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C. SPAETH

2,218,345

INCANDESCENT LAMP

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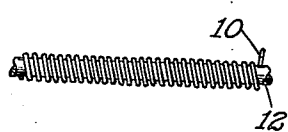


Fig. 1.

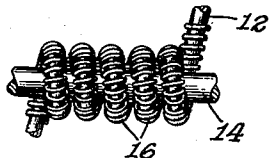


Fig. 2.

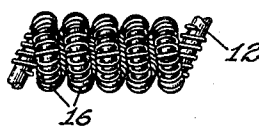


Fig. 3.

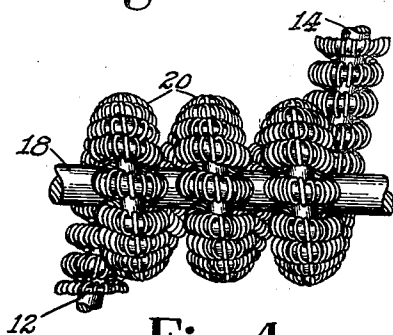


Fig. 4.

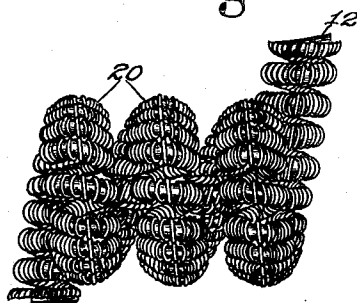


Fig. 5.

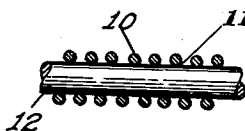


Fig. 6.

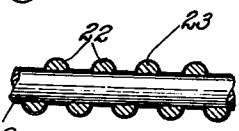


Fig. 7.

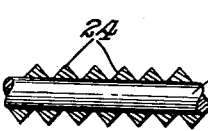


Fig. 8.



Fig. 9.

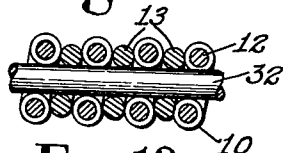


Fig. 10.

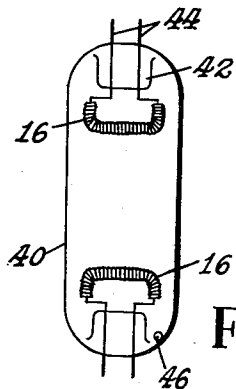


Fig. 12.

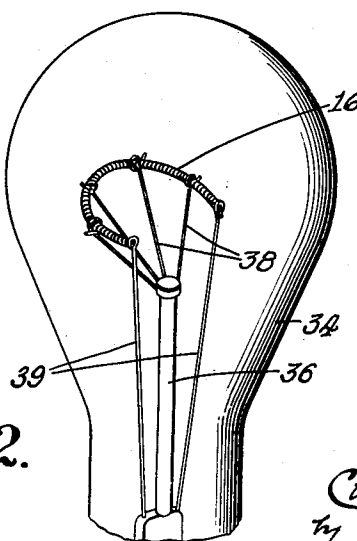


Fig. 13.

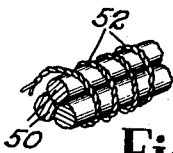


Fig. 11.

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UNITED STATES PATENT OFFICE

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INCANDESCENT LAMP

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14 Claims. (Cl. 176-40)

This invention relates to radiating units such as incandescent filaments, and is particularly applicable to electric incandescent lamps.

In one aspect the invention consists in an improved light-radiating unit or filament in which the usual metallic filament wire is employed as a core around which a helix of relatively fine wire is so wound as to increase the efficiency of the unit and to strengthen the core against sagging and offsetting. In another aspect the invention consists of an incandescent lamp embodying the filament of my invention and on this account being of improved efficiency and increased life as compared to incandescent lamps heretofore known. The invention includes also within its scope the novel method herein disclosed of making radiating units of the character described.

Various metals or alloys may be satisfactorily employed in the construction of the unit of my invention. For example, a helix of relatively fine tungsten wire or of tantalum, rhenium, hafnium, zirconium or molybdenum may be wound upon a core of heavier tungsten wire, or upon a core of other conductive material having a high melting point and a low vapor pressure at the operating temperature of the unit.

I have discovered that a radiating unit constructed in accordance with the preferred embodiment of this invention has important and novel advantages in use as compared with filaments of the usual, standard smooth-surfaced wire. Briefly, these advantages are: (1) a considerable increase in strength of the filament against sagging and offsetting, (2) longer lumen maintenance (less evaporation of the filament and blackening of the bulb), (3) longer life to burn out, (4) increased radiating surface per unit length of filament, and (5) increased radiation efficiency per unit area thereof, the last two advantages together resulting in increased filament efficiency, or a reduction of the power consumption per lumen. These advantages result in part from the fact that the temperature of the filament herein described is always lower than that of a standard filament giving the same light. The first advantage above mentioned is also due in large measure to the mechanical cooperation between helix and core. As herein shown, the helix is tightly wound upon the core, and under these conditions each element cooperates with the other in producing a particularly strong and sturdy unit, that is, the core supports the helix and the helix in turn reinforces the core, because the tensile strength of the helix is many times greater than the strength of the core against

bending and offsetting. This results in a filament of greatly improved non-sagging and non-offsetting properties.

It has been found advantageous not only to wind the helix tightly upon the core but actually to unite the coils thereof in permanent contact with the core, as by fusing or welding them thereto. This expedient insures uniformity and regularity in shape of the helix, prevents displacement or rearrangement of the individual coils, and increases the strength of the unit. The desired union may be effected, after the shape of the unit has been first carefully established, by temporarily raising the temperature of the core to the fusing point, as by the passage of an electric current, and while the parts are maintained in vacuum or surrounded by a non-oxidizing gas. In this operation the core first tends to expand as it is heated so that the coils of the helix are brought into binding relation thereto, and then as the temperature is further raised fusing, or welding, occurs at the points of contact. It is preferable that these welded points of contact be as nearly contiguous as possible; indeed, the ideal condition occurs when the helix is welded continuously throughout its length to the core. In practice, however, a continuous weld is difficult to obtain, and it has been found that when point welds occur with sufficient frequency, substantially the same results are attained as when the weld is continuous, both as regards strengthening the filament and increasing its efficiency.

Distinct advantages follow from the practice of but one characteristic step of my invention alone, without the other. That is to say, even if the helix be wound relatively loosely on the core and welded thereto at widely spaced points or not at all, as long as it is in such contact therewith as to afford fair heat-conduction therefrom, the advantages of longer lumen maintenance, longer life to burn-out and increased filament efficiency result. This is increasingly true of secondary and tertiary helices because by increasing the concentration of the helices the effects due to the primary helix are compounded. The reinforcement against sagging and offsetting can be obtained when the filament is in fast contact with the core, which condition results from tight winding, and preferably from frequent welding as above explained.

Preferably and as herein shown, the core enclosed in its helix is coiled upon a mandrel into a secondary helix of greater diameter, and the radiating unit is thus given one shape in which it may be used. After it has thus been shaped,

the mandrel is removed, leaving a coreless secondary helix formed of a primary helix enclosing a metallic core. If desired, the secondary helix thus formed may be wound upon another mandrel of still greater diameter and both mandrels then removed in a single operation in forming a radiating unit of still greater capacity. Other forms of unit may be built up based upon the core-containing or primary helix above described.

For example, one core may be wound with a spacing of helix designed to receive a second core-containing helix, or a core may be employed which is not circular in cross section should it be desired to increase the radiation of the unit in certain directions rather than others.

In an incandescent lamp embodying a radiating unit or filament constructed in accordance with my invention, the rate of evaporation of the radiating unit or filament material may be reduced by filling the lamp with argon, xenon, krypton or other gases or mixtures or vapors, such as mercury vapor, which are relatively poor heat conductors. Generally speaking, the pressure used in the lamp in which my novel unit is employed may be from a fraction of a millimeter of a mercury column up to atmospheric pressure, or even above atmospheric pressure.

The efficiency and life of the lamp may be still further improved by coating the surface of the radiating unit with certain carbides, oxides or mixtures thereof which have an extremely high melting point and a low vapor pressure. This not only protects the surface of the unit against evaporation but tends to reduce the deposit of light absorbing films of filament material upon the inside of the bulb, with the resulting blackening and loss of lighting efficiency. The desired coating may be supplied by preparing the carbides or oxides in powdered or colloidal form in a ball mill, making a paste thereof with a suitable binder, spraying or otherwise applying the paste to the unit, and then burning off the binder. Where tantalum, rhenium and certain other metals of high melting point are employed as material for the wire helix, the desired surface may be secured by carbonizing the surface of the completed unit, as by raising it to a high temperature in the presence of carbon or a hydrocarbon atmosphere.

These and other features of the invention will be best understood and appreciated from the following description of certain preferred embodiments thereof, selected for purposes of illustration and shown in the accompanying drawing, the first eleven figures of which are drawn on an enlarged scale and in which—

Fig. 1 is a view in elevation of the primary helix upon its core;

Fig. 2 is a view in elevation of a secondary helix wound upon its mandrel;

Fig. 3 is a view in elevation of a portion of the unit made by removing the mandrel from the helix shown in Fig. 2;

Fig. 4 is a view in elevation of a tertiary helix upon its mandrel;

Fig. 5 is a similar view of a portion of the radiating unit formed by removing the two mandrels from the helices shown in Fig. 4;

Fig. 6 is a view in elevation, on a still larger scale, of a portion of the primary helix on its core, suggesting the metallic union between the elements thereof;

Fig. 7 is a similar view of a unit embodying helix wire half-round in cross section;

Fig. 8 is a similar view showing helix wire of

triangular cross section wound upon the core;

Fig. 9 is a similar view showing helix wire of semi-oval cross section wound upon an oval core;

Fig. 10 is a sectional view of a modified unit;

Fig. 11 is a fragmentary view in perspective showing a portion of a core having a multiple-strand core and helix;

Fig. 12 is a more or less diagrammatic view of a glow lamp employing a unit like that shown in Fig. 3; and

Fig. 13 is a fragmentary view of a lamp made up with a unit like that shown in Fig. 3.

Figs. 1 and 2 illustrate successive steps in making the filament shown in Fig. 3. The first step consists in winding wire 10 in the form of a helix upon a straight cylindrical wire core 12. For a filament to be used with a 200 watt, 120 volt, gas-filled lamp, for example, the wire 10 may be tungsten and of a diameter of about .0005 inch or, as already suggested, other high melting, ductile metals having low vapor pressures at the normal operating temperature of the unit or filament may be used instead of tungsten. The core 12 may also be of tungsten and a suitable diameter is .004 inch or thereabouts. Having completed a sufficient length of helix, as shown in Fig. 1 or Fig. 6, which, for convenience, will be termed the primary helix, this may now be wound with its core upon a mandrel 14, as shown in Fig. 2, to form a secondary helix 16. The turns of the secondary helix may be arranged in a substantially compact manner and, as will be apparent, each coil is thus made up of a plurality of coils of the primary helix. The mandrel 14 in this case may be .01 inch in diameter and of steel or other material which may be dissolved from the unit without injuring the material of the helix. The third step of the method consists, then, in removing the mandrel 14, as by dissolving it, thereby producing the unit shown in Fig. 3 which, as will be understood, is coreless in respect to the secondary helix 16 but in which the primary core 12 is maintained within the primary helix. The coils of the primary helix may now be permanently united to their core 12 by passing an electric current through the core 12, and in this step the core first tends to expand into binding engagement with the coils of the helix 10 and then, as the temperature of the unit is still further increased, fusion takes place at the contact surfaces so that the core and helix become preferably one integral piece with the coils permanently secured in place therein and in spaced relation through a permanent metallic union or weld.

For convenience of expression in this disclosure the term core is used to designate the element remaining within the coils of the helix, and the term mandrel to designate an element used only in shaping one or other of the helices and subsequently removed. Thus the core 12 remains in the helix 10 while the mandrel 14 is removed by being dissolved after the completion of the secondary helix.

The core 12 may be of other high melting point material. For example, a molded carbon core may be employed, or a core composed of carbides or other current-conductive composition. As before, the helix should be in fast contact with its core. Moreover, the core may be circular in cross section, as shown in Fig. 6, or it may be of oval cross section, as the core 26 shown in Fig. 9. Again, the core may be composed of a plurality of strands or wires, such as the core shown in Fig. 11, which is composed of three strands

of tungsten wire laid in parallel relation or twisted together, and wound with a helix 52 of small wire or wires. The meeting surfaces of the strands 50 constituting the core form in effect longitudinal reentrant valleys or grooves in the peripheral surface of the core. As before, it is preferred that the helix wire should be welded to the core wires.

The wire employed in the primary helix 10 may be circular in cross section, as shown in Figs. 1 and 6, or it may have any desired cross section for example, it may be modified to present a flat contact face to the core and to increase the radiating surfaces. As shown in Fig. 7, the wire 22 of the helix is semi-circular in cross section and is wound with its flat face in intimate contact with the surface of the core 12, the turns of the coil being separated by a slight space. In this figure the surface of the radiating unit is shown as having a protective coating 23 of carbides, oxides or mixtures thereof, this coating having, as already stated, a high melting point and low vapor pressure. In Fig. 8 the wire 24 is substantially triangular in cross section and is wound with one flat face in contact with the core 12. In this case the turns of the helix are close wound without any intermediate space and, consequently, the entire surface of the core 12 is enclosed. This construction permits the employment of a core of material which need not have a low vapor pressure since evaporation of the material of the unit takes place solely from the helix wire within which the core is protected. In Fig. 9 is disclosed a still further modification in the shape of the wire 28 of the helix which, in this case, is semi-oval in cross section and has a flat contact face coinciding with its major axis. In all the examples given the coils of the primary helix may be fused to the core in the manner already explained.

In Fig. 4 is illustrated a step which may be carried out in converting the secondary helix of Fig. 2 into a tertiary helix of still greater diameter and having greater radiating surface than the filament shown in Fig. 3. In this case a mandrel 18 is employed and the secondary helix, including its mandrel 14, is wound upon the mandrel 18, producing a tertiary helix built up of the primary wire helix 10 upon the core 12, the secondary helix 16 upon the mandrel 14, and finally the secondary helix 16 with its mandrel 14 wound into the form of a tertiary helix. After this helix has been accurately shaped, the straight mandrel 18 and the helical mandrel 14 are removed, for example by dissolving them in an acid which does not attack the material of the coils or of the core 12. The resulting unit or filament is shown in Fig. 5 and is coreless except for the core 12 of the primary helix. Various variations of these steps may be carried out to produce different forms of unit best suited to different requirements. For example, as shown in Fig. 10, a helix may be formed of wire 13 upon the core 32 with an appreciable space between the turns of the helix. Then a primary helix, comprising the core 12 and wire 10, may be wound upon the core 32 in the space between the turns of the wire 13. In all cases it is preferable to fix the turns of the helix to its core and this is done in the manner already explained after the helix has been fully shaped.

In Fig. 13 is illustrated an incandescent lamp having its filament constructed as shown in Fig. 3, that is to say, a coreless wire helix 16 comprising a wire helix of smaller diameter having a

metallic core therein. The filament is substantially U-shaped and supported upon anchor wires 38 and lead-in wires 39 which are connected to the ends of the core 12, the helix terminating somewhat short of the ends thereof. In this figure, 36 represents the glass rod carrying the anchor wires and 34 the bulb of the lamp. Although four anchor wires are illustrated it is not always necessary that so many be employed to support the filament—one or two ordinarily being sufficient with a filament constructed according to this invention. The additional anchors are sometimes required to assure against breakage due to vibration in shipment.

The helix of tungsten wire is a relatively high resistance electric conductor shunted across the core, and a fractional part of the total current passes through it and contributes to the heat generated in it. The greater portion of its heat, however, is received by direct conduction from the core which carries by far the larger part of the total current. The helix is therefore maintained always at a somewhat lower temperature than the core, whereby its continued tensile strength and low rate of evaporation are assured.

A radiating body having cavities, the inner portions of which are incandescent, is well known to be more efficient as a radiator than a smooth-surfaced body at the same true temperature. As shown in Fig. 6, cavities 11 occur in my filament where the core and helix are nearly but not quite in contact, as well as between adjacent turns of the secondary and tertiary helices. To this extent the radiation efficiency of a filament according to my invention surpasses that of a smooth wire filament.

Were it not for the presence of the core, the incandescent helix, at least in a gas-filled lamp, would lose a substantial portion of its heat by convection because the gas inevitably washes past and through it. The core behaves as a baffle, entirely preventing this objectionable gas flow within the primary helix and reducing its velocity everywhere in the general neighborhood thereof, including the outside of its turns and the regions inside the secondary and tertiary helices. Thus the filament formed of a fine helix wound about a core affords not only an improvement in radiation efficiency over that of a smooth wire surface, but also a further improvement, in gas-filled lamps, over that of a coreless helix.

In Fig. 12 I have shown the filament of my invention as embodied in a glow type of lamp comprising the tubular bulb 40 having at each end a support or mount 42 through which extend lead-in wires 44. At opposite ends of the lamp are mounted filaments 16 similar to that shown in Fig. 3, comprising a secondary coreless helix made up of a primary helix wound upon a core 12. The bulb is filled with neon, argon, xenon or krypton gas, or with a mixture of these gases, and the bulb contains a globule 46 of mercury or sodium metal. In use, a glow discharge is set up between the filaments 16 which, on account of the large effective radiating surface, render the lamp as a whole of high efficiency. In this instance it will be understood that the units 16 act as electrodes for the glow discharge as well as radiating units for light rays. The total light of the lamp, therefore, consists of the light radiated from the units and the light radiated from the ionized vapor between them.

While I have described the unit of my inven-

tion in its field of use in lighting devices, it is also useful as a unit in heating devices, such as radiant heaters or in any unit from which it is desired to derive light or heat radiation, or radiation of invisible rays such as infra red and ultra violet.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of making radiating units, which consists in winding a wire helix with spaced turns upon a metallic core, winding that enclosed core into a helix, and heating the core by passing an electric current therethrough to cause the core to expand against coils of the wire surrounding it and to become welded thereto.

2. The method of making radiating units, which consists in winding a helix of wire with spaced turns upon a metallic core, winding the enclosed core upon a mandrel, removing the mandrel, and welding coils of the wire comprising the first helix to the core within them.

3. The method of making radiating units, which consists in winding a helix of wire with spaced turns upon a metallic core, winding a helix of wire on a second metallic core, and then winding said second enclosed core upon the first-mentioned core in the spaces between the coils of its helix, so that the turns on the second core are substantially at right angles to those on the first core.

4. The method of making radiating units, which consists in winding a helix of wire on a metallic core, winding the helix thus formed in a helix upon a mandrel, removing said mandrel, welding the coils of the first-mentioned helix to its core in positively spaced relation, and then coating the helix and core with material of high melting point and low vapor pressure.

5. An incandescent lamp comprising a gas filled bulb, and a concentrated radiating unit comprising a primary wire helix having its turns spaced from each other and permanently secured upon a core of current-conductive material, and being wound with its core to form a secondary helix of greater diameter, and said secondary helix being wound to form a tertiary helix of still greater diameter.

6. A radiating unit comprising a primary helix of wire of relatively small diameter, wound with its turns welded in spaced relation upon a solid core of current-conductive material of larger diameter and being wound with its core to form a secondary coreless helix of greater diameter, the solid core extending throughout the entire length of the primary helix.

7. A radiating unit of the incandescent filament type comprising a primary wire helix of substantially uniform diameter having its turns

wound in spaced relation upon a solid core of current-conductive material of a diameter larger than that of the helix wire and being wound with its core to form a secondary helix of greater diameter, said secondary coreless helix being wound to form a tertiary helix of still greater diameter.

8. A radiating unit comprising a core of tungsten wire and a wire helix wound thereon and welded thereto, the diameter and spacing of the turns of said helix being such as substantially to reinforce said core throughout its entire length against off-setting and the reinforced core being wound into a coreless secondary helix.

9. The method of making radiating units which includes the steps of winding a helix of wire in spaced turns upon a refractory core, helically winding the core and its helix in spaced turns upon a mandrel, removing the mandrel and permanently fixing the helix of wire to its core to increase the rigidity of the unit.

10. The method of making radiating units which includes the steps of winding a primary helix of wire in spaced turns upon a refractory core, helically winding the core and its primary helix in a secondary helix of spaced turns upon a mandrel, helically winding said mandrel and its secondary helix in a tertiary helix of spaced turns on a second mandrel, removing both mandrels and permanently fixing the helix wire to its core to increase the rigidity of the unit.

11. An electric lamp comprising a gas-filled bulb, and a filament comprising a helical metallic core with a fine reinforcing wire coiled thereon, and fixed thereon in uniformly spaced turns and coated with an oxide composition of high melting point and low vapor pressure, said reinforcing wire providing increased coating area and rigidity to said core.

12. An incandescent lamp comprising a bulb filled with a gas of low heat conductivity and a filament comprising a multiple-strand core partially enclosed by a helical wire coiled thereon, and presenting a radiating surface of high melting point and low vapor pressure.

13. In an incandescent lamp, a filament comprising a helix of fine wire wound throughout its entire length with its turns in permanently spaced relation upon a core presenting longitudinal valleys in its peripheral surface.

14. The method of making radiating units which consists in winding a helix of wire with spaced turns upon a metallic core, winding the enclosed core upon a mandrel thereby forming a secondary helix, winding the secondary helix thus formed upon a second mandrel to form a tertiary helix, removing both mandrels, and welding the coils of the wire comprising the primary helix to the core within them.

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