This invention relates to fluorescent lamps having a filling of inert gas, and especially to lamps of that type for high power loading.

Fluorescent lamps of the usual types generally have a filling of argon gas, which works satisfactorily for operation of the lamps at the usual low power inputs of about 10 watts per linear foot of lamp.

However, when the power input is increased to about 25 or more watts per linear foot of lamp tube, an argon filling is no longer satisfactory. Fillings of neon or helium give greater efficiency.

The use of neon increases the rate of disintegration of the cathode and reduces the life of the lamp. On the other hand, the use of pure helium increases the lamp voltage too much for most uses.

We have discovered, however, that the lamp life can be greatly increased and the voltage kept within reasonable limits by using a mixture of helium and argon, a preferred mixture being about 15% helium and 85% argon. This mixture unexpectedly gives both long life and high efficiency at high power input.

In addition, we have discovered that such a lamp with a helium-argon filling gives a considerable and quite unexpected increase in maintenance of light output during use, that is, the light output of the lamp drops less rapidly during life than it would with a filling of another gas or mixture of gases.

A fluorescent lamp with a filling of neon will have shorter life than one filled with argon, and so will a lamp even with a filling of only 80% neon and 20% argon. Tests have shown that lamps with the latter filling have had an average life of about 3000 hours with loadings of about 25 watts per foot, the average life being taken on the point at which half of the lamps on test failed. On the other hand, lamps with the 15% helium and 85% argon filling have run more than 5000 hours without any failures at all on some tests, and with only a small percentage of failures on others.

The amount of helium added to the argon gas is quite important, and should be between 5% and 25% by volume of the total mixture for good lamp life. Pressures above zero but less than 5% give poorer life and so do pressures above 25%. For best operating conditions the helium content should be at least 10% but not greater than 15%.

For example at about 10%, the life appears to be about 10% greater than at either 5% or 25%.

The life with the 10% to 15% argon-helium mixture is about twice that obtained with the prior commercially used mixture of 80% neon and 20% argon.

Efficient heavily loaded lamps have been designed as described in copending patent application, Ser. No. 742,928, filed June 18, 1938. This copending application details the reasons for a high electron temperature in a heavily loaded lamp with a low pressure mercury discharge. This present disclosure will describe another method of obtaining a high electron temperature resulting in efficiencies only slightly lower than for neon/argon or pure neon filled lamps operating at loadings of the order of 25-watts per foot. This method has other important advantages not associated with a high percent neon filled fluorescent lamp.

By reduction of the pressure of the fill in a low pressure mercury arc discharge, the mobility of mercury ions is increased. This results in an increased rate of loss of ions due to recombination at the bulb wall. The electron temperature increases due to the requirement of an increased rate of production of ions to offset the increased rate of loss of ions. Thus, a lamp filled with argon at say 0.8 mm. mercury pressure will have an electron temperature higher than a lamp filled to 3.0 mm. pressure of mercury with the same gas. It follows that the plasma efficiency of an 0.8 mm. pressure lamp at high loadings will be superior to a 3.0 mm. pressure lamp.

Such a lamp as discussed above, when operated at 25-watts per foot will have a current about 2.0 amperes. Electrode losses are taken as equal to a factor of nineteen times the lamp current. Thus, this lamp will have electrode losses of 38 watts. This is a sizeable portion of the total power input to a four-foot lamp and since these losses produce little or no light, the overall lamp efficiency will be adversely affected.

The lamp current can be decreased significantly at this loading by the introduction of small amounts of helium to the argon. This, in turn, will decrease the electrode losses and result in higher overall lamp efficiency.

Lamps about 48 inches long and about 1½ inches in diameter have been made using an 85/15 mix of argon and helium with an H type mount structure as described in the previously-mentioned copending application, and life tested. These lamps deliver approximately 6200 lumens for an input of 107-watts. The lamp current and voltage are 1.4 amperes and 90 volts, respectively.

Other objects, features and advantages of the invention will be apparent from the following specification taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a graph of the probability of exciting collisions against voltage for an argon-helium mixture as compared to a neon-argon mixture; and

FIGURE 2 is a view, partly in section of a lamp according to the invention.

Exhaustive studies have been made of the cathode potential during the time of transition from zero current to operating current or phase of high loaded lamps. During this time the potential attains values of the order of 100-150 volts which can cause severe sputtering of cathode materials. Thus, it is helpful to minimize the time of this transition. It has been observed that argon-helium filled lamps passed through this transition in considerably less time than similar lamps filled with a neon/argon mix. This difference in transition time is the result of the difference in probability of making exciting or ionizing collisions as a function of voltage for the two different gas mixtures. Such curves for excitation are shown in FIG. 1. As can be seen, for a given probability, say 0.4, only 12.9 volts are needed in an argon/helium mix while in a neon/argon mix 16.4 volts are required. The lower voltage requirement for argon/helium mix results in less severe ion bombardment of the cathode and correspondingly less sputtering or erosion of cathode material. During steady state rapid start type lamp operation some energy is supplied to the cathode by ion bombardment. Due to this difference in probability discussed above, for a given number of ions falling into the cathode a lower potential is required for an argon/helium fill as compared to a neon/argon fill. It follows that the cathode fall of an argon-rich fill lamp will be somewhat lower than for a neon-rich fill lamp. Such a difference in cathode fall does exist and amounts to about 1.0 volt for a good cathode.

In the case of a poor cathode, the difference in cathode fall will be greater. Thus, it follows from the previous discussion, a poor cathode will not only operate more efficiently but be sputtered less when operating in an argon
rich atmosphere as compared to a neon rich atmosphere. A further advantage of the argon/helium mix in a lamp is the slower rate of loss of light as a function of operating time. Data have been obtained showing a considerably improved maintenance of lamps filled at 1.0 mm. pressure of 85/15 argon/helium mix as compared to that of lamps filled at 0.80 mm. pressure 80/20 neon/argon mix.

In FIGURE 2, a sealed glass tube 1, about 4 feet long and 1/2 inches in diameter, having a phosphor coating 2 on its inside surface, contains a small quantity of mercury and has an electrode 3 at each end of the tube. The electrode is a coil 4, preferably of the usual triply-coiled type, of tungsten wire, the coil being filled in the usual manner with alkaline earth oxides to increase its electron emissivity. The coil is supported by the two side wires 5, 6, which extend forward of the coil 4, for example, as explained in copending Ser. No. 742,928, filed June 18, 1958, now Patent No. 2,961,566, issued November 22, 1960, by Waymouth et al., and auxiliary electrodes 7, 8, which may be in the form of curved wires, are supported by and connected to the side wires 5, 6, at their free ends.

The same side wires 5, 6, insulated by the ceramic tubules 9, 10, except where they are connected to ends of coil 4, are butt-welded to lead-in wires passing through the press 11 of stem 12, and being connected to recessed contacts in the insulating base 13 in lamp base 14. There is a similar lamp base 15 at the other end of tube 1.

An aluminum disk 16 is connected to lead-in wire 6 and supported therefrom, the other lead-in wire 5 passing through an insulating bushing 17 in disk 16.

Thus far the lamp is of a construction standard in fluorescent lamps of the very high output type; that is, lamps having an input of about 25 watts or more per linear foot. But while lamps prior to our invention have been filled with a mixture of about 80% neon and 20% argon, by volume, the lamp according to the invention is filled with a gas mixture of about 15% helium and 85% argon. The pressure of the mixture was about 1 millimeter of mercury in each case.

At the same 100 watt input, the helium/argon lamp gave about twice as long a life as the neon/argon filled lamp, and maintained its output better during life. In fact, the helium/argon lamps in general gave over 10% more light at 3000 hours life than the neon/argon lamp or any other known type of very high output lamp.

Although with the neon/argon lamp the auxiliary electrodes 7, 8, are preferably placed in the Faraday dark space, in front of the cathode, the auxiliary electrode 7, 8, in the helium argon lamp can be placed in the plane of the cathode, if desired, although the end discoloration during life will be greater in that case. By the plane of the cathode we mean a plane perpendicular to the axis of tube 1 and through the cathode.

In that case, the support wires 5, 6, would not extend into the discharge beyond the cathode coil 4.

What we claim is:

1. A fluorescent lamp comprising a sealed envelope, electrodes at each end thereof, said electrodes being tungsten wire coils containing alkaline earth oxides a coating of phosphor on the inner surface of said envelope, and a filling of mercury vapor therein, and a mixture of helium and argon therein, the helium comprising between about 5% and 25% of the gas mixture by volume.

2. A fluorescent lamp comprising a sealed envelope, electrodes at each end thereof, said electrodes being tungsten wire coils containing alkaline earth oxides a coating of phosphor on the inner surface of said envelope, and a filling of mercury vapor therein, and a mixture of helium and argon therein, the helium comprising between about 10% and 15% of the gas mixture by volume.

3. A fluorescent lamp comprising a sealed envelope, electrodes at each end thereof, said electrodes being tungsten wire coils containing alkaline earth oxides a coating of phosphor on the inner surface of said envelope, and a filling of mercury vapor therein, and a mixture of helium and argon therein, the helium comprising between about 5% and 25% of the gas mixture by volume, and means for operating said lamp at a loading of 25 watts per linear foot.

4. A fluorescent lamp comprising a sealed envelope, electrodes at each end thereof, said electrodes being tungsten wire coils containing alkaline earth oxides a coating of phosphor on the inner surface of said envelope, and a filling of mercury vapor therein, and a mixture of helium and argon therein, the helium comprising between about 10% and 15% of the gas mixture by volume, and means for operating said lamp at a loading of about 25 watts per linear foot.

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