Aug. 30, 1927. **1,640,829**

J. A. HEANY

INCANDESCENT ELECTRIC LAMP

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Fig. 6

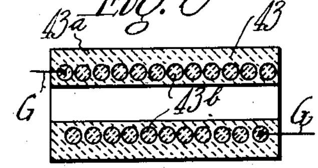


Fig. 7.

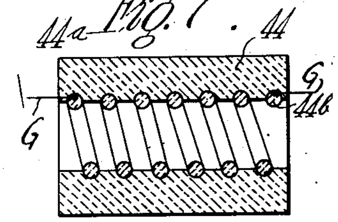


Fig. 3.

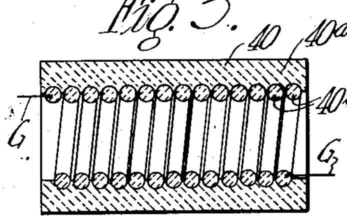


Fig. 8

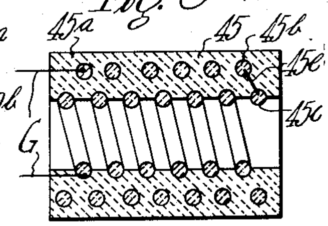


Fig. 4

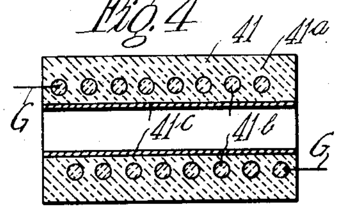


Fig. 9.

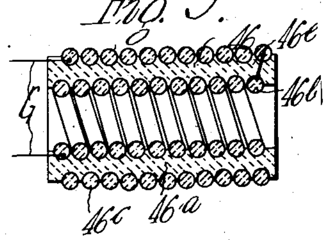


Fig. 2

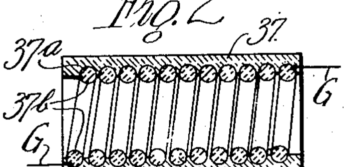
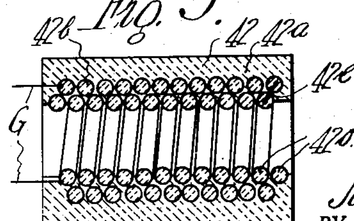


Fig. 5.



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Aug. 30, 1927. | J. A. HEANY | 1,640,829

INCANDESCENT ELECTRIC LAMP

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Fig. 10.

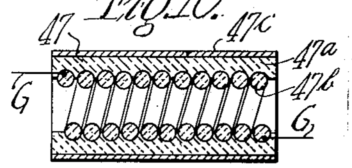


Fig. 11.

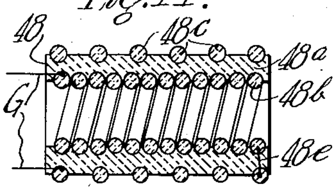


Fig. 15

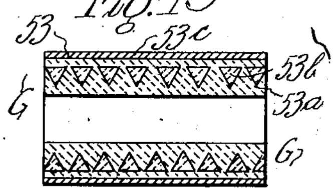


Fig. 12.

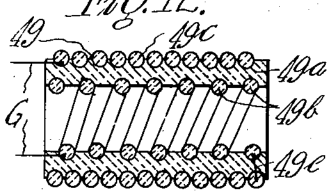


Fig. 17.

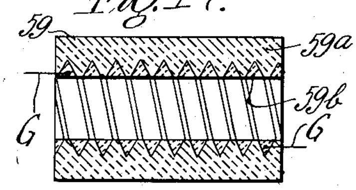


Fig. 13.

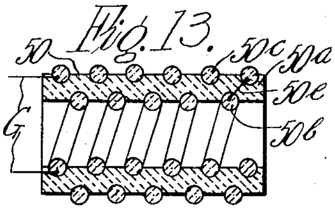


Fig. 18

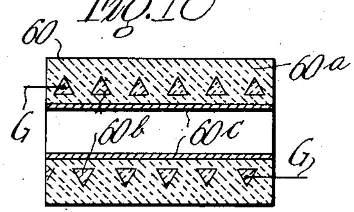


Fig. 14.

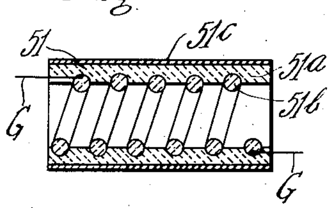
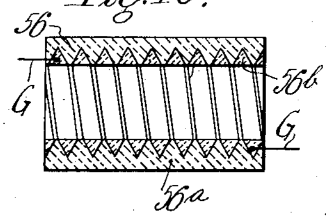


Fig. 16.



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INCANDESCENT ELECTRIC LAMP

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Fig. 19.

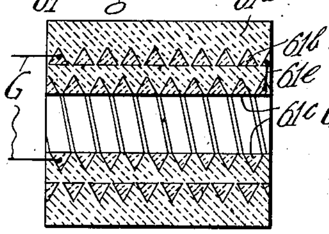


Fig. 23.

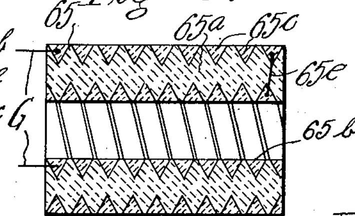


Fig. 27.

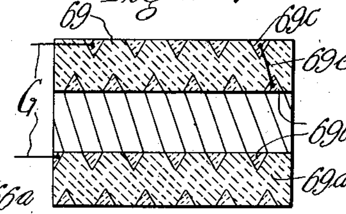


Fig. 20.

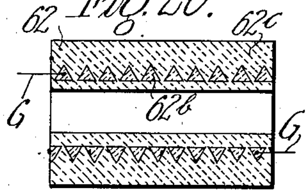


Fig. 24.

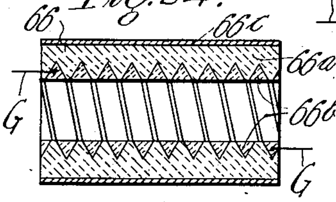


Fig. 21.

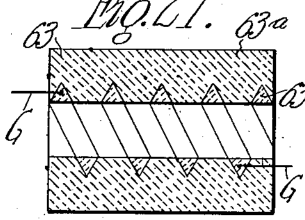


Fig. 25.

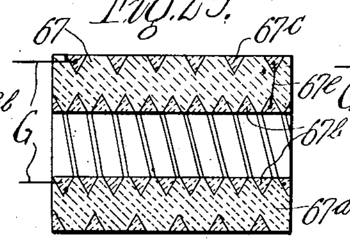


Fig. 28.

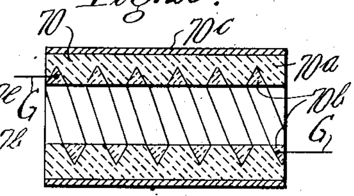


Fig. 22.

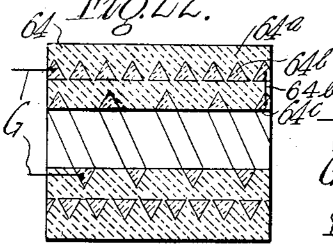
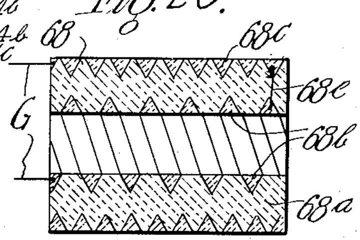


Fig. 26.



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Patented Aug. 30, 1927. **1,640,829**

UNITED STATES PATENT OFFICE.

JOHN ALLEN HEANY, OF NEW HAVEN, CONNECTICUT.

INCANDESCENT ELECTRIC LAMP.

Application filed May 15, 1918. Serial No. 234,756.

This invention relates to incandescent electric lamps and has for its object the provision of an improved lamp, which is highly efficient and has an unusually long life. This is accomplished by constructing the glower in the novel manner hereinafter described.

The invention is a modification of the invention described in my application entitled "Incandescent electric lamps", filed July 3, 1916, Serial No. 107,367 and in which the right to claim the invention broadly is reserved.

According to the present invention, the glower is made of such sizes and in such shapes as to materially reduce the convection losses. This is accomplished without sacrificing any strength of the necessary resistivity to produce the proper degree of incandescence, due to the fact that the glower is constructed of materials which possess great strength at the operating temperature, and are capable of reaching a high degree of incandescence, even in the small candle power lamps and on relatively low voltages. The glower may be cylindrical, tubular, plate-like, hemispherical, nearly spherical in form or any other suitable form.

In general the glower comprises a resistor preferably of tungsten or tungsten alloy and a support preferably composed of a highly refractory material, such as a rare oxide or a mixture of rare oxides, which possesses marked rigidity at the operating temperature. The resistor is so associated with the support that the former heats the latter to incandescence. The resistor may comprise finely divided refractory metal uniformly distributed throughout the refractory material, may be formed by impregnating refractory metal throughout the refractory material, or may be formed by merely impregnating a thin zone of refractory material with a refractory metal. The resistor may also be composed of refractory metal wire wound in any desired form or may consist of a thread of refractory metal placed in a groove provided in the support.

The radiating surface of this glower may be of several different kinds. The resistor may also act as the radiating surface, and may, therefore, be in the nature of a helix or of a portion of a sphere, or be convoluted in any suitable manner and wound upon the support. The resistor may be completely embedded in the support in which case the material of the support is the radiating surface, or the radiator may be composed of a thin layer of refractory material different from that of the support or of a thin layer of refractory metal. Another form of radiating surface is one in which the surface is composed partly of refractory metal and partly of refractory material. When the radiating surface is of this character the metal forming the resistor is partially embedded in the support and the exposed portions thereof are separated by the surface of the support. Another form of radiating surface of this type is provided when a resistor in which finely divided metal is uniformly distributed throughout the refractory material or refractory metal is impregnated in the refractory material is used in such a way that the resistor is exposed. In such a case the radiating surface is part refractory metal and part refractory material.

Thus it is seen that in this glower there may be five different types of resistors and three different types of radiating surfaces together with several modifications of each type.

The materials used in the construction of this glower must be endowed with certain characteristics. The refractory compound to be used for the support possesses great strength at the operating temperature and is capable of becoming highly incandescent at said operating temperature. Furthermore, the material used in the support is capable of withstanding extremely high heat, such as that of the oxy-hydrogen flame without being subject to appreciable evaporation or disintegration of any character. Another characteristic of this material is that it is highly resistive at the operating temperature so as not to allow current to leak to it from the resistor. Again, it has the property of being a poor conductor of heat as well as of electricity. Another important property possessed by the material of which the support is constructed is that known as selective radiation, or the ability to emit a high percentage of rays in the visible portion of the spectrum at the temperature of operation of the lamp. The materials possessing these qualifications and which are therefore best suited for the purpose are the rare earth oxides, such for example as zirconia, thoria, magnesia or the like either singly or in combination.

The refractory metal made use of in this glower is capable of radiating a large amount of light per unit of surface area and incandesces at the temperature at which platinum volatilizes. Such a metal is tungsten, tungsten alloy or the like.

As above stated the glower may be made in any one of a number of forms. Each one of these forms is of such a type that the convection losses therefrom are reduced to a minimum. It is a well known fact that an increase in the diameter of a filament or glower reduces the percentage of convection loss. For this reason the cylindrical and tubular forms of glower are so formed that they are relatively large in cross section as compared with the filament of the ordinary strung type lamp, but are at the same time very short as compared with said filament and are relatively small as compared with the bulb of the lamp. As the diameter of the glower is increased its percentage loss approaches, as a limit, that of a plane surface having the same area. For this reason the glower is also constructed in a flat plate-like form, so as to approach as nearly as possible a plane surface, thus also reducing the percentage of the convection loss. The hemispherical and nearly spherical types of glower also serve to reduce the convection losses, due to their peculiar shape and to the fact that they have a relatively large diameter. Furthermore these types retain within their opening the hot gases, thus helping to reduce the convection losses and at the same time stop evaporation losses, due to the fact that the gas within their opening becomes saturated and is then incapable of absorbing any more of the metal.

All these types of glowers may be operated either in vacuum or else in an inert gaseous medium, such as nitrogen, argon, helium or the like.

When any of these forms are operated in vacuum they are more efficient than the present vacuum lamp, due to the fact that they suffer but two end losses whereas the present type of lamp suffers two end losses and several supporting losses. Those forms of the glower in which the refractory metal is exposed may be operated at the same temperatures that the present type of vacuum lamp is operated and yet will be more efficient for the same candle power, because of the reduction of the losses to the supports. It is preferable, however, to operate those types of glowers in which the refractory metal is exposed in an inert gaseous medium under a pressure of a little less than one atmosphere. This allows the glower to be operated at a higher temperature, due to the fact that under pressure the volatilizing point is raised appreciably. Those types of glower in which the refractory metal is completely embedded may be operated in vacuum even at a higher temperature than the other in an inert gaseous medium, due to the fact that the refractory material used has a much higher volatilizing point.

The one big advantage of this glower is that it will operate as efficiently for the low candle power lamps as for the high candle power lamps, due to the fact that even with the low candle power glowers the convection losses are practically negligible.

The invention is illustrated in the accompanying drawings in which:—

Figs. 1, 3, 4, 5, 15, 17, 18 and 19 are similar sections of tubular glowers in which the radiating surface is composed of metal.

Figs. 2, 6, 16 and 20 are similar sections in which the radiating surfaces are composed of refractory oxides.

Figs. 7, 8, 21 and 22 are similar sections in which the radiating surface is composed partly of refractory metal and partly of refractory oxide.

Figs. 9 to 14 and 23 to 28 inclusive are similar sections of further modifications of the tubular type glower.

The glower 34 disclosed in Fig. 1 is composed of a tube 34ª of refractory material near the exterior surface of which is embedded a helix 34ᵇ of refractory metal wire and on the surface of which is provided a thin sheet 34ᶜ of refractory metal. In Fig. 2 the glower 37 is composed of a tube 37ª of refractory material on the inner surface of which is placed a helix 37ᵇ of refractory metal wire the turns of which are spaced apart merely enough to prevent short circuiting and are let into the tube approximately half their diameter.

The glower 40 shown in Fig. 3 comprises a tube 40ª of refractory material on the inner surface of which is provided a helix 40ᵇ of refractory metal wire, the turns of which are spaced merely enough to prevent short circuiting and embedded enough to prevent displacement. In Fig. 4 the glower 41 comprises a tube of refractory material having embedded therein a helix 41ᵇ of refractory metal wire located near the inner surface of the tube. This glower is also provided on its inner surface with a thin sheet 41ᶜ of refractory metal. The glower 42 disclosed in Fig. 5 comprises a tubular support 42ª of refractory material in which there is embedded a helix 42ᵇ of refractory metal wire and on the inner surface of which is located another helix 42ᶜ of refractory metal wire. The second helix 42ᶜ is in series with the first helix 42ᵇ and is connected thereto at 42ᵉ. This helix 42ᶜ has its turns spaced apart merely enough to prevent short circuiting and embedded sufficiently in the refractory material to prevent their displacement.

43 represents the glower as a whole in Fig. 6 and is composed of a tube 43^a of refractory material in which there is embedded close to the inner surface of the tube a helix 43^b of refractory metal wire.

The glower of Fig. 7 is designated as 44 and consists of a tube 44^a of refractory material on the inner surface of which is provided a helix 44^b of refractory metal wire, the turns of which are spaced apart their own diameter and embedded approximately half their diameter. In Fig. 8 the glower 45 comprises a tube 45^a of refractory material, a helix 45^b of refractory metal wire completely embedded in the said tube and a second helix 45^c of refractory metal wire located on the inner surface of the tube and having its turns spaced apart their own diameter and embedded approximately half their diameter. The two helices are connected at 45^e.

The glower 46 in Fig. 9 consists of a tube 46^a of refractory material having a helix 46^b of refractory metal wire on its inner surface and a helix 46^c of refractory metal wire on its outer surface, these two helices being connected at 46^e. The turns of each helix are separated merely enough to prevent contact and are embedded in the support sufficiently to prevent displacement. In Fig. 10 the glower 47 is composed of a tube 47^a of refractory material on the inner surface of which is provided a helix 47^b of refractory metal wire, the turns of which are slightly embedded in the refractory material to prevent displacement and are spaced merely enough to prevent the adjacent turns contacting with each other. On the outer surface of this glower there is provided a thin sheet 47^c of refractory metal.

In Fig. 11 the glower 48 comprises the usual tube 48^a of refractory material and is provided with an inner helix 48^b and an outer helix 48^c of refractory metal wire connected in series at 48^e. Both of these helices are embedded in the refractory material sufficiently to prevent displacement. The turns of the inner helix are as close as they can be without being in actual contact, while the turns of the outer helix are spaced apart their own diameter. The glower 49 of Fig. 12 is formed of a tube 49^a of refractory material the inner surface of which is provided with a helix 49^b and the outer surface with the helix 49^c of refractory metal wire. These two helices are connected with each other at 49^e. The turns of the outer helix are relatively close to each other but not in contact, while the turns of the inner helix are spaced apart approximately their own diameter. Both helices are slightly embedded in the support to prevent displacement. In Fig. 13 the glower is designated as 50 and comprises a tubular support 50^a of refractory material the inner surface of which is provided with a helix 50^b and the outer surface with a helix 50^c joined to each other at 50^e. The turns of each helix are spaced apart their own diameter and are embedded approximately one-half their diameter. The glower 51 of Fig. 14 comprises the tube 51^a of refractory material on the inner surface of which is provided a helix 51^b of refractory metal wire the turns of which are spaced apart their own diameter and embedded approximately one-half their diameter. Surrounding the support is a thin sheet 51^c of refractory metal.

Figs. 15 to 28 inclusive are the same as Figs. 1 to 14 inclusive with the exception of the fact that instead of having helices of refractory metal wire the glowers are provided with helical grooves or threads filled with refractory metal. In these figures the reference numerals 53 to 70 inclusive designate the glower as a whole and the reference characters 53^a to 70^a inclusive represent the tube of refractory material which constitutes the support. The reference characters 53^b to 70^b designate the resisting elements of the respective figures.

In Figs. 15 and 18 the reference characters 53^c and 60^c respectively designate the thin sheets of refractory metal which act as the radiating surfaces in these figures. In Figs. 19 and 23 the reference characters 61^c and 65^c respectively denote metal filled grooves which act as the radiating surfaces. In Figs. 21 and 22 the reference characters 63^c and 64^c respectively denote metal filled grooves which together with the refractory material between the turns of the same, form the radiating surface. In Figs. 19, 22, 23, 25, 26 and 27 the reference characters 61^e, 64^e, 65^e, 67^e, 68^e and 69^e denote the connections between the inner and outer helices. In Figs. 23, 24, 25, 26, 27 and 28 there are provided metal helical filled grooves 65^b, 66^b, 67^b, 68^b, 69^b and 70^b on the inner surface of the tubes, the surfaces of which lie flush with the inner surfaces of the tubes. In Figs. 23, 24 and 25 the turns of these grooves are spaced merely enough to prevent short circuiting, while in Figs. 26, 27 and 28 they are spaced apart their own width. In Figs. 23, 25, 26 and 27 there are provided metal filled helical grooves 65^c, 67^c, 68^c and 69^c on the exterior of the tubes, the surfaces of which lie flush with the outer surfaces of the tubes. In Figs. 23 and 26 the turns of these grooves are spaced apart merely enough to prevent contact, while in Figs. 25 and 27 they are apart their own width. In Figs. 24 and 28 the reference characters 66^c and 70^c denote thin sheets of refractory metal.

In Figs. 1, 3, 4, 5, 9, 10, 15, 17, 18, 19, 23 and 24 the radiating surface is of refractory metal either in the form of a thin sheet of metal or a helix of the metal, the turns of which are spaced close to each other to form almost a continuous surface or a combination of both. In Figs. 1 and 15 this radiating surface is placed on the exterior of the tube. In Figs. 3, 4, 5, 17, 18 and 19 the radiating surface is on the interior of the tube while in Figs. 9, 10, 23 and 24 the radiating surface is both on the exterior and interior of the tube. In Figs. 3, 4, 5, 17, 18 and 19 the portion of the support exterior of the helices is made thick enough to act as a heat insulator to force the radiation to come from the interior of the tube.

In Figs. 2, 6, 16 and 20 the radiating surface is composed of refractory material. In Figs. 2 and 16 the resisting elements are spaced close to the exterior of the tube and therefore the radiation is from the exterior surface. In Figs. 6 and 20 the resisting element is placed close to the interior of the tube making the radiation come from the internal surface.

In Figs. 7, 8, 11, 12, 13, 14, 21, 22, 25, 26, 27 and 28 the radiating surface is composed partly of refractory metal and partly of refractory compound. In Figs. 7, 8, 21 and 22 that portion of the support exterior of the helices is relatively thick and acts as a heat insulator forcing the radiation to come from the interior of the tube. In Figs. 11, 12, 13, 14, 25, 26, 27 and 28 the radiation takes place both from the interior and exterior of the tubes.

In several of the glowers, the radiating surface is composed either wholly or in part of rare oxides. The oxide used as the radiating surface may be either the same as that used in the construction of the support or may be a different oxide or combination of oxides from that so made use of.

A simple method of making the glowers above is as follows:

The rare earth oxides such as zirconia, thoria, magnesia or the like in their raw condition, either singly or in combination are thoroughly mixed with a dissipating binder, for example, any hydrocarbon binder. The paste thus formed consisting of the raw oxide or oxides and binder is next molded into strands. The molded strands are then subjected to an extremely high heat, such for example as that of the oxyhydrogen flame. By the application of this high heat the binder is driven out together with the water of crystallization contained in the oxide or oxides, leaving the oxide in a dehydrated condition. During the dehydration a perceptible shrinkage takes place in the strand. The oxide will not after its dehydration, again absorb any water nor will it be subject to any further shrinkage. This step is a very important one, because without it the glower formed would not be practical. If a glower were to be constructed out of oxides which had not been dehydrated, it could not stand the temperature at which the lamp operates without being seriously affected. When such a glower is placed in a lamp and ignited, the heat generated tends to drive out the water of crystallization and brings about a corresponding shrinkage of the support. The glower would then be destroyed due to the fact that the support would crumble and waste away; also the relation between the support and the resisting element would be destroyed.

After the strand of oxide has been dehydrated, the material is placed in a ball mill or any other suitable apparatus and is reduced by means thereof to an extremely fine powder. In its pulverulent condition, the oxide is again intimately mixed with a dissipating binder, and a second paste is formed. While in this plastic condition the material is molded into the desired shape that the glower is to be provided with in its final form. The material is then thoroughly dried, either in an oven or by a water bath. At the same time provision is made for the introduction of the resisting elements. The material at this stage of the process can be easily worked. Grooves or threads can be cut in which refractory wire or metal is to be later placed or the resisting elements can be placed in the support at this time.

Following this step, the support is again subjected to a high heat to drive out the binder and to sinter the oxide into a hard porcellaneous structure.

I claim as my invention:

1. In an incandescent electric lamp, a glower of the type described, comprising a relatively short diameter tube of refractory material, and a resisting element of refractory metal partly embedded in the interior surface of said tube capable of heating the tube to incandescence.

2. In an incandescent electric lamp, a glower of the type described comprising a tube of refractory material and a resisting element composed of a closely wound helix of refractory metal partly embedded in the interior surface of said tube and capable of heating the tube to incandescence.

3. In an incandescent electric lamp, a glower of the type described comprising a tube of refractory material, a radiating element of refractory metal and a resisting element consisting of a helix of refractory metal partially embedded in said tube adjacent the interior thereof and capable of heating the glower to incandescence.

4. In an incandescent electric lamp, a glower of the type described comprising a tube of refractory material, an exposed helix of refractory metal on the exterior of the tube and a second exposed helix of refractory metal on the inner surface of the tube.

5. In an incandescent electric lamp, a glower of the type described comprising a tube of refractory material, a helix of refractory metal on one surface of the tube and a helix of refractory metal on the other surface of the tube capable of heating the same to incandescence.

6. In an incandescent electric lamp, a glower of the type described, comprising a tube of refractory material, an exposed helix of refractory metal on the exterior of the tube and a second exposed helix on the inner surface of the tube, one of said helices being closely wound.

7. In an incandescent electric lamp, a glower of the type described, comprising a tube of refractory material, an exposed helix of refractory metal on the exterior of the tube and a second exposed helix on the inner surface of the tube, one of said helices having its adjacent turns spaced apart.

8. In an incandescent electric lamp, a glower of the type described, comprising a tube of refractory material, an exposed helix of refractory metal on the exterior of the tube, and a second exposed helix on the inner surface of the tube, one of said helices being closely wound and the other having its adjacent turns spaced apart.

9. In an incandescent electric lamp, a glower of the type described, comprising a tube of refractory material, a resistor embedded in said tube interior having elements positioned uniformly distant from the axis of said tube, and a radiating surface positioned at another distance from said tube.

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