PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in High-Pressure Mercury-Vapour Electric Discharge Lamps

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

This invention relates to high-pressure mercury vapour electric discharge (H.P.M.V.) lamps. The term "mercury" implies that no considerable part of the emitted light consists of radiation from material, such as cadmium or zinc, whose spectrum is richer in red light than the spectrum of mercury emitted by the lamp; it does not imply that no light comes from materials whose spectrum is not richer in red light, but no advantage for the purpose of the invention is known to attach to the presence of such materials.

In what follows the term "red ratio" means the percentage of the visible light from a lamp that is transmitted by a filter of the kind known by the trade name Wratten No. 25.

The red ratio of the H.P.M.V. lamps of the type used for street-lighting and like purposes in the years 1932 to 1935 did not exceed 2.

We have discovered that the red ratio of a H.P.M.V. lamp can be very greatly increased by increasing the ratio of the power dissipated in the discharge column to the volume of that column. This discovery may not be entirely new; it appears to have been observed that the red ratio of lamps in which this ratio is large (such as those in which the discharge passes through a narrow water-cooled tube) is somewhat greater than in lamps of the aforesaid type in which it is much smaller. But the extent to which it can be increased in lamps that require no water-cooling, does not appear to have been noticed; indeed we are not aware that any H.P.M.V. lamps in which the red ratio is greater than 5 have ever been made.

When the discharge column is not enclosed in a narrow tube, that is to say, when the distance between the terminations of the discharge column is less than the mean distance of those terminations from the envelope of the discharge, the volume of the discharge column is not limited by the envelope. The condition for a high red ratio is then that both W/l and V/l should exceed certain mutually related limits, where W is the power dissipated in the discharge column in full operation, V the voltage across it, and l its length. It is well known that, at a given current, V/l is a measure of the pressure. The conditions for a high red ratio are therefore (1) that the distance between the electrodes on which the discharge terminates in operation should be small in relation to the wattage, and (2) that the temperature of the coolest spot on the envelope, which limits the vapour-pressure available, must be high. At the same time, if the lamp is to have a life of more than a few hours, (3) the temperature of the hottest spot of the envelope must not exceed a limit set by the refractoriness of the material of the envelope. A further discovery on which the invention rests is that, if the general principles of design set forth in co-pending application No. 855/37 (Serial No. 485,489) are followed, the ratio W/l can be increased so that a high red ratio is obtained.

According to the invention, in a H.P.M.V. lamp of the type in which the distance between the terminations of the discharge column in full operation is so much less than the mean distance of those terminations from the envelope that no cooling, otherwise than by natural convection and radiation is required, the said ratios W/l and V/l are so high that the red ratio is at least 5%. In estimating the red ratio, the light from incandescent electrodes, if any, is to be regarded as light from the lamp; but no incandescent bodies other than electrodes are to be regarded as contributing to the light of the lamp.

In one embodiment of the invention, described by way of example, the structure of the lamp is as shown in the accom-

[Price 1/-]

panying drawing by sections (a), (b), in two mutually perpendicular planes. Here 1 is a quartz envelope 3 mm. thick; 2, 2^1 are the running electrodes 1.5 mm. apart; 3, 3^1 starting electrodes behind them. The dimensions represented by *a*, *b*, *c* are respectively 23, 23 and 28 mm. The lamp is adapted to consume 250 watts in full operation on an A.C. circuit, the voltage across the running electrodes being then 36. The red ratio is about 9; the initial spherical luminous efficiency is about 42 lumen/watt; the efficiency does not decrease by more than 30% during the first 100 hours of operation. Such a decrease is not usually objectionable if the lamp is used as a source in optical projection apparatus.

Dated the 12th day of November, 1937.
For the Applicants,
NORMAN R. CAMPBELL.

COMPLETE SPECIFICATION

Improvements in High-Pressure Mercury-Vapour Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, and VICTOR JAMES FRANCIS, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a British subject, 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 mercury-vapour electric discharge (HPMV) lamps of the type in which the distance (hereinafter called L) between the terminations of the discharge path in full operation is less than the mean distance of either termination from the envelope. So far as we are aware, in lamps of the said type the area of a cross section of the envelope by a plane bisecting and perpendicular to the straight line joining the said terminations has always been greater than that of a circle of 5 mm. diameter; no lamp in which this condition is not fulfilled is to be regarded as of the type specified.

Lamps of the type specified are commercially useful only when they are operated so that the power dissipated within them in full operation lies within narrow limits. Accordingly no lamp is to be regarded as of the type specified unless it is characterised by a prescribed power W to be dissipated within it in full operation. Further, with the dissipation of power W will be associated, in any given cooling conditions, a certain RMS voltage between the terminations of the discharge. If the cooling conditions are prescribed by the maker or vendor of the lamp, V hereinafter means the said voltage in these conditions; if no cooling conditions are thus prescribed, V means the said voltage when the lamp as sold is exposed in the atmosphere, free from draughts, at 20° C.

The term " mercury " in the definition of the type specified implies that no considerable portion of the light emitted from the discharge (as distinct from the electrodes) consists of radiation from material, such as cadmium or zinc, whose spectrum is richer in red light than the spectrum of mercury emitted from the discharge.

Further it is to be understood that substantially all the light emitted by the lamp comes from the discharge and the electrodes on which it terminates, these electrodes being heated by the discharge only. Lamps provided with incandescent filaments, even if the filaments are heated by the discharge current, or with incandescent bodies heated by heat from the discharge but not connected to leads by which current is conveyed to the discharge, are excluded from the type specified.

Hereinafter the term " red ratio " means (in accordance with convention well known to makers of HPMV lamps in this country) the percentage of the visible light from the lamp that is transmitted by a filter of the kind known by the trade name Wratten No. 25.

So far as we are aware, no HPMV lamp of the type specified had been described or sold at the date of this application in which the red ratio was greater than 5. It is well-known that red ratios exceeding 5 would be preferable for many purposes; the object of this invention is to provide HPMV lamps of the type specified having a red ratio greater than 5.

We have found that this object may be attained by making W/L much greater than has hitherto been usual for lamps of the type specified and at the same time maintaining V/L at a sufficient value. For a given W, V/L is known to be roughly a measure of the pressure of the vapour; hence the second condition means that the pressure must be suffi-

ciently high, and therefore that the temperature of the coolest spot on the envelope must be sufficiently high.

The effect of increasing W/L, the pressure being always suitable, is two-fold. First, the red ratio of the radiation from the discharge is increased. The nature of this increase may be seen from the following table, which gives the results of measurements made on certain lamps of which only those numbered 1 and 2 are of existing commercial types. In this table the columns give respectively L, W^1, V^1, W^1/L, V^1/L and the red ratio of the light from the discharge. The rows numbered 1, 2, 3, 4, 5, 6, 7 refer to different lamps.

W^1 and V^1 in the table are the power dissipated and the volts between the external terminals of the lamp. As explained below, an appreciable fraction of the power is dissipated in the electrodes and radiated or conducted therefrom and some small fraction of the volts is dropped in the electrodes and their leads. Accordingly W^1/L and V^1/L are somewhat larger than W and V as hereinbefore defined; but if the values of W and V were given in place of W^1 and V^1, the trend of the red ratio with W/L and V/L (which is all that the table is meant to illustrate) would be unaltered. On the other hand in estimating the red ratio, light from the electrodes is neglected.

	L (cm.)	W^1 (watts)	V^1 (volts)	W^1/L	V^1/L	Red ratio
1	16	400	140	25	8.75	1.0
2	3	125	120	42	40	1.6
3	0.72	250	100	347	139	2.8
4	0.50	500	68	1,000	136	3.2
5	0.34	500	49	1,470	144	3.7
6	0.14	400	35	2,860	250	3.9
7	0.12	600	30	5,000	250	4.5

It will be seen that, even for the highest value of W/L and V/L, the red ratio does not reach 5. Accordingly a second effect is necessary. This is an increase in the amount of thermal radiation from the electrodes if they are of sufficiently refractory material; for the addition of thermal radiation at any temperature that electrodes can attain in practice always increases the red ratio. A limit is set to the temperature of the electrodes by their evaporation and the consequent blackening of the envelope by deposition. It is to be understood that no discharge device is to be regarded as a lamp for the purpose of this specification, if during the first 100 hours of life its luminous efficiency falls to less than 50% of its initial value. We have found that, even subject to this limitation, the light from incandescent tungsten electrodes can be made to contribute to the total light from the lamp so as to produce a red ratio greater than 5.

The presence of and necessity for this second effect is the reason why it is not desirable to increase V/L without limit. For while increase in V/L, W/L being constant, usually increases the red ratio of the light from the discharge, it decreases the current in the discharge; it is the current carried by the discharge rather than the voltage between the electrodes, which determines the temperature of the electrode. Accordingly it has been found that it is seldom desirable to increase the pressure above 50 atmospheres; on the other hand if the pressure is less than 10 atmospheres, the discharge is liable to become diffuse and its red ratio to decrease. The corresponding values of V/L are roughly 250 and 50 volts per cm.

Since V/L, the pressure, and therefore the minimum temperature of the inner surface of the envelope, have not to exceed values that are known to be attainable in lamps cooled only by radiation and the natural convection of air, lamps according to the invention can be designed so as not to require water-cooling or forced air-cooling. On the other hand it is known to be sometimes desirable to use a smaller envelope than is strictly necessary, and to apply forced cooling to it, even when a larger envelope with natural cooling would permit a discharge of the same character to be obtained. Accordingly lamps with forced cooling (being always of the type specified) are not excluded from the invention. On the other hand any lamp in which the character of the discharge is influenced by the proximity of the envelope to it, so that a discharge of the same character could not be obtained with a larger envelope, are excluded from the scope of the invention.

We are aware that in Patent Specification No. 482,070 it is proposed (in effect) to increase the red ratio of a H.P.M.V. lamp by making the relevant part of an electrode so small that it acquires a temperature of at least 2,200° C. and yields at least 1% of the total light emitted by the lamp. But the lamps in connection with which this proposal is made are not of the type specified, since the internal diameter of the envelope is limited to less than 5 mm.; our experience with H.P.M.V. lamps suggests (though this is not stated in the specification) that the lamps described in the specification are of the type in which forced cooling is necessary. The value assigned to V/L in the said specification is definitely higher than that which our experiments show to be generally desirable in lamps of the type specified. The specification appears to contain no suggestion that the value of W/L affects the red ratio.

According to the invention in a H.P.M.V. lamp of the type specified W/L exceeds 1,000 watts per cm., the electrodes on which the discharge terminates in full operation are of material not substantially less refractory than tungsten and are so shaped that they are incandescent during operation, and the red ratio of the total light emitted from the lamp is not less than 6.

A suitable form for the said electrodes is a tungsten cylinder s mm. long and d mm. in diameter. d should increase with W, being preferably about 2 mm. for W = 250 watts, 3 mm. for W = 500 watts, 4 mm. for W = 1,000 watts. The value of s is not nearly so important; suitable values corresponding to the said three values of W are 3, 4, 5 mm.; but variation in a ratio of at least 2 to 1 is permissible. The running electrodes on which the discharge terminates are preferably associated in known manner with activated starting electrodes from which the discharge transfers itself to the running electrodes during the run up.

The principles according to which a lamp of the type specified can be designed so as to be characterised by any assigned values of W/L and V/L (so long, of course, as these assigned values can be obtained at all) are sufficiently described in Patent Specification No. 485,489. It is sufficient here to describe a single embodiment of the invention by way of example; this embodiment is illustrated in the drawing accompanying the provisional specification in which (a) and (b) show sections in two mutually perpendicular planes. Here 1 is a quartz envelope 3 mm. thick; 2, 2^1 are the running electrodes 1.5 mm. apart; 3, 3^1 starting electrodes behind them. The dimensions represented by a, b, c are respectively 23, 23 and 28 mm. The lamp is adapted to consume 250 watts in full operation on an A.C. circuit, the voltage across the running electrodes being then 36. W/L is thus 1,667 watt/cm., V/L 240 volt/cm. The red ratio is about 9; the initial spherical luminous efficiency is about 42 lumen/watt; the efficiency does not decrease by more than 30% during the first 100 hours of operation.

In virtue of the short discharge path, lamps according to the invention are well suited for sources in optical projection apparatus; but of course they may be used for other purposes.

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 H.P.M.V. lamp of the type specified wherein W/L (hereinbefore defined) exceeds 1,000 watt/cm., wherein the electrodes on which the discharge terminates in full operation are of material not substantially less refractory than tungsten and are so shaped that they are incandescent during operation, and wherein the red ratio of the total light emitted from the lamp is not less than 6.

2. A lamp according to Claim 1 wherein V/L (hereinbefore defined) lies between 50 and 250 volt/cm.

3. A H.P.M.V. lamp substantially as hereinbefore described with reference to the drawing accompanying the provisional specification.

Dated the 14th day of September, 1938.
NORMAN R. CAMPBELL
For the Applicants.

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