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EUROPEAN PATENT APPLICATION

21 Application number: 83300141.5

51 Int. Cl.³: H 01 J 61/54

22 Date of filing: 12.01.83

30 Priority: 29.01.82 GB 8202526

43 Date of publication of application:
10.08.83 Bulletin 83/32

84 Designated Contracting States:
DE FR GB IT NL SE

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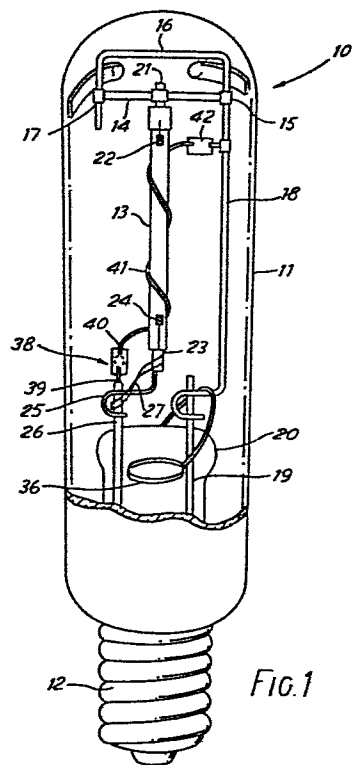
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54 Improvements in discharge lamps.

57 A high pressure sodium vapour discharge lamp is provided including a starting aid in the form of an electrically conductive wire wound around the lamp envelope and in the vicinity of the lamp electrode. A spark gap in the form of an envelope of insulating material is inserted between one of the inleads and the conductive wire. The spark gap envelope may be filled with air, rare gas or may be evacuated and ensures that the lamp is electrically isolated during normal running but breaks down under high voltage pulses applied to start the lamp.



IMPROVEMENTS IN DISCHARGE LAMPS

This invention relates to metal halide lamps and more particularly but not exclusively to high pressure sodium lamps using ceramic arc tubes and to the problems of starting such lamps.

- 5 The arc tubes of high pressure sodium vapour lamps usually contain an inert gas, typically Xenon, in addition to the sodium, mercury and occasionally other additives such as cadmium. The inert gas facilitates starting and during operation also acts as a buffer gas together with the mercury
- 10 vapour. Lamp starting is usually achieved by applying a voltage pulse higher than mains voltage or a train of such pulses across the arc tube and with a Xenon filling pressure of between 10 to 50 torr at 300k a voltage pulse of the order 1.5 to 5kV usually suffices to start the lamp. A voltage pulse of
- 15 this order is within the requirements to avoid arcing between lamp components such as the cap and holders and satisfies the requirements for creepage and clearance distances and also gives satisfactory lamp performance for life and efficacy characteristics. However, it is known that further increases
- 20 in Xenon pressure would give further increases in efficacy, for example, if the Xenon pressure is increased to within the range 50 to 1000 torr at 300k the luminous efficacy would be increased, according to UK Patent No. 1,587,987, by about 15%. While such an increase in efficacy obviously would be desirable,
- 25 lamps having arc tubes gas filled to this higher pressure are more difficult to start and may require a peak voltage pulse in

excess of the recommended limits for lamp caps, holders and associated control gear. In order to keep the voltage within the usual value of around 1.5 to 5kV it is necessary to use a starting aid. Such aids can comprise an auxiliary electrode in the form of a strip or spiral extending along or looped around the arc tube envelope. A variety of starting aids are available but all have some shortcomings either in terms of cost or complexity or effectiveness. For example, to be effective, the strip or spiral mentioned above must be directly connected to one main electrode of the arc tube but if so connected it leads to sodium loss due to electrolysis through the arc tube wall and hence premature lamp failure. Such an arrangement is disclosed in UK Patent No.1,340,551. An attempt to overcome this problem is disclosed in UK Patent No.1,514,416 which discloses the use of a wire loop in combination with a variable voltage divider. The variable voltage divider includes a temperature sensitive resistance which does not completely disconnect the starting aid from the supply when the lamp is running and hence, while this arrangement does reduce sodium loss it still remains a significant problem. Other arrangements have been tried, for example, a thermal switch in the form of bi-metallic strip. Generally these mechanical arrangements require a long re-set time. In other words if the lamp is switched off it is necessary to allow the lamp to cool before attempting to re-strike it. This generally takes between 5 to 15 minutes whereas it is generally accepted that a satisfactory hot re-strike, that is, switching the lamp on again just after it has been switched off should take place within about 30 seconds. A type of thermal switch is shown in UK Patent No.1,505,847 where a bi-metallic strip has leg portions curved around to engage an arc tube. The heating of the leg portions due to the increase in temperature when the lamp is running causes the curved legs of the switch to swing clear of the arc tube and hence reaction between the arc tube wall and the starter is avoided. A difficulty with this type of

arrangement again is a very long re-set time of between 15 minutes to 30 minutes. Moreover it is difficult to ensure that the metallic strips accurately re-locate themselves around the arc tube. Even more sophisticated solutions than this have
5 been proposed and UK Patent No.1,587,987 discloses the use of a capacitor in circuit with a conductive wire looped around the arc tube. U.K. Patent 1603959 is another patent which discloses the use of a capacitor in circuit with a conductive wire with the capacitor being supported in position by suitable
10 insulating glass bead member. However, since the leakage resistance of the capacitor dielectric is temperature dependent, during the operation of the lamp small leakage currents can exist which will have a significant effect over the very long life of these lamps. It should be noted that whereas in
15 earlier lamps an average life of 6,000 hours would be considered satisfactory the average life of present lamps is nearer 24,000 hours. Other semi-conductive devices, for example diodes, have been tried but these also are temperature dependent and cannot withstand the working temperature of about 300°C.

20 An object of this invention is to provide a starting arrangement for a discharge lamp substantially free, and if not free, certainly improved upon the performance of the prior art arrangements described above.

According to the present invention we provide a high
25 pressure discharge lamp having an arc discharge tube including electrodes for supporting a discharge, inleads connected to respective electrodes, a starting aid including a conductor co-operating with the electrodes and a spark gap connected between the conductor and one of the inleads.

30 The spark gap according to the invention provides a much simpler and less complex solution to a problem which has been present in the art for many years. It provides, for example:

a) a simple inexpensive design, which acts as a non-mechanical switch responding only to the high voltage
35 starting pulse,

b) a hot restrike action using a suitable ignitor within the required 30 secs, and

c) is not significantly temperature sensitive.

Insulating material used in the construction of the spark
5 gap should have high electrical resistivity of the order
10⁶ ohms cms at 650 K which is thought to be suitable for most
lamp applications. Aluminosilicate and borosilicate glasses
come into this category. Of course other materials with higher
resistivity, for example ceramic could be suitable. Soda lime
10 silicate glass which has lower resistivity of 10⁵ ohm cms at
650 K could also be suitable depending on lamp duty. It is
advantageous to have the co-efficient of expansion of the
insulating material compatible with the co-efficient of
expansion of the material of the conductors. The nearer these
15 properties are to being the same the less tendency there is for
cracking of seals to occur. Refractory metals such as
molybdenum and tungsten wire have been found suitable conductors
as well as the nickel iron alloy known commercially as NIO.
As a general guide the spark gap should be designed so that it
20 will not breakdown below about 2 x mains voltage but should
breakdown below about $\frac{1}{2}$ x the applied starting voltage pulse.
However from the following description it will be clear that the
spark gap can be designed to meet a variety of conditions. It
will also be clear to those skilled in the art that while the
25 following description is in terms of a high pressure sodium
vapour lamp the spark gap can be used in a variety of lamps
requiring starting aids and ignitors or the like.

Preferably the lamp of the invention should include a small
amount of argon or neon or a mixture thereof which we have found
30 to aid starting with little influence on luminous efficacy.

The invention will now be described by way of example only
and with reference to the accompanying drawings wherein:

Figure 1 is a part sectional view of a high pressure sodium
lamp according to the present invention,

35 Figure 2 is a sectional view of an end closure assembly

used in the lamp of Figure 1,

Figure 3 is a first example of a spark gap according to the invention,

Figure 4 is a second example of a spark gap according to
5 the invention,

A high pressure sodium vapour discharge lamp 10 according to one embodiment of the invention is shown in Figure 1. This comprises an outer envelope 11 of borosilicate glass fitted to an edison screw end portion 12 forming the base of the lamp
10 10. The envelope 11 contains a ceramic arc discharge tube 13 suspended from a cross part 14 attached at one side 15 and, by means of an overhanging portion 16 to the other side 17 of a substantially rigid electrically conductive support rod 18. The support rod 18 is welded to a main electrical inlead 19
15 projecting through a borosilicate glass stem 20. Spring-like brackets attached to the support rod 18 ensure the arc tube is properly centred within the lamp envelope. The cross piece 14 is attached to a niobium tube 21 hermetically sealed to the discharge arc tube 15 and the tube 21 in turn is connected to
20 discharge electrode 22 thus forming one main electrical inlead for the arc tube. At the other end of the arc tube 13 there is attached a second niobium tube 23 which is a sliding fit on a support wire 25 welded to a substantially rigid electrically conductive rod 26 projecting through the borosilicate glass stem
25 20. A flexible conductive foil 27 is attached to the niobium tube 23 and the substantially rigid rod 26 and this arrangement thus forms a second main electrical inlead to the discharge electrode 24. This arrangement allows for movements of the components due to temperature expansion effects. The niobium
30 tube end closure arrangement which is shown in greater detail in Figure 2 is but one of several possible arrangements and the particular arrangement of end closure chosen is not critical to the invention. In Figure 2 the niobium tube 23 is hermetically sealed within an alumina plug 28, which in turn is hermetically
35 attached by means of a suitable sealing composition 29 within

the discharge tube 13. The niobium tube 23 carries a shank 30 supporting the discharge electrode 24.

The arc tube of the above lamp can have a gas filling comprising a mixture of 90 to 98% Xenon, with the balance of 2-10% being argon, neon or a combination of both filled to a total pressure of between 50 and 1000 torr at 300K. The argon and or neon gives some improvement in starting, with little influence on luminous efficacy. In addition the arc tube contains charges of sodium and mercury which during lamp operation will produce a partial pressure of sodium of 40 to 400 torr and a partial pressure of mercury of 40 to 1400 torr. The outer glass envelope of the lamp 10 is usually evacuated to minimise losses but in some cases may be gas filled with a non-reactive gas or mixture. A means of gettering, for example ring 36, is included in the outer envelope to clear up impurities such as hydrogen.

In accordance with this embodiment of the present invention a spark gap generally indicated at 38 is provided. One end 39 of the spark gap is connected to the inlead 26 while the other end 40 is connected to a conductive wire 41. This wire 41 loops around the arc tube as shown and co-operates with the discharge electrodes 22 and 24 to facilitate the starting of the lamp. The end of the wire 41 remote from the spark gap 38 is anchored within an insulating member 42 attached to the rod 18. The insulating member 42 is a solid piece of borosilicate glass with the conductive wire 41 embedded therein.

According to the present invention several versions of spark gap can be used. In figure 3 a linear version is shown comprising a length of aluminosilicate glass forming an elongate envelope 43 defining a container sealed at each end 44 and 45 around co-axial conductors 46 and 47 thereby hermetically sealing the conductors 46 and 47 within the envelope 43. The envelope 43 can be evacuated or enclose a fill of air or one or more gas species the pressure of which, together with the spark gap, may be used to control the breakdown voltage. A spark gap

as shown in figure 3 typically could be 14 mm in overall length with an outside diameter of 3 mm. The conductors 46 and 47 could be molybdenum wire 0.3 mm in diameter and with a gap between the conductors of between $\frac{1}{2}$ to 1 mm. The conductors 46 and 47 can be joined to stainless steel wires 48 and 49 approximately 0.7 mm in diameter which assists in the mounting and assembly procedure. A spark gap as described contains a fill of argon at a pressure between 75 and 250 torr and would be arranged to break down between 1,000 and 3,000 volts. A different version of spark gap is shown in figure 4. This comprises a bulbous envelope portion 50 also defining a container having one end 51 pinch sealed around spaced parallel conductors 52 and 53 thereby hermetically sealing the conductors within the envelope 50. The envelope in this case is of alumino silicate glass, approximately 8 mm in diameter and about 8mm long. The conductors are as before, molybdenum wire approximately 0.3 mm in diameter which are joined to 0.7 mm diameter stainless steel wires 54 and 55. The gap between the conductors is between $\frac{1}{2}$ to 1mm, the bulb is filled with argon, in the range 75-250 torr. Breakdown is arranged to occur in the range 500 to 2000 volts.

In operation we have found that if the spark gap is positioned such that it is directly exposed to the light from the arc tube some photo electric emission can take place between the electrodes. In one test we found a current of the order of 7 micro amps existed. We find, however, that we can prevent this by providing suitable shielding, for example by providing screens around the spark gap, or by locating the spark gap in an area not exposed to the light. Another alternative is to provide the spark gap 38 with a suitable non-conducting covering of opaque material 56 and 57 as shown in figures 3 and 4 (much exaggerated for purposes of illustration) respectively. Such a covering could be, for example, zirconia.

In use a lamp incorporating the spark gap of the invention will be placed in circuit with a suitable igniter which will

provide high voltage pulses of the order 1.5 to 5 KV. The spark gap provided will be arranged to break down under these high voltage pulses and will then be able to pass current to the wire conductor 41 to facilitate the starting of lamp. As soon
5 as the high voltage pulses cease to be applied no current will pass across the spark gap and hence no sodium loss will be incurred through leakage current circulating in the conductor 41 drawing out sodium ions through the arc tube. No resetting of component parts is required and it will be evident from the
10 description that the design of spark gap is extremely simple and economical. In addition to the high pressure sodium lamp described herein it will be appreciated that the spark gap may be used with any discharge lamp in which the ignition phase is preceeded by the application of a high voltage pulse. In
15 particular we have obtained excellent starting in short arc metal halide lamps.

What we claim is:-

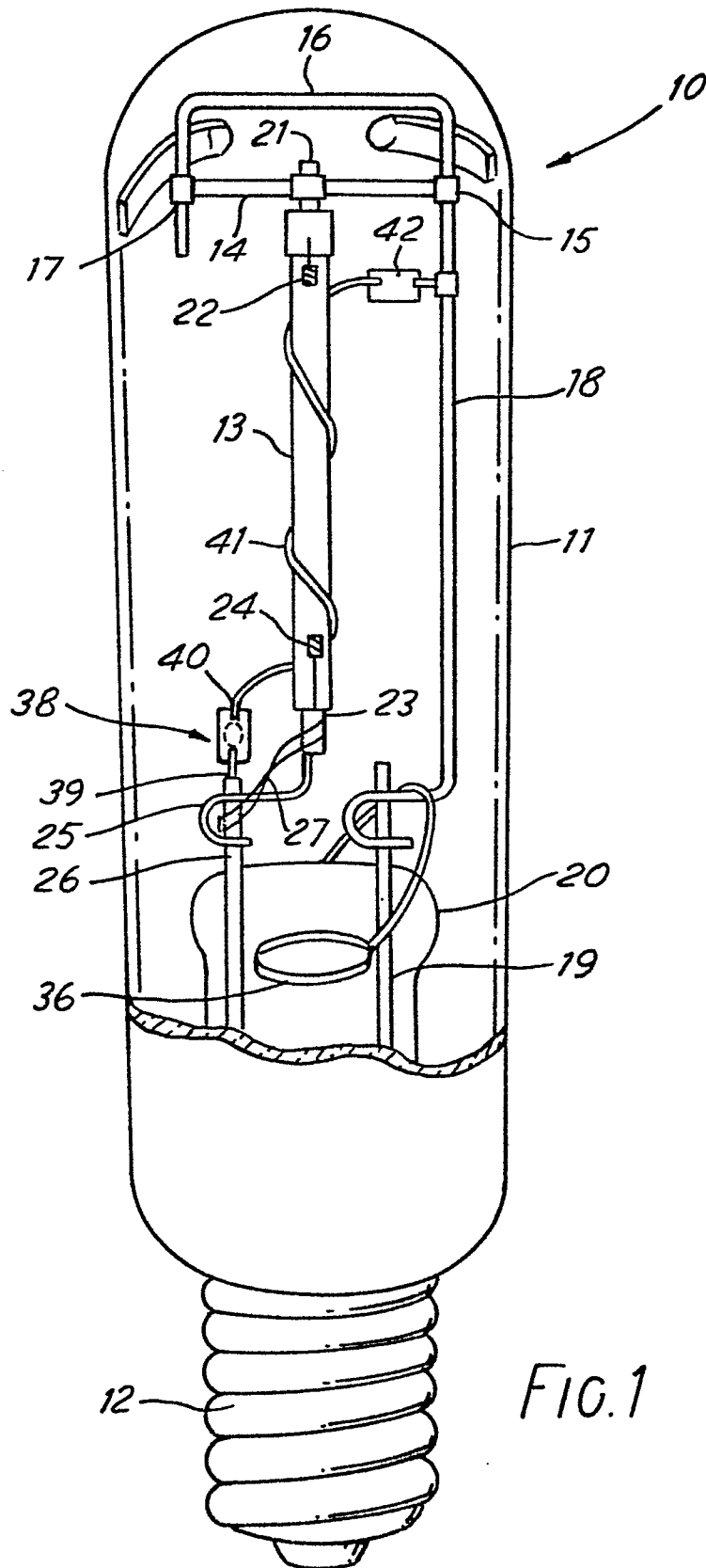
1. A discharge lamp having an arc discharge tube including electrodes for supporting a discharge therebetween, inleads connected to respective electrodes, a starting aid including a conductor co-operating with the electrodes and a spark gap
5 connected between the conductor and one of the inleads, said spark gap comprising an envelope of insulating material defining a container and two or more conductors hermetically sealed to and projecting within the envelope to define a gap between the conductors.
- 10 2. A discharge lamp according to Claim 1 wherein the spark gap envelope includes a fill of gas.
3. A discharge lamp according to Claim 2 where the gas is air.
4. A discharge lamp according to Claim 2 wherein the gas is a rare gas.
- 15 5. A discharge lamp according to Claim 4 wherein the gas is argon with a pressure in the range 40 to 400 torr.
6. A discharge lamp according to Claim 1 wherein the spark gap envelope contains a vacuum.
7. A discharge lamp according to Claim 1 wherein the spark gap
20 envelope includes a covering of non-conducting opaque material.
8. A discharge lamp according to Claim 1 wherein the spark gap envelope 13 covered with zirconia.
9. A high pressure sodium vapour discharge lamp having an arc discharge tube with a fill including a mixture of 90 to 98%
25 xenon, with the balance being selected from argon or neon, separately or in combination and with the resultant gas fill being at a total pressure of between 50 and 1000 torr at 300°K, said lamp arc discharge tube further comprising an envelope, two electrodes extending into said envelope and hermetically sealed
30 therewith, said electrodes being spaced apart in said envelope to support an arc discharge path therebetween, said lamp further comprising a starting aid including a conductor leading to the vicinity of the electrodes to co-operate therewith, and a spark gap connected between an inlead of said lamp and said conductor,
35 said spark gap comprising an envelope of insulating material

defining a container and two or more conductors hermetically sealed to and projecting within the envelope to define a gap between the conductors, said spark gap being adapted to electrically isolate the lamp during normal running of the lamp
5 and break down under high voltage pulses applied to start the lamp.

10. A discharge lamp according to Claim 1 wherein the arc discharge tube includes a fill selected from:

- argon at a pressure of between 75 to 250 torr;
- 10 xenon at a pressure of between 50 to 1000 torr at 300°K;
- sodium wherein the partial pressure is between 40 and 400 torr during lamp operation;
- mercury wherein the partial pressure is between 40 and 1400 torr; and
- 15 a mixture of 90 to 98% xenon with the balance of 2 to 10% being selected from argon or neon, separately or in combination and with the resultant gas fill being at a total pressure of between 50 to 1000 torr at 300°K.

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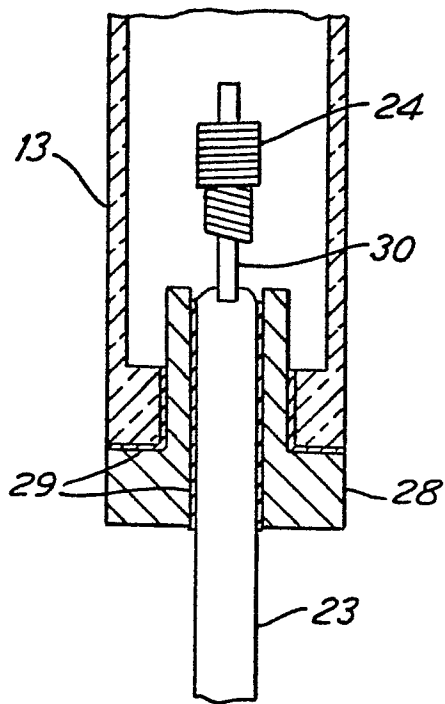


FIG. 2

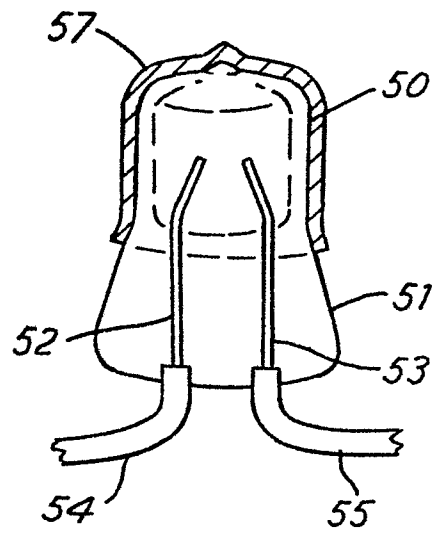


FIG. 4

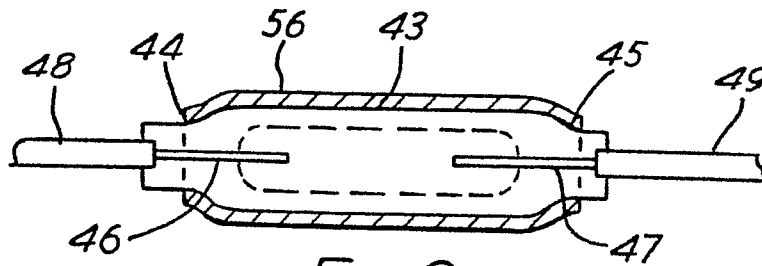


FIG. 3