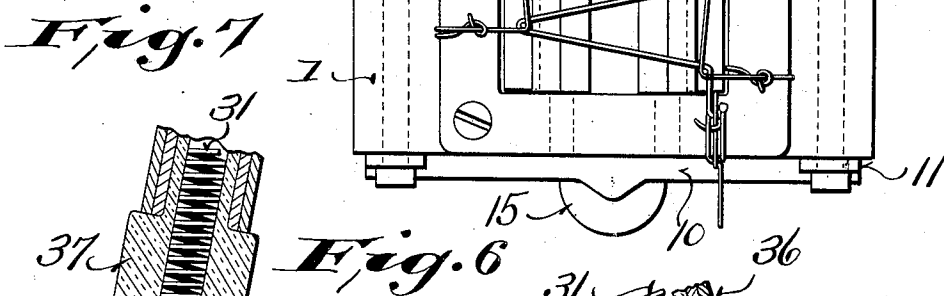
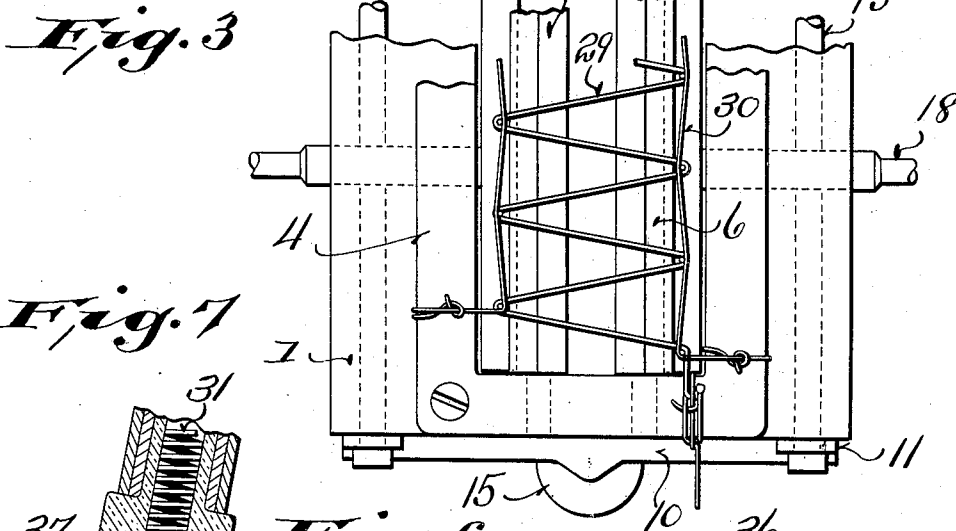
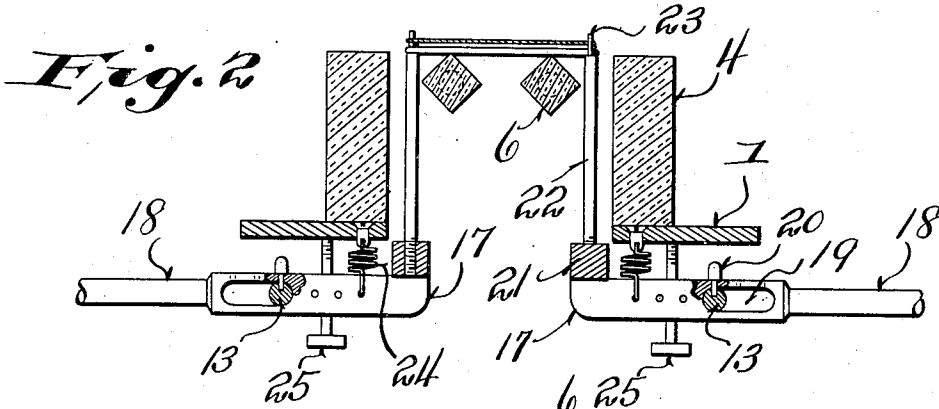
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

2,112,968

PROCESS AND DEVICE FOR MAKING  
CATHODESAristote Mavrogenis, Milwaukee, Wis., assignor  
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Application October 11, 1926, Serial No. 140,848

7 Claims. (Cl. 250—27.5)

This invention relates to the method of making cathodes for electron discharge devices, and to the device which may be used for making such cathodes.

5 Prior to this invention, the usual practice in making equipotential or indirectly heated cathodes has been to form a metal cylinder and place the heater within the cylinder, such cylinder functioning as the cathode in the electron discharge device, or else to provide a glass tube or its equivalent through which the filament is threaded with a cylindrical metal body surrounding the tube.

10 When an insulator is employed between the metal exterior and the filament, it has been found that these insulators are very fragile and are readily broken, so that it is almost an impossibility to mount and handle such a construction without snapping the thin glass or similar tube, and further, a slight abnormal difference of expansion of the parts is sufficient to break the tube.

15 Attempts have been made to utilize a porous insulating material, such, for example, as porcelain, but the occluded gases in the porcelain can not be extracted entirely during the evacuation of the tube and it is found that when the tube is used with porcelain that gradually the vacuum is destroyed by the liberation of these occluded gases.

20 Further than this when no insulator whatsoever is employed between the metal equipotential or indirectly heated cathode and the heater, it is necessary to have zero potential difference between the heater and the cathode, if an equipotential cathode effect is desired.

25 This invention is designed to overcome the defects noted above and objects of this invention are to provide a process of making an equipotential or indirectly heated cathode in which the heater, the insulator, and the cathode form in reality a unitary non-porous structure, which is extremely rugged and which does not occlude gases.

30 A further object is to provide a method of forming an insulating refractory coating on an electrical conductor or filament used as a heating element for an equipotential or indirectly heated cathode.

35 A further object is to provide a method of forming an impervious insulating coating upon an electrical conductor to be used as a heater for an electron emitting cathode, in which the insulating coating is maintained solid through the operating temperature of the cathode.

40 A further object is to provide a method of form-

ing an insulating refractory body on a filament or electrical conductor for use as a heating element for an equipotential or indirectly heated cathode in which the insulating body is firmly or adhesively bound to the filament or conductor.

45 A further object is to provide a method of forming an insulating refractory coating upon an electrical conductor which is to be used as a heat radiating body for an electron emitting, equipotential, or indirectly heated cathode, in which the coating has substantially the same coefficient of expansion as the electrical conductor throughout the operating temperature of the cathode.

50 A further object of this invention is to provide a process of making a unitary equipotential, or indirectly heated cathode and heater in which the cathode may be made as small as desired.

55 Further objects are to provide a process of producing an equipotential, or indirectly heated cathode and heater, in which the danger of burning out the heater is reduced to a minimum as the entire body is for all practical purposes a unitary structure.

60 Further objects are to provide a method of producing an equipotential, or indirectly heated cathode, in which the evaporation of the filament is prevented and which, consequently, vastly prolongs the effective life of the unit, while permitting the heating of the cathode in air, if desired.

65 Further objects of this invention are to provide a process of making the unitary equipotential or indirectly heated cathode, which may be readily followed in a simple and easy manner, which will insure the proper coating of the filament and the proper formation of the low electron affinity coating for the cathode, and which will produce in a practical manner a device which will not crack, which is strong, rugged, and compact, and free from blistering or other defects of this type.

70 Further objects are to provide a simple type of device for carrying this process into effect, and which permits the ready manipulation of a large number of units at a single time to markedly reduce the cost of production.

75 Further objects are to provide a process in which a single treatment of the filament is sufficient to form the insulating coating although, as will hereinafter appear, a plurality of treatments may be given the filament, and in which a single treatment of the coating is sufficient to form the cathode with its low electron affinity oxides, if desired.

80 In the drawings, a form of device has been illus-

trated which is practical and serviceable in carrying out the steps of the process, and further, the drawings illustrate to a very large scale the resulting product.

5 Figure 1 is a perspective view of the device with parts broken away;

Figure 2 is a transverse sectional view through the device;

10 Figure 3 is a fragmentary plan view of the structure shown in Figure 1;

Figure 4 is a view showing the relation of the various threads with the filament.

Figure 5 is an elevation of the structure shown in Figure 4;

15 Figure 6 shows a completely formed unit;

Figure 7 is an enlarged fragmentary sectional view through the finished unit;

Figure 8 is a similar view showing a modified form.

20 Referring first to the device, it will be seen that it comprises a bed plate 1 supported by standards 2 which may be provided with feed 3 adapted for bolting to a table. This bed plate carries a porcelain block or ring 4 of rectangular contour, as shown in Figures 1 and 2. The ring is temporarily held in place by means of long screws 5 which engage the bed plate. However, it is intended that the ring be removed in one step in the process and, therefore, it has been found sufficient to secure it upon the bed plate temporarily by two screws. Other means, of course, may be substituted for those shown.

25 This ring carries a pair of porcelain bars 6 which are of rectangular cross section and extend from one end wall of the ring to the other. These porcelain bars are journaled by means of trunnions 7 which fit into one end wall and which may be made of separate porcelain pieces, if desired, so as to facilitate assembly of the device. The other ends of the bars 6 are of rectangular cross section and are indicated by the reference character 8 in Figure 1. They are adapted to be received temporarily by a locking block 9 of porcelain to hold the bars against rotation when they are in the position shown in Figures 1 and 2. By removing the block 9 the bars may be rotated to present flat faces upwardly.

30 The uprights 2 carry cross heads 10 at their ends which are provided with extensions 11. These extensions receive the squared ends of rods 13. The cross heads are provided with downwardly extending screws 14 which are engaged by the nuts 15, such nuts passing through a slot formed in the uprights and preferably being provided with a groove into which a tongue 16 projects to thus hold the nuts in place.

35 The rods 13 carry a series of levers. The levers are preferably arranged in pairs on opposite sides of the device, as indicated at 17 in Figure 1. These levers are provided with operating handles 18 which are preferably provided with slots 19 to permit a limited adjustment inwardly or outwardly with reference to the rods 13. Any suitable means may be employed for locking the levers to the rods temporarily as, for example, the pins 20 shown in Figure 2.

40 The lever ends 17 carry bars 21 (see Figures 1 and 2) which are provided with upwardly extending vertical pins or rods 22. The upper ends of these rods are provided with pins 23, preferably of extremely small diameter. Further, it is to be noted that springs 24 are provided for urging the inner ends of the rods upwardly. This upward motion is regulated by means of adjust-

able set screws 25, or in any other suitable manner.

45 It is to be noted also that the block or ring 4 is provided with apertures 26 through which a short length of relatively heavy tungsten or similar wire 27 is threaded and secured. Further, the ring is provided with apertures 28 for a purpose hereinafter to appear. If desired, other apertures may be formed in the ring to aid in securing the various threads used in forming the unit, as will appear hereinafter.

50 In using the device, a relatively heavy thread 29 is looped alternately about the pins 23, as shown in Figures 1 and 3. This thread is the bottom one used in forming the device, and both ends are hooked beneath the heavy tungsten wire loop 27. Further, a pair of relatively smaller threads 30 extend lengthwise of the device, as shown particularly in Figure 4 and are laid upon the thread 29. They loop alternately in front of and behind the pins 23. The ends of the threads are passed through apertures 28 in the porcelain block and secured. These threads, as thus far described, are formed of cotton or similar combustible material.

55 The filament, as indicated in Figure 4, by the reference character 31, consists of a very fine metal wire formed of tungsten, tantalum, molybdenum, platinum, nickel, or other suitable metal, or an alloy of such metals. This filament, as stated is extremely small. In some cases, 1/1000th of an inch diameter filament is employed. This filament is coiled, as indicated in the drawings, to form a continuous helix from one end to the other and preferably, the external diameter of this helix is maintained very small. For example, 5/1000th of an inch has been found satisfactory, although of course, the exact dimensions may be varied, if desired. This filament, it will be seen, is very fragile and difficult to handle under ordinary conditions. However, it is readily handled with a device of this type as it is carried by the pins 23 and looped alternately back and forth, as shown in Figures 2, 4, and 5. The ends of the filament are connected to the tungsten wire loops 27 (see Figure 1) so as to form an electrical connection for the filament.

60 It is obvious that the use of the above described device is advantageous more particularly in case of heaters such as filaments, wires, or conductors having a small diameter or a very reduced cross section. Heaters of small cross section, as cited immediately above, made either in straight or in coiled form, are usually very flexible and fragile and they may even be abnormally deformed during the insulating process under the influence of even the proper weight of the insulating material, but by providing through said device adequate supports and other means, such defects are avoided and a uniform insulating coating is secured on the heater. Further it is obvious that in the coating process the same device may be used to handle heaters of relatively larger cross section or diameter, which may be more or less self-supporting. It is obvious, however, that the process as claimed may be followed without the use of the particular device described in detail above.

65 After the parts have been arranged in this manner, it is to be noted that the filament is carried by the small pins 23 and is spaced from the large thread 29. Thereafter, an insulating coating is applied to the filament in any suitable manner as, for example, by spraying or by painting it with a small brush upon the filament

and thread 29, or by applying it by means of a small tube such, for example, as a dropper or minute nozzle can. Nevertheless the substance, which is to form the insulating refractory body or coating on the heater in whatsoever form or state it may be used, must always cover the heater either partially or wholly; in other words, the substance must be put in contact with the heater surface which is to be coated or which is to have the insulating body formed thereon before subjecting said substance to a temperature sufficient to fuse this substance or to convert this substance into a refractory insulating body adhesively bound to the heater. This insulating coating will be described in greater detail hereinafter.

It is to be noted that the filament 31 parallels the thread 29 and thus the insulating solution is carried not only by the filament, but also by the thread, so that a relatively large quantity is held in contact with the filament in the form of a film surrounding the filament and thread and filling the space between the filament and thread. In addition to this, the filament is not stretched due to the weight of this adhering liquid, as the weight is borne by the thread 29.

After this stage in the process the porcelain rods 6 are rotated so that they present their corner edges upwardly in contact with the thread 29, as shown most clearly in Figure 2. Thereafter, the pins 20 (see Figures 1 and 2) are released and the lever 17 may be slightly rocked to cause the rods or pins 22 and the upper pins 23 to disengage the filament by actuating the handles. It will be noted that the pins 23 move inwardly and downwardly when the levers are slightly rocked. Further, the cross heads 10 are lowered by means of the screws and nuts 14 and 15 so that the filament and the threads are supported by the porcelain rods 6, and are carried on the sharp edges of these rods.

It is preferable to allow a small lapse of time to occur between the painting or coating of the filament and the soaking of the thread 29 so that the desired consistency of the solution may be attained to afford the requisite strength to permit the entire threads and filament in their coated state to be carried by the porcelain rods 6. This, however, only takes a brief interval of time.

Thereafter, the screws 5 are loosened and the porcelain ring is removed from the device and a new ring takes its place for the next cycle of operation. The removed porcelain ring is placed on a suitable support and a more thorough drying is permitted until the exact consistency desired is attained. Thereafter, the porcelain ring is placed in any suitable type of furnace. Preferably in a furnace having a vacuum chamber by means of which the vapors from the solution and the other parts of the equipment may be withdrawn. Before applying the vacuum, however, the tungsten wire loops 27 (see Figure 1) are preferably connected externally of the vacuum vessel.

It is obvious that, when the heater is of very small diameter or of very reduced cross section such as mentioned hereinbefore, or when the heat employed is applied slowly to the material or materials, as is the case with an external heat supply source, the heating is preferably carried on in a non-oxidizing medium, such as in vacuum, for example, in order to avoid excessive oxidation of the heater's surface and eventually the destruction of the heater itself. However, when the heat is applied to the material or ma-

terials of the insulating coating for a very short time, such as by passing electric current through the heater momentarily, or the heater is of relatively large diameter or cross section, the heating may be carried out even in a more or less oxidizing medium such, for example, as in the air. Nevertheless, whatsoever is the manner employed of applying heat to the material or materials, and whatsoever is the medium in which the heating process is carried out, it is always necessary that the temperature employed be sufficient to cause the material or materials to adherently bind to the heater. The material or materials used in making the insulating coating may fuse either wholly or partially.

Thereafter, heating takes place and preferably current is sent through the filament to aid in this heating. The threads burn away and leave a substantial coating of the insulating compound upon the filament which is thoroughly baked and dried. This process is preferably carried on at a rate to prevent bubbling or unnecessary agitation of the insulating coating. Obviously, since the dielectric material is baked in situ, that is, on the filament, it is hardened adhesively or fused on the filament. Hence, a firmly binding contact between the dielectric material and the filament is obtained. Further, as will be described hereinafter, the coating is such that it forms a strong, durable, non-cracking, non-blistering, and non-porous coating over the filament.

It is to be understood that other modes of baking may be followed, if desired. If it is thought sufficient, however, to describe one manner in which the baking can take place.

The ring is removed from the furnace and, if it is desired to form enlargements at certain portions of the insulating coating, such enlargements may be readily formed by applying at the desired point another slight amount of the insulating solution, and subsequently rebaking under the conditions described above.

The next step in the process is to cut the filament into lengths such as to form a series of permanently V-shaped filaments, if the type of tube described in my Patent No. 1,638,499 for Electron discharge devices, is to be used. Obviously, if a straight filament is desired, a single length may be employed.

It is obvious that the insulating coating process may be carried out either with chemically or mechanically clean wires or with oxidized or otherwise coated wires. For example, in certain of the processes disclosed the wires may become oxidized during heating. Even under these conditions it has been found that a satisfactory adherent body or coating may be secured.

After the filament has been cut into the desired lengths the insulating coating at its terminals is squeezed or broken off and relatively heavier conductors 32 are pinched or clamped around the ends of the filament, as shown in Figure 7. Also, a few turns of wire, as indicated at 33, are wrapped about the insulating coating at suitable points to connect with the metallic coating to be subsequently formed.

In the form shown in Figure 6, three such wire connectors are indicated. This type of filament may be used with the tube illustrated in my Patent No. 1,638,499, for Electron discharge devices.

It is obvious that the filament or heater may be of any type or shape desired, depending upon the particular type of tube with which it is

used. Also it is clear that the characteristics of the dielectric material will be varied to correspond to the particular type of filament or heater with which it is associated.

5 Thereafter, the insulating coating, indicated by the reference character 34 in Figures 7 and 8, is coated with a metallic or electrically conducting film, such as indicated at 35. This metallic or electrically conducting film may be separated  
10 into parts, as shown, for instance, in Figures 6, 7 and 8. The metallic or electrically conducting coating may be formed in a number of different ways. For example, it may be formed by applying a solution of silver compound, nickel chloride,  
15 or electrically conducting chlorides of other metals. This coating is changed into metal by means of heat, preferably by heating the apparatus within a vacuum.

Other modes of coating the device to form the  
20 metal equipotential, or indirectly heated cathode may comprise the use of a colloidal solution of the metals to be subsequently baked thereon. Thereafter, a third coating is formed on the metal coating and is indicated by the reference  
25 character 36 in Figures 6, 7, and 8. This third coating is formed of calcium, barium, strontium, thorium, or similar low electron affinity oxides or hydroxides, or their compounds. This coating may be prepared by using a solution of such materials or their compounds and simply dipping  
30 the equipotential, or indirectly heated cathodes therein and leaving them to dry or else by using a melted mass of these materials.

A further method of forming both the metal  
35 equipotential, or indirectly heated cathode and the coating thereon may be followed. For example, a solution containing a mixture of the metallic compounds used for the main cathodes with one or more of such low electron affinity oxides may be prepared and the insulating coating  
40 may itself be coated with this solution. Thereafter, the equipotential or indirectly heated cathode may be mounted in its normal and permanent position inside the tube and brought above  
45 its normal operating temperature by means of the heater sufficiently to melt the low electron affinity oxides. It is found that when this heating takes place, that the oxides come out on the surface and form an efficient coating while the  
50 metal inner sheath is also formed.

Further, a mixture of the low electron affinity oxides and colloidal solution of the proper metals may be made and applied directly to the insulating sheath, subsequent heating being employed in the manner described above.  
55

It is to be noted also that there is no danger of burning out the heater or filament as it is coated by the insulating strongly adherent sheath. Further, the evaporation of the filament is practically zero as the opening in the helix is so small that no portion of the filament escapes during heating. The filament can be heated even in the open air, if desired, although, in view of the fact that the oxides enumerated  
60 above are hygroscopic, it is preferable to heat the device in its permanent mounting within the tube and while the tube is being exhausted.

Other materials may be used for forming the metal coating and oxide coating. For example,  
70 chlorides of platinum, palladium, rhodium, ruthenium, iridium, and osmium, may be used, or chlorides of nickel, iron, cobalt, or any mixture of two or more of these. Further, to reduce the expense of manufacture, the solution may be mixed  
75 with metal in its powdered form, such as silver,

tungsten, molybdenum, tantalum, iron, or nickel, or any mixtures of these. Preferably, these metals are suspended in a colloidal form. Further, if desired, a small proportion of binding agent may be used as a metallic lead oxide or sodium borate,  
5 or any mixture thereof. These mixtures can be applied either mixed in a cold solution or else they may be melted to form a melted bath into which the coated heater is dipped. The low affinity oxides may be added to this mixture at  
10 the time that it is formed, if desired. As a rough illustration of a few of the relative amounts that may be used in groups, the following is submitted:

For example, 6% oxides, 93% chlorides, and  
15 1% binding agent can be used satisfactorily. Another mixture may consist of 49% of a mixture of oxides and chlorides in the relation of 10% oxides to 90% chlorides. To this 49%, 50% of metals, as described above, and 1% binding agent  
20 can be added.

In the modified form illustrated in Figure 8, substantially the same process has been followed with the exception that the conducting and supporting wires 32 are pinched around or  
25 secured to the filament 31 prior to its being coated with the insulating sheath 34. In this manner, the ends of the wires 32 are also embedded within the insulating sheath.

Further, in the form shown in Figure 8, the enlargements of the insulating sheath, indicated by the reference character 37 in Figure 7, have been omitted and the successive metal and oxide coated portions are merely spaced along the insulating sheath. Otherwise, the two structures  
35 are identical.

In forming the insulating sheath 34, it is preferable to use basic metal compounds for the coating, such as molybdenum oxides, or hydroxides, or nickel oxides, or nickel hydroxides, or a  
40 mixture of them in which a small percentage of tungsten oxide may be added, if so desired. Further, any variety of silica, such as quartz, silicic oxide, feldspar, or the like may be used with or in place of any of the immediately above noted  
45 metal oxides in forming the insulating sheath 34. All of these materials are preferably very finely ground, as fine as is mechanically possible and, of course, preferably chemically pure ingredients are used.  
50

To the above described high heat resisting and insulating materials, a small percentage of other materials may be added in order to make it more compact, elastic, mechanically strong, and non-porous, and free from cracking, blistering, or the  
55 like, and so that an air-tight, strongly adherent and preferably moisture-proof surface may be formed, such materials are, for instance, sodium oxide, usually used in its compound form, tetraborate of sodium or borax, sodium nitrate, silicate of sodium, or the equivalent compounds of potassium, lead oxide, zinc oxide, double fluorite of sodium and aluminum, or calcium fluorite. Some of the materials may somewhat increase the coefficient of expansion and form powerful  
60 adherent agents during heating. Other compounds may be used to vary the co-efficient of expansion such, for example, as boric oxide. These different ingredients are proportioned so as to secure substantially the same co-efficient  
70 of expansion as that of the filament itself. Further, it has been found that boric acid, lead oxide, or zinc oxide, increase the strength and elasticity and compactness of the insulating coating.

As stated, the various ingredients are selected  
75

in accordance with the exact requirements. They are herein in order to give a full and adequate disclosure of the several steps in the process.

When lead oxide is used in the insulating coating, it is preferable to use a small percentage of carbonate or nitrate of sodium which prevents the reduction of the lead oxide to the metallic state during baking.

It is also found advantageous to add a small percent of finely ground clay, free from any metal and free from grease, oil, or other impurities. The clay can be very finely ground in water and acts as a suspension agent to keep the non-soluble material floating throughout the entire liquid. Distilled water is, of course, preferably used, as it is probably the cheapest liquid, although any other liquid may obviously be used when such liquid secures similar results.

The consistency of the mixture depends upon the manner in which it is applied. If it is applied with a brush, it is preferably of a paint-like consistency. A syrupy consistency is preferable when the coating is sprayed lightly or dropped upon the device.

The following table is submitted to show a possible combination of chemicals to produce this coating. The percents and the particular chemicals selected from the groups named above are not to be understood in any way limiting, but merely to give a more complete and full explanation of the process for a unit weight of the material. The following proportions may be employed:

Percent

|                                                                      |    |
|----------------------------------------------------------------------|----|
| Nickel or nickelous oxides.....                                      | 15 |
| Silicic acid.....                                                    | 33 |
| Tetraborate of sodium.....                                           | 25 |
| Red lead oxide.....                                                  | 20 |
| Sodium nitrate or carbonate.....                                     | 3  |
| Double fluoride of sodium and aluminum.....                          | 4  |
| To 64% of this mixture 33% of distilled water and 3% clay are added. |    |

Obviously, the various proportions may be varied to vary its characteristics, as described above in detail, or to vary its consistency as by varying the water content.

Further, either molybdenum oxide or tungsten oxide, or both, may be added to the batch at the expense of the nickel oxides.

In the several processes which are disclosed, the insulating or binding ingredients have been given in their complex forms. The reason for this is that they frequently occur in nature in these forms and are very often extremely cheap when purchased in their complex forms. However, it is apparent that the ingredients may be used individually in their simpler forms, such as oxides or salts of the various elements discussed in this disclosure.

It is obvious that any other suitable adherent agent or binder, besides those mentioned immediately above, taken in a suitable form may be used in the mixture, if so desired.

Another mode of forming mixture is to melt the ingredients mixed in the proportion named, and thereafter suddenly cool the mass by spraying on distilled water, thus rendering the cake extremely brittle and in a condition to be easily powdered. Thereafter, this cake is ground to an impalpable powder and distilled water and clay are added in the proportions given above. It may be found desirable to add a small percent of a binding agent, such as borax or lead oxide with

the water and clay. In this case, the proportion of borax or lead oxide is slightly reduced in the original mixture.

Although the invention has been described in considerable detail, such description is intended as illustrative rather than limiting as the invention may be variously embodied and as the scope of such invention is to be determined as claimed.

I claim:

1. The method of coating a heater with a dielectric coating comprising suspending the heater between spaced members, applying a portion of the refractory coating in a liquid form to said heater, providing a temporary, combustible support below said heater for carrying the major portion of said coating while in a liquid form, and subjecting the heater to the action of heat and vacuum and burning away the supporting member.

2. An apparatus for coating a filament with a dielectric coating comprising a supporting member, a plurality of pins movably mounted by said supporting member and adapted to hold said filament and a supporting thread, a heat resisting ring removably carried by said supporting member and positioned around said pins, and a pair of heat resisting bars carried by said ring and adapted to support the said filament when the pins are withdrawn and said ring removed from said supporting member.

3. A device for use in coating a filament with dielectric material comprising a main supporting member, movable bars carried by said member, means for adjusting said bars, pins supported from said bars and adapted to temporarily hold the filament in an extended condition, a refractory ring surrounding said pins and removably attached to said supporting member, and refractory means carried by said ring and removable therewith for supporting said filament when said pins are withdrawn, whereby said filament may be extended over said pins and held temporarily thereby and may be subsequently supported by said refractory supporting means when said ring is removed from said supporting member.

4. A device for use in coating a filament comprising a main supporting member, a pair of bars movably and adjustably supported by said member and having a plurality of spaced pins over which said filament may be looped, a removable member of refractory material carried by said supporting member, and a pair of rectangular rods of refractory material adapted for positioning below said filament and carried by and removable with said ring, whereby said filament may be supported by said bars when said ring is removed from the supporting member.

5. A device for use in forming a coated filament comprising a main supporting member, a pair of bars mounted for vertical adjustment upon said supporting member, means for vertically adjusting said bars, levers for rocking said bars, a plurality of pins carried by said bars and arranged in staggered relation and adapted to have a filament stretched therebetween, a ring of refractory material surrounding said pins, a pair of revolvably mounted refractory bars having flat faces and pointed edges, said bars being carried by said ring and being adapted for rotation into a position to support said filament when said ring is removed from said supporting member.

6. The method of coating a heater with a dielectric coating comprising suspending the heater

between spaced members, applying a portion of the refractory coating in a liquid form to said heater, providing a temporary, combustible support below said heater for carrying the major portion of said coating while in a liquid form, 5 spacing said heater from said supporting member by a thread, and subjecting the heater to the action of heat and vacuum and burning away the thread and the supporting member.

10 7. The process of coating a heater for an indirectly heated electron-emitting cathode with

an insulating, refractory substance, said process including suspending the heater between spaced members, covering said heater with a mixture including a fluid and a refractory material, providing a temporary combustible support below 5 said heater for carrying a portion of said mixture, and subjecting the said heater to the action of heat and burning away the said temporary support.

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