July 26, 1960 C. MOREHEAD 2,946,909

DISCHARGE DEVICE

Filed March 30, 1959

FIG. 1.

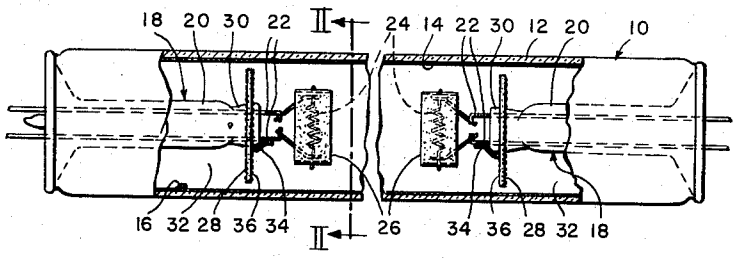
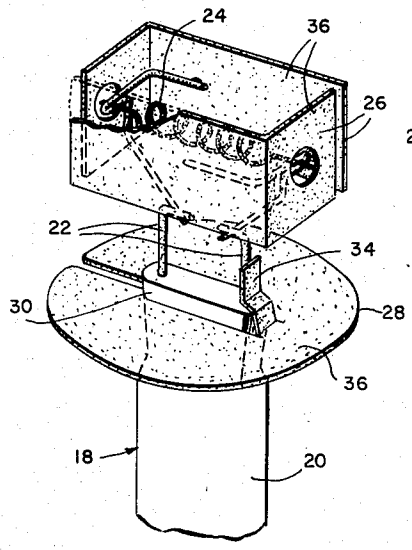


FIG. 3.



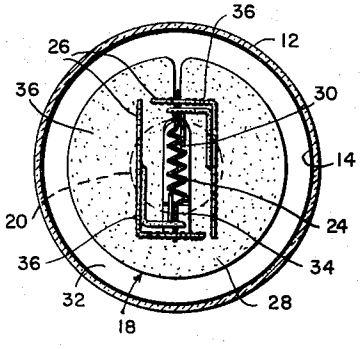
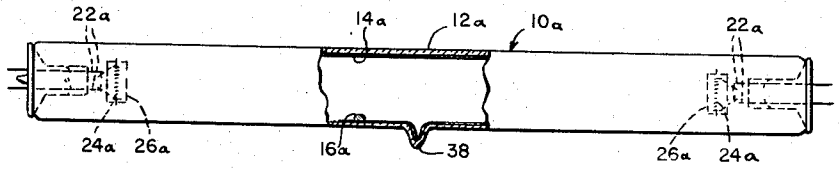


FIG. 2

FIG. 4.



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DISCHARGE DEVICE

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5 Claims. (Cl. 313—43)

This invention relates to electric discharge devices and, more particularly, to fluorescent lamps intended to be operated under conditions of relatively high loading and to a method of minimizing the loss of light output during the useful life of such lamps.

It is well-known that the luminous efficiency of a fluorescent lamp is largely determined by the amount of 2537 A. radiation which reaches the phosphor coating from the mercury discharge. It is also well-known that the intensity of 2537 A. radiation reaches a peak when the mercury-vapor pressure is within the range of about 6 to 10 microns and that this pressure can be maintained by providing a region within the lamp that has a normal operating temperature of 40° C. to 45° C. With the standard fluorescent lamp, this condition is readily obtained since the power input is such that the major portion of the lamp envelope has a normal operating temperature within the aforesaid range. Increasing the power input of a fluorescent lamp without providing means for controlling the mercury-vapor pressure causes the latter to increase resulting in a decrease in the intensity of the 2537 A. radiation and the lumen per watt efficiency of the lamp. It has, accordingly, been impractical from an efficiency standpoint merely to increase the loading of a fluorescent lamp in an attempt to increase its light output. In referring to the loading of a fluorescent lamp it is customary to express it in terms of the number of watts per unit of lamp length. Thus, a standard 40 watt fluorescent lamp 4 feet in length is said to have a loading of 10 watts per foot. Fluorescent lamps of conventional design having a loading as high as 16 watts per foot are known but are relatively inefficient compared with lamps having the normal loading of 10 watts per foot and thus have not been widely adopted, at least in this country.

Recently there have been developed highly loaded fluorescent lamps capable of operating at much higher loadings than the aforesaid upper limit of 16 watts per foot heretofore employed in fluorescent lamps of standard design. In these highly loaded lamps the mercury-vapor pressure is controlled by providing a relatively cool region within the lamp which has a normal operating temperature within the required temperature range of 40° C. to 45° C. This cool region may be created by shielding the ends of the lamp to provide cooling chambers thereat or by forming a centrally located protrusion on the envelope. Lamps of this character have been marketed having loadings as high as 25 watts per foot and even higher loadings are possible. It has been found, however, that the lumen maintenance of such highly loaded lamps is very poor compared to standard type lamps having a normal loading of 10 watts per foot. That is, the curve of the light output versus hours of operation drops off much faster with highly loaded lamps than with standard type fluorescent lamps. In copending application Serial No. 786,993, filed January 15, 1959, by A. Wainio and owned by the present assignee, now U.S. Patent No. 2,930,919, dated March 29, 1960, there is disclosed and claimed an improved heat shield and anode structure for an end-cooled type high loaded lamp wherein by coating the aforesaid structure with black chrome-vanadium plating the lumen maintenance is greatly improved over control lamps made without such plating. Even with this improvement, however, the lumen maintenance performance of highly loaded fluorescent lamps is much poorer than that of normally loaded lamps and thus disadvantageous from an efficiency and lighting cost standpoint.

It is accordingly the general object of this invention to avoid and overcome the foregoing and other difficulties of and objections to the prior art by the provision of a highly loaded fluorescent lamp wherein the loss of lumen output during life more nearly approaches that of standard fluorescent lamps of normal loading.

The aforesaid object of the invention, and others which will become apparent as the description proceeds, are achieved by introducing a predetermined amount of nitrogen into a highly loaded fluorescent lamp the non-emissive portions of the mount structures whereof have been provided with black chrome-vanadium plating in accordance with the aforesaid U.S. Patent No. 2,930,919. The nitrogen is preferably mixed with the fill gas and introduced into the lamp during the gas-filling operation. For reasons not yet understood the combination of the aforesaid black plating and nitrogen effects an improvement in the lumen maintenance of a highly loaded lamp over and above that produced by the black plating alone and of approximately the same order of magnitude as that effected by such plating over a conventional lamp of this character. The present invention accordingly constitutes an improvement over the invention disclosed and claimed in the above-mentioned U.S. Patent No. 2,930,919.

For a better understanding of this invention reference should be had to the accompanying drawing wherein:

Fig. 1 is an elevational view, partly in section, of one type of highly loaded fluorescent lamp in which the present can be advantageously employed;

Fig. 2 is an enlarged sectional view along the line II—II of Fig. 1, in the direction of the arrows;

Fig. 3 is an enlarged perspective view of the electrode and shield portion of a mount for the lamp shown in Fig. 1, illustrating in further detail the plated heat shield, lead-in conductors and enlarged anodes; and

Fig. 4 is another form of highly loaded fluorescent lamps in which this invention can be incorporated.

With specific reference to the form of the invention illustrated in the drawing, the lamp **10** in Fig. 1 comprises a tubular envelope **12** which carries a phosphor coating **14** on its inner surfaces and encloses an inert, ionizable starting gas such as a mixture of 20% argon-80% neon at a pressure of about 2 mm. and a small charge of mercury **16**. At each end of the envelope **12** is provided a mount **18** comprising the usual re-entrant stem **20** having a press portion **30** through which is sealed a pair of lead-in conductors **22**. The ends of the lead-in conductors **22** which extend inwardly into the envelope **12** are electrically connected to and carry enlarged L-shaped anodes **26** arranged to form a rectangular enclosure, as shown more particularly in Figs. 2 and 3. Electrodes **24** such as coiled-coil tungsten filaments filled with a conventional mixture of alkaline-earth oxides are attached to and supported between the inner ends of the lead-in conductors **22** and are centrally disposed within the enclosure formed by the enlarged anodes **26**, in accordance with the usual practice. Metallic heat shields **28** are affixed to the press portions **30** of each stem **20** proximate the associated end of the envelope **12** and closer thereto than the electrodes **24**. The heat shields **28** are considerably smaller in diameter than the envelope **12** to permit the gas to circulate freely and thereby provides a

cooling chamber 32 at each end of the envelope 12 adapted to maintain the operating mercury-vapor pressure within the desired 6 to 10 micron range, as is well-known in the art. Each of the heat shields 28 is provided with a tab 34 which is electrically connected with one of the lead-in conductors 22 that support each of the electrodes 24 so that said heat shields also serve as anode surfaces.

In accordance with the present invention at least the enlarged anodes 26 and heat shields 28 are provided with a black chrome-vanadium plating or coating 36 and nitrogen within the range of .3% to 3% by volume is added to the fill gas normally introduced into the lamp 10 during manufacture. A plating of the aforesaid character is disclosed in copending application Serial No. 591,206 filed June 13, 1956, by Wainio and Sutter, now U.S. Patent No. 2,885,587, owned by the present assignee. A similar plating is also disclosed in U. S. Patent No. 2,824,829 dated February 25, 1958. The black chrome-vanadium plating can be applied to the anodes 26 and heat shields 28 in the manner outlined in detail in the aforesaid Patent No. 2,885,587. Briefly, this plating 36 is formed of chromium, vanadium and oxygen in which there are from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium with the vanadium in the plating essentially compounded as vanadium trioxide. The chromium in the plating is partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in the plating being from 2:1 to 100:1. The thickness of the plating is not critical although the exterior surfaces of the anodes 26 and shields 28 should be completely covered. As an example, the coating can have a thickness of about 0.05 mil. The surfaces of the plating adjacent the base metal forming the anodes and shields may tend to interact slightly with the base metal to form a complex compound, but the bulk of the plating including all exposed portions remains unreacted with the base metal.

The nitrogen is preferably mixed with the fill gas and introduced into the lamp during the gas-filling operation so as not to interfere with normal sequence of operations followed in fabricating the lamp. It can, however, be introduced separately before or after the lamp has been charged with the fill gas normally employed. Any suitable noble gas or mixture thereof may be employed along with the nitrogen, as for example argon, 7% krypton-93% neon or 10% helium-90% argon. The most pronounced improvement in lumen maintenance has been obtained when nitrogen is added within the range of about .5% to 1.5% with optimum results being achieved with addition of 1% nitrogen. Upon seasoning the completed lamp 10 the nitrogen essentially disappears from the gas phase and the fill gas is restored to its original noble gas constituents. The exact form in which the nitrogen is still present within the seasoned lamp and the mechanism by which the nitrogen effects the resultant improvement in the lumen maintenance thereof is not known at the present time. It is theorized, however, that due to the increase in 1850 A. radiation incident with the increase in the lamp loading the halophosphate type phosphor customarily employed in fluorescent lamps deteriorates or is otherwise deleteriously affected at a faster rate than heretofore. It is further theorized that because of the presence of the above-specified black chrome-vanadium plating the nitrogen is allowed to react with the mercury-vapor to form mercury nitride or some other mercury complex which inhibits in some manner the deterioration of the halophosphate phosphor coating 14 and establishes a beneficial nitrogen cycle within the finished lamp. Whatever the reason, it is a definitely established fact that the combination of nitrogen within the range of .3% to 3% and black chrome-vanadium plating on at least the enlarged anodes 26 and shields 28 effects a marked improvement in the lumen maintenance of highly loaded lamps employing conventional halophosphate type phosphors, which phosphors are well-known and described in U.S. Patent No. 2,488,733 dated November 22, 1949. As will be obvious, small amounts of other types of phosphors such as green-emitting zinc silicate or blue-emitting calcium tungstate may be added to the halophosphate phosphor to comprise the coating 14 and thereby adjust the color of the light output without materially effecting the degree of improvement obtained in lumen maintenance.

The lumen maintenance of a control group of lamps having unplated lead-in conductors, anodes and shields and another group having the aforesaid parts coated with black chrome-vanadium plating were compared with otherwise-identical lamps incorporating both the black plating and nitrogen addition to the fill gas in accordance with this invention. The lamps were designed to operate at a loading of 25 watts per foot, had an overall length of 4 feet and an O.D. of 1½ inches and had nickel anodes, heat shields and inner lead-conductors. After 500 hours of operation the control lamps without the black plating or nitrogen displayed a light output which was approximately 83% of the light output measured at 100 hours operation. After the same 500 hours period of operation the other group of control lamps incorporating the black chrome-vanadium plating on the shields, lead-in conductors and anodes displayed a light output which was approximately 88% of the light output as measured at 100 hours operation. In contrast, lamps manufactured in accordance with this invention and having both the black plating and a 1% nitrogen addition to the fill gas displayed a light output approximately 92% of the light output as measured at 100 hours operation and comparable lamps with 2% nitrogen addition gave 89% of the 100-hour light output after 500 hours burning. Due to the variations in light output incident with the first 100 hours of operation the 100-hour value has been used for rating purposes as is customary in the art. The aforesaid comparative test data are listed in the following table, designated Table I:

Table I

Lamp Type	Construction	Percent Maintenance		
		100 hrs.	500 hrs.	1,000 hrs.
40W-T12	Standard	100	96.5	94
100W-T12 (highly loaded)	do	100	83	70
Do	Black Plating	100	88	77
Do	Black Plating @ 1% N2.	100	92	85
Do	Black Plating @ 2% N2.	100	89	82

As will be noted, the use of a 1% nitrogen addition to the fill gas and black chrome-vanadium plating on the non-emissive metallic portions of the mount structure produced at least a 4½% improvement in maintained lumen output after 500 hours operation over the control group lamps incorporating only the black plating and at least 10½% improvement over the control group of lamps without such plating. For this particular size of lamp this represents a gain in light output of about 240 lumens and 540 lumens, respectively, during the first 500 hours of operation. Of equal importance, the addition of nitrogen unexpectedly inhibited the rate at which the light output dropped after the first 500 hours, as evidenced by the fact that after 1000 hours operation the control lamps with only black plated parts had a light output equivalent to only 77% of the 100-hour value whereas lamps having a 1% nitrogen addition and black plating had a light output 85% of the 100-hour value that is, an overall improvement of over 10% or—an additional improvement in maintained lumen output

at 1000 hours of at least 5½% compared to that exhibited after 500 hours burning.

The foregoing performance figures were obtained from highly loaded fluorescent lamps wherein the black chrome-vanadium plating **36** was applied to the enlarged anodes **26**, heat shields **28** and to the inwardly-extending portions of the lead-in conductors **22** that is, to the non-emissive metallic portions of the mounts **18**. If desired, the plating **36** may be omitted from the lead-in conductors **22** in which case the improvement in the maintenance of light output will be slightly decreased but will still be significantly better than either group of control lamps.

The invention may be also advantageously employed in a highly loaded fluorescent lamp **10***a* identical in construction with the end-cooled type lamp **10** above-described except that the desired cooling effect is achieved by means of a protrusion **38** at the center of the lamp envelope **12***a* rather than by end cooling chambers. In this type lamp the heat shields are accordingly eliminated and the lamp mounts proportionately decreased in length. As a specific example lamps of this type may have a loading of 25 watts per foot, an envelope **12***a* approximately 5 feet long and approximately 1⅜ inches in diameter, and a protrusion **38** about $^{13}/_{32}$ of an inch in diameter and about $^{13}/_{32}$ of an inch long.

It will be recognized that the objects of the invention have been achieved by providing a fluorescent lamp which is adapted to be operated at relatively high loadings with a lumen maintenance which is not only significantly better than that heretofore obtained with similar lamps but which approaches that of normally loaded lamps.

While two best-known embodiments have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

I claim:

1. A fluorescent lamp adapted when normally operated to have a loading in excess of 16 watts per foot comprising, an envelope having a small charge of mercury sealed therein, a phosphor coating on the inner surface of said envelope comprising a halophosphate phosphor, a gaseous filling within said envelope initially comprising a mixture of at least one inert ionizable gas and nitrogen wherein the nitrogen is within the range of .3% to 3% by volume, lead-in conductors sealed through and extending inwardly into said envelope, a mount structure at each end of said envelope including electrodes carried by said lead-in conductors, means comprising an integral part of said lamp for controlling the mercury-vapor pressure when said lamp is normally operated, and a black chromium-vanadium plating on the non-emissive portions of each of said mount structures.

2. A fluorescent lamp adapted when normally operated to have a loading in excess of 16 watts per foot comprising, an envelope having a small charge of mercury sealed therein, a phosphor coating on the inner surface of said envelope comprising a halophosphate phosphor, a gaseous filling within said envelope initially comprising a mixture of at least one inert ionizable gas and nitrogen wherein the nitrogen is within the range of .5% to 1.5% by volume, lead-in conductors sealed through and extending inwardly into said envelope, electrodes connected to said lead-in conductors, enlarged anodes positioned proximate said electrodes and electrically connected to said lead-in conductors, means comprising an integral part of said lamp for controlling the mercury-vapor pressure when said lamp is normally operated, and a black chromium-vanadium plating on said enlarged anodes, said plating principally comprising from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium, the vanadium in said plating essentially compounded as V_2O_3, and the chromium in said plating partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in said plating being from 2:1 to 100:1.

3. A fluorescent lamp adapted when normally operated to have a loading in excess of 16 watts per foot comprising, an elongated envelope having a small charge of mercury sealed therein, a phosphor coating on the inner surface of said envelope comprising a halophosphate phosphor, a gaseous filling within said envelope initially comprising a mixture of at least one inert ionizable gas and nitrogen wherein the nitrogen is within the range of .3% to 3% by volume, lead-in conductors sealed through and extending inwardly from each end of said envelope, electrodes connected to said lead-in conductors, enlarged anodes positioned proximate said electrodes and electrically connecting with said lead-in conductors, metallic heat-deflecting shields proximate each end of said envelope and positioned closer to the ends of said envelope than said electrodes to form cooling chambers thereat, each of said shields electrically connecting with one of the lead-in conductors connected to each of said electrodes, and a black chromium-vanadium plating on said enlarged anodes and heat shields, said plating principally comprising from 100 to 9.5 parts by weight of a total chromium per part by weight of vanadium, the vanadium in said plating essentially compounded as V_2O_3, and the chromium in said plating partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in said plating being from 2:1 to 100:1.

4. A fluorescent lamp adapted when normally operated to have a loading in excess of 16 watts per foot comprising, an elongated envelope having a small charge of mercury sealed therein, a phosphor coating on the inner surface of said envelope comprising a halophosphate phosphor, a gaseous filling within said envelope initially comprising a mixture of at least one inert ionizable gas and nitrogen wherein the nitrogen is within the range of .3% to 3% by volume, lead-in conductors sealed through and extending inwardly from each end of said envelope, electrodes connected to said lead-in conductors, enlarged anodes positioned proximate said electrodes and electrically connecting with said lead-in conductors, means comprising an integral part of the wall of said envelope for controlling the mercury vapor pressure during normal operation of said lamp, and a black chromium-vanadium plating on said enlarged anodes, said plating principally comprising from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium, the vanadium in said plating essentially compounded as V_2O_3, and the chromium in said plating partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in said plating being from 2:1 to 100:1.

5. A fluorescent lamp adapted when normally operated to have a loading in excess of 16 watts per foot comprising, an elongated envelope having a small charge of mercury sealed therein, a phosphor coating on the inner surface of said envelope comprising a halophosphate phosphor, a gaseous filling within said envelope initially comprising a mixture of at least one inert ionizable gas and nitrogen wherein the nitrogen is within the range of .5% to 1.5% by volume, lead-in conductors sealed through and extending inwardly from each end of said envelope, electrodes connected to said lead-in conductors, enlarged anodes positioned proximate said electrodes and electrically connecting with said lead-in conductors, metallic heat-deflecting shields proximate each end of said envelope and positioned closer to the ends of said envelope than said electrodes to form cooling chambers thereat, each of said shields electrically connecting with one of the lead-in conductors connected to each of said electrodes, and a black chromium-vanadium plating on said enlarged anodes, the portions of said lead-in conductors extending

within said envelope and on said heat shields, said plating principally comprising from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium, the vanadium in said plating essentially compounded as V_2O_3, and the chromium in said plating partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in said plating being from 2:1 to 100:1.

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