

PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Sodium Vapour Electric Discharge Lamps

5 We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to sodium vapour electric discharge lamps of the positive column type having an elongated tubular discharge envelope containing electrodes for the passage of an electric discharge and a filling of sodium for providing a sodium vapour discharge in normal operation of the lamp, together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed.

15 In order that such a lamp should operate at high efficiency, it is desirable firstly that the current density of the discharge should be low and secondly that the sodium vapour pressure in normal operation should be at or near an optimum value. In present practice this optimum value is usually arranged to be somewhat below the pressure giving maximum efficiency in order to obtain a suitably long useful life for the lamp by reducing the effect of the sodium vapour attacking and blackening the internal surface of the discharge envelope and to avoid unduly rapid loss of efficiency resulting from an uneven distribution of sodium metal caused by thermal migration, which effect is accelerated by the use of high vapour pressures.

20 The first of the above requirements calls for the use of a discharge envelope of relatively large diameter, but as the diameter of the envelope is increased, its wall temperature for a given wattage dissipation in the discharge, and with it the operating vapour pressure of the sodium, is reduced, and too wide an envelope results in too low a sodium vapour pressure for high efficiency; a compromise has

45 therefore, to be made between these requirements, and in order to obtain the best compromise it is desirable to provide means for conserving the heat of the discharge envelope to enable as wide a diameter envelope as possible to be used consistent with its wall temperature not falling to an undesirably low value. The efficiency attainable with a given design of lamp depends largely on the effectiveness of the heat conserving means, which means usually consists of a highly evacuated outer jacket into which the discharge envelope is fitted.

50 Various forms of such evacuated outer jacket have been used or proposed. The form at present most commonly used consists of a double-walled hollow cylinder closed at one end and the space between the walls of which is sealed and highly evacuated. The discharge tube, usually in the shape of a letter U, is inserted into the jacket from the open end, and the lamp is operated with air present in the space between the discharge envelope and the inner wall of the outer jacket, the evacuated space between the inner and outer walls of the jacket, which is usually known as a Dewar jacket, providing the necessary heat conservation. The inner wall of the Dewar jacket serves as a screen for the absorption of infra-red radiation from the discharge envelope, which screen is protected by the evacuated space from the loss of heat to the outer atmosphere and thus helps to keep up the temperature of the discharge envelope; the screen also reflects back to the discharge envelope some of the infra-red radiation emitted by the latter.

55 In order to increase further the effectiveness of the heat conserving means, and with it the lamp efficiency, it has been proposed to seal the discharge envelope into the Dewar jacket and evacuate the space between the discharge envelope and the inner wall of the Dewar jacket, so as to provide a further evacuated space between the discharge envelope and the

outer atmosphere. Such an arrangement is, however, more expensive to make and the increases in lamp efficiency attainable with it have not been so great as to justify the additional expense.

Another form of outer jacket which has been used consists of a single-walled envelope into which the discharge envelope is sealed, the space between the discharge envelope and the jacket being highly evacuated.

Such an arrangement is not in itself as effective for heat conservation as the use of a Dewar jacket since the wall of the jacket, which is heated by the absorption of infra-red radiation from the discharge, is directly exposed to the outer atmosphere. However, for further reducing the heat loss from the discharge envelope in such a lamp, it is proposed effectively to duplicate the conditions obtained with a Dewar jacket by surrounding the discharge envelope with a heat-conserving cylindrical glass sleeve intervening between the discharge envelope and the outer jacket; this sleeve is insulated from the outer atmosphere by an evacuated space, as is the inner wall of a Dewar jacket, and serves to absorb and reflect infra-red radiation from the discharge.

Such sleeves have been used both in lamps having straight discharge envelopes and in lamps having discharge envelopes of U-shape. The sleeve in the latter case contained both limbs of the U. With each of these arrangements, experience indicated that the gain in efficiency obtainable by the use of such sleeves with the single-wall type of evacuated jacket was not so great as to enable lamps of this kind to compete successfully with the Dewar-jacketed type of lamp, which has particular advantages.

Thus it is less expensive in the long run, since the Dewar jacket can be made separately from the discharge envelope and the jacket and envelope simply assembled together without sealing; the Dewar jacket has a longer life than the discharge envelope and the same jacket can be re-used, usually more than once, with a different discharge envelope at the end of a normal lamp life. Also with the Dewar-jacketed lamp the fact that air is present in the space immediately surrounding the discharge envelope helps to equalise the temperature distribution of the latter in operation of the lamp. A disadvantage introduced by this last feature is that the presence of moisture in this air under conditions of high humidity, such as may be experienced by a lamp used for street-lighting, tends to render starting of the lamp difficult or unreliable; in addition it is difficult to tell when a Dewar jacket has failed, and repeated use of such jackets can readily lead to use of a lamp with a poor Dewar jacket, but despite these advantages the Dewar-jacketed lamp has been accepted for many years as the best form of sodium lamp.

We have now found that, contrary to the

teachings of past experience, by the use of a particular form of discharge envelope and heat-conserving sleeve arrangement in a single wall type of evacuated jacket, increases of efficiency can be obtained which are so surprisingly great as to render such lamps preferable to the Dewar-jacketed lamps for at least some uses.

According to the present invention, a sodium vapour electric discharge lamp of the positive column type has an elongated tubular discharge envelope of U-shape containing electrodes for the passage of an electric discharge and a quantity of sodium for providing a sodium vapour discharge in normal operation of the lamp together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed, the discharge envelope is sealed into a single-walled outer jacket with a highly evacuated space between the inner surface of the jacket and the outer surface of the discharge envelope and each limb of the discharge envelope is individually provided with a sleeve of transparent heat-insulating material which fits closely round the limb along the whole or the greater part of the length of the limb.

It is on the use of a U-shaped discharge envelope with the limbs individually provided with closely fitting sleeves (the exact nature of which will be further defined later) that the high efficiencies attainable with a lamp in accordance with the invention depend. It may at first sight appear surprising that the use of such individual sleeves with a U-shaped discharge envelope had not previously been proposed in connection with the single-wall type of evacuated jacket, but this can readily be explained. Thus lamps of the single-wall jacket-type in which the whole of a straight discharge envelope had been closely surrounded by a thermally insulating sleeve had been tried and found to be inferior to the Dewar-jacketed lamps, and lamps of the single-wall jacket type in which both limbs of a U-shaped discharge envelope had been contained within a single thermally insulating sleeve had also been tried but found to be of no especial merit. There was, therefore, no evidence to suggest that a U-shaped discharge envelope with the limbs individually provided with closely fitting sleeves would be markedly superior, and in fact the natural inference to be drawn from the experience gained with the sleeved straight lamps would be that no particular advantages could be expected from such individual sleeving. Prior experience thus pointed away from the present invention and it is surprising to find that the inferences to be drawn from this experience are not, in fact, correct.

In the foregoing statement of the invention, and hereinafter, the term "fits closely" implies that the internal diameter of the sleeve is not more than 50% greater than the external



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diameter of the limb of the discharge envelope on which it is fitted, the diameters being taken in a cross-section at right angles to the axis of the sleeve or limb. Usually the sleeves and limbs will all be of circular cross-section, but where this is not the case each said diameter is to be taken as the maximum diameter in the corresponding cross-section, that is to say, as the longest straight line which can be drawn joining two points on the inner or outer periphery, as the case may be, of the cross-section. With the dimensions at present usual for sodium lamps of the kind used for street lighting purposes, this means that each sleeve will usually be everywhere nearer to the outer surface of the limb of the discharge envelope on which it is fitted than it is to the inner surface of the outer jacket. On the other hand the term "fits closely" also implies that along the whole or the greater part of the length of the sleeve, the sleeve is not in such intimate contact with the wall of the limb around its whole periphery as in effect, as regards loss of heat, merely to constitute a thickening of the wall of the limb, and does not include sleeves which consist merely of coating on the walls of the limbs.

Preferably the internal diameter of each sleeve is only slightly greater, for example not more than two millimetres greater, than the external diameter of the limb on which it is fitted.

For obtaining the best results with a lamp in accordance with the invention, the degree of vacuum within the outer jacket should be as high as possible and should not in any case be less than that customarily used in the evacuated outer jackets of known lamps of the kind to which this invention relates, that is to say, the residual gas pressure must not be substantially higher than 10^{-3} millimetres of mercury. A suitably high degree of vacuum can be ensured during manufacture of the lamp by exhausting the outer jacket to a high degree, preferably at least 10^{-4} millimetres mercury, and then dispersing a getter within the jacket to clean up residual gas; the getter should not, of course, be so dispersed as to obscure any appreciable part of the outer jacket or discharge envelope through which light is required to emerge in use of the lamp. The use of a getter is also desirable for ensuring the maintenance of a high degree of vacuum within the outer jacket in use of the lamp, by absorbing occluded gas which may be liberated from the walls of the jacket and discharge envelope, or from other parts within the jacket, and a sufficient excess of getter for absorbing such occluded gas throughout the normal life of the lamp is preferably used.

The statement that the said sleeves in a lamp in accordance with the invention are of transparent heat-insulating material means that the material must be a good absorber and/or reflector of infra-red radiation so as, in opera-

tion of the lamp, to reduce the rate of loss of heat from the limbs of the discharge envelope on which the sleeves are fitted; the term "transparent" (which term in this specification and in the appended claims includes translucent) means that the sleeves must absorb little or none of the visible radiation from the discharge. The wall thickness of the sleeves should, of course, be such as to give a high infra-red radiation absorption.

In general glass will be the most suitable and convenient material for the sleeves, but other materials, for example quartz, which have similar properties and are otherwise suitable for use in lamps in accordance with the invention, and in particular are capable of withstanding the heat developed in operation of the lamp without deterioration or without becoming discoloured so as to absorb appreciably the visible light from the discharge, could be used.

Spacing means may be employed, if desired, for holding the sleeves coaxially on the limbs of the discharge envelope, but in general we have found that such spacing means are not necessary for securing the required high lamp efficiencies, and the sleeves may merely be slid onto the limbs and retained in position without the use of spacing means and without being coaxial with the limbs. However, the use of spacing means may in some cases be desirable for preventing rattling of the sleeves on the discharge envelope.

If it is desired positively to attach the sleeves to the discharge envelope, each sleeve may be attached to the limb on which it is fitted at one or more regions whose total axial length is small compared with the axial length of the said limb. Where a sleeve is attached to the limb of the discharge envelope on which it is fitted in this way, it should be attached to it for only a relatively short axial distance, so that the area of contact between the limb and the sleeve will be small compared with the surface area of the discharge envelope and the heat conserving effect of the sleeve will not be appreciably reduced.

If such attachment of the sleeves is used, preferably each sleeve is attached to the limb at a single region only, and in such an arrangement the attachment of each sleeve to its respective limb is preferably effected at the end of the limb remote from the bend in the discharge envelope. In a lamp in which the electrode leads are sealed into the ends of the envelope by means of pinches, as is usual in known types of sodium vapour lamp, and the sleeves are of glass, each sleeve may be sealed to the pinch formed at the end of the limb over which the sleeve is fitted, provided that the thermal expansion coefficient of the glass of the sleeve is similar to that of the glass of the discharge envelope.

In the manufacture of a lamp in accordance with the invention where this latter construc-



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tion is employed the sealing in of the electrode lead or leads and the sealing of a sleeve to the respective limb of the discharge envelope may conveniently be carried out in a single operation, the lead or leads, the discharge envelope and the sleeve being held in predetermined relative positions in which they are to be sealed together, for example by means of suitably constructed jigs, the end of the limb surrounding the electrode lead or leads and the adjacent end of the sleeve being heated to soften the glass, and the heat-softened ends of the sleeve and the limb being squeezed together, for example by a pair of metal jaws, so as to form a pinch in which the electrode lead(s) is/are sealed, and so that the sleeve and the limb are sealed together in a fixed predetermined position after the cooling of the glass below its softening temperature.

The sealing of the two sleeves to their respective limbs by this method may be effected simultaneously if desired.

It will be appreciated that where each sleeve is attached to a limb at more than one region, the regions of attachment should not hermetically close the space between the limb and the sleeve bounded by these regions, in order to allow said space to be exhausted when the outer jacket is evacuated.

With some lamps in accordance with the invention a further increase in efficiency may sometimes be obtained by providing one or more further sleeves of transparent heat-insulating material of the kind aforesaid on each limb of the discharge envelope, each such further sleeve extending along the whole or greater part of the length of the corresponding limb of the discharge envelope.

The presence of such further sleeves further reduces the rate of loss of heat from the discharge envelope, which enhances the lamp efficiency, but also reduces slightly the emission of useful light by absorption which detracts from the lamp efficiency, and in practice there will in general be little advantage in using more than two, or at the most three, sleeves on each limb of the discharge envelope.

Preferably the internal diameter of each such further sleeve is not more than 50% greater than the external diameter of the sleeve which it immediately surrounds, the diameters being taken in a cross-section at right angles to the axes of the sleeves, said diameters to be taken as the maximum diameters (as hereinbefore said) in the cross-section if the sleeves are not of circular cross-section. Preferably said diameters differ by only a few millimetres for example not more than two millimetres.

The plurality of sleeves on each limb may be loosely fitted, or they may be supported from each other and the discharge envelope by suitable spacers, or they may be attached together at one or more regions of small axial length, for example with glass sleeves of suitable thermal expansion coefficient they may all be

sealed together and to the pinched end of the limb of the discharge envelope at the time of forming said pinch.

The effect of the sleeves in reducing the rate of loss of heat from the discharge envelope in a lamp in accordance with the invention may be utilised to increase the lamp efficiency in two different ways; thus either the lamp may be arranged to operate at a higher sodium vapour pressure than that possible for the same current density with a lamp of similar construction not provided with the sleeve or sleeves, or the diameter of the discharge envelope in the lamp in accordance with the invention may be increased over that used in the unsleeved lamp to enable the former to attain the same vapour pressure at a lower current density than is possible with the latter.

In general it will be preferable to utilise the effect in the second of these two ways, since in most cases an increase in the sodium vapour pressure is liable to shorten the useful life of the lamp by increasing the rate of attack of the sodium vapour on the inner glass surface of the discharge envelope and/or by accelerating the rate of sodium migration within the discharge envelope. In some cases, however, a combination of the two ways may be used.

Two sodium vapour lamps in accordance with the invention will now be described by way of example with reference to Figures 1 and 2 of the drawing accompanying the Provisional Specification filed with Patent Application No. 2517/54, which represent two side views of one of the lamps taken substantially at right angles to each other, and with reference to Figures 1 and 2 of the drawing accompanying the Provisional Specification filed with Patent Application No. 20306/54, which represent similar views of the second lamp, the lamps being shown in part section along the lamp axis in each of the four figures; the same reference numerals are employed to denote similar parts of the two lamps in each figure of the drawings.

Thus referring to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54 the lamp shown therein comprises a substantially U-shaped discharge envelope 1 of glass, each limb 2 of which is approximately 32 centimetres long and has an internal diameter of 15 millimetres, with a wall thickness of about 1.0 millimetre, the inner surface of the envelope being of sodium resistant glass. The discharge envelope is filled with neon containing 0.5% by volume of argon at a total pressure of 10 millimetres of mercury, together with about 1 gramme of sodium. The lamp electrodes 3, which are of the kind employed in known kinds of sodium lamp, are mounted near the ends of the discharge envelope so as to provide an arc strength of 600 millimetres.

The discharge envelope 1 is mounted within a cylindrical glass outer jacket 4, of approxi-

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mately 50 millimetres outside diameter and wall thickness of about 1.5 millimetres, closed at one end by a dome-shaped end portion 5 and at the opposite end by a pinched foot-tube 6, the outer ends of the leads 7 to the lamp electrodes 3 being connected to two stout mounting wires 8 which are sealed into the pinch 9 of the foot-tube for supporting the envelope in position within the jacket, and the mounting wires 8 themselves pass through holes in a circular mica disc 17 which is held in position coaxially within the outer jacket 4 by means of an additional support wire 18 sealed into the pinch between the mounting wires, the mica disc serving to prevent lateral movement of the mounting wires 8 and so holding the ends of the discharge envelope 1 in position within the outer jacket.

The curved end of the U-shaped discharge envelope 1 is supported centrally within the outer jacket 4 near to the domed end thereof by means of a length of wire 12 which passes through a tubular glass bush 13 carried between the limbs of the discharge envelope, a wire loop 14 which fits closely around the two limbs, and which is spot welded to the wire on opposite sides of the discharge envelope, holding the envelope in position on the wire, and the two ends of the wire being spot welded to curved metal plates 15 arranged to bear against the inner surface of the outer jacket, thus supporting the envelope within the jacket.

Over each limb 2 of the discharge envelope 1 is placed a cylindrical glass sleeve 16 having an internal diameter of 18.0 millimetres, which is approximately 1.0 millimetre larger than the external diameters of the limbs, the sleeves, which have a wall thickness of about 0.5 to 0.75 millimetre, extending the whole length of the limb of the discharge envelope.

Axial movement of the sleeves 16 on the limbs of the discharge envelope is prevented by means of wire stops 8' spot welded to the mounting wires 8, and bent so as to hold the sleeves against the wire loop 14 which surrounds the discharge envelope 1.

The space between the discharge envelope 1 and the outer jacket 4 is highly evacuated, and contains a getter element 19 attached to the support wire 18 for providing a coating of getter material on part of the wall of the outer jacket near to the pinched foot-tube 6, the getter material serving to absorb occluded gas which may be liberated from the glass walls surrounding the evacuated space during the life of the lamp and so maintain the vacuum. The mica disc 17 besides acting as a support for the lamp serves to prevent the evaporated getter material from spreading into the space between the discharge envelope and outer

jacket and may also serve to reduce heat losses to a certain extent by reflecting back part of the heat radiated from the discharge envelope 1 in the direction of the glass pinch 9. As an aid to starting the lamp a thin nickel wire (not shown) is connected to each of the electrode leads 7, each wire winding helically round one of the glass sleeves 16 and being insulatingly attached to the support for the curved end of the discharge envelope 1.

For carrying out the evacuation of the outer jacket, the following method was used. The jacket, with the discharge envelope mounted therein, was placed in a baking oven so as to be shielded from direct radiation from the heating elements and heated conductively by hot air. Then whilst the lamp as a whole was raised to a temperature of between 100° C. and 125° C. in the oven the outer jacket was evacuated to a pressure of about 10^{-4} millimetres of mercury with an exhaust pump provided with a liquid air trap in known manner. With the lamp at the above temperature the outer jacket was disconnected from the pump, filled with dry oxygen-free nitrogen at a pressure of 10–20 millimetres of mercury, and the temperature of the lamp then raised to 365° C.

The jacket was then re-connected to the pump, exhausted to a pressure of about 10^{-4} millimetres of mercury, and then refilled with a second quantity of dry oxygen-free nitrogen at the same pressure as before, the temperature of the lamp being maintained at 365° C. throughout this operation and for a further 5 minutes. The jacket was then again connected to the pump and evacuated to a pressure of about 10^{-4} millimetres of mercury, the lamp being baked at a temperature of 365° C. during this operation and for a further 5 minutes. The lamp was then allowed to cool and the outer jacket sealed off when the lamp temperature was about 100° C. When the lamp had finally cooled to room temperature, the getter element was heated to cause getter material to evaporate and condense on the adjacent parts of the wall of the outer jacket.

The lamp is intended to be operated with a nominal wattage dissipation of 85 watts and a current density of 0.35 amps per square centimetre, and with such a lamp so operated we have succeeded in obtaining an initial luminous efficiency of about 90 lumens per watt.

Here it may be remarked that where in this specification specific luminous efficiencies are referred to, these were measured by a spherical integrating photometer of 5-foot diameter fitted with a photoelectric unit approximately corrected to the C.I.E. average eye response; the individual measurements are subjected to the usual limits of accuracy of commercial photometry of about $\pm 5\%$ relative to true values, but the differences between any two efficiency measurements have a higher degree of accuracy and indicate the differences in

efficiency with an error of not more than 2 or 3 lumens per watt, and probably less than this.

For a lamp similar to that just described, having the same arc length of 600 millimetres and arranged to operate with the same wattage dissipation as the lamp described with reference to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54, but not provided with the glass sleeves 16 surrounding the limbs of the discharge envelope 1, we found it necessary to employ a discharge envelope of smaller diameter that is to say of about 12 millimetres bore, in order to maintain the same vapour pressure in operation of the lamp. With such an envelope the lamp operated at a current density of 0.52 amps. per square centimetre for an 85 watt dissipation, and we found that the initial luminous efficiency was only about 77 lumens per watt.

With a lamp constructed as shown in Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54, but having a discharge envelope with an internal diameter of 19 millimetres and an arc length of 800 millimetres, and designed for operation at a nominal wattage dissipation of 140 watts, a current density of 0.33 amps. per square centimetre was used to give the same vapour pressure as before and the initial luminous efficiency was found to be about 95 lumens per watt.

It will be appreciated that each limb of the discharge envelope in a lamp substantially as described with reference to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54 could be provided, if desired, with a further glass sleeve fitting closely over the sleeve 16. In one such lamp, having a discharge envelope with an arc length of 800 millimetres and a tube bore of 15 millimetres, and arranged to operate at a current density of approximately 0.34 amps per square centimetre, but otherwise constructed substantially as described by way of example with reference to Figures 1 and 2 of the drawings with the addition, on each limb of the discharge envelope, of a further sleeve having an internal diameter approximately 1 millimetre greater than the external diameter of the sleeves 16 and a wall thickness of between 0.5 to 0.75 millimetre, the luminous efficiency under the operating conditions referred to was found to be about 100 lumens per watt.

Referring now to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 20306/54, the lamp shown therein also comprises a U-shaped discharge envelope 1 mounted within a cylindrical glass outer jacket 4, the internal diameter of the discharge envelope being about 15 millimetres and the length of the limbs 2 of the envelope being such as to provide an arc length of 600 millimetres between the lamp electrodes 3; the

envelope, which has a wall thickness of about one millimetre, has the same gas and sodium metal filling as the lamp described with reference to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54.

The curved end 23 of the discharge envelope 1 is supported within the jacket 4 by means of a length of wire 12 which passes through a tubular glass bush 13 carried between the limbs 2 of the envelope, as in the lamp shown in Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54, and two curved metal plates 15 which are attached to the ends of the wire and bear against the inner surface of the outer jacket; a wire loop 14 which fits closely round the two limbs and is spot welded to the wire 12 on opposite sides of the envelope prevents transverse movement of the envelope on the wire.

At the other end of the lamp the outer jacket is closed by a pinched foot tube 6 having two mounting wires 8 sealed into the pinch and connected at their outer ends to the terminals 10 of a bayonet type lamp cap 11 secured to the jacket as in the lamp previously described. In this lamp however, the ends of the mounting wires 8 within the jacket are bent back away from the discharge envelope 1 so as to lie along the foot tube, and are connected to the respective electrode leads 7 by means of two nickel sleeves 20, one pair of leads 7 and the bent back end of the corresponding mounting wire 8 being inserted into the same end of one of the sleeves and being secured in place by spot welding. By this method of mounting, the discharge envelope can be located close to the foot tube 6, thereby reducing the length of the outer jacket necessary for housing the envelope.

A sheet of mica 17 extends across the outer jacket with its ends in contact with the inner surface thereof as an additional support for the discharge envelope as in the lamp shown in Figures 1 and 2, although in this lamp the electrode leads 7 themselves extend through holes provided in the sheet, the connection to the mounting wires 8 taking place on the opposite side of the sheet to the discharge envelope.

The space between the discharge envelope 1 and the outer jacket 4 is exhausted and contains a getter element 19 welded to the end of a support wire 18 which is sealed at its opposite end into the pinch of the foot tube 6 between the two mounting wires 8, the end of the support wire 18 to which the getter element is attached being bent back in a similar manner to the mounting wires 8 so as to lie along the foot tube 6.

In accordance with the invention there is fitted over each limb 2 of the discharge envelope 1 a cylindrical transparent glass sleeve 16 having an internal diameter of approximately 18 millimetres, which is of the

order of 1.0 millimetre larger than the external diameter of the limbs, the sleeves, which have a wall thickness of about 0.5 to 0.75 millimetre, extending substantially the whole length of the limbs and being sealed to the limbs on which they are fitted, by the sealing of one end of each sleeve to the pinch 24 at the end of the limb into which the electrode leads 7 are sealed. The sleeves 16 are thus supported coaxially on their respective limbs, and rattling of the sleeves is thereby prevented. Moreover, the sealing of the sleeves to the limbs prevents relative axial movement between the sleeves and the limbs from taking place, thereby dispensing with the need for additional stops at the ends of the sleeves.

The sealing-in of the electrode leads 7 at the ends of the discharge envelope 1 and the sealing of the sleeves 16 to the limbs 2 is conveniently effected in a single operation, the electrodes 3, the discharge envelope 1 and the sleeves 16 being held in predetermined relative positions by suitably constructed jigs, the glass of the limbs 2 and sleeves 16 at the ends surrounding the electrode leads 7 being heated until soft, and two jaws being arranged to pinch the softened glass so as to squeeze the end of each sleeve and limb into sealing contact with each other and simultaneously seal the electrode leads into the glass pinch which is formed.

The lamp is provided with starting wires surrounding the glass sleeves 16 in a similar manner to the lamp shown in Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54, and is intended to be operated at a nominal wattage dissipation of 85 watts and a current density of about 0.35 amps. per square centimetre. With such a lamp operating under these conditions we have succeeded in obtaining an initial luminous efficiency of about 90 lumens per watt.

It will be appreciated that the discharge envelope of the lamp substantially as described by way of example with reference to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 20306/54 may be provided with one or more additional transparent heat-insulating sleeves, if desired, and these additional sleeves can be fitted loosely over the sleeves 16, although in some cases they may be attached to the sleeves 16 and to the discharge envelope 1.

WHAT WE CLAIM IS:—

1. A sodium vapour electric discharge lamp of the positive column type having an elongated tubular discharge envelope of U-shape containing electrodes for the passage of an electric discharge and a quantity of sodium for providing a sodium vapour discharge in normal operation of the lamp together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed, wherein the discharge envelope is sealed into a single-walled outer jacket with a

highly evacuated space between the inner surface of the jacket and the outer surface of the discharge envelope, and wherein each limb of the discharge envelope is individually provided with a sleeve of transparent heat-insulating material which fits closely (as hereinbefore defined) round the limb along the whole or the greater part of the length of the limb.

2. A sodium vapour electric discharge lamp according to Claim 1, wherein the internal diameter of each sleeve is not more than two millimetres greater than the external diameter of the limb on which the sleeve is fitted.

3. A sodium vapour electric discharge lamp according to Claim 1 or 2, including a getter material within the outer jacket for absorbing residual gas within said highly evacuated space and maintaining a high degree of vacuum within said space during the life of the lamp.

4. A sodium vapour electric discharge lamp according to any preceding claim, wherein the said sleeves are held on the limbs of the discharge envelope by means which restrain the sleeves against relative longitudinal displacement, but without the sleeves being attached to the limbs and without the intervention of spacing means between the sleeves and the limbs.

5. A sodium vapour electric discharge lamp according to any preceding claim, wherein each said sleeve is of glass.

6. A sodium vapour electric discharge lamp according to Claim 1, 2 or 3, wherein each sleeve is attached to the limb on which it is fitted at one or more regions whose total axial length is small compared with the axial length of said limb.

7. A sodium vapour electric discharge lamp according to Claim 6, wherein each sleeve is attached to the limb on which it is fitted at a single region only.

8. A sodium vapour electric discharge lamp according to Claim 7, in which the electrode leads are sealed into the ends of the discharge envelope by means of pinches and wherein each sleeve is of glass whose thermal expansion coefficient is similar to that of the glass of the discharge envelope and is sealed to the pinch formed at the end of the limb over which the sleeve is fitted.

9. A sodium vapour electric discharge lamp according to any preceding claim, wherein each limb of the discharge envelope is provided with one or more further transparent heat-insulating sleeves each extending along the whole or the greater part of the corresponding limb of the discharge envelope, the internal diameter of each of which further sleeves is not more than 50% greater than the external diameter of the sleeve which it immediately surrounds, the diameter being taken in a cross-section at right angles to the axes of the sleeves, and being the maximum diameter if the sleeves are not of circular cross-section.

10. A sodium vapour electric discharge lamp



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order of 1.0 millimetre larger than the external diameter of the limbs, the sleeves, which have a wall thickness of about 0.5 to 0.75 millimetre, extending substantially the whole length of the limbs and being sealed to the limbs on which they are fitted, by the sealing of one end of each sleeve to the pinch 24 at the end of the limb into which the electrode leads 7 are sealed. The sleeves 16 are thus supported co-axially on their respective limbs, and rattling of the sleeves is thereby prevented. Moreover, the sealing of the sleeves to the limbs prevents relative axial movement between the sleeves and the limbs from taking place, thereby dispensing with the need for additional stops at the ends of the sleeves.

The sealing-in of the electrode leads 7 at the ends of the discharge envelope 1 and the sealing of the sleeves 16 to the limbs 2 is conveniently effected in a single operation, the electrodes 3, the discharge envelope 1 and the sleeves 16 being held in predetermined relative positions by suitably constructed jigs, the glass of the limbs 2 and sleeves 16 at the ends surrounding the electrode leads 7 being heated until soft, and two jaws being arranged to pinch the softened glass so as to squeeze the end of each sleeve and limb into sealing contact with each other and simultaneously seal the electrode leads into the glass pinch which is formed.

The lamp is provided with starting wires surrounding the glass sleeves 16 in a similar manner to the lamp shown in Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54, and is intended to be operated at a nominal wattage dissipation of 85 watts and a current density of about 0.35 amps. per square centimetre. With such a lamp operating under these conditions we have succeeded in obtaining an initial luminous efficiency of about 90 lumens per watt.

It will be appreciated that the discharge envelope of the lamp substantially as described by way of example with reference to Figures 1 and 2 of the drawing accompanying Provisional Specification No. 20306/54 may be provided with one or more additional transparent heat-insulating sleeves, if desired, and these additional sleeves can be fitted loosely over the sleeves 16, although in some cases they may be attached to the sleeves 16 and to the discharge envelope 1.

WHAT WE CLAIM IS:—

1. A sodium vapour electric discharge lamp of the positive column type having an elongated tubular discharge envelope of U-shape containing electrodes for the passage of an electric discharge and a quantity of sodium for providing a sodium vapour discharge in normal operation of the lamp together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed, wherein the discharge envelope is sealed into a single-walled outer jacket with a

highly evacuated space between the inner surface of the jacket and the outer surface of the discharge envelope, and wherein each limb of the discharge envelope is individually provided with a sleeve of transparent heat-insulating material which fits closely (as hereinbefore defined) round the limb along the whole or the greater part of the length of the limb.

2. A sodium vapour electric discharge lamp according to Claim 1, wherein the internal diameter of each sleeve is not more than two millimetres greater than the external diameter of the limb on which the sleeve is fitted.

3. A sodium vapour electric discharge lamp according to Claim 1 or 2, including a getter material within the outer jacket for absorbing residual gas within said highly evacuated space and maintaining a high degree of vacuum within said space during the life of the lamp.

4. A sodium vapour electric discharge lamp according to any preceding claim, wherein the said sleeves are held on the limbs of the discharge envelope by means which restrain the sleeves against relative longitudinal displacement, but without the sleeves being attached to the limbs and without the intervention of spacing means between the sleeves and the limbs.

5. A sodium vapour electric discharge lamp according to any preceding claim, wherein each said sleeve is of glass.

6. A sodium vapour electric discharge lamp according to Claim 1, 2 or 3, wherein each sleeve is attached to the limb on which it is fitted at one or more regions whose total axial length is small compared with the axial length of said limb.

7. A sodium vapour electric discharge lamp according to Claim 6, wherein each sleeve is attached to the limb on which it is fitted at a single region only.

8. A sodium vapour electric discharge lamp according to Claim 7, in which the electrode leads are sealed into the ends of the discharge envelope by means of pinches and wherein each sleeve is of glass whose thermal expansion coefficient is similar to that of the glass of the discharge envelope and is sealed to the pinch formed at the end of the limb over which the sleeve is fitted.

9. A sodium vapour electric discharge lamp according to any preceding claim, wherein each limb of the discharge envelope is provided with one or more further transparent heat-insulating sleeves each extending along the whole or the greater part of the corresponding limb of the discharge envelope, the internal diameter of each of which further sleeves is not more than 50% greater than the external diameter of the sleeve which it immediately surrounds, the diameter being taken in a cross-section at right angles to the axes of the sleeves, and being the maximum diameter, if the sleeves are not of circular cross-section.

10. A sodium vapour electric discharge lamp



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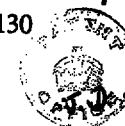
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according to Claim 9, wherein the internal diameter of each further sleeve is not more than two millimetres greater than the external diameter of the sleeve it immediately surrounds.

11. A sodium vapour electric discharge lamp which is constructed substantially as shown in and as hereinbefore described with reference to

Figures 1 and 2 of the drawing accompanying Provisional Specification No. 2517/54 or Figures 1 and 2 of the drawing accompanying Provisional Specification No. 20306/54.

For the Applicants,
J. E. M. HOLLAND,
Chartered Patent Agent.

PROVISIONAL SPECIFICATION
No. 2517, A.D. 1954.

Improvements in or relating to Sodium Vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, do hereby declare this invention to be described in the following statement:—

This invention relates to sodium vapour electric discharge lamps, such lamps having a sealed envelope containing electrodes for the passage of an electric discharge and a filling of sodium for providing a sodium vapour discharge in normal operation of the lamp, together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed.

In order that such a lamp should operate at high efficiency, it is desirable that the current density of the discharge should be low and also that the sodium vapour pressure in normal operation should be at or near an optimum value.

The first of these requirements calls for the use of an envelope of relatively large diameter, but as the diameter of the envelope is increased, its wall temperature for a given wattage discharge, and with it the operating vapour pressure of the sodium, is reduced, and too wide an envelope results in too low a sodium vapour pressure for high efficiency; a compromise has, therefore, to be made between these requirements, and in order to obtain the best compromise it is desirable to provide means for conserving the heat of the discharge envelope to enable as wide a diameter envelope as possible to be used consistent with its wall temperature not falling to an undesirably low value. The heat conserving means usually employed consists of an evacuated outer jacket into which the discharge envelope is fitted.

Two main forms of such evacuated outer jacket have been used or proposed; the form at present most commonly used consists of a double-walled hollow cylinder closed at one end, the space between the walls of which is sealed and evacuated, and the discharge tube, in the shape of a letter U, has been inserted within the jacket from the open end; air is usually present in the space between the discharge envelope and the inner wall of the outer jacket, but the evacuated space between the inner and outer walls of the jacket, which is

usually known as a Dewar jacket, provides the necessary heat conservation; the inner wall of the Dewar jacket serves as a screen for the absorption of infra-red radiation from the discharge envelope, which screen is protected by the evacuated space from the loss of heat to the outer atmosphere and thus helps to keep up the temperature of the discharge envelope; the screen also reflects back to the discharge envelope some of the infra-red radiation emitted by the latter.

The other form of outer jacket referred to consists of a single-walled envelope into which the discharge envelope is sealed, the space between the discharge envelope and the jacket being evacuated; this form of outer jacket has been proposed mainly for use with straight tubular discharge envelopes, but use with U-shape lamps has also been proposed. For further reducing the heat loss from the discharge envelope in such a lamp, it has been proposed effectively to duplicate the conditions obtained with a Dewar jacket by surrounding the discharge envelope with a heat-conserving glass sleeve intervening between the discharge envelope and the outer jacket, this sleeve serving to absorb and reflect infra-red radiation from the discharge and being insulated from the outer atmosphere by an insulated space, as is the inner wall of a Dewar jacket. However the use of such glass sleeves has not hitherto led to such a gain in the efficiency of the lamps as to make worthwhile the complications of manufacture entailed by them.

A combination of the above two forms of outer jacket, which combination may be described either as a double-walled evacuated outer jacket the space between the walls of which is evacuated, or as a Dewar jacket having the discharge envelope sealed therein and the interior evacuated, has also been proposed, but is difficult to make and is not much more efficient than either the single-wall jacketed lamp or Dewar jacketed lamp alone, so that it has not, in fact, come into use.

We have now found, however, that by the use of a particular form of heat-conserving sleeve in conjunction with a lamp of U-shape sealed into an evacuated space, worthwhile



increases of efficiency can be obtained, which increases of efficiency are most surprisingly great in the case of single-wall jacketed lamps.

5 According to the present invention, a sodium vapour electric discharge lamp comprises a discharge envelope of U-shape containing electrodes for the passage of an electric discharge and a filling of sodium for providing a sodium vapour discharge in normal operation of the lamp together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed, an outer jacket into which the discharge envelope is sealed, the space between the inner surface of the jacket and the outer surface of the discharge envelope being evacuated, and at least one of the limbs of the discharge envelope is surrounded by a sleeve of transparent heat-insulating material which fits closely round the limb along the whole or the greater part of the length of the limb.

The term "fits closely" means that the inner surface of the sleeve lies everywhere nearer to the outer surface of the limb of the discharge envelope than it does to the inner surface of the outer jacket, and preferably the inner diameter of the sleeve is only slightly greater, for example not more than a few millimetres greater, than the outer diameter of the limb. The sleeve may be a sliding fit on the limb but must not be in such intimate contact with it that the sleeve constitutes in effect merely a thickening of the wall of the limb. In some cases the sleeve may be held out of contact with the limb by the use of spacing means, but in general we have not found such spacing means necessary for securing the required high lamp efficiencies, although their use may sometimes be desirable for preventing rattling of the sleeve on the discharge envelope or for holding the sleeve at an optimum spacing from the discharge envelope.

The statement that the sleeve is of transparent heat insulating material means that the material must be a good absorber and/or reflector of infra-red radiation so as, in operation of the lamp, to reduce the rate of loss of heat from the limb of the discharge envelope over which it is fitted, and it is preferably also a poor thermal conductor; the term "transparent" (which term includes translucent) means that the sleeve must absorb little or none of the visible radiation from the discharge, but it need not necessarily be colourless; thus the sleeve may in some cases be formed of a yellow glass so as to transmit the yellow sodium light but to absorb other radiations and thereby increase still further the conservation of the heat of the discharge envelope, as described in copending Patent Application No. 24882/52.

The thickness of the sleeve should be such as to give maximum infra-red radiation absorption, and in some cases its infra-red

absorbing and/or reflecting properties may be improved by the application of a thin transparent film of metal, such as gold, on either the inner or the outer surface of the sleeve, or on both surfaces.

In general glass will be the most suitable and convenient material for the sleeve, but other materials, for example quartz, which have similar properties and are otherwise suitable for use in lamps in accordance with the invention, and in particular are capable of withstanding the heat developed in operation of the lamp without deterioration or without becoming discoloured so as to absorb appreciably the visible light from the discharge, could be used.

The effect of the sleeve or sleeves in reducing the rate of loss of heat from the discharge envelope in a lamp in accordance with the invention may be utilised to increase the lamp efficiency either by enabling the lamp to operate at a higher sodium vapour pressure than possible for the same current density with a lamp of similar construction not provided with the sleeve or sleeves, or the diameter of the discharge envelope in the lamp in accordance with the invention may be increased over that used in the unsleeved lamp to enable the former to attain the same vapour pressure at a lower current density than possible with the latter, or a combination of the two effects may be used.

For attaining the highest gain in lamp efficiency, preferably each of the two limbs of the U-shaped discharge envelope is provided with a heat-insulating sleeve in accordance with the invention. The two sleeves may be similar or they may in some cases be different. Thus the use of different sleeves, producing different heat conserving effects, may be used to overcome a difficulty which has sometimes been experienced hitherto with sodium lamps of U-shape operated with one limb of the U above the other; this difficulty is that the upper limb tends to run hotter than the lower limb and gives rise to migration of the sodium to the lower limb, with resulting loss of light output from the upper limb and a fall in the efficiency of the lamp; by using on the upper limb, in a lamp in accordance with the invention, a sleeve giving a smaller heat-conserving effect than that on the lower limb, for example by increasing the diameter of the upper sleeve above the optimum value, the temperatures of the two limbs can be equalised and the migration of sodium prevented or considerably reduced; in some cases it may be preferable for this reason to omit altogether the sleeve from the upper limb of the discharge envelope, care then being taken that the lamp should run with the sleeved limb lowermost.

In order to maintain the vacuum within the outer jacket, preferably a getter material is included within the jacket which will absorb gas which may be liberated from the inner

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surface of the jacket or from the parts within the jacket in use of the lamp.

The invention is likely to be of the greatest practical value in connection with single-wall jacketed lamps, and one sodium vapour lamp of this kind in accordance with the invention will now be described by way of example with reference to Figures 1 and 2 of the accompanying drawings which represent two side views of the lamp taken substantially at right angles to each other, both part-sectional along the axis of the lamp.

The lamp comprises a substantially U-shaped discharge envelope 1 of glass, each limb 2 of which is approximately 32 centimetres long and has an internal diameter of 14 millimetres, with a wall thickness of about 1.0 millimetre, the inner surface of the envelope being of sodium resistant glass. The discharge envelope is filled with neon containing 0.5% by volume of argon at a total pressure of 10 millimetres of mercury, together with sodium vapour and about 1 gramme excess sodium when at normal room temperature. The lamp electrodes 3, which are of the kind employed in known kinds of sodium lamp, are mounted near the ends of the discharge envelope so as to provide an arc length of 600 millimetres.

The discharge envelope 1 is mounted within a cylindrical glass outer jacket 4, of approximately 50 millimetres outside diameter and wall thickness of about 1.5 millimetres, closed at one end by a dome-shaped end portion 5 and at the opposite end by a pinched foot-tube 6, the outer ends of the leads 7 to the lamp electrodes 3 being connected to two stout mounting wires 8 which are sealed into the pinch 9 of the foot-tube for supporting the envelope in position within the jacket, the mounting wires connecting the leads 7 to two contact terminals 10 of a bayonet type lamp cap 11 which is sealed by means of a suitable cement to the end of the outer jacket. The mounting wires 8 themselves pass through holes in a circular mica disc 17 which is held in position coaxially within the outer jacket 4 by means of an additional support wire 18 sealed into the pinch between the mounting wires, the mica disc serving to prevent lateral movement of the mounting wires 8 and so holding the ends of the discharge envelope 1 rigidly in position within the outer jacket.

The curved end of the U-shaped discharge envelope 1 is supported centrally within the outer jacket 4 near to the domed end thereof by means of a length of wire 12 which passes through a tubular glass bush 13 carried between the limbs of the discharge envelope, a wire loop 14 which fits closely around the two limbs, and which is spot welded to the wire on opposite sides of the discharge envelope, holding the envelope in position on the wire, and the two ends of the wire being spot welded to

curved metal plates 15 arranged to bear against the inner surface of the outer jacket, thus supporting the envelope within the jacket.

Over each limb 2 of the discharge envelope 1 is placed a cylindrical glass sleeve 16 having an internal diameter of 17.5 millimetres, which is approximately 1.0 millimetre larger than the external diameters of the limbs, the sleeves, which have a wall thickness of about 0.5 to 0.75 millimetres, extending the whole length of the discharge envelope.

Axial movement of the sleeves 16 on the limbs of the discharge envelope is prevented by means of wire stops 8' spot welded to the mounting wires 8, and bent so as to hold the sleeves against the wire loop 14 which surrounds the discharge envelope 1.

The space between the discharge envelope 1 and the outer jacket 4 is exhausted, and contains a getter element 19 of known kind attached to the support wire 18 for providing a coating of getter material on part of the wall of the outer jacket near to the pinched foot-tube 6, the getter material serving to absorb occluded gas which may be liberated from the glass walls surrounding the evacuated space during the life of the lamp and so maintain the vacuum. The mica disc 17 besides acting as a support for the lamp also serves to reduce heat losses to a certain extent by reflecting back part of the heat radiated from the discharge envelope 1 in the direction of the glass pinch 9, and may also serve to prevent the evaporated getter material from spreading into the space between the discharge envelope and outer jacket.

The lamp is arranged to be operated with a wattage dissipation of 85 watts and a current density of 0.44 amps per square centimetre.

For a similar lamp having the same arc length of 600 millimetres and arranged to operate with the same wattage dissipation as a lamp as described by way of example, but not provided with the glass sleeves 16 surrounding the limbs of the discharge envelope 1, we have found it necessary to employ a discharge envelope of smaller diameter, that is to say of about 12 millimetres bore, in order to maintain the same vapour pressure in operation of the lamp. With such an envelope the lamp operated at a current density of 0.55 amps per square centimetre and we found the luminous efficiency to be about 77 lumens per watt.

A lamp constructed in accordance with the invention as described by way of example, with a discharge envelope having a bore of 14 millimetres and a current density of 0.44 amps per square centimetre, was found to have a luminous efficiency exceeding 90 lumens per watt.

For the Applicants,
J. E. M. HOLLAND,
Chartered Patent Agent.

PROVISIONAL SPECIFICATION

No. 20306, A.D. 1954.

Improvements in or relating to Sodium Vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, do hereby declare this invention to be described in the following statement:—

This invention relates to sodium vapour electric discharge lamps and is a modification of the invention which forms the subject matter of our co-pending Patent Application No. 2517/54.

According to the invention described in said co-pending patent application a sodium vapour electric discharge lamp comprises a discharge envelope of U-shape containing electrodes for the passage of an electric discharge and a filling of sodium for providing a sodium vapour discharge in normal operation of the lamp, together with a filling of rare gas for enabling the lamp to start and the sodium vapour discharge to be developed, and an outer jacket into which the discharge envelope is sealed, the space between the inner surface of the jacket and the outer surface of the discharge envelope being evacuated, and at least one of the limbs of the discharge envelope is surrounded by a sleeve of transparent heat insulating material which fits closely round the limb along the whole or the greater part of the limb. The term "fits closely" means that the inner surface of the sleeve lies everywhere nearer to the outer surface of the limb of the discharge envelope than it does to the inner surface of the outer jacket, the inner diameter of the sleeve preferably being only slightly greater, for example not more than a few millimetres greater than the outer diameter of the limb.

The sleeve or sleeves in accordance with said invention serve to reduce the rate of loss of heat from the discharge envelope and thereby increase the lamp efficiency, for example either by enabling the lamp to operate at a higher sodium vapour pressure than a lamp of similar construction not provided with the sleeve or sleeves operating at the same current density or by enabling a lamp discharge envelope of greater diameter to be employed for obtaining the same vapour pressure at a lower current density than a similar unsleeved lamp.

According to the present invention in a lamp provided with one or more sleeves as aforesaid at least one said sleeve is formed of glass and is sealed to the limb on which it is fitted at one or more regions whose total axial length is small compared with the axial length of the lamp.

Such an arrangement has the advantage that the sleeve is thereby prevented from rattling

on the discharge envelope, and thereby reduces the possibility of damage being caused to the sleeve or to the envelope during transport of the lamp or when inserting it in its holder, and moreover enables the sleeve to be mounted with the major part of it at a predetermined spacing from the limb for obtaining the optimum degree of heat conservation in operation of the lamp.

By arranging that each sleeve is sealed to the limb for only a relatively short distance the area of contact between them is small compared with the surface area of the discharge envelope and the heat conserving effect of the sleeve is maintained, the sleeve preferably being sealed to the limb at a single region only.

Thus in the preferred embodiment the sealing of the sleeve to the limb is preferably effected at the end of the limb through which the electrode leads are sealed, and in a lamp wherein the electrode leads are sealed into the envelope by means of a pinch, as is commonly employed in known types of sodium vapour lamp, the sleeve is preferably sealed to the pinch itself.

In the manufacture of a lamp in accordance with the invention where this construction is employed the sealing in of the electrode leads and the sealing of the sleeve to the limb of the discharge envelope may conveniently be carried out in a single operation, the leads, the discharge envelope and the sleeve being held in predetermined relative positions, for example by means of suitably constructed jigs, the end of the limb of the envelope in which the electrode is to be sealed and the adjacent end of the sleeve being heated to soften the glass, and a pair of metal jaws being arranged to squeeze the softened glass of the sleeve and the limb so as to form a pinch in which the electrode lead is sealed, and so that the sleeve and the limb are sealed together in a fixed predetermined position after the cooling of the glass below its softening temperature.

Preferably each limb is provided with a sleeve sealed to it in accordance with the present invention and the sealing of the two sleeves to their respective limbs may then be effected simultaneously if desired.

It will be appreciated that where each sleeve is sealed to a limb at more than one region the seals employed should not hermetically seal the space between the limb and the sleeve bounded by the seals, in order to allow said space to be exhausted when the outer jacket is evacuated.

The term "transparent" (which term

includes translucent) means that a sleeve must absorb little or none of the visible radiation from the discharge but it need not necessarily be colourless; for example it may be formed of a yellow glass so as to transmit the yellow sodium light but to absorb other radiations and thereby increase still further the conservation of heat of the discharge envelope as described in co-pending Patent Application No. 24882/52.

The thickness of the sleeve should be such as to give maximum infra-red radiation absorption, and in some cases its infra-red absorbing and/or reflecting properties may be improved by the application of a thin transparent film of a suitable material on either the inner or outer surfaces of the sleeve, or on both surfaces; for example the film may consist of a thin coating of a metal such as copper or gold, or alternatively titanium dioxide may be used.

Where sleeves are provided on both limbs they will usually be similar, although different sleeves may sometimes be employed. Thus the use of different sleeves, producing different heat conserving effects may be used to overcome a difficulty which has sometimes been experienced hitherto with sodium lamps of U-shape operated with one limb of the U above the other; this difficulty is that the upper limb tends to run hotter than the lower limb and gives rise to migration of the sodium to the lower limb with resulting loss of light output from the upper limb and a fall in the efficiency of the lamp; by using on the upper limb a sleeve giving a smaller heat conserving effect, for example by increasing the diameter of the upper sleeve above its optimum value, the temperatures of the two sleeves can be equalised and the migration of the sodium prevented or considerably reduced. In some cases it may be preferable to omit altogether the sleeve on the upper limb, care then being taken that the lamp should run with the sleeved limb lowermost.

The outer jacket may either be of the single-walled or the double-walled type, although the invention is more likely to be of greater practical value with lamps employing the former type of jacket, and one sodium vapour electric discharge lamp of this kind in accordance with the invention will now be described by way of example with reference to Figures 1 and 2 of the accompanying drawings which represent two side views of the lamp taken at right angles to each other, the outer jacket and other parts of the lamp being shown in section in order to reveal the construction of the lamp more clearly.

The lamp comprises a substantially U-shaped discharge envelope 1 of glass, each limb 2 of which is approximately 32 centimetres long and has an internal diameter of 14 to 16 millimetres, with a wall thickness of about 1.0 millimetre, the inner surface of the

envelope being of sodium resistant glass. The envelope is filled with neon containing 0.5% by volume of argon at a total pressure of 10 millimetres of mercury, together with about 1 gramme of sodium metal when at normal room temperature. The lamp electrodes 3 which are of the kind employed in known kinds of sodium lamp are mounted near the ends of the discharge envelope so as to provide an arc length of 600 millimetres.

The discharge envelope 1 is mounted within a cylindrical glass outer jacket 4 of approximately 50 millimetres external diameter and having a wall thickness of about 1.5 millimetres, closed at one end by a dome-shaped end portion 5 and at the other end by a pinched foot-tube 6. Two mounting wires 8 are sealed into the pinch of the foot-tube, the ends of the wires within the jacket being bent back away from the discharge envelope 1 so as to lie along the foot tube, and are rigidly connected to the respective electrode leads 7 by means of two nickel sleeves 20, one pair of electrode leads 7 and the bent back end of the corresponding mounting wire 8 being inserted into the same end of one of the sleeves 20 and being secured in place by spot welding. By this method of mounting the discharge envelope can be located close to the pinched foot-tube 6, thereby reducing the length of the outer jacket necessary for housing the envelope. This is an advantage since a decrease in the surface area of the jacket improves its heat conserving qualities by reducing the amount of radiation therefrom in operation of the lamp. The mounting wires 8, which also constitute leads to the electrodes 3, are connected to two contact terminals 10 of a bayonet type lamp cap 11 which is sealed by means of a suitable cement to the adjacent end of the outer jacket, for enabling the lamp to be connected to suitable supply terminals. As an additional support for the discharge envelope a sheet of mica 17, approximately rectangular in shape with curved ends, extends across the outer jacket perpendicular to its axis and with the curved ends in contact with the inner surface thereof, the electrode leads 7 passing through two small holes provided in the sheet 17 for that purpose.

The curved end of the U-shaped discharge envelope 1 is supported centrally within the outer jacket 4 near the domed end thereof by means of a length of wire 12 which passes through a tubular glass bush 13 carried in a part circular gap formed between the limbs of the envelope where they merge into the curved portion 23 of smaller cross sectional area, a wire loop 14 which fits closely around the two limbs and which is spot welded to the wire on opposite sides of the discharge envelope, holding the envelope in position on the wire and the two ends of the wire being spot welded to curved metal plates 15 arranged to bear against the inner surface if the outer jacket 4,

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thus supporting the envelope within the jacket.

Over each limb 2 of the discharge envelope 1 is fitted a cylindrical transparent glass sleeve 16 having an internal diameter of approximately 17.5 millimetres, which is of the order of 1.0 millimetre larger than the external diameter of the limbs, the sleeves, which have a wall thickness of about 0.5 to 0.75 millimetre, extending substantially the whole length of the limbs.

In accordance with the invention the sleeves are sealed to the limbs on which they are fitted, by the sealing of one end of each sleeve to the pinch 24 at the end of the limb into which the electrode leads 7 are sealed, the sleeves 16 thus being supported coaxially on their respective limbs, and rattling of the sleeves being thereby prevented. Moreover the sealing of the sleeves to the limbs prevents relative axial movement between the sleeves and the limbs from taking place, thereby dispensing with the need for additional stops at the ends of the sleeves.

The sealing in of the electrode leads 7 at the ends of the discharge envelope 1 and the sealing of the sleeves 16 to the limbs 2 is conveniently effected in a single operation, the electrodes 3, the discharge envelope 1 and the sleeves 16 being held in predetermined relative positions by suitably constructed jigs, the glass of the limbs 2 and sleeves 16 at the ends surrounding the electrode leads 7 being heated until soft, and two jaws being arranged to pinch the softened glass so as to squeeze the end of each sleeve and limb into sealing contact with each other and simultaneously seal the electrode leads into the glass pinch which is formed. The discharge envelope is provided at the opposite end with a tipped off pumping stem through which the envelope is exhausted

and filled with the rare gas and sodium filling after the attachment of the sleeves and before being mounted in the outer jacket.

The space between the discharge envelope 1 and the outer jacket 4 is exhausted and contains a getter element 19 of known kind attached to a support wire 18 for providing a coating of getter material on part of the wall of the outer jacket near to the pinched foot tube 6, the getter material serving to absorb occluded gas which may be liberated from the glass walls surrounding the evacuated space during the life of the lamp and so maintain the vacuum.

The lamp is arranged to be operated at a nominal wattage dissipation of 85 watts and a current density of about 0.4 amps per square centimetre.

Under these operating conditions a lamp constructed as described by way of example with reference to the drawing was found to have a luminous efficiency exceeding 90 lumens per watt.

If desired each of the sleeves may alternatively be sealed to a different region of the respective limb of the discharge envelope than at the pinch, for example at the centre of each limb, although it will be appreciated in such a construction an increased degree of cooling may be obtained in the region of the seal and give rise to a reduction in the efficiency of the lamp. However provided the axial length of the seal is small compared with the length of the discharge envelope the resultant decrease in efficiency should not be appreciable, and in some cases this form of construction may be more convenient.

Dated the 12th day of July 1954.

For the Applicants,
J. E. M. HOLLAND,
Chartered Patent Agent.

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