

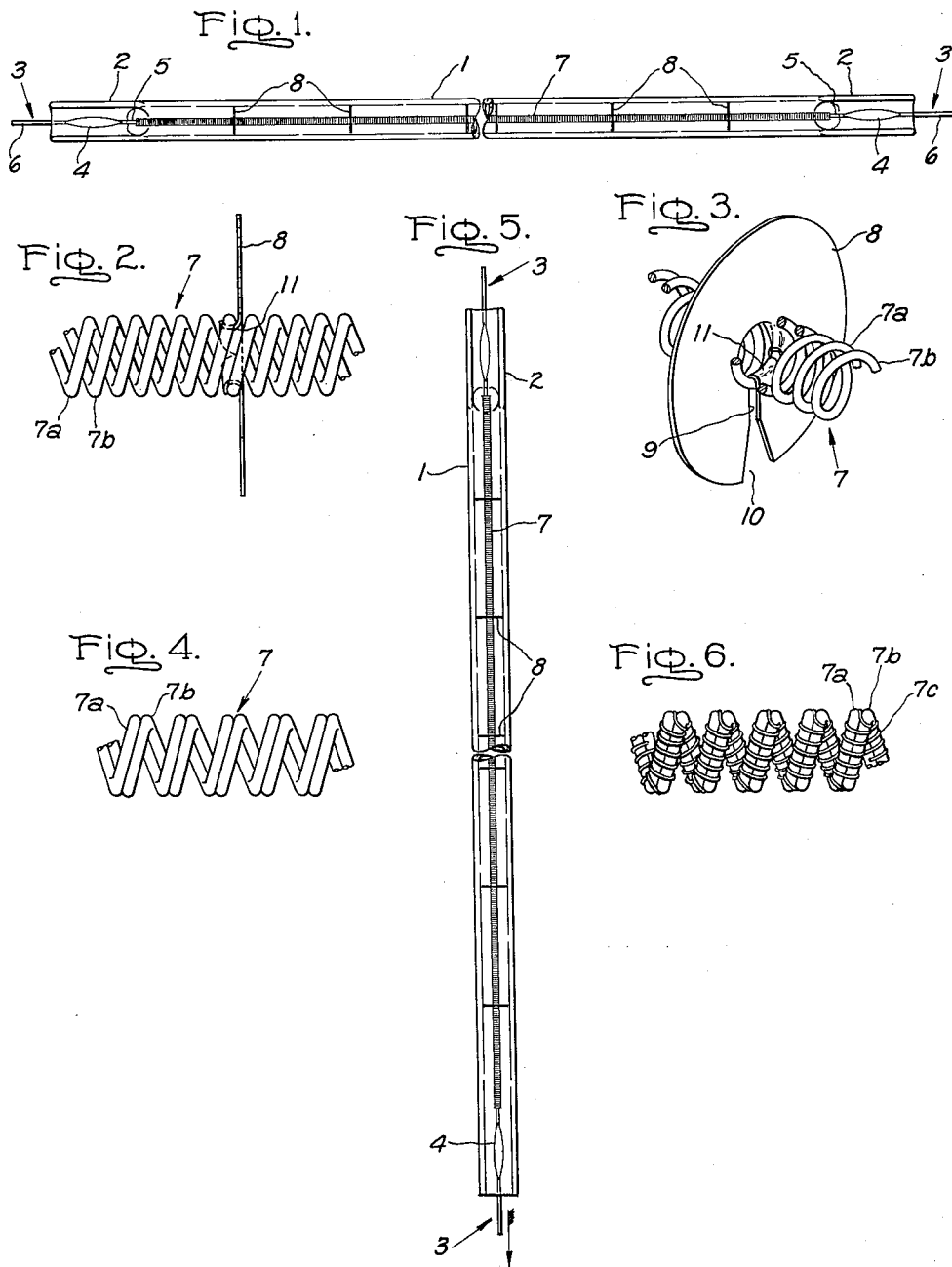
Jan. 15, 1963

W. F. HODGE

3,073,986

ELECTRIC INCANDESCENT LAMP

Filed April 20, 1960



Inventor:
William F. Hodge
by *Otto Tichy*
His Attorney

1

3,073,986

ELECTRIC INCANDESCENT LAMP**William F. Hodge, Lyndhurst, Ohio, assignor to General Electric Company, a corporation of New York**

Filed Apr. 20, 1960, Ser. No. 23,450

4 Claims. (Cl. 313-279)

This invention relates generally to incandescent electric lamps comprising a sealed envelope containing a filament of refractory metal such as tungsten which is heated to incandescence for emission of radiant energy. More particularly, the invention relates to incandescent lamps of the elongated type having a tubular envelope of relatively small diameter with a helically coiled filament extending axially thereof between lead-in conductors at opposite ends of the envelope.

Several years ago there was introduced on the market a lamp of the type described above and designed principally for the emission of infrared radiant energy. Such a lamp is disclosed and claimed in Patent 2,864,025, Foote et al. which is assigned to the assignee of the present application. The lamp comprises a tubular envelope, preferably consisting of fused silica or quartz, usually of less than one-half inch outside diameter, having lead-in conductors hermetically sealed through opposite ends thereof, and an axially extending, helically coiled tungsten filament connected at its ends to said lead-in wires and designed to operate at a color temperature between about 2400° K. and 3000° K. or higher. Lamps of this type are designed to dissipate 100 or more watts per inch of length of the coiled filament (lighted length) at an applied potential of some 15 to 28 or more volts per inch. Thus, for operation from a 120 volt source, a 500 watt lamp has a lighted length of approximately 5 inches. A 1000 watt lamp requires a voltage of 240 and has a lighted length of about 10 inches, and a 2500 watt lamp requires a voltage of 480 and has a lighted length of about 25 inches.

There has always been a demand for lamps of longer length and higher wattage operable at relatively lower voltage at a given color temperature. For example, it is desirable to provide a lamp having a lighted length of 10 inches or more and a wattage of 1000 or more operable from a 120 volt source, as compared with the currently available 500 watt lamp of 5 inch lighted length operable at the same voltage. Attempts to make such lamps in the past have been unsuccessful.

One reason for the lack of success involves stiffness of the resulting filament coil. Although the elongated filament coil is supported in the axis of the tubular bulb by support members, such as wire spirals or preferably metallic discs which engage the bulb wall, the coil must be mounted under tension sufficient to prevent it from buckling or bowing upon thermal expansion of the coil when heated to incandescence. The tension maintains the axis of the filament straight and aligned with the bulb axis, which is necessary in some cases for optical accuracy of the lamp in a reflector, and it avoids buckling of the filament such as would result in short circuiting of the coil turns and engagement of the coil with the inner bulb wall. Tension is applied to the filament during the sealing-in operation wherein the lead-in wires, having extremely thin, intermediate foil sections, are hermetically sealed in fused and compressed seals at the ends of the envelope or bulb. After one seal has been made, the filament is stretched to place it in tension by pulling down the lead-in wire connected to the free end of the filament prior to sealing that lead-in wire in the adjacent end of the envelope.

Ordinarily, the application of tension to the filament presents no problem. However, in order to provide the desired relatively long length and high wattage at a given

2

color temperature and for operation at a relatively low voltage, the resulting required tungsten wire diameter in combination with the relatively short wire length and coil diameter results in a very stiff coil. The tension necessary to prevent it from buckling when hot is generally so great as to break the foil section of the lead-in wire which is heated during the sealing operation. It has been attempted to make such a lamp by introducing the tension after sealing both ends of the lamp, by heating the quartz envelope and stretching it along with the filament coil. However, it was found to be impossible to obtain sufficient tension so that the filament could be operated at normal temperatures without buckling. Attempts to achieve sufficient tension resulted in a permanent stretching of the filament, indicating that the elastic limit for the coil is exceeded before tension sufficient to compensate for thermal expansion can be applied.

Another reason for lack of success in the past involves the attachment of the supporting members. These supports are preferably of the type disclosed and claimed in Patent 2,813,993, Fridrich and are formed and attached by the method and apparatus disclosed and claimed in Patent 2,813,327, Fridrich. The supports are in the form of discs, preferably of tantalum, made from slitted strip stock which is slipped between an adjacent pair of turns of the filament coil, after which a pointed mandrel is inserted axially through the interior of the coil to pierce the strip and form a furcated collar with curled tabs which clamp onto a turn of the coil to lock the strip in place, after which a disc is punched from the strip. The relatively short wire length required for lower voltage operation, when coiled to a reasonable diameter, results in a turn spacing or pitch so large that the support discs cannot be applied in the described manner. The tabs formed by the piercing mandrel will not lock the disc in place.

Accordingly, it is an object of the invention to provide an elongated lamp of the type described having a comparatively long lighted length and high wattage dissipation for operation at relatively low voltages at a given color temperature. Stated in another way, it is an object to increase the lighted length of the lamp without increasing the voltage needed to maintain a minimum wattage per unit of length and without excessively stiffening the coil so that it can be placed in tension sufficient to avoid buckling. It is a specific objective for example, to provide a practicable lamp construction which will dissipate at least 100 watts per inch of lighted length at an applied voltage of not more than about 12 volts per inch with a color temperature of at least about 2400° K.

In accordance with one aspect of the invention, the objects are attained by substituting for the single wire coil of relatively heavy wire of short length, a multiple coaxial coil of several longer and finer wires which will provide the same color temperature at a lower voltage. Thus, for example, a double coiled filament for operation at 120 volts with a dissipation of at least 1000 watts over a lighted length of ten inches, may be made by taking a single coil of a type used in a lamp of 1350 watts, 280 volts and 10 inch lighted length, stretching it to twice its original length, cutting the stretched coil at the center thereof, and screwing the one half into the other so that the two halves are meshed together over their entire length. The resulting coil assembly has the same turn spacing or pitch as the original coil so that supports may be attached thereto with no difficulty. Although the stiffness of the two coils is greater than that of the original coil, it is much less than that of a coil made of one piece of wire for the same voltage and wattage. No difficulty is had in sealing such a coil into the lamp. The resulting electrical characteristics are a dissipation of 1150 watts at

3

120 volts and 9.6 amperes, with a color temperature of about 2675° K. With minor changes in geometry of the double coil it can be made to duplicate more exactly the characteristics of the 1350 watt lamp. Instead of screwing together two identical coils, the double coil may be made by simultaneously coiling two wires in side by side relation around a mandrel. The wires may be of the same or different sizes and, when desired, the multiple coil may be made by coiling together more than two wires.

Further features and advantages of the invention will appear from the following detailed description and from the drawing wherein:

FIG. 1 is a side view of a lamp comprising the invention;

FIGS. 2 and 3 are fragmentary side and perspective views, respectively, of a portion of a doubled coil filament of evenly spaced turns with a support disc attached thereto;

FIG. 4 is a fragmentary side view of a double coil with adjacent turns of the two wires in contact;

FIG. 5 is an elevation showing a partially completed lamp prior to forming the seal at the lower end; and

FIG. 6 is a fragmentary side view of a modified form of double coil.

Although the invention is applicable to lamps designed principally for the emission of visible radiations it will be specifically described herein with reference to quartz infrared lamps which are designed principally for the emission of infrared radiation.

Referring to FIG. 1, the lamp illustrated therein comprises a tubular quartz bulb or envelope 1 which may have an outside diameter of about $\frac{3}{8}$ inch or $\frac{1}{2}$ inch (wall thickness about 0.40 inch) and is filled with a suitable gas, such as argon at about 600 mm. pressure at room temperature. Each end of the envelope has a compressed pinch or pressed seal portion 2 through which is sealed a lead-in conductor 3 having an extremely thin intermediate foil portion 4 hermetically sealed and embedded in the pinch 2. The foil portion 4 may be a separate piece of molybdenum welded to the ends of the inner and outer lead wire portions 5 and 6, and the inner lead portion 5 may consist of a molybdenum wire and the outer portion 6 of molybdenum or platinum. Preferably, however, the foil portion 4 is an integral foliated portion of a single length of molybdenum wire including the inner and outer portions 5 and 6, and is formed by longitudinally rolling and compressing an intermediate portion of the wire to a thickness between about .0005 to .001 inch, as disclosed and claimed in Patent 2,667,595, Noel et al.

A helically coiled filament 7 of tungsten wire extends axially of the envelope 1 and is electrically and mechanically connected at its ends to the inner end portions 5 of the lead-in conductor 3 in any suitable manner as is well known in the art. The filament 7 supported in the axis of the envelope by suitable supporting members 8, preferably tantalum sheet metal discs of the type disclosed in the aforesaid Fridrich Patent 2,813,993.

In accordance with the invention, and as shown more clearly in FIGS. 2 to 4, the filament 7 is a multiple helical coil, in this case a double coil consisting of two wire coils 7a, 7b of the same wire diameter and coil size and which are both connected at their ends to respective lead-in conductors 3 so as to be electrically in parallel circuit. As shown in FIG. 2, the two coils are evenly spaced apart whereas in FIG. 4 they are in side by side contact. As a matter of fact, a slightly uneven pitch in the coils may result in portions of the same filament having its turns evenly spaced as in FIG. 2, whereas, other portions have the turns in contact as in FIG. 4. Such unevenness causes no substantial visible temperature variations when the lamp is observed through dark glasses while operating.

As pointed out above, the filament 7 is under sufficient

4

physical tension between the lead-in wires 3 to prevent it from buckling when it undergoes thermal expansion when heated to its operating temperature by passage of current therethrough. The tension is applied during manufacture of the lamp which may be performed as described in Patents 2,855,265, Foote et al. or 2,900,771, Levand. As illustrated in FIG. 5, after the seal or pinch has been formed at one end (the upper end in FIG. 5) and just prior to forming the pinch seal at the lower end by heating the envelope and compressing it, the filament 7 is stretched by pulling down on the lower lead-in wire 3 to stretch the filament a predetermined amount which should be determined empirically for a particular filament design.

In one case, by way of example, a filament 7 composed of two coils 7a, 7b of 9 mil wire coiled about a 28 mil mandrel at a pitch of 240% (ratio of turn spacing to wire diameter) for each coil, and a coil length of about 10 inches between the inner ends 5 of the lead-in wires, is preferably stretched 6 to 8 millimeters. This amount of stretch is more than is actually needed (about $1\frac{1}{2}$ mm.) but provision is made for the higher amount of stretch in order to take care of certain manufacturing variables such as small variations in coil size and length and placement of the envelope 1 and lower lead wire 3 in the respective supporting members of the assembly equipment.

A coil of the size described immediately above dissipates about 1000 watts at an applied voltage of about 120, and operates with a color temperature of about 2600° K. A coil consisting of a helix of a single piece of wire having the same characteristics is so stiff, by virtue of large wire diameter, that it cannot be stretched sufficiently to prevent buckling without tearing the foil portion 4 of the lead wire 3. Moreover, even if the two ends of the envelope are first sealed and such a single wire filament is subsequently stretched by heating and stretching the envelope 1 therewith, it is not possible to apply sufficient tension to the coil to avoid buckling at normal operating temperature because the coil apparently takes a permanent set, indicating that the elastic limit for the coil is exceeded before stretch sufficient to compensate for thermal expansion can be applied.

After the lamp is completed with both ends thereof sealed, the filament 7 is flashed by momentarily passing a current therethrough to heat it above its normal operating temperature and to its recrystallization temperature, whereby the tungsten filament is transformed from a ductile fibrous structure to a non-ductile crystalline structure. Although some of the tension in the coil is relieved during this flashing operation, sufficient tension remains to prevent the coil from buckling when hot.

The double coil design also provides a sufficiently close spacing between the adjacent turns of alternate coils to assure proper mounting of the support members 8. As herein illustrated, the members 8 are sheet metal wafers or discs of the type described in the aforesaid Fridrich Patents 2,813,993 and 2,813,327. For installation onto the filament coil, the disc is provided with a radial slit 9, and insertion of the filament wire into the slit is facilitated by a flaring of the slit at 10. The disc is locked in place on the filament coil by a furcated collar-like portion 11 at the center thereof which is formed by a pointed piercing mandrel inserted through the interior of the coil. The collar portion has tabs which curl around a turn of the filament coil to lock it in place. Actually, depending upon the degree of insertion of the slit 9 into the coil, the tabs on the collar portion 11 may engage a single turn of only one of the coils 7a or 7b, or they may engage portions of a turn of both coils 7a and 7b. In one case, the inner end of the slit 9 goes all the way to the bottom of the coil and the piercing mandrel forms a collar portion 11 which locks onto a single turn of one of the coils 7a or 7b. In the other case, the inner end of the slit 9 is stopped by the top of one coil turn and the collar 11 is formed in

5

the slitted portion 9 with the tabs thereon engaging portions of adjacent turns of both coils 7a and 7b. In either case, the disc 8 is firmly locked in place on the coils.

In FIG. 6 there is illustrated a modified form of the double coil wherein the two strands 7a and 7b of tungsten wire are placed side by side and have thereon an overwind of much finer tungsten wire 7c. The assembly of an overwound double strand is then helically coiled as shown in the drawing. This assures uniform contact between the two filament wires 7a and 7b throughout their length and also assures concentricity about their common axis.

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

1. An elongated double-end incandescent electric lamp comprising a tubular envelope of vitreous material, lead-in conductors sealed through opposite ends of said envelope, and a helically coiled filament extending axially of said envelope and anchored at its ends to respective lead-in wires, wherein said filament is composed of a plurality of helical wire coils in coaxial relationship and connected between said lead-in conductors in parallel electrical relation and under sufficient tension to avoid buckling upon expansion thereof when heated to incandescence, said filament being proportioned to dissipate at least 100 watts per inch of lighted length at an applied voltage not exceeding about 12 volts per inch with a color temperature of at least about 2400° K., whereby the lamp has a comparatively long lighted length and high wattage dissipation at relatively low voltage for the stated color temperature and the filament has sufficient resilience that, without ex-

6

ceeding its elastic limit, it is under sufficient tension to avoid buckling when heated to its operating temperature.

2. A lamp as set forth in claim 1 wherein the said helical wire coils are of substantially the same diameter.

3. A lamp as set forth in claim 1 wherein portions of the lead-in conductors sealed in the ends of said envelope are of extremely thin foil-like form.

4. A lamp as set forth in claim 1 wherein the said helical wire coils are of substantially the same diameter and are supported from the walls of said envelope by a plurality of spaced metallic discs, each of said discs being disposed transversely of the coils between adjacent turns thereof and having a central aperture therein and a furcated collar portion at the margin of said aperture within the interior of the coils and engaging and curled about a turn of at least one of said coils to secure the disc thereto.

References Cited in the file of this patent

UNITED STATES PATENTS

1,600,563	Proctor	Sept. 21, 1926
1,957,242	Berger	May 1, 1934
1,980,675	Fredenburgh	Nov. 13, 1934
2,078,360	Ziegenbein	Apr. 27, 1937
2,126,155	Van Dyck	Aug. 9, 1938
2,813,993	Fridrich	Nov. 19, 1957
2,922,916	Sharkey	Jan. 26, 1960

FOREIGN PATENTS

806,112	Great Britain	Dec. 17, 1958
---------	---------------	---------------