ABSTRACT OF THE DISCLOSURE

An alkali vapor lamps in which the lead wires are protected by insulating sleeves and a shield for said sleeves, the shield being of insulating material or of metal closely connected to the lead wires, the shield being preferably cup-shaped with the open end of the cup facing backwardly from the discharge.

The invention relates to low pressure alkali metal discharge lamps. Low pressure sodium lamps have been made in a variety of forms and wattage ratings. It is necessary in all types to employ thermionic emitting cathodes which in lamps, designed to operate on alternating current supplies, must also act as anodes.

The utilisation of the electrical input to such a lamp may for descriptive convenience be divided into two parts viz electrode dissipation and dissipation occurring in the plasma or positive column of the discharge in the lamp.

The electrode dissipation is composed of anode and cathode losses which occur when current enters and leaves the gas discharge. Each electrode in an alternating current lamp acts alternately as anode and cathode, the combined losses serving mainly to heat the electrodes. Little or no light is generated by energy dissipated at the electrodes and hence this energy is generally regarded as a loss, but it does serve a useful purpose.

In order that the electrodes may emit a sufficient quantity of electrons to support the electrical discharge, their construction includes materials or compounds of metals and other elements having relatively low "work function" i.e. a minimum energy is required to cause them to emit electrons.

These low work function materials, such as examples as potassium oxide, strontium and calcium oxide, are usually supported on a refractory metal base such as tungsten and/or molybdenum. In operation, these electrodes are heated by the electrode losses in the following way. Considering firstly the plasma column of the lamp, this occupies most of the space between the electrodes and emits almost the entire light output of the lamp. The processes responsible for the generation of light by the atoms of gas and/or vapour in the positive column also result in the production of free ions and electrons. The population of the positive column by substantially equal densities of ions and electrons results in a very high electrical conductivity and a low potential gradient along the column. For example the voltage gradient in the positive column of a low-pressure sodium lamp whose arc tube is some 26 mm. in diameter and 750 mm. long is approximately 6 mm. per volt. Considering next the electrode discharge, there will be a deficiency of positive ions at the cathode, but a surplus of negative ions. The anode serves to collect electrons constituting the current flowing in the lamp. In order to perform its function of electron collection the anode is positively charged with respect to the positive column or plasma. Negative electrons are therefore attracted to the anode but positively charged ions will be repelled.

Dependent upon the energy they possess, gas pressure, gas temperature and type and other factors, positive ions from the plasma will not be able to approach within a finite distance of the anode, so cancelling the near equilibrium density conditions of the positive column. As a result the electrical conductivity of the discharge will decrease greatly and the power lost in this region of the discharge will be very large when measured in terms of power used per unit length of the plasma or positive column. The absence of positive ions near the anode will allow the resulting high potential gradient to accelerate electrons towards the anode with which they will collide and impart their energy. As a result of this action the electrode acting as an anode will be heated. The degree of anode heating will depend very largely upon the product of lamp current and the voltage difference between the anode and the nearest part of the plasma, often referred to as the anode voltage drop. The actual value of anode voltage drop will be determined by the pressure, type and temperature of the gas filling and to a smaller extent by the anode material, geometry etc. None of these determining factors may be expected to vary by more than a few percent during the normal life of a lamp. The anode voltage drop and hence anode heating may therefore be expected to remain substantially constant or increase only slightly during the normal life of the lamp.

When an electrode of an alternating current lamp is acting as a cathode, it will already have received a certain amount of heating during the previous half cycle when it acted as an anode and from subsequent operation. The cathode is electrically negative with respect to all other parts of the lamps, for it is the entry point for the electrical supply to the discharge. The electrical supply will leave the cathode and enter the discharge in the form of electrons. The cathode must be capable of emitting sufficient electrons to support the required current in the discharge. The type of electron emission occurring with oxide-coated cathodes as previously described is known as thermionic emission and this emission per unit area of cathode varies with temperature, according to established mathematical laws. Should the cathode temperature be insufficient for the cathode to emit the required quantity of electrons to support the current in the lamp, then with a deficit of conduction electrons in the immediate vicinity of the cathode the potential difference between the cathode and the positive column will rise and the cathode will electro-statically attract positive ions from the discharge. The attracted positive ions will bombard the cathode and impart to it an additional acceleration energy to the cathode. The cathode temperature will thereby be raised, so giving rise to the emission of further electrons.

If for any reason the cathode should emit more electrons than required by the current discharge, then there will be in the immediate vicinity of the cathode, a surplus of low energy electrons available for recombination with any positive ions attracted towards the cathode. Ion bombardment of the cathode will thereby be much reduced or cease altogether. The cathode temperature of low pressure sodium lamps and indeed of many other forms of gas discharge lamp is to a very large extent self-maintaining when the heating energy has its origin in the gas discharge. Should the electron emission properties of the cathode deteriorate in any way during the life of the lamp then cathode losses and hence its temperature will rise in order to maintain the surroundings and in the ability of the cathode for any reason to emit electrons during the life of the lamp will result in an increase in cathode voltage drop and a consequent increase in ion bombardment of the cathode.

It will be seen from the gas discharge mechanisms described that the electrode acting as an anode and its associated lead wires and supports etc., will always be positive with respect to the positive column or plasma of
the lamp while the electrode acting as the cathode will always be negative with respect to the positive column of the discharge. In a lamp designed for alternating current operation, the electrodes will alternate between positive and negative with respect to the positive column and, dependent upon the absolute values of these two voltages, it is possible that the two electrodes may have an average plus or minus voltage with respect to the plasma.

A mechanism of the discharge, known as ionic pumping, occurs in low pressure sodium lamps and also in lamps employing a plurality of gases or vapours whose ionisation potentials are widely different. The mechanism operates in the following manner. A low pressure sodium lamp designed to give a maximum efficiency of conversion of input energy into light output requires partial pressures of metal vapour and gas such that conduction electrons within the plasma achieve a mean acceleration energy of approximately 2.5 electron volts. The distribution of electron energies will follow the Maxwellian distribution.

With a mean electron energy of 2.5 electron volts, a rapidly decreasing number of electrons will attain higher or lower energies. Some, however, will attain sufficient energy to ionise sodium atoms at a little over 5 electron volts.

The products of ionisation of sodium vapour will be a negative electron and a sodium ion. The electron, which is extremely mobile when compared with the ion, will find its way quickly to the wall of the arc tube irrespective of direction of movement, and once at the wall electrons will constitute a negatively charged wall sheath. The negatively charged sheath at the arc tube wall will attract from the plasma sodium ions which, upon reaching the wall, will combine with an electron and return to a normal state sodium atom.

By this process the inner surface of the lamp arc tube will be bombarded by sodium ions, the majority of which will recombine with electrons and return to normal state sodium atoms, before actual contact with the wall. Some sodium atoms, however, may be expected to reach the wall before recombination and these ions have particular significance when they bombard the scratching glass of the electrode lead wires and supports.

As shown in the accompanying drawing the lead wires are sheathed in glass for the electrical protection and strength and to prevent contact between the lead wire and metallic sodium content of the lamp. Particularly when the cathode to plasma voltage is greater than the anode to plasma voltage, as may readily happen due to cathode deterioration during lamp life, a potential gradient will exist through the glass sheathing such that sodium ions arriving at the glass surface will be electrolytically transported through the glass sheathing to the surface of the lead wire where they will return to normal state atoms. Sodium metal appearing at the interface of lead wire and glass sheath will eventually result in sufficient physical pressure to crack off the glass from the lead wire and eventually to cause the lamp to fail when a crack penetrates down the lead wire to the outside of the arc tube.

Various schemes to reduce this electrolytic activity have been devised. For example, since the resistivity of glass is high with respect to that of metal glass used for the sheathing of the lead wires has been made from the highest resistivity glass commercially available. The electrodes which constitute a source of heat, have been removed as far as possible from the extremities of the sheathing lead wires and the lead wires have been made small. Lead wires have also been made of very slight conductivity material so as to conduct as little heat as possible to the extremities of the glass sheathing. In order to protect the extremities of the glass, ceramic tubes have been sealed to these extremities to shorten the length of glass sheathing required.

Such measures have had some success in preventing early lamp failures during life. None of them however can be regarded as completely successful and problems such as the following arise from their use. High resistivity glasses are generally expensive and may need coating with a sodium resistant glass in order to protect them from chemical attack by hot sodium metal. The removal of the electrodes as far as possible from the ends of the sleeving glass implies the use of a large back space behind the electrodes within the arc tube which may then run cooler than the remainder of the lamp and hence collect sodium metal distillate. All the sodium content of the lamp may eventually migrate behind the electrodes so that the lamp ceases to operate as designed. With appreciation of ion bombardment of the internal surface of the lamp arc tube including the sleeving glass of the lead wires and knowledge of cathode and anode effects on arc potential distribution within the lamp, it has been possible to design an electrode assembly free from electrolytic failure of the glass to metal seals supporting the cathode assembly.

According to the present invention there is provided a low pressure alkali metal discharge lamp in which lead wires connecting the electrodes to the outside of the lamp envelope are embedded in sleeves of insulating material extending within the envelope of the lamp including screening means arranged to shield the insulating sleeves from bombardment by ions from the plasma during discharge.

The screening means may be in the form of cups surrounding, and spaced from, the insulating sleeves or may be in the form of a plate generally perpendicular to the axis of the lamp. The screening means may be of metal, in which case they should be electrically connected to the respective electrode, or they may be of a ceramic material.

The invention may be utilised in sodium or other alkali metal discharge lamps.

Two embodiments of the invention will now be described with reference to the accompanying drawing, in which:

FIG. 1 is a section of one end of a discharge lamp according to the invention, showing one form of the screening means which may take, FIG. 1A as an enlarged detail, and FIG. 2 is a section of one end of another discharge tube according to the invention embodying another form of screening means, FIG. 2A as an enlarged detail.

Referring to the drawing, there are shown sections of one end of the envelope 1 of a sodium discharge lamp. Lead wires 2 supply an electrode 3 of the lamp. The wires are embedded in glass sleeves 4 which enter the lamp through a glass pinch seal 5 at the end of the envelope.

In FIGS. 1 and 1A, there is shown an embodiment of the invention in which the screening means is in the form of metal cups 6 surrounding each glass sleeve. The cups are made from sheet metal, punched metal, or wire mesh, and are welded at 9 in FIG. 1A to the lead wires 2 at or near the point 7 where they leave the glass sleeves. The cups are spaced from the lamp envelope and the sleeves by a sufficient extent to ensure that there will be no electrical contact between the cups and any sodium which may migrate into the end of the lamp and be deposited on the glass surfaces during the burning life of the lamp. The cups, being welded to the lead wires, will assume the electrode potential and may act as anodes during the appropriate half cycles. The cups will not normally act as cathodes, as they will preferably be made from a material, such as nickel plated steel, not possessing a low work function. However, if the space between the cup and the glass is insufficient the cup is made of a cup to make contact with sodium which has condensed on the glass surface, the sodium, having a low work function, may act as a cathode. In such a case the sodium at the point of contact would form an electrode spot, and the heat generated at that point by the electrode action might be sufficient to crack the glass surface.
The cups may alternatively be made of sodium resistant insulating material such as a ceramic. In this case the screening effect would be physical rather than electrostatic as in the case of the metal cups.

In FIG. 2 there is shown a section of a discharge lamp in which the screening means is in the form of a flat plate 8. This plate may be made of metal or metal gauze, and is welded to one of the lead wires 2 at, or near, the point 7' where it leaves the glass sleeve 4. The plate may, alternatively, be made of a ceramic material positioned in contact with both the lead wires 2 at, or near, the points 7 where they leave the glass sleeve 4, and it may be sealed to the lead wires at these points 9 in FIG. 2 or to the ends of the glass sleeve 4.

The optimum diameter of the plate is slightly more than half the internal diameter of the envelope of the lamp in the region of the lead wires. We have found that the screen need not be circular but may be oval or oblong providing that the average chord diameter of the plate is approximately half the diameter, or in the case of a non-circular envelope, the average chord diameter, of the lamp envelope in the region of the lead wires.

We have found that in the embodiments described the screening means prevent sodium ions from reaching the glass sleeves around the lead wires. An important cause of electrolytic cell cracking is removed so that special high resistant glass is not required for the sleeves, thus reducing the manufacturing cost. The effective lamp life is also increased.

What I claim is:

1. A low pressure alkali metal discharge lamp in which lead wires connecting the electrodes to the outside of the lamp envelope are embedded in sleeves of insulating material extending within the envelope, the lamp including screening means arranged to shield the insulating sleeves from bombardment by ions from the plasma during discharge, in which the screening means is a cup-shaped member on each lead wire, the wall of each member surrounding the sleeve and the open end of the cup facing away from the centre of the lamp.

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JAMES W. LAWRENCE, Primary Examiner
D. O'REILLY, Assistant Examiner

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