Dec. 18, 1956 F. N. C. HANSEN 2,774,905

INDUCTION LAMP

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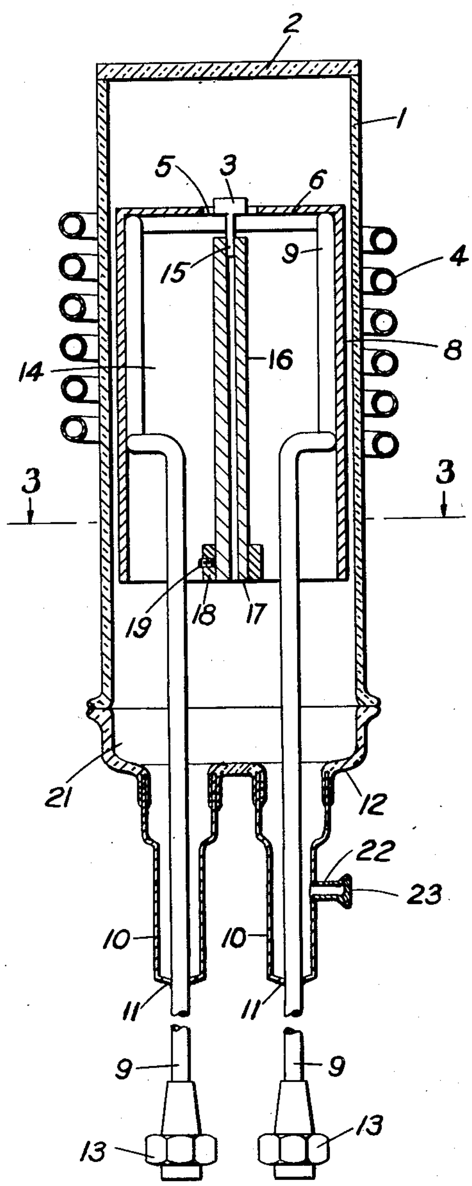

Fig. 2

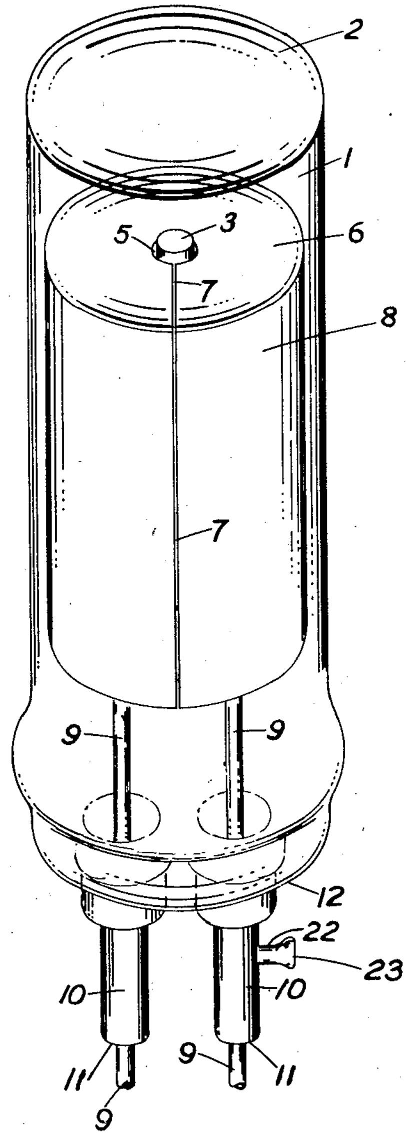

Fig. 1

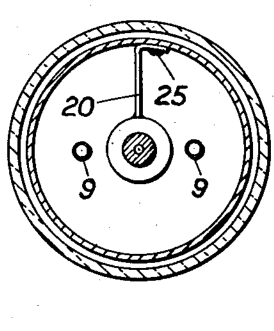

Fig. 3

INVENTOR:

FRITHJOF NIELS CARL HANSEN

BY Laurence Burns,

ATTORNEY.

United States Patent Office

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INDUCTION LAMP

Frithjof Niels Carl Hansen, Beverly Farms, Mass., assignor to Sylvania Electric Products Inc., Salem, Mass., a corporation of Massachusetts

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10 Claims. (Cl. 313—161)

This invention relates to electric lamps, and especially to lamps in which light is emitted by an incandescent body.

Such lamps have previously been either of the point-source arc-heated type or of the wire filament type, neither of which is satisfactory for use when a uniformly illuminated field is desired for projection devices, film printers and the like.

At present, incandescent lamps are generally used for such purposes, the lamp having a series of parallel filaments arranged side-by-side in a plane. In an optical system, the image produced by such a series of filaments is obviously non-uniform in brightness, and in order to reduce the non-uniformity, the system has to be defocussed, that is, the image is focussed at a point other than that at which the light is to be used. For example, in a film printer, the so-called "film gate" is the position at which the light is desired, but the image of the filament has to be focussed at a position beyond the gate, so that the image is sufficiently out of focus at the gate to blue it and give a more uniform light pattern.

Such defocussing, however, entails a considerable loss of light. For reasonable uniformity, the loss can be as much at 73% in a conventional projector system, leaving only about 27% of the light available at the film gate. Thus the major portion of the light is lost. For an incandescent filament source, therefore, the ratio of the amount of light available to the amount which can actually be used is about 3.7. A light source with the same total light output and the proper size and shape with uniform brightness could deliver 3.7 times as much light at the film gate. If the source were circular in shape and the film gate square, about 40% of the light would be lost in the part of the image outside the circumscribed square, but such a source would still deliver 2.2 times as much light as a filament source.

In addition to the loss from the amount of defocussing required, there is an additional loss with incandescent filament sources due to their inability to fill the lens of the optical system completely, because of the non-uniformity of the source. The nearer this filling is achieved, the greater will be the light output from the system. A source of uniform brightness will accordingly give a considerable gain in effective light output over that from sources hitherto used.

A light source of uniform brightness throughout its frontal luminous surface, that is, throughout the surface designed for exposure to a lens, can be achieved by using as the light source an inductively-heated body of refractory material, such as, for example hafnium carbide, tantalum carbide or niobium carbide, as shown in a copending application Serial No. 520,718, filed on July 8, 1955, by Sandford Christopher Peek, Jr. For convenience, the inductively heated body is referred to as a "target."

The target can be heated inductively from a coil placed around it and carrying high frequency current. A field concentrator between the coil and the target is very effective in improving the efficiency of energy conversion to the target. For example, a concentrator has been used in the form of a metal cylinder closed at one end except for an opening in which the target is placed. The cylinder is slotted longitudinally along its side, the slot extending radially into the closed end, in order to eliminate

any direct loop around the intensifier itself, transverse to the field.

Prior to my invention, the frontal surface of the target was set flush with the plane of the frontal surface of the annular concentrator disc, or flush with the frontal edge thereof. I have found, however, that under such a condition, the extreme outside edge of the light pattern is less bright than that from the remainder of the frontal surface. I discovered that the difference in brightness between the extreme outside circumferential edge and the remainder of the face could be eliminated if the target were set so that its frontal surface was a short distance in front of the plane of the concentrator disc, if the latter were flat, or in general a short distance in front of the front edge of the inside opening in the concentrator disc.

The loss in brightness of the circumferential edge of the target when the latter is not positioned according to my invention appears to be due to the formation of a smooth shiny surface on the cylindrical sides of the target in the neighborhood of the central opening in the concentrator disc. The smooth shiny surface has poorer radiating characteristics than the remainder of the target surface, and alters the heat distribution. By projecting the target a short distance in front of the concentrator disc, the smooth shiny surface is confined to a region farther from the front circumferential edge of the target, and the radiation characteristics and brightness of the front surface of the target become uniform. The target extends into the opening in the concentrator disc, and in general will extend back to the back edge of the annular opening in the concentrator disc.

Fig. 1 is a perspective view of one embodiment of the invention; Fig. 2 is a profile section of the device of Fig. 1; and Fig. 3 is a cross section through the middle of the device.

In Figure 1, the glass envelope **1** includes the plane glass disc **2**, of a type generally called an optical flat, through which light from the cylindrical target **3** can emerge when the latter is heated by the passage of a high frequency current in coil **4**, which is external to the lamp and not an integral part thereof. The target **3** is set in the central opening **5** of an annular metal disc **6**, and is of smaller diameter than said opening. The disc **6** has the radial slot **7** so that there will not be a complete conductive turn in which current can flow by induction. The disc **6** acts as a closure member for one end of the cylindrical metal shell **8**, which extends longitudinally back in the envelope **1**, preferably for a distance equal to the length of the coil **4** and in register therewith. The slot **7** extends from disc **6** longitudinally down the wall of cylinder **8**, to prevent the cylinder's acting as a complete conductive turn, that is, as a so-called "shorted" turn. The disc **6** and shell **8** act to concentrate the magnetic field in the vicinity of the target.

The tubes **9**, **9** should not extend across the slot **7** at any point, for if they did, they would short circuit it. In cases where liquid cooling is not desired, the concentrator disc **6** and shell **8** can be supported in some other manner than by tubes **9**,**9**, for example by being supported from the glass walls of envelope **1**.

The cylinder **8** is supported by the hollow metal tubes **9**, **9** which are attached to the copper thimbles **10**, **10** at the external ends **11**, **11** thereof, said copper thimbles being sealed to the bottom wall **12** of the glass envelope **1** in a manner customary in the art of such seals, which are generally called "housekeeper seals."

As shown in Figure 2, the hollow tubes **9**,**9** terminate in the customary type of metal connectors **13**, **13** used for sealing copper tubing together. Inside the envelope **1**, the tubes **9**, **9** extend around and across the inner wall **14** of cylinder **7**, being attached thereto by soldering or in some other convenient manner.

The hollow tubes **9**,**9** are not electrical lead-in conductors, but are merely conductors for the circulation of a cooling liquid such as water. If the water supply is grounded, however, the tubes 9, 9 and the cylinder 8 and disc 6 to which they are thermally connected, will also be at ground potential.

The thickness of target 3 is greater than that of the disc 6, and the target is placed so that part of it extends above the plane of the top of said disc. In one example, the target thickness was about 3/32 inch and the disc thickness about 1/16 inch. The disc was about 2 inches in diameter. Beyond the 3/32 inch thickness of the target itself, the target piece was machined down to a diameter of about 1/16 inch to provide a projecting support 15 for the main portion of the target 3, said supporting extending about 3/8 inch back from said target itself. The diameter of the target 3 itself was 5/12 inch.

The bottom end of projecting support 15 is fitted into a zirconia supporting tube 16 at a considerable distance, about 1/4 inch in one example, from the main target 3, in order to reduce heat losses. The zirconia tube extends downward along the axis of cylinder 7, and its lower end 17 is held in collar 18 by set screws 19, supported from the lower end of cylinder 7 in the bracket 20, shown in Figure 3 held to said cylinder by the screw 25, or in some other convenient manner. Other refractory materials than zinconia can be used, the zirconia being given as an example.

The whole internal unit or "mount" is thus supported from the Housekeeper seal thimbles 10, 10, set in the glass base of "header" 20. The seals to the thimbles 10, 10 can therefore be made before the glass header 21 is sealed to envelope 1, the sealing being accomplished in a manner well-known in the art.

After sealing the header 21, to envelope 1, the lamp can be exhausted in a manner usual in the art, through the metal exhaust tube 22 which is brazed to the side of one of the thimbles 10. The tube can then be filled with argon at about 1½ atmospheres absolute pressure, for example, and the exhaust tube 22 then sealed off to complete the lamp. The exhaust tube 22 being of metal, for example copper, can be flattened together at one part of its length to seal the lamp from the exhaust system, and then cut off at the flattened part. Such seals are well-known in the art.

In operation, one of the tubes 9 is connected to a water inlet by connector 13, and the other tube 9 is connected to a water outlet by its connector. Water, or other cooling fluid, is then circulated through the tubes 9, thereby keeping the disc 6 and shell 8 cool. A high frequency source of say 4 megacycles although other frequencies can be used, is connected to coil 3, through which high frequency current will accordingly flow. The magnetic field inside said coil is concentrated, by disc 6 and shell 8, around the refractory target 3, which is accordingly heated by the currents induced in it. The target 3 becomes very hot, its temperature rising to about 3600° K. if sufficient energy is supplied.

The light from the front surface of target 3 then travels through the optical flat 2 to the plane in which it is to be used.

The embodiment described is merely by way of illustration, and the invention is not limited to that embodiment. Many modifications will be apparent to those skilled in the art, without departing from the scope and spirit of the invention. For example, the metal carbide targets can be heated by means other than induction if desired.

What I claim is:

1. An electric induction lamp comprising a magnetic field concentrator; a refractory induction target in operative relation therewith to be heated by the magnetic field of said concentrator, the field in the immediate region of the concentrator deteriorating the surface thereof in said region during operation of the lamp, said target extending away from said concentrator for a distance greater than that over which appreciable deterioration occurs.

2. An electric induction lamp comprising a magnetic field concentrator; a refractory induction target in operative relation therewith to be heated by said field, said target having a uniformly rough surface and the field in the immediate region of the concentrator being such as to smooth the roughened surface of the target in said region, said target extending away from said concentrator for a distance greater than that over which appreciable smoothing of said target surface occurs.

3. An electric induction lamp comprising: a magnetic field concentrator including a disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the rim of the inner opening in the direction of useful light emission from the target.

4. An electric induction lamp comprising: a magnetic field concentrator including a flat disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the plane of the disc in the direction of light emission from the target.

5. An electric induction lamp comprising: a magnetic field concentrator including a disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the rim of the inner opening in the direction of light emission from the target, whereby the apparent brightness of light emission from said target is substantially constant over the lateral surface of said target on the side from which useful light is emitted.

6. An electric induction lamp comprising: a magnetic field concentrator including a disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the rim of the inner opening in the direction of useful light emission from the target, a light-transmitting envelope enclosing said concentrator and said target, and a filling of gas in said envelope.

7. An electric induction lamp comprising: a magnetic field concentrator including a flat disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the plane of the disc in the direction of light emission from the target, a light-transmitting envelope enclosing said concentrator and said target, and a filling of gas in said envelope.

8. An electric induction lamp comprising: a magnetic field concentrator including a disc having an opening therein; and an induction target of a refractory material selected from the group consisting of tantalum carbide, zirconium carbide, hafnium carbide, said target extending within said opening but spaced therefrom and projecting beyond the rim of the inner opening in the direction of useful light emission from the light.

9. An electric induction lamp comprising: a magnetic field concentrator including a flat disc having an opening therein; and an induction target of a refractory material selected from the group consisting of tantalum carbide, zirconium carbide, hafnium carbide, said target extending within said opening but spaced therefrom and projecting beyond the plane of the disc in the direction of light emission from the target.

10. An electric induction lamp comprising: a magnetic field concentrator including a disc having an opening therein; and a refractory induction target extending within said opening but spaced therefrom and projecting beyond the rim of the inner opening in the direction of useful slight emission from the target, said target not extending beyond the rim of the inner opening in the direction opposite to that of useful light emission from the target.

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