PATENT SPECIFICATION

509,801

Application Date: March 11, 1938. No. 7638/38.
„ „ Oct. 3, 1938. No. 28671/38.

One Complete Specification Left: Jan. 12, 1939.

(Under Section 16 of the Patents and Designs Acts, 1907 to 1938.)

Specification Accepted: July 21, 1939.

PROVISIONAL SPECIFICATION
No. 7638 A.D. 1938.

Improvements in High-pressure Metal-vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNETZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a German citizen, do hereby declare the nature of this invention to be as follows:—

This invention relates to high-pressure metal-vapor electric discharge (H.P.M.V.) lamps of the type in which the greater part of the metal vapour present in full operation is mercury, so that the high-pressure features (and especially the constricted column) would be present even if there were no addition to the mercury, but in which a relatively small proportion of another metal vapour is also present.

Hitherto other metals, and especially zinc and cadmium, have been added to the mercury in H.P.M.V. lamps in order to modify the colour of the light from the discharge and especially to add red to it. Their presence has usually (so far as the applicants are aware, always) reduced the luminous efficiency. We have discovered that the addition of thallium, while not increasing the red content of the light, may increase the luminous efficiency considerably.

According to the invention the metal filling of a H.P.M.V. lamp of the type specified comprises thallium whereby the luminous efficiency of the lamp in full operation is substantially greater than that which would be obtained if the thallium were absent and the other relevant factors remained unchanged. The relevant factors are the envelope, and the electrodes, W the wattage dissipated, and V_T the voltage between the electrodes in full operation.

If the said factors are unchanged, the efficiency increases regularly within wide limits with the vapour pressure of the thallium. The thallium has little effect unless its vapour pressure corresponds to a temperature above 450° C. The coldest spot of the envelope must therefore be above this temperature and as hot as possible. Since the maximum temperature of the envelope inevitably exceeds considerably the minimum temperature, even when (as is particularly desirable in lamps according to the invention) all known precautions for promoting uniformity of temperature are adopted, the envelope will usually have to be of quartz or other similarly refractory material.

The vapour pressure of mercury at all relevant temperatures is much greater than that of thallium. If the minimum temperature of the envelope is made as high as possible in order to obtain the necesary vapour pressure of the thallium, and if the vapour pressure of the mercury corresponded to the same temperature as that of the thallium, V_T would usually be undesirably high. For, though in lamps according to the invention (as in all H.P.M.V. lamps) the efficiency generally increases with W/l and V_T/l (where l is the distance between the electrodes), a limit is set to V_T by the condition that it must not approach the supply voltage so nearly that the lamp is extinguished by a sudden drop in that voltage, such as may occur if the supply is from mains. Accordingly it is usually desirable to limit V_T by limiting the supply of mercury, so that it is all evaporated at a dissipation much less than W and not (as is usual) at a dissipation about 0.9.W.

If the envelope is not more refractory than known quartz envelopes, and if the efficiency is not to decrease by more than 20% during the first 100 hours of life, it is undesirable than W/S should exceed 40 watts/sq. cm., where S is the area of the internal surface of the envelope.

Lamps according to the invention may be associated with luminescent materials just as are lamps containing mercury alone.

[*Price* 1/-]

Dated the 11th day of March, 1938.

NORMAN R. CAMPBELL,
For the Applicants.

PROVISIONAL SPECIFICATION
No. 28671 A.D. 1938.

Improvements in High-pressure Metal-vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNETZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a German citizen, do hereby declare the nature of this invention to be as follows:—

This invention relates to high-pressure metal-vapour electric discharge (H.P.M.V.) lamps of the type in which the greater part of the metal vapour present in full operation is mercury, so that the high-pressure features (and especially the constricted column) would be present even if there were no addition to the mercury, but in which a relatively small proportion of another metal vapour is also present.

Hitherto other metals, and especially zinc and cadmium, have been added to the mercury in H.P.M.V. lamps in order to modify the colour of the light from the discharge and especially to add red to it. Their presence has usually (so far as the applicants are aware, always) reduced the luminous efficiency. We have discovered that the addition of thallium, while not increasing the red content of the light, may increase the luminous efficiency considerably.

According to the invention the metal filling of a H.P.M.V. lamp of the type specified comprises thallium whereby the luminous efficiency of the lamp in full operation is substantially greater than that which would be obtained if the thallium were absent and the other relevant factors remained unchanged. The relevant factors are the envelope, and the electrodes, W the wattage dissipated, and V_r the voltage between the electrodes in full operation.

If the said factors are unchanged, the efficiency increases regularly within wide limits with the vapour pressure of the thallium. The thallium has little effect unless its vapour pressure corresponds to a temperature above 450° C. The coldest spot of the envelope must therefore be above 450° and preferably is considerably above that temperature: on the other hand there is some evidence that there is an optimum temperature that should not be exceeded. Since the maximum temperature of the envelope inevitably exceeds considerably the minimum temperature, even when all known precautions for promoting uniformity of temperature are adopted, the envelope will usually have to be of quartz or other similarly refractory material.

Further it is preferable, for the reasons set forth in Patent Specification No. 458,604, that the coldest spot should not be behind the electrodes. For the temperature in this region is difficult to control; accidental differences in manufacture lead to considerable differences in the vapour pressure of the thallium and therefore in the efficiency and operating characteristics. It is preferable to maintain the temperature behind the electrodes so high by known methods (such as placing the electrodes near to the end of the envelope, lagging, reflecting paints, and thickening of the wall of the envelope) that the coldest spot lies between the electrodes and at a more regular and easily controllable place. On the other hand, it is not necessary, as is proposed in the said specification, to arrange that the coldest spot should lie on the substantially widest undistorted part of the envelope.

The vapour pressure of mercury at all relevant temperatures is much greater than that of thallium. If the minimum temperature of the envelope is made as high as possible in order to obtain the necessary vapour pressure of the thallium, and if the vapour pressure of the mercury corresponded to the same temperature as that of the thallium, V_r would usually be undesirably high. For, though in lamps according to the invention (as in all H.P.M.V. lamps) the efficiency generally increases with W/l and V_r/l (where l is the distance between the electrodes), a limit is set to V_r by the condition that it must not approach the supply voltage so nearly that the lamp is extinguished by a sudden drop in that voltage, such as may occur if the supply is from mains. Accordingly it is usually desirable to limit V_r by limiting the supply of mercury, so that it is all evaporated at a dissipation much less than W and not (as is usual) at a dissipation about 0.9.W.

If the envelope is not more refractory

than known quartz envelopes, and if the efficiency is not to decrease by more than 20% during the first 100 hours of life, it is undesirable that W/S should exceed 40 watts/sq. cm. where S is the area of the internal surface of the envelope.

Lamps according to the invention may be associated with luminescent materials just as are lamps containing mercury alone.

Dated the 3rd day of October, 1938.
NORMAN R. CAMPBELL,
For the Applicants.

COMPLETE SPECIFICATION

Improvements in High-pressure Metal-vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNEITZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a German citizen, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to high-pressure metal-vapour electric discharge (HPMV) lamps of the type in which the greater part of the metal vapour present in full operation is mercury, so that the high-pressure features (and especially the constricted column) would be present if there were no addition to the mercury, but in which a relatively small proportion of another metal vapour is also present.

Hitherto other metals, and especially zinc and cadmium, have been added to the mercury in HPMV lamps in order to modify the colour of the light from the discharge and especially to add red to it. Their presence has usually (so far as the applicants are aware, always) reduced the luminous efficiency. We have discovered that the addition of thallium, while not increasing the red content of the light, may increase the luminous efficiency considerably. The increase of efficiency appears to arise from the addition of the thallium spectrum to the mercury spectrum; the efficiency with which the mercury spectrum is excited does not appear to be increased. The increase of efficiency is associated with a change of colour, the light becoming greener. The addition of thallium may not therefore be desirable if the colour of the light is important.

According to the invention (subject to a condition hereinafter imposed) the metal filling of a HPMV lamp of the type specified comprises thallium, whose vapour pressure during operation is adjusted in accordance with the considerations set forth in the following paragraph so that the luminous efficiency of the discharge in full operation is substantially greater than that which would be obtained if the thallium were absent and the other relevant factors were unchanged. The relevant factors are the envelope, the electrodes and their position relative to each other and to the envelope, W the wattage dissipated, and V_r the voltage between the electrodes in full operation. In order that the comparison may be made, the value of V_r can be restored for the same W when the thallium is subtracted, by modifying the ambient temperature or the quantity of mercury or both.

Whatever the pressure of the mercury vapour (so long as it is always great enough to cause the lamp to be HPMV) thallium appears to have little effect unless its pressure is greater than that corresponding to a temperature of 500° C. (The pressure corresponding to a temperature T^o means, as usual, the pressure of vapour in equilibrium with thallium maintained at T^o). Accordingly this condition is imposed as the aforesaid limitation on the scope of the invention. Further, if the aforesaid relevant factors are unchanged, the efficiency increases regularly with the pressure of the thallium vapour within a wide range of that pressure. It is probable that it does not increase indefinitely; indeed our experiments indicate that when the pressure attains a value (corresponding to 800° or 1000° C.) that is difficult to attain in the present state of the art, the efficiency may fall with further increase of pressure, for at least some values of the said relevant factors, especially when the pressure of the mercury is not much more than 1 atmosphere. Nevertheless, in the present state of the art, a safe general rule is that, if the highest possible efficiency is required, the pressure of the thallium should be made as great as is consistent with such other desiderata as long life, uniformity in manufacture, and stability in operation.

As is well known, the pressure of the thallium vapour can never exceed the limit corresponding to the temperature of the coolest spot on the boundary of the space to which the vapour has access. (If, as in known water-cooled lamps, the envelope has a narrow bore partly occupied by un-

evaporated metal, this coolest spot may be on the surface of the metal and not on the envelope itself). Accordingly the said general rule means that the lamp should be designed so that the temperature of the said coolest spot is as great as the said desiderata permit, and that it is usually undesirable to limit the amount of thallium so that it is all evaporated at a dissipation much below that for which the lamp is designed, and so that in normal operation the pressure is much below the said limit. Indeed it may be desirable to have a considerable quantity of unevaporated thallium, in order that it may occupy irregularities in the envelope, where the said coolest spot would otherwise lie; the said coolest spot will then, as indicated just above, lie on the surface of the thallium which will be slightly warmer than the envelope below it.

In respect of life, the determining considerations are much the same as those prevailing in normal HPMV lamps. Thus if the envelope is not more refractory than known quartz envelopes, and if the efficiency is not to decrease by more than 20% during the first 100 hours of life, it is undesirable that W/S should exceed 40 watts/sq. cm., where S is the area of the internal surface of the envelope.

In respect of the uniformity of manufacture and stability in operation, it is sometimes preferable, for the reasons set forth in Patent Specification No. 458,604, that the said coolest spot should not be behind the electrodes or otherwise at an irregularity of the envelope. For the temperature at such irregularities is difficult to control; accidental differences in manufacture lead to considerable differences in the vapour pressure of the thallium, in the efficiency, and in operating characteristics. Then, as proposed in the said specification, the temperature behind the electrodes may be maintained so high by known methods (such as placing the electrodes near to the end of the envelope, lagging, reflecting paints, and thickening of the wall of the envelope) that the coldest spot lies between the electrodes and at a more regular and easily controllable place. On the other hand, it is not necessary, as claimed in the said specification, to arrange that the coldest spot should lie on the substantially widest undistorted part of the envelope.

The vapour pressure of mercury at all relevant temperatures is much greater than that of thallium. If the pressure of the mercury vapour corresponded to the same temperature as that of the thallium vapour, the total pressure and/or V_T in the lamp would usually be undesirably high (except in water-cooled lamps). Accordingly it is usually desirable to limit the quantity of mercury present, in known manner, so that its pressure in full operation is much less than that corresponding to the said coolest spot. The procedure will therefore generally be to design the lamp, as aforesaid, with reference to the thallium pressure only and then to adjust the quantity of mercury so as to give the desired V_T.

In selecting the quantity of mercury, it must be remembered that mercury and thallium form an amalgam over which the vapour pressure of mercury is less than over mercury at the same temperature, and decreases with decreasing mercury content. If there is excess thallium, the mercury introduced will never be completely evaporated; the amount required to produce a given pressure will depend upon the amount of thallium as well as on the volume of the envelope.

These instructions concerning the quantity of mercury do not apply to water-cooled lamps of the known type aforesaid. In them it is usually necessary for known reasons that excess mercury should be present at the ends of the narrow tubes; a mercury pressure corresponding to a temperature nearly as high as that to which the thallium pressure corresponds may have to be tolerated.

The considerations that determine L, the length of the discharge column, are the same as in pure mercury lamps. The efficiency generally increases with W/L and V_T/L, so that a small L is desirable, subject to known limitations. It may be observed that, for a given W/L and V_T/L, the presence of thallium, while it increases efficiency, does not greatly increase the brightness of the discharge column.

One embodiment of the invention will now be described, by way of example, with reference to Figures 1 and 2 of the accompanying drawing.

In Figure 1, 1 is a quartz tubular envelope, having an electrode 2 at each end. The internal bore of the tube is 8 mm.; the electrodes are tungsten spirals enclosing a rod of alkaline earth silicate, and are 3 mm. long; the distance between them is 30 mm. The whole of the envelope behind the front edge of the electrodes and the seals 3 are coated with a reflecting layer 4. The envelope contains a portion of thallium 5 of which only a small part is evaporated in operation, and also mercury 6 which is nearly all evaporated in full operation. The lamp is adapted to be operated with the straight line between the electrodes vertical and with the envelope surrounded by an evacuated jacket.

Figure 2 shows how the gain in

efficiency due to the presence of the thallium varies with the watts dissipated in full operation; it is assumed that, for each wattage dissipated, the quantity of mercury is adjusted so that V_x is always 150 volts. The abscissae are the watts dissipated; the ordinates the ratio of the light output when thallium is present to the light output when thallium is absent, W and V_x being the same in both cases. The absolute efficiency in the presence of the thallium when W=250 is about 70 L/watt. It must, of course, be understood that all the values of lumens and of efficiency are subject to the errors inherent in heterochromatic photometry. When a source differs from a standard as much as a HPMV lamp differs from an electric incandescent lamp, these errors may be as great as 15%.

Lamps according to the invention may be associated with luminescent materials just as are pure mercury HPMV lamps.

We are aware that Patent Specification No. 402,747 proposes to make thallium part of the filling of a HPMV lamp in order to obtain green light. But we are not aware of any previous proposal to adjust the vapour pressure of the thallium so that the luminous efficiency of the discharge is substantially greater than that which would be obtained in the absence of the thallium. The highest pressure suggested in the said specification is that corresponding to 500° C.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A HPMV lamp of the type specified wherein the metal filling comprises thallium whose vapour pressure during operation is greater than that corresponding to a temperature of 500° C., and is adjusted in accordance with the considerations hereinbefore set forth so that the luminous efficiency of the discharge in full operation is substantially greater than that which would be obtained if the thallium were absent and the other relevant factors aforesaid were unchanged.

2. A HPMV lamp according to Claim 1 wherein only a small part of the thallium is evaporated in operation.

3. A HPMV lamp according to Claim 2 in which the quantity of mercury is so small that in full operation the pressure of the mercury vapours is much less than that corresponding to the temperature to which the pressure of the thallium vapour corresponds.

4. A lamp according to Claim 1, 2, or 3 wherein means are provided for maintaining the temperature behind the electrodes so high that the coldest spot of the envelope during operation lies on the regular part of the envelope between the electrodes.

5. A HPMV lamp substantially as hereinbefore described with reference to Figure 1 of the accompanying drawing.

Dated the 12th day of January, 1939.

NORMAN R. CAMPBELL,
For the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

efficiency due to the presence of the thallium varies with the watts dissipated in full operation; it is assumed that, for each wattage dissipated, the quantity of mercury is adjusted so that V_r is always 150 volts. The abscissae are the watts dissipated; the ordinates the ratio of the light output when thallium is present to the light output when thallium is absent, W and V_r being the same in both cases. The absolute efficiency in the presence of the thallium when W = 250 is about 70 L/watt. It must, of course, be understood that all the values of lumens and of efficiency are subject to the errors inherent in heterochromatic photometry. When a source differs from a standard as much as a HPMV lamp differs from an electric incandescent lamp, these errors may be as great as 15%.

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Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A HPMV lamp of the type specified wherein the metal filling comprises thallium whose vapour pressure during operation is greater than that corresponding to a temperature of 500° C., and is adjusted in accordance with the considerations hereinbefore set forth so that the luminous efficiency of the discharge in full operation is substantially greater than that which would be obtained if the thallium were absent and the other relevant factors aforesaid were unchanged.

2. A HPMV lamp according to Claim 1 wherein only a small part of the thallium is evaporated in operation.

3. A HPMV lamp according to Claim 2 in which the quantity of mercury is so small that in full operation the pressure of the mercury vapours is much less than that corresponding to the temperature to which the pressure of the thallium vapour corresponds.

4. A lamp according to Claim 1, 2, or 3 wherein means are provided for maintaining the temperature behind the electrodes so high that the coldest spot of the envelope during operation lies on the regular part of the envelope between the electrodes.

5. A HPMV lamp substantially as hereinbefore described with reference to Figure 1 of the accompanying drawing.

Dated the 12th day of January, 1939.

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